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Evaluation of new sorghum varieties for grain production cultivated in mineral soil

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Abstract

Sorghum bicolor L. (Sorghum) has been recognized as the fifth largest cereal crop in the world, following maize, wheat, rice, and barley, with a mean annual production of more than 5.89 million tons over the past five years. Grain sorghum is one of the cultivated varieties of the sorghum genus. It is primarily used as human food and animal feed due to the beneficial effects of bioactive compounds in the grain. Sorghum is less popular and unrecognizable in Malaysia, as it was not included in the reports by the Agriculture Department regarding plantation areas. In Malaysia, sorghum is limited because this crop is considered new, and no studies were conducted on the adaptability of its varieties to Malaysian soil and local climatic conditions. Crop production practices such as variety selection, planting density and fertilization will affect yield production. Therefore, a study on grain sorghum varieties (Brachy Sorgho, Jumbo Super, India and Pacific Seed 99) was conducted to evaluate the growth and yield performance of sorghum. Jumbo Super had a significantly higher value for plant height, followed by Brachy Sorgho, India and Pacific Seed 99. India showed the highest value of leaf fresh and dry weight, but no significant difference compared with Brachy Sorgho. Brachy Sorgho recorded the highest value of stem fresh and dry weight, while the least was recorded for Pacific Seed 99. Brachy Sorgho and India showed significantly higher grain yields than Jumbo Super and Pacific Seed 99 in terms of panicle length, panicle weight without grain, grain weight without panicle per plant, number of grains per panicle, and 100-grain weight. The highest gross weight of grain sorghum is Brachy Sorgho (140.00 g/plant), which showed no significant difference compared to the India variety (131.13 g/plant). Meanwhile, Jumbo Super and Pacific Seed 99 varieties showed the lowest grain weight, 77.27 g/plant and 80.16 g/plant, respectively. Overall, all four varieties are adaptable in mineral soil and are considered potential alternative crops for grain production. Bachy Sorgho and India varieties showed the best performance on grain yield compared to Jumbo Super and Pacific Seed 99 varieties. Thus, Brachy Sorgho and India varieties can be recommended for future grain production in mineral soil.

Keywords: Alternative crop; Grain yield; Growth performance; Mineral soil; Varieties

1. Introduction

Sorghum bicolor L. has a cultivation history of around 5000 years and has been widely planted worldwide [1]. It has been recognized as the fifth largest cereal crop in the world, following maize, wheat, rice, and barley, with a mean annual production of more than 5.89 million tons over the past five years [2]. Sorghum is highly diverse in its cultivated varieties, each owning miscellaneous characteristics which contribute to its versatile utilization. Therefore, sorghum is an excellent source of human food, animal feed, and bioenergy source [3,4]. Grain sorghum is one of the cultivated varieties of the sorghum genus. It is primarily used for its grain as human food and animal feed due to the beneficial effects of bioactive compounds in the grain [5]. Sorghum grows in a wide range of agro-ecologies, most notably in the drought-prone parts where other crops can least survive and food insecurity is rampant [6]. This makes sorghum preferred by farmers in drought-prone areas due to its tolerance to drought and harsh environments. Sorghum is essential to the diets of poor people in the semi-arid tropics, where droughts cause frequent failures of other crops [7]. Sorghum is less popular and unrecognizable in Malaysia as it was not included in the report by the Agriculture

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Department regarding the plantation areas [8]. Farmers in our country are less familiar with this crop. However, several reports of sorghum plants being planted on a small scale in neighbouring countries such as Indonesia, Philippines and Thailand. Based on the reports and studies abroad, sorghum is suitable for growing in dry soils including those that are exceptionally shallow and heavy clay types. Sorghum is also reported to have a better resistance level in dry environments than most other cereal crops. It can tolerate drought better than most other grain crops. It can be attributed to an exceptionally well-developed and finely branched root system, which is very efficient in water absorption. Thus, sorghum might be a suitable alternative crop for better water absorption in dry areas. In Malaysia, sorghum is limited because this crop is considered new, and no studies have been conducted on the adaptability of its varieties to Malaysian soil and local climatic conditions. Crop production practices such as variety selection, planting density, and fertilization will affect yield production. Therefore, a study on grain sorghum varieties (Brachy Sorgho, Jumbo Super, India and Pacific Seed 99) was conducted to evaluate the growth and yield performance for grain production. The introduction should be typed in Cambria with font size 10. Author can select Normal style setting from Styles of this template. The simplest way is to replace (copy-paste) the content with your own material. In this section highlights the importance of topic, making general statements about the topic and presenting an overview on current research on the subject. Your introduction should clearly identify the subject area of interest.

2. Material and methods

2.1. Planting materials

Four, grain sorghum varieties, Brachy Sorgho (V-1), Jumbo Super (V-2), India (V-3), and Pacific Seed 99 (V-4), were used in this study (Figure 1), which was conducted at MARDI, Serdang. The soil (Serdang series) is classified as a low-grade metamorphic mineral with characteristics of deep soil profiles having sandy loam to sandy clay loam textures. (DOA, 2008). The experimental plot had a dimension of 2 x 5 m, and two seeds were sown per hole at a depth of 3–5 cm with a planting distance of 75 x 10 cm. Each plot was applied with an organic fertilizer seven (7) days before seeds were planted at a rate of 3 tons/ha. Each experimental plot had a dimension of 2 x 5 m, and two seeds were sown per hole at a depth of 3–5 cm with a planting distance of 75 x 10 cm. After the seed was sown, the experimental plot was applied with NPK 15:15:15 at 800 kg/ha. After 30 days of planting, plants were applied with urea fertilizer at a rate of 260 kg/ha. Plants were irrigated immediately after sowing and twice per day using a sprinkler system. Plants from each plot were thinned to one plant per hole a week after sowing. Pest and disease observation and weed management were controlled when necessary.

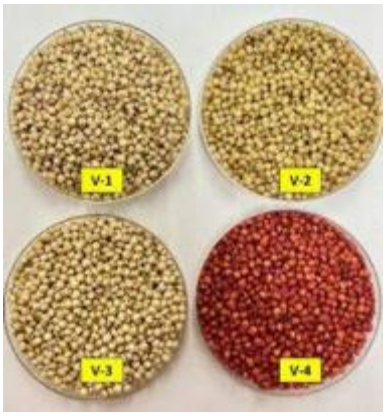

Figure 1 Different varieties of sorghum; Brachy Sorgho (V-1), Jumbo Super (V-2), India (V-3) and Pacific Seed 99 (V-4).

2.2. Experimental layout

Seeds from each variety were sown at 75 cm x 10 cm planting distances. The area of each experimental plot was 10 m2 consisting of three (3) rows and 50 plants in one row. The total number of plants per plot is 150, equivalent to 133,333 per hectare.

2.3. Data collection

Five plants were randomly selected from each treatment. Parameters were measured during the experiment on growth performance at 90 days after sowing (DAS), which included plant height (cm), stem girth (cm), number of leaves, leaf width and length (cm), leaf area (cm2) and dry weight of leaf, stem and root. Twenty plants in each variety were randomly sampled at 105–110 days after planting to record the grain yield. The grain panicle was harvested, and its

length was measured using measuring tape. The grain was sun-dried until it reached a relative humidity of 12–13%. Then, the grain was separated from the panicle. Panicles and grains of each panicle were weighed separately using a digital balance (QC 35EDE-S Sartorius, Germany).

2.4. Experimental design and data analysis

The treatments consist of four varieties of S. bicolor L. arranged in a randomized complete block design (RCBD) with four replications, approximately 150 plants per replication. The data obtained was analyzed by using one-way analysis of variance (ANOVA) in the SAS software (Version 9.4 SAS Institute Inc., Cary, North California, USA), and the difference between treatments was compared using the Least Significant Difference (LSD) at P ≤0.05%.

3. Results and discussion

3.1. Growth performance of sorghum varieties at 90 DAS

The vegetative responses in plant height, stem girth, leaf length, leaf width, and leaf area showed significant differences (P<0.05) among all varieties at 90 days after sowing (DAS) (Table 1). Meanwhile, the number of leaves showed no significant difference (P<0.05) among all varieties. The Jumbo Super variety had a significantly higher value for plant height, followed by Brachy Sorgho, India and Pacific Seed 99 varieties. The results also showed that the Pacific Seed 99 had a significantly lower value in plant height, stem girth, number of leaves, leaf length, and leaf area than other varieties. The highest stem girth was recorded for Brachy Sorgo (16.72 mm), while the lowest girth was recorded for Jumbo Super (13.16 mm), but there was no significant difference between India and Pacific Seed 99 varieties. Besides that, the number of leaves and leaf length showed no significant difference between Brachy Sorgo, Jumbo Super and India varieties. However, in terms of leaf area, Brachy Sorgho (3657.00 cm2) and Jumbo Super (35.64.20 cm2) showed highly significant differences compared to India (2369.00 cm2) and Pacific Seed 99 (1887.20 cm2). Table 2 showed significant growth performance in terms of leaf fresh weight, leaf dry weight, stem fresh weight, and stem dry weight and while root fresh weight and root dry weight showed no significant difference (P<0.05) among sorghum varieties at 90 days after sowing. India varieties showed the highest value of leaf fresh and dry weight, but no significant difference was observed when compared with Brachy Sorgho. Other than that, Brachy Sorgho recorded the highest value of stem fresh and dry weight, while the lowest was recorded for Pacific Seed 99. The variation in the growth performance of various sorghum varieties may be attributed to the difference in the genetic makeup of these cultivars. Different varieties of sorghum differed in growth performance [9].

Table 1 Growth performance in plant height, stem girth, no of leaves, leaf width and length, and leaf area on different sorghum varieties at 90 days after sowing.

Variety	Plant height (cm)	Stem girth (mm)	No. of leaf	Leaf length (cm)	Leaf width (cm)	Leaf area (cm2)
Brachy Sorgho	200.89 b	16.72 a	9.78 ab	91.33 a	8.48 a	3657.00 a
Jumbo Super	227.78 a	13.16 b	9.44 ab	90.33 a	5.80 b	3564.20 a
India	157.00 c	14.49 b	10.67 a	87.22 a	7.99 a	2369.00 b
Pacific Seed 99	95.56 d	13.64 b	8.22 b	76.67 b	8.40 a	1887.20 b
p-value	**	**	ns	**	**	**

Note: ** Significant at 1% probability level, *Significant at 5% probability level, ns: Not significant. Means in each column with the difference letters within each parameter indicate a significant difference at P≤0.05% level according to LSD.

Table 2 Growth performance in leaf fresh weight, leaf dry weight, stem fresh weight, stem dry weight, root fresh weight, and root dry weight on different sorghum varieties at 90 days after sowing

Variety	Leaf fresh weight (g)	Leaf dry weight (g)	Stem fresh weight (g)	Stem dry weight (g)	Root fresh weight (g)	Root dry weight (g)
Brachy Sorgho	93.17 a	31.92 a	349.84 a	93.88 a	72.34 a	26.34 ab
Jumbo Super	55.34 b	23.17 b	260.28 b	70.40 b	70.49 a	26.47 ab
India	101.06 a	33.02 a	264.54 b	63.42 b	70.69 a	33.01 a
Pacific Seed 99	50.06 b	20.87 b	118.41 c	34.06 c	39.93 a	17.57 b
p-value	**	**	**	**	ns	ns

Note: ** Significant at 1% probability level, *Significant at 5% probability level, ns: Not significant. Means in each column with the difference letters within each parameter indicate a significant difference at P≤0.05% level according to LSD.

3.2. Yield performance and yield component of sorghum varieties

Table 3 showed significant differences (P≤0.05) for almost all parameters with different varieties. Brachy Sorgho and India varieties showed significantly higher grain yields compared to Jumbo Super and Pacific Seed 99 in terms of panicle length, panicle weight without grain, grain weight without panicle per plant, number of grains per panicle, and 100-grain weight for grain sorghum production. The sorghum varieties also showed different characteristics in terms of leaf, panicle shape, and grain (Figure 2). Based on Table 3, there is a significant difference between the four varieties, where the Jumbo Super produced the highest panicle length (35.67 cm), followed by the Brachy Sorgho (33.80 cm) and the India (32.47 cm). In contrast, the Pacific Seed 99 had the lowest panicle length (28.67 cm). India showed a higher value than the Jumbo Super for the parameter panicle weight without grain, with a significant reduction of 80%. The gross weight of grain sorghum in Brachy Sorgho is 140.00 g/plant, and in India, it is 131.13 g/plant. The lowest grain yield was Jumbo Super (77.27 g/plant) and Pacific Seed 99 (80.16 g/plant). The reduction in the higher gross grain yield of Brachy Sorgho compared to the lowest gross grain yield of Jumbo Super is 45%. The difference in yield of various sorghum varieties might be due to variation in seed viability, diversity in seed weight, or genetic ability of these varieties [10]. However, all four varieties have the potential as alternative crops planted in mineral soil for grain production (Figure 3). In particular, the Brachy Sorgho and India varieties have a greater potential to produce a higher grain yield for human consumption. The popularity of grain sorghum as human food has increased due to its bioactive compounds which are beneficial to human well-being [4]. Therefore, breeding for grain sorghum varieties as human nourishment has become a trending research topic among sorghum breeders.

Table 3 Yield component in terms of panicle length, panicle weight, grain weight, no of grain, and 100-grain weight of different sorghum varieties at 105-110 days after sowing.

Variety	Panicle length (cm)	Panicle weight without grain (g)	Grain yield/ plant (g)	No of grain/panicle	100-grain weight (g)
Brachy Sorgho	33.80 a	18.65 a	140.00 a	3925.3 a	3.01 ab
Jumbo Super	35.67 a	4.72 c	77.27 b	2432.5 b	2.73 b
India	32.47 ab	23.34 a	131.13 a	3668.7 a	3.22 a
Pacific Seed 99	28.67 b	13.09 b	80.16 b	2847.6 b	2.20 c
p-value	*	**	**	**	**

Note: ** Significant at 1% probability level, *Significant at 5% probability level, ns: Not significant. Means in each column with the difference letters within each parameter indicate a significant difference at P≤0.05% level according to LSD.

Figure 2 Leaf and panicle shape for sorghum varieties; (V-1) Brachy Sorgho, (V-2) Jumbo Super, (V-3) India and (V-4) Pacific Seed 99 Figure caption should be of font size 10pt, Cambria, Centre align

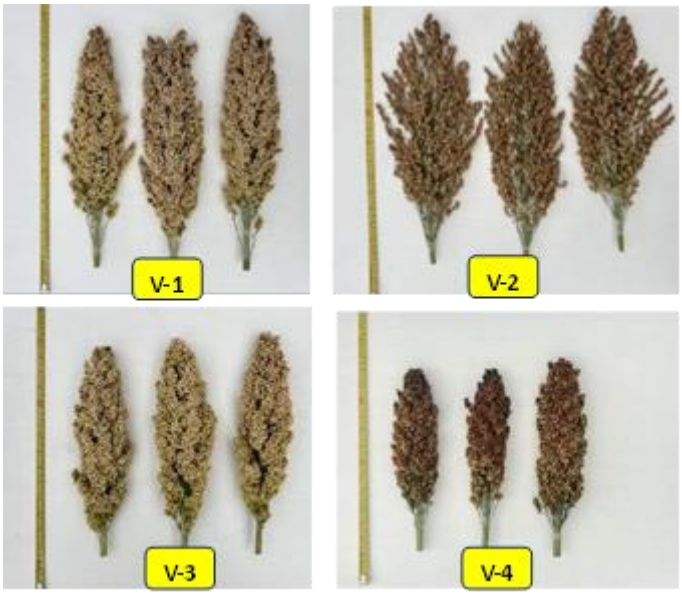

Figure 3 Grain sorghum varieties; (V-1) Brachy Sorgho, (V-2) Jumbo Super, (V-3) India and (V-4) Pacific Seed 99

4. Conclusion

In conclusion, different varieties of sorghum differed in growth performance and yield. Overall, all four varieties are adaptable in mineral soil, produce grain yields, and are potential alternative crops for grain production. The Brachy Sorgho and India showed the best performance on growth and grain yield compared to the Jumbo Super and Pacific Seed 99. Thus, the Brachy Sorgho and India varieties are recommended for future grain production in mineral soil.

Compliance with ethical standards

Acknowledgements

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Disclosure of conflict of interest

No conflicts of interest to be disclosed

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