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Yield of *Sorghum bicolor* (L.) Moenh Genotypes in A Plastic Mulch Planting System in Gunungkidul

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Abstract. *Sorghum is a strategic commodity with good nutritional and high antioxidant content that can be used as a source of food, feed, and industrial raw materials. Sorghum is a relatively low and less intensive crop than other staple food crops. Sorghum yield can be increased by establishing plant population through a mulching planting system. The purpose of this study was to determine the yield power of several sorghum genotypes, namely three new superior varieties (Bioguma, Kawali, and Samurai) and three local varieties (Plonco, Hitam Wareng, and Ketan Merah), planted with a plastic mulch planting system. The research was conducted on farmers' land in Karangmojo, Gunungkidul, Daerah Istimewa Yogyakarta, which is a dryland soil type. The experimental design used a randomized complete block design (RCBD) with 5 replications. Observation parameters included growth components and sorghum production. The results showed that sorghum planting with a mulching planting system was able to provide yields for the Bioguma variety of 7.70 tons/ha, Plonco variety of 8.41 tons/ha, Samurai variety of 5.38 tons/ha, Kawali variety of 8.21 tons/ha, Hitam Wareng variety of 3.91 tons/ha, and Ketan Merah variety of 4.00 tons/ha. Based on the results of the study, it was found that the genotypes of local varieties were able to compete with new superior varieties and had the best growth response and yield power in the rainy season planting.*

Keywords: *genotypes, Gunungkidul, plastic, sorghum, yield*

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INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moenh) is a type of cereal crop that is a strategic commodity with economic value as a source of food, animal feed, and industrial raw materials and can be a substitute for wheat flour (Sirappa, 2013). Even with its good nutritional content, sorghum can replace rice.Sorghum is an original plant from East Africa (Martiwi, 2023), which is now a plant that continues to spread throughout the countries of the world. Sorghum is commonly cultivated in several developing countries in Asia and Africa, as well as in developing countries of the Americas. In India, about 1% of calorie needs are met from sorghum and partly from other cereal sources (Nedumeran et al., 2013; Kusmiadi, 2013). FAO data in 2013 showed that there are 110 sorghum-growing countries. Indonesia has been planting sorghum since the beginning of the fourth century as a sorghum producer, although the development of the harvest area is still relatively small (Sembiring & Subekti, 2013).

In Indonesia, sorghum cultivation has not been as intensive as that of staple food crops such as rice, corn, soybeans, and other popular food sources. Sorghum cultivation is limited to a few regions in Indonesia, mainly in Java, South Sulawesi, Southeast Sulawesi, West Nusa Tenggara (NTB), and East Nusa Tenggara (NTT) (Sumarno et al., 2013). One of the distinctive traits of sorghum is its tolerance to drought and inundation (Anas, 2017). The productivity of potential sorghum plants has a seed weight of 40–100 grams per panicle. The average seed production is 6.36 tons per hectare and can even reach 8–9 tons per hectare. Sorghum stems weight is 400–800 grams per stem and can be used as a source of feed and fuel. Some superior varieties of sorghum from the Agricultural Research and Development Agency can produce sorghum biomass reaching 45–50 tons per hectare (Lestari et al., 2019). The leaves and stems of sorghum plants are a source of feed that can boost the weight of livestock and increase meat and milk production. Sweet sorghum stems are a source of bioethanol, liquid sugar, crystal sugar, and other products depending on efforts in handling derivative products (Bardono, 2020).

At present, the availability of productive land such as irrigated rice fields and rainfed rice fields for planting food is increasingly limited, including in the Yogyakarta region. For this reason, dry land, which has a large area, is a solution for the development of food commodities, including sorghum. The area of dry land in Indonesia that can be used for food crop production is around 13.26 million ha (Mulyani et al., 2023). The problem with dryland agriculture is that productivity tends to be low, has not been optimally utilized, and relies on rainfall as a source of irrigation. Water availability is an important element of production and occupies a portion of no less than 16% of the contribution of increased production (Haryono, 2013; Purwantini et al., 2013; Fuadi, 2016).

Sorghum can be developed on marginal drylands such as acidic drylands, vacant land, or other non-productive land. Sorghum development can increase land productivity and food diversification to support food security. The most prominent characteristics of sorghum plants are wide adaptation, high genetic diversity, easy cultivation, and a very small risk of crop failure, but the commodity has the potential to be exported (Subagio & Suryawati, 2013; Trikoesoemaningtyas and Suwarto, 2006). Even in dry climates, sorghum can be cultivated as food where other food crops are unable to produce optimally and adaptively (Almodares & Hadi, (2009) ; Butchee et al., 2012).

Gunungkidul is one of the regencies in Yogyakarta that has 1485.36 km2 of area or around 46.63% of the total area of Yogyakarta. The topography of Gunungkidul is divided into 3 zones, namely the North Zone, Central Zone, and South Zone. One of the areas in Gunungkidul Regency that cultivates sorghum plants is Karangmojo. Karangmojo has 80.12 km2 of area and is at 226 m above sea level. The land type in Gunungkidul is mostly dry land (90%) which depends on the climate and rainfall. The wet months in Gunungkidul range from November to February and the rest are dry months (BPS Gunungkidul, 2021).

As it has been said, sorghum can be planted in marginal conditions (dry land with minimal irrigation conditions). The Karangmojo farming community has been cultivating sorghum for several years, either in monoculture or by intercropping with other crops. However, the results are still not optimal. Therefore, cultivation techniques are needed to increase sorghum production. This includes technical improvements in land processing that are easy and economical (Khairunnisa et al., 2015). Land processing can minimize land preparation costs and increaseplant intensity by saving time for land preparation, one is by using mulch. Mulching could potentially serve the purpose by reducing soil evaporation, conserving moisture, controlling soil temperature, reducing weed growth, and improving microbial activities. Additionally, mulches could provide economical, aesthetic, and environmental advantages to agriculture and landscape. Moreover, in the restoration sites, mulches are widely used for the plantation of trees which need no significant care (Iqbal et al., 2020). Irmansyah et al. (2020) and Rahayu (2022) in their research, used plastic mulch and it has been able to increase sorghum production. For this reason, the purpose of this study was to determine the yield power of sorghum with a plastic mulch planting system in the rainy season on dry land in the Yogyakarta Province area.

MATERIALS AND METHODS

The research was conducted on farmers' land in Karangmojo, Gunungkidul, Yogyakarta, during the first planting season (MT-1) in October 2022 – March 2023. The method used was a field demonstration plot with a planting area of 1000 m2. The research started from seedling to harvest. Wet conditions were used as the wet season in Karang Mojo Gunungkidul, Yogyakarta, Indonesia, occurred from November 2022 to May 2023, with heavy rainfall during this period. Average daytime temperatures range from 30°C (86°F) in January to 31°C (89°F) in April. There is a chance of rain on most days during the wet season, with the wettest month being January. As for the soil pH, the result was 7.

The agroecosystem was rainy-season dry land with technological innovations in sorghum planting with various local genotypes and as a comparison for national superior varieties. The planting system used a planting distance of 60 cm x 25 cm. The number of seeds per planting hole was 2–3 seeds, then covered with husk ash or soil. Sorghum seeds used national varieties of sorghum (Bioguma (S1), Samurai (S4), and Kawali (S6)), and local varieties (Plonco (S3), Ketan Merah (V3), and Hitam Wareng (V4), were harvested and used as seeds (Table 1). Agricultural production facilities applied were organic fertilizer/cage 2,500 kg/ha, dolomite 150 kg/ha, NPK 16:16:16 fertilizer at a dose of 200 kg/ha, urea 150 kg/ha, and SP-36 50 kg/ha. Field auxiliary materials used were sign boards, wood, bamboo, measuring tapes, ropes, sickles, etcetera. For maintenance, weeding was carried out according to field conditions at least twice, accompanied by fertilization, the first weeding was about 14–21 days after planting and the second weeding was carried out at the age of 45 days after planting. Basic fertilization was given together with final tillage consisting of organic fertilizer, dolomite, and phosphate fertilizer (SP36). While chemical fertilization of NPK and urea was done twice, 7–14 days after planting with a fertilizer usage dose of 35% of the total fertilizer, and about 30–35 days after planting, with an application of 65% of the total dose of fertilizer. Pest and disease control was carried out according to field conditions. Harvesting was done manually using a sickle, when the harvest age was around 100–105 days. In this study, field harvest was carried out on February 9, 2023, February 19, 2023, and February 22, 2023.

The data observed included vegetative growth variables such as plant height and number of leaves, and generative variables related to production components of sorghum such as stem weight, number of fruits, fruit weight, etcetera. Harvesting was carried out by sampling each plot as many as 10 times, repeated five times. Data analysis was carried out by an analysis of variance RCBD at the 5% test level, with further tests using Duncan.

Table 1. Sorghum material used

Labeled	Name of Varieties	Type of Varieties
S1	Bioguma 3	National variety
S3	Plonco	Local variety
S4	Samurai	National variety
S6	Kawali	National variety
V3	Ketan Merah	Local variety
V4	Hitam Wareng	Local variety

RESULTS AND DISCUSSION

This study tested six sorghum genotypes in the rainy season in a conventional planting system using plastic mulch. Based on some research are no specific studies that directly compare the yield of sorghum crops grown with or without plastic mulch. However, some studies have investigated the effect of plastic mulch on the growth and yield of other crops, such as beans, corn, and chili peppers. These studies suggested that the use of plastic mulch can increase crop yield and improve plant growth. Therefore, it is possible that using plastic mulch could also have a positive effect on the growth and yield of sorghum crops. However, the percentage difference in yield between sorghum crops grown with and without plastic mulch cannot be determined without specific studies on sorghum. As a comparison, according to Saenong et al. (2017) and Alislami (2019), the use of plastic mulch in corn cultivation can increase corn (*Zea mays*) yields by 12.89 percent tons/hectare compared to cultivation without plastic mulch. This is related to the need for nutrients and the state or factors of the planting environment. One of the indicator variables that describe the growth of sorghum plants can be observed from the plant's height and number of leaves. Plant height and the number of leaves are components of the vegetative growth of a plant. The results of the study showed that the plastic mulch sorghum planting system with various genotypes showed significant differences in the growth component in the form of plant height variables and the number of sorghum leaves both at the vegetative age of the plant (age 30 after planting) and the plant height and number of leaves at harvest sorghum (Table 2).

According to Pramanda et al. (2015), differences in genotypes determine differences in plant height. Furthermore, according to Sitepu et al. (2015), plant height is strongly influenced by genetic factors. Plant growth will be optimal if the nutrients needed are available in the amount and form that suit the plants' needs. Nutrients N, P, and K are available in the soil in sufficient quantities so that the vegetative growth of plants, namely leaves, stems, and roots, will be better (Manik et al., 2016). In Table 2, V3 (Ketan Merah) has the least number of leaves, resulting in the lowest stalk weight. This also correlates with stem diameter. In addition to environmental influences, plant genetics play a role in this.

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Table 2. Growth components of various sorghum genotypes, Gunungkidul, Year 2023

Genotypes	Number of Leaves	Stalk (Kg)	Plant Height (cm)
S1	10.12a	0.84a	205.36 ab
S3	10.26a	0.56b	152.46 c
S4	9.78ab	0.544b	102.12 d
S6	9.22ab	0.544b	233.04 a
V3	6.40c	0.116c	177.20 bc
V4	8.00bc	0.523b	110.80 d
F count	6.12	7.3	19.35

Notes: Numbers accompanied by the same letter in the same column indicate the results are not significantly different in the 5% Duncan test, (S1: Bioguma 3, S3: Planco, S4: Samurai, S6: Kawali, V3: Ketan Merah,

The parameter of stem diameter (Table 3) shows that V3 is significantly different from all genotypes. The size of the stem diameter of sorghum plants can be an indicator of stem strength, making plants sturdier. According to Sutrisna et al. (2013), plants with a larger stem base diameter tend to be sturdier and more resistant to damping. The development of stem diameter depends on the availability of nutrients in the soil. According to Selvia et al. (2014), and Siera et al. (2015), nutrients can encourage the vegetative growth of plants, including the formation of chlorophyll in the leaves that spurs the rate of photosynthesis. Observations of flowering age showed that the plants flowered between 53.00 and 89.00 DAP.

Table 3. Growth components of various sorghum genotypes, Gunungkidul Regency Area, Year 2023

Genotypes	Stem Diameter (mm)	Flowering Age (DAP)	Harvesting Age (DAP)
S1	23.23 a	60.40 cd	106.60 abc
S3	21.46 a	68.60 bc	104.00 bcd
S4	21.15 a	75.20 b	111.40 ab
S6	19.45 a	53.00 d	93.20 cd
V3	12.29 b	55.40 d	90.80 d
V4	19.48 a	89.00 a	120.60 a
F count	9.09	23.50	10.92

Notes: Numbers accompanied by the same letter in the same column indicate the results are not significantly different in the 5% Duncan test, (S1: Bioguma 3, S3: Planco, S4: Samurai, S6: Kawali, V3: Ketan Merah, V4: Hitam Wareng).

Genotype S6 showed a low flowering age (Table 3). This indicates the presence of environmental factors that influence the slow flowering age. According to Sugianto et al. (2015), the flowering age of plants is more influenced by environmental factors, especially light intensity, rainfall, and daily temperature. Plant response to solar radiation is divided into three aspects, namely: intensity, quality, and photoperiodicity. High rainfall during the research process, especially in the rainy season, can result in a different quality of solar radiation compared to the dry season. Rainfall can affect the photoperiod of plants, which has an impact on the process of photosynthesis as well as phytochrome and plant biology. Furthermore, Stirling et al. (2022) explained that plant growth is influenced by photoperiod through the formation of flowers, fruits, and seeds. According to Thomas (2017), Caniato et al. (2017), aspects of plant development, including flower blooming, are influenced by day length when conducting research, especially the response to the duration of light and darkness, although each variety differs in sensitivity to photoperiod (Kumar et al., 2013). In this study, the harvest age ranged from 90.80 to 120.60 DAP.

According to Sulistyowati et al. (2016) and Maddonni et al. (2016), the longer the panicle, the more panicle branches and the number of seeds that will increase seed production. In the parameter of panicle weight per plant, Table 4 shows that genotype V3 is significantly different from all test genotypes. The number of seeds contained in the primary branches of panicles and panicle characteristics will affect the weight of panicles per plant. According to Ruchaniningsih (2008), panicles will get heavier as the number of seeds increases. The sorghum flowers will later become sorghum grains. According to Firmansyah (2018), the size of the panicle length, panicle diameter, and the greater weight of the panicle can result in the greater weight of the panicle seeds.

Meanwhile, the parameter of panicle weight per plot showed that S6 had the highest value and was significantly different from all genotypes observed. According to Sembiring & Subekti (2013), differences in genetic makeup are one of the factors determining diversity in the appearance of a plant.

Observations of seed weight per plant showed that genotype S6 had the highest value and was significantly different from all genotypes observed. Seed weight per plant as an indicator of seed quality is very important in measuring the yield power of a genotype. According to Sugandi et al. (2013), and Liu et al. (2014) weighty seeds are good-quality seeds and worth to be developed. Table 4 shows that S3 has the highest potential production per hectare at 8.41 tons. This can be expected because the genotype is better at bringing out its potential and adapting well to the rainy season. According to Panjaitan et al. (2015), and Agrios, (2015), each genotype has a different potential according to its genes. This means that the success of a plant in producing higher production is caused by the genes of the plant itself so the production results achieved depend on its genetic potential. In addition to genetic factors, differences in yield power are determined by the genotypes' responses to environmental conditions, nutrient absorption, and plant growth phases.

Table 4. Yield components of various sorghum genotypes, Gunungkidul District, Year 2023

Genotypes	**Panicle Lengh(cm)**	**Widh Panicle(cm)**	**Weight Panicle per Plant (g)**	**Weight Panicle per Plot (g)**
S1	17.56 c	6.98 b	144.72 a	2557.20 a
S3	23.31 bc	6.06 b	158.14 a	2472.60 a
S4	20.73 c	6.70 b	101.42 b	1767.61 ab
S6	17.71 c	9.86 a	154.66 a	2727.80 a
V3	32.16 a	6.75 b	28.48 c	314.60 b
V4	27.04 ab	10.64 a	74.40 b	730.40 b
F count	9.51	7.90	22.69	7.10

Notes: Numbers accompanied by the same letter in the same column indicate the results are not significantly different in the 5% Duncan test, (S1: Bioguma 3, S3: Planco, S4: Samurai, S6: Kawali, V3: Ketan Merah, V4: Hitam Wareng).

In the 1000 seed weight parameter (Table 5), the results were not significantly different between S1, S3, and S6, or between S4, V3, and V4. So it can be said that the variable weight of 1000 seeds in the genotypes observed is not uniform, which ranges from 23.00 to 40.90 g. Wahida (2013) stated that seed yield is determined by the number and size of seeds. This means that all genotypes tested have relatively unequal seed sizes. According to Panjaitan et al. (2015), the weight of 1000 seeds is a trait that has low variation; in this study, the genotypes that were not different had almost the same seed color and size. Furthermore, according to Tarigan et al. (2015), 1000 seed weight is not influenced by the environment because seed size is more controlled by genetic factors.

Table 5. Yield components of various sorghum genotypes, Gunungkidul District, Year 2023

Genotypes	Seed Weight per Plant (g)	Production per Hectare (tons)	1000 Seed Weight (g)
S1	58.78 ab	7.70 a	40.20 a
S3	85.96 c	8.41 a	39.00 a
S4	67.42 abc	5.38 b	20.20 b
S6	136.86 d	8.21 a	40.90 a
V3	70.81 abc	3.91 b	23.00 b
V4	57.29 a	4.00 b	23.70 b
F count	21.69	8.90	105.39

Notes: Numbers accompanied by the same letter in the same column indicate the results are not significantly different in the 5% Duncan test, (S1: Bioguma 3, S3: Plonco, S4: Samurai, S6: Kawali, V3: Ketan Merah, V4: Hitam Wareng).

CONCLUSION

Based on the results of the study, it was found that the genotypes of sorghum local varieties were able to compete with new superior varieties and had the best growth response and yield power in the rainy season planting.

AUTHOR CONTRIBUTION

A.M., S.W. and B.S.D. were designed the research and supervised all the process, A.M. collected and analyzed the data and wrote the manuscript with B.S.D, and S.W.

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CONFLICT OF INTEREST

The Author declare that there are no conflicts of interest related to the research or the funding of the research.

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