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Agronomic Adaptation of Three Sweet Sorghum (*Sorghum bicolor L.*) Varieties of Two Semi-Arid Dryland Agroecosystems on Lombok, Indonesia

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Abstract: Lombok Island, Indonesia, possesses approximately 893,758 ha of dryland with significant potential for developing drought-tolerant crops such as sweet sorghum (Sorghum bicolor L.) to strengthen food security in semi-arid regions. This study evaluated the agronomic adaptation of three sweet sorghum varieties, namely Bioguma 3, Soper 9, and Numbu, under two contrasting dryland agroecosystems: clay-textured Vertisol in East Lombok (pH 6.8, organic C 2.2%, CEC 64.6 me/100 g) and sandy loam Entisol in North Lombok (pH 6.3, organic C 1.0%, CEC 15.9 me/100 g). The experiment employed a randomized complete block design with four replications, observing stem biomass, leaf biomass, and grain yield at 75, 90, and 105 DAS. Results demonstrated that soil physical and chemical properties strongly influenced varietal performance. The Vertisol soil, characterized by high cation exchange capacity and moisture retention, significantly enhanced vegetative growth, with Bioguma 3 producing the highest stem biomass (75.00 tons/ha) and leaf biomass (8.18 tons/ha). In contrast, the Entisol soil generated lower biomass yields (41.64 tons/ha stems and 5.55 tons/ha leaves) but supported more stable grain production across varieties. Soper 9 recorded the highest grain yield, reaching 6.09 tons/ha on Vertisol and 4.70 tons/ha on Entisol. These findings highlight the importance of integrating appropriate varietal selection with soil management strategies to improve dryland agricultural productivity and promote sustainable food security.

Keywords: Adaptation; Biomass; Grain-yield; Lombok; Semi-arid; Sorghum

Introduction

Sorghum (Sorghum bicolor L. Moench) is a cereal crop with a high tolerance to drought, making it a strategic choice for cultivation on drylands (Halim *et al.*, 2022). Compared to maize, which requires approximately 600–670 mm of water per growing season (Bhattarai *et al.*, 2020) Sorghum needs only about 420–500 mm (Ozeki *et al.*, 2022), indicating superior water-use efficiency (Andriani *et al.*, 2013). Sorghum is also known as a multipurpose crop: its grains serve as food, its stalks—particularly in sweet sorghum varieties-contain juice suitable for bioethanol production (Tabri *et al.*, 2014), and its leaves and bagasse provide additional value as livestock feed or industrial raw material (Sembiring and Subekti, 2013).

Rainfed drylands with Vertisol soils, characterized by clay texture in East Lombok, generally exhibit higher water and nutrient retention capacities due to their high clay content and shrink-swell characteristics (Matheus *et al.*, 2022). Vertisol can store water within microscopic pores and maintain soil moisture for extended periods (Mganga *et al.*, 2024), although they present mechanical constraints such as hardening when dry and stickiness when wet, which can restrict root growth if not properly managed (Sukartono *et al.*, 2013). Conversely, drylands

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with sandy-textured Entisol, such as those in North Lombok (Suwardji, 2013), exhibit high porosity and rapid water infiltration but low nutrient and moisture retention, making them vulnerable to drought and nutrient leaching. These conditions hinder plants from maintaining adequate water and nutrient supply, especially during prolonged dry periods (Capra *et al.*, 2008). The distinct physical and hydrological characteristics between Vertisol and Entisol soils form an important context for assessing the agronomic adaptation of sweet sorghum varieties in semi-arid drylands (Sukartono *et al.*, 2022).

In addition to its drought tolerance, sorghum offers other agronomic advantages, including ease of cultivation, relatively low production costs, and flexibility within various cropping systems—whether monoculture, intercropping, or ratoon-based (Olivia Mukondwa *et al.*, 2024). These attributes make sorghum a promising commodity for farmers in semi-arid regions to enhance both food security and feed availability (Yulita, 2006).

However, sorghum development in Lombok's drylands remains suboptimal due to biophysical constraints, including low soil organic matter, limited nutrient availability, irregular rainfall, and prolonged dry seasons (Fikri *et al.*, 2024). High fluctuations in water availability often induce drought stress during both vegetative and reproductive stages (Tang *et al.*, 2018), Moreover, varieties that lack adaptation to marginal soil and water-deficient conditions tend to fail in maintaining stable productivity (Mulyani *et al.* 2013). Under Lombok's semi-arid climate, the development of sorghum varieties capable of sustaining productivity under drought and nutrient limitations is therefore essential (Silva *et al.*, 2022).

Currently, several sweet sorghum varieties have been developed, each exhibiting distinct genetic and agronomic adaptation traits (Sarungallo *et al.*, 2020). For successful dryland sorghum cultivation in Lombok, it is necessary to identify varieties that are site-specifically adaptive to diverse soil typologies—those capable of maintaining stable yields both on clay-dominated soils with higher nutrient and water reserves and on sandy drylands constrained by limited moisture and fertility (Tang et al., 2018).

Therefore, this study aims to evaluate the agronomic adaptation of three sweet sorghum varieties under two contrasting dryland typologies in Lombok Island. The findings are expected to provide a scientific basis and recommendations for selecting the most adaptive and stable sweet sorghum varieties for sustainable cultivation in the semi-arid drylands of West Nusa Tenggara (NTB), contributing to food and feed security through resilient agricultural systems.

Method

Research Site

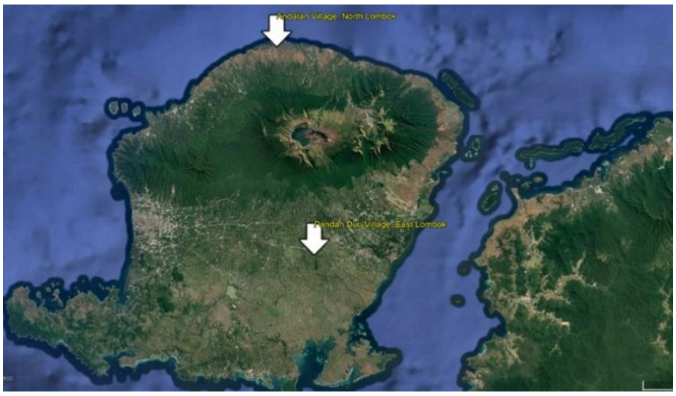


Figure 1. Imagery of the research location: Andalan Village, North Lombok Regency, and Pandan Duri Village, East Lombok Regency, West Nusa Tenggara Province, Eastern Indonesia

The study was conducted at two dryland locations with different soil typologies: (i) Pandanduri Village, East Lombok Regency, characterized by Vertisol soils with clay texture, and (ii) Andalan Village, North Lombok Regency, characterized by Entisol soils with sandy loam texture.

Analysis of soil physical and chemical properties-including pH (H_2O), organic carbon (C-organic), cation exchange capacity (CEC), texture, available P, and available K was carried out at the Soil Science Laboratory, University of Mataram, before the experiment to determine land suitability (Djaenudin *et al.*, 2011; Zubair, 2018).

Soil Property Analysis

Soil samples were collected from the topsoil layer (0–30 cm) using a composite sampling method at each site before planting. The analysis was conducted at the Soil Science Laboratory, University of Mataram, with the following parameters:

1. Soil pH (H_2O) was determined using a pH meter in a 1:2.5 soil-to-water suspension (Mindari *et al.*, 2023).
2. Organic carbon (C-organic) was measured using the Walkley and Black method (Black, 2020).
3. Cation exchange capacity (CEC) was analyzed using the 1N NH_4OAc method at pH 7 (Reeuwijk, 2002).
4. Soil texture was determined by the Bouyoucos hydrometer method (Dou *et al.*, 2016).
5. Porosity was calculated from bulk density and particle density values (Mindari *et al.* 2023).
6. Available phosphorus (P) was measured using the Bray I extraction method (Djaenudin et al, 2011).

7. Available potassium (K) was determined using 1N NH_4OAc extraction and measured with a flame photometer (Schumacher, 2002).

The analytical results were used to characterize the initial soil conditions and to serve as the basis for interpreting the agronomic responses of the sorghum varieties.

Experimental Design and Layout

The experiment was arranged in a Randomized Complete Block Design (RCBD) with a single factor, namely the sweet sorghum variety, consisting of Bioguma 3, Soper 9, and Numbu, and replicated four times. A total of 12 experimental plots were established at each site, each measuring 15 m × 10 m (150 m^2). Field procedures followed the standard dryland sorghum management practices (Tabri et al., 2014; Ilwati et al., 2025).

Land Preparation

Land preparation was carried out two weeks before planting using manual tillage with hoes to remove weeds and crop residues and to improve soil tilth. Twelve plots, each measuring 15 m × 10 m (150 m^2), were prepared at each site.

1. Seed Preparation and Planting

Planting holes were made using a dibbling method with a spacing of 60 cm × 20 cm. Five seeds were sown per hole, followed by thinning at 14 days after sowing (DAS) to retain one healthy plant per hill.

2. Crop Maintenance

Fertilization was applied twice using NPK fertilizer at a rate of 200 kg/ha, at 14 and 40 DAS. In addition, Green Tonik liquid fertilizer was applied weekly. Irrigation was performed as needed, especially during critical growth stages-germination, flowering, and grain filling (Aqil *et al.,* 2013; Allamine et al. 2023). Weed control was conducted manually at 10 DAS, 30 DAS, and during the reproductive stage, combined with hilling-up at 30 DAS. Pest control involved the use of Furadan 3G (20 kg/ha) and contact pesticides as necessary, while diseases were managed through a combination of mechanical and chemical control measures.

3. Observation and Sampling

Observations and data collection were conducted three times, at 75, 90, and 105 DAS (harvest stage). The observed parameters included stem weight, leaf weight, and grain yield. Sampling was carried out using the quadrant method, with an area of 2.0 m × 2.4 m per plot.

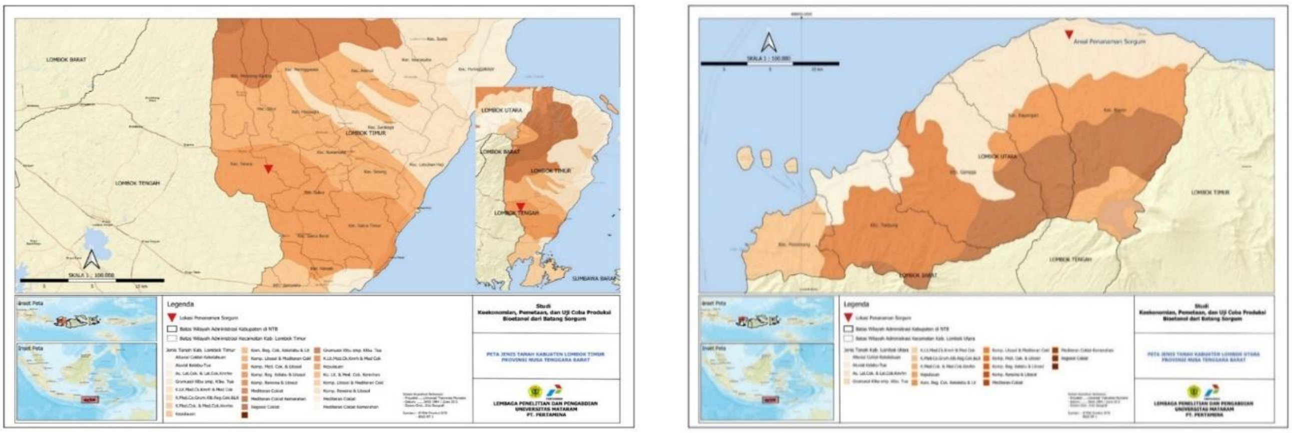
Data Analysis

The collected data were analyzed using analysis of variance (ANOVA) according to the RCBD model. When significant differences were detected, means were separated using the Least Significant Difference (LSD) test at the 5% significance level to compare varietal effects (Kemanian *et al.,* 2007; Sheleme *et al.,* 2015).

Result and Discussion

Characteristics of the Vertisol and Entisol

The most significant difference between the two sorghum cultivation sites lies in their soil orders. In Terara Subdistrict, East Lombok Regency, the soil is dominated by the clay fraction (Figure 2a), whereas in Bayan Subdistrict, North Lombok Regency, the dominant soil order is Entisol, characterized by a higher proportion of sand and silt fractions (Figure 2b). The soils in Terara are classified within the clay texture class and belong to the Vertisol order (grayish-brown Grumusol) (Suwardji *et* al., 2024).



(a) (b)

Figure 2. Soil Type Map in East Lombok Regency (a) and North Lombok Regency (b)

According to Mahrup *et al.,* (2005) Vertisols are mineral soils with a dark gray to black color, containing approximately 58.93% clay, 18.23% sand, and 22.84% silt (Table 1) at a depth of 50 cm. The dominant clay mineral is montmorillonite, which causes Vertisols to exhibit high shrink–swell behavior. These soils lack distinct eluvial and illuvial horizons, with the surface layer typically showing a granular structure (cauliflower-like), while the subsoil is blocky or massive (Matheus & Kantur, 2022). The cementing materials are primarily calcium carbonate, and the soils have a high expansion and contraction coefficient that fluctuates with soil moisture (Mindari *et al.,* 2023).

The microrelief is commonly gilgai-shaped, the consistency is plastic, and the parent material consists of calcareous or basaltic deposits. The solum depth averages 75 cm, with a dark gray to black color and low chroma values (Priyono et al., 2021). These properties indicate that Vertisols in East Lombok have high nutrient and water-holding capacities, which support more stable soil moisture and nutrient availability compared to Entisols.

Table 1. Soil Characteristics

Characteristic	Vertsiol Order		Entisol Order	
	Value	Criteria	Value	Criteria
pH (H2O)	6.8	Neutral	6.3	Neutral
Organic-C (%)	2.2	Medium	1.0	Low
CEC (me%)	64.6	Low	15.9	Low
Porosity (%)	44	Low	56	High
Bulk density (gr/cm^3)	1.1	High	1.2	Low
Particle density (gr/cm^3)	2.1	High	2.3	Low
Soil Texture:				
Sand (%)	18.2		43.66	
Silt (%)	22.8	Clay	39.87	Loam
Clay (%)	58.9		16.47	

Source: Results of analysis of the Soil Science laboratory, 2024

Susilowati *et al.,* (2021) stated that Vertisol soils generally exhibit high chemical fertility, characterized by abundant Fe^{2+} content, relatively high CEC, high base saturation, strong water-holding capacity, and a soil pH ranging from 6.0 to 8.5. The total potassium (K) content is usually very high, but available K tends to be relatively low due to potassium fixation between the interlayers of clay minerals (Patzel *et al.,* 2000). In addition, the vertic properties of Vertisol cause wide cracks that may disrupt plant root systems, particularly in crops with shallow root structures.

In contrast, the soils in Bayan Subdistrict, North Lombok Regency, differ markedly from those in Terara. The soil texture is classified as loam and belongs to the Entisol order (grayish-brown alluvial soils) (Priyono *et al.,* 2021). The soil characteristics are quite variable: the pH is slightly acidic, around 6.3, while the total N and organic C contents are relatively low, 0.13% and 1.15%, respectively. However, both available phosphorus (P) and available potassium (K) are rated high to very high, at 52.61 ppm and 86.23 ppm, respectively (Sukartono *et al.,* 2011).

These conditions inevitably influence the land suitability for sorghum cultivation. Overall, the soil characteristics at both experimental sites were considered suitable for sorghum growth, as the measured pH values fall within the optimal range of 5.5–7.5 (Zubair & Padjadjaran, 2018) or 5.5–8.2 (Djaenudin *et al.,* 2011).. Although the organic carbon content was classified as low, it still meets the minimum requirement for suitable sorghum soils, which is greater than 0.4% (Djaenudin *et al.,* 2011).

Agronomic Adaptation Related to Stem Biomass

All three sorghum varieties cultivated on Vertisol drylands exhibited high stem biomass, which continued to increase from 75 to 105 days after sowing (DAS). The highest stem weights at 105 DAS were recorded by Bioguma 3 (75.00 t/ha), followed by Soper 9 (70.26 t/ha) and Numbu (64.45 t/ha) (Figure 3). According to Andriani et *al.,* (2013)This growth pattern is consistent with the properties of Vertisol, which contains more than 50% clay, has a high water storage capacity, moderate to high cation exchange capacity (CEC), and adequate nutrient availability. These conditions support internode thickening and the accumulation of biomass and juice during the advanced growth stages. In sweet sorghum, stem elongation and thickening are typically accompanied by sucrose deposition in the internodes until near maturity, resulting in increased stem weight when water and nutrients are not limiting (Harvest, 2024).

In contrast, in North Lombok (Entisol/sandy soils), stem biomass was lower for all varieties—at 90 DAS: Bioguma 3 = 41.64 t/ha; Numbu = 36.90 t/ha; Soper 9 = 35.52 t/ha—and tended to decline by 105 DAS (Figure 3). Akande *et al.,* (2024) reported that Entisols, dominated by sand fractions, have large porosity (up to 52%), but low water retention and CEC (Table 1), which easily lead to terminal drought and nutrient limitation. These conditions reduce carbon assimilation, stomatal conductance, and cell turgor, thereby inhibiting stem growth (Abreha et al., 2022).. During the post-flowering stage, water deficit accelerates senescence, induces remobilization of stem reserves to the panicle/grain, and decreases stem mass and moisture content, leading to lower values at 105 DAS (Bhattarai et al., 2020). Similar findings were reported by Yang *et al.,* (2022), who found that water deficit in sorghum reduces stem biomass, enhances dry matter remobilization, and accelerates leaf and stem senescence.

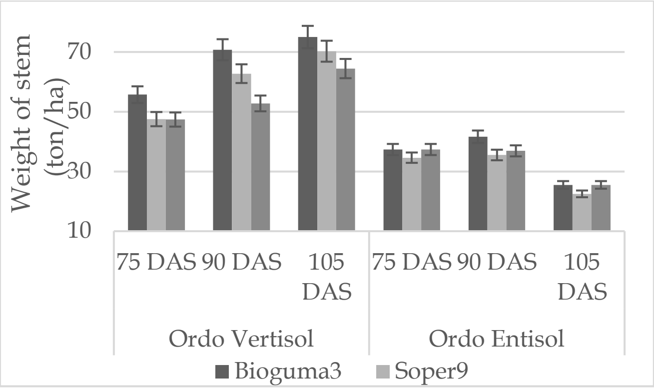


Figure 3. Comparison of Stem Weight between Varieties at 75, 90, and 105 DAS

The variation in varietal ranking across locations reflects a clear genotype × environment (G×E) interaction (Ngidi et al., 2024). Bioguma 3 and Soper 9 exhibited stronger vegetative vigor and greater stem-filling capacity when water and nutrient availability were sufficient, as observed in Vertisol soils (Matheus et al., 2022). Conversely, under sandy Entisol conditions, performance was more dependent on drought tolerance and water-use efficiency. Genotypes possessing "stay-green" traits and adaptive stem or root architecture tended to maintain higher biomass under water-limited environments (Susilowati et al., 2021).

The results of the Least Significant Difference (LSD) test at the 5% significance level (Table 2) indicated that Bioguma 3 consistently produced the highest stem biomass at 75, 90, and 105 DAS compared with Soper 9 and Numbu. At 75 DAS, Bioguma 3 differed significantly from the other two varieties, while Soper 9 and Numbu did not differ significantly from each other. By 90 and 105 DAS, varietal differences became more pronounced, following the trend Bioguma 3 > Soper 9 > Numbu.

According to Kong et al., (2018) this pattern indicates that the capacity for stem biomass accumulation is strongly influenced by the genetic characteristics of each variety, which regulate both vegetative growth efficiency and the transition to the reproductive phase (Dong et al., 2022).

Table 2. Effect of Variety on Average Stem Weight at 75, 90, and 105 DAS

Varietas	Average Bar Weight (kg/plot)					
	East Lombok			North Lombok		
	75 DAS	90 DAS	105 DAS	75 DAS	90 DAS	105 DAS
Bioguma3	26.75^{a}	33.96^{a}	36.00^{a}	17.93^{a}	19.99^{a}	12.24^{a}
Soper 9	22.81^{b}	30.12^{b}	33.72^{b}	16.62^{b}	17.05^{b}	10.80^{b}
Numbu	22.75^{b}	25.33^{c}	30.94^{c}	17.93^{a}	17.71^{b}	12.24^{a}

Description: Means followed by the same letter in the same column are not significantly different based on the Least Significant Difference (LSD) test ($p \leq 0.05$)

These findings are consistent with previous studies that reported significant genetic variability in sorghum biomass accumulation. Ozeki et la., (2022) observed that biomass-type genotypes can maintain high photosynthetic capacity under stress conditions, while Najam et al., (2021) emphasized that biomass-related traits exhibit high heritability and genetic advance. Furthermore, Kong et al., (2018) identified several quantitative trait loci (QTLs) and pleiotropic genes associated with plant architecture and biomass yield.

Therefore, the superiority of Bioguma 3 is likely associated with a combination of genetic traits that enhance photosynthetic efficiency, assimilate allocation, and optimal plant architecture, resulting in greater stem biomass accumulation compared to the other varieties (Turp & Özdemİr, 2023).

Agronomic Adaptation Related to Leaf Biomass

Vegetative growth of sorghum during the 75–105 days after sowing (DAS) period showed significant variation among varieties and locations, indicating a clear genotype × environment (G×E) interaction (Pabendon et al., 2017). On Vertisol soils in East Lombok, the varieties Bioguma 3 and Numbu produced the highest leaf biomass, reaching 15.12 t/ha and 14.60 t/ha, respectively, at 75 DAS (Figures 4a and 4c). In contrast, Soper 9 recorded a lower leaf biomass (13.24 t/ha, Figure 4b), although its performance remained competitive. Mahrup et al., (2005) reported that Vertisol soils with a high clay fraction possess greater cation exchange capacity (CEC) and moisture retention, which likely support leaf biomass accumulation in genotypes with strong vegetative vigor. Consequently, Bioguma 3 and Numbu exhibited superior performance compared with Soper 9 under these conditions (Nurcholis et al.,2019).

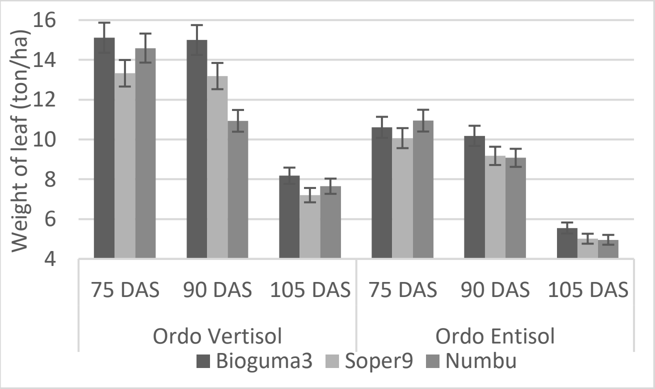


Figure 4. Comparison of Leaf Weight between Varieties at 75, 90, and 105 DAS

In Bayan Subdistrict, North Lombok, a slightly different trend was observed, where the Numbu variety outperformed the others with leaf biomass of 10.95 t/ha at 75 DAS (Figure 4), higher than Bioguma 3 (10.61 t/ha) and Soper 9 (10.07 t/ha) (Figure 4). This finding suggests that Numbu is more adaptive to sandy-textured soils characterized by low fertility and limited water-holding capacity (Adiansyah et al., 2016). The superior performance of Numbu is likely associated with its physiological traits, particularly greater water-use efficiency and tolerance to environmental stress, consistent with Vadez et al., (2011) Sorghum varieties with higher water-use efficiency tend to perform better under marginal dryland conditions, as reported.

In general, leaf biomass across all varieties decreased after 90 to 105 days after sowing (DAS) (Figure 4), reflecting the transition from the vegetative to the reproductive growth phase. According to Turp et al., (2023) characterize this process by the remobilization of photosynthates from leaf tissues toward the formation of panicles and grains, leading to leaf senescence and consequently a reduction in total biomass. Pabendon et al., (2017) further confirmed that the compatibility between genetic potential and environmental characteristics strongly influences varietal performance.

Therefore, in terms of vegetative growth, Bioguma 3 and Soper 9 tended to produce higher biomass on Vertisol drylands, which are relatively rich in nutrients, whereas Numbu exhibited higher performance on Entisol drylands, characterized by lower bio-physical fertility (de Cárcer et al., 2019).

Table 3. Effect of Variety on Average Leaf Weight at 75, 90, and 105 DAS

Varietas	Average Stem Weight (kg/plot)					
	East Lombok			North Lombok		
	75 DAS	90 DAS	105 DAS	75 DAS	90 DAS	105 DAS
Bioguma 3	7.25^{a}	7.20^{a}	3.92^{a}	5.09^{a}	4.87^{a}	2.66^{a}
Soper 9	6.39^{c}	6.33^{b}	3.46^{b}	4.83^{a}	4.40^{a}	2.40^{a}
Numbu	7.00^{b}	5.25^{c}	3.67^{ab}	5.25^{a}	4.36^{a}	2.38^{a}

Description: Means followed by the same letter in the same column are not significantly different based on the Least Significant Difference (LSD) test ($p \leq 0.05$)

Data in Table 3 show that the highest average leaf biomass in East Lombok (Lotim) was recorded for Bioguma 3 (15.115 t/ha), while in North Lombok (KLU), the highest value was obtained by Numbu (10.947 t/ha). Analysis of variance (ANOVA) and the LSD test ($p \leq 0.05$) indicated that in the East Lombok site, the variety had a significant effect on leaf biomass, whereas in the North Lombok site, varietal differences were not significant (Dolciotti et al., 1998).

At 90 DAS, the highest average leaf biomass in both sites was again observed for Bioguma 3, with 15.000 t/ha in East Lombok and 10.183 t/ha in North Lombok. Similar to the results at 75 DAS, ANOVA showed a significant varietal effect on leaf biomass in East Lombok but no significant impact in North Lombok (Ibitoye et al., 2023).

At 105 DAS, Bioguma 3 also maintained the highest average leaf biomass in both locations (8.177 t/ha and 5.550 t/ha, respectively). The ANOVA results revealed that in East Lombok, varietal effects were significant, with Bioguma 3 differing significantly from Soper 9, but not from Numbu. In contrast, varietal differences in North Lombok remained non-significant.

These differences can be attributed to the clay-rich Vertisol soils in East Lombok, which possess high cation exchange capacity (CEC) and strong water-holding capacity, thereby enhancing the expression of genetic vigor in responsive varieties (Vadez et al., 2011). Conversely, in the Entisol soils of North Lombok, limited nutrients and moisture suppressed the expression of genetic potential, resulting in more uniform varietal performance (Zegada et al., 2012). This contrast clearly illustrates a genotype × environment (G×E) interaction, where fertile soils amplify varietal differentiation, while marginal soils tend to homogenize physiological responses through accelerated senescence and remobilization of photosynthates (Mastrorilli et al., 1995).

Agronomic Adaptation Related to Yield

The grain yield of the three sweet sorghum varieties exhibited clear differences between the two soil orders (Figure 5). Under Vertisol soils in East Lombok, all varieties produced higher grain yields compared to those grown on Entisol soils in North Lombok (Kubiku et al., 2024). The Soper 9 and Bioguma 3 varieties achieved the highest yields, exceeding 6.0 tons/ha, while Numbu produced slightly lower yields at around 5.7 tons/ha. In contrast, under Entisol conditions, the yield of all varieties decreased to approximately 4.5–4.8 tons/ha, indicating the strong influence of soil physical and chemical properties on yield formation (Shahandeh et al., 2015).

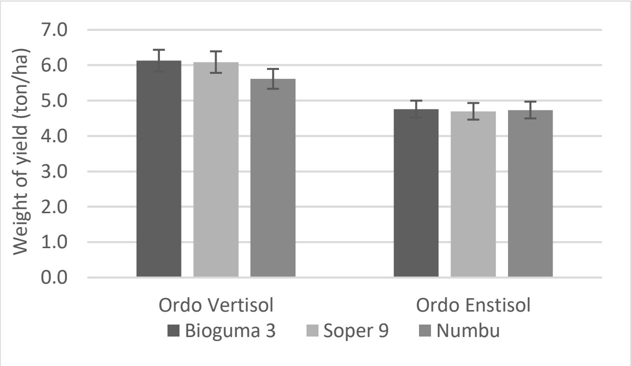


Figure 5. Comparison of Grain Weight among Sweet Sorghum Varieties (Bioguma

Olivia Mukondwa et al., (2024) stated that the higher yield performance on Vertisol can be attributed to its clay-rich texture, high cation exchange capacity (CEC), and greater water-holding capacity, which promote nutrient retention and stable soil moisture during the crop's critical growth stages. These conditions favor photosynthesis and translocation of assimilates, resulting in enhanced grain filling (Sheleme et al., 2015). Conversely, Entisol, characterized by its sandy loam texture, low organic matter, and limited water retention, restricts nutrient availability and moisture stability, resulting in reduced biomass accumulation and grain yield (de Cárcer et al., 2019).

The mean leaf biomass data (Table 3) further support this finding. In East Lombok (Vertisol), Bioguma 3 (2.943 kg/plot) and Soper 9 (2.923 kg/plot) had significantly higher leaf weights than Numbu (2.695 kg/plot), suggesting greater photosynthetic capacity and vegetative vigor (de Cárcer et al., 2019). However, in North Lombok (Entisol), differences among varieties were not statistically significant, with leaf weights ranging between 2.255–2.285 kg/plot, reflecting uniform but lower growth under nutrient- and water-limited conditions (Tang et al., 2018).

Table 4. Average Grain Weight as Affected by Variety

Varietas	Average Leaf Weight (kg/plot)	
	East Lombok	North Lombok
Bioguma 3	2.943^{a}	2.285^{a}
Soper 9	2.923^{a}	2.255^{ab}
Numbu	2.695^{b}	2.273^{a}

Description: Means followed by the same letter in the same column are not significantly different based on the Least Significant Difference (LSD) test ($p \leq 0.05$)

The superior performance of Bioguma 3 and Soper 9 under Vertisol conditions indicates better adaptation to soils with high clay content and nutrient-holding capacity (Pabendon et al., 2017). Meanwhile, the relatively stable performance of Numbu across both locations suggests greater tolerance to stress in coarse-textured soils. Overall, these results confirm that soil fertility and texture heterogeneity significantly influence sorghum's physiological responses, particularly biomass production and grain yield, under semi-arid dryland environments (Galicia-ju et al., 2021).

Conclusion

The Vertisol soils in East Lombok provided sufficient water and nutrient availability to support stem biomass accumulation up to 105 DAS, whereas the Entisol soils in North Lombok limited both water and nutrient supply, leading to a decline in stem biomass at 105 DAS due to drought stress and remobilization of stored assimilates.

The Bioguma 3 and Soper 9 varieties performed optimally in East Lombok, where favorable soil conditions promoted vigorous vegetative growth. In contrast, in North Lombok (Entisol), Bioguma 3 showed superior performance due to its genetic adaptability to drought stress and low nutrient availability.

These findings demonstrate a strong interaction between varietal genetic factors and environmental conditions, which collectively determine the agronomic adaptation of the three sweet sorghum varieties under semi-arid dryland conditions.

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Author Contributions

Conceptualization; F.; methodology.; S,W.; validation; S,K; formal analysis; F.; investigation.; resources; L.S,K; data curation: F; writing original; F; draft preparation. F.; writing review and editing: I.G. L,P.T. & T.R; Laboratory process: T.R A.All authors have read and agreed to the published version of the manuscript

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Conflicts of Interest

The authors declare no conflict of interest. in the publication of this scientific article

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