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# The Effect of Variety and Harvesting Time of Sorghum Planted in Stylosanthes Pasture on Growth, Production and Prussic Acid Content

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**ABSTRACT**

This research was aimed to determine the growth, production and prussic acid content of sorghum variety that planted on stylosanthes pasture with different harvesting time. This research was done using split-plot design with three replications which sorghum variety (brown midrib resistance (BMR) and Super-2) as the main plot and harvesting time (6, 8 and 10 weeks) as the sub plot. The sorghum seeds were germinated for 12 days before planted on the 30 days stylosanthes pasture which was planted with planting space 25x25 cm. Sorghum was planted with planting space 75x25 cm. The variables observed were plants height, dry and organic matter production and prussic acid. Data obtained were analyzed statistically using analysis of variance and significantly different between means were tested with Duncan's New Multiple Range Test (DMRT). Sorghum BMR had plant height, dry and organic matter production higher (P<0.05) than Super-2. Prussic acid content of BMR was lower (P<0.05) than Super-2. The older harvesting time increase (P<0.05) plant height, dry matter and organic production, but reduced (P<0.05) prussic acid content from 727.34 mg/kg to 241.71 mg/kg. Based on the results it can be concluded that the oldest harvesting time (10 weeks) produced the highest dry and organic matter, and reduce prussic acid content. Sorghum BMR is more productive and grew faster than Super-2. Sorghum BMR that harvested in 10-week shows the best in growth and productivity also had lower prussic acid content.

Keywords: BMR sorghum, Growth, Harvesting time, Production, Prussic acid, Super sorghum

## Introduction

Livestock is an important commodity to provide protein. The constrain of livestock development especially in Indonesia is availability of feed. The problem for feeding ruminant was the lack of quality and quantity of forage because it was very important to meet nutrient requirements for ruminants. Sirait *et al.* (2005) stated that forage feed was needed about 60% of dairy cattle from the total feed. The forage has not been optimally cultivated in Indonesia. Pasture land was exploited by grazing also cutting and carry method that need high quality forage to meet the nutrient requirements of the animal.

Legume has quite high protein content rather than grass, because it able to do Nitrogen (N) fixation from the atmospher by rhizobium symbiosis. *Stylosanthes guianensis* has many benefits, especially drought resistance, able to improve physical condition and fertility of the soil, and provide permanent vegetation. *Stylosanthes guianensis* has the disadvantage of low biomass production. Kiyothong *et al*. (2002) stated that *Stylosanthes guianensis* has a dry matter production as much as 4 tons/ha/harvest.

Optimalization of pasture biomass using *Stylosanthes guianensis* can be done by intercropping with high-yielding dry-resistant grass. Intercropping is a planting method between two types of plants to improve the quality and quantity of forage (Stoltz and Nadeau, 2014). Intercropping has several benefits, namely reducing weeds due to increased plant density, increase dry matter production per unit area, and improve forage quality. Telleng *et al*. (2016) stated that the intercropping system between sorghum and indigofera produced 8.2 tons/ha of dry matter. The result is higher than planting sorghum on monoculture which only produces 4.28 tons/ha of dry matter (Koten *et al*., 2012). Telleng *et al*. (2016) stated that dry matter production per unit area is high in intercropping. The N fixation of legumes also increase legume protein. Dried legume leaves as grass fertilizer can increase biomassa production (Sirappa, 2003). Sorghum Super-2 has higher fresh production than Brown Midrib Resistance (BMR), but BMR has lower lignin content (Talanca and Andayani, 2016). Astigarraga *et al*. (2014) stated that BMR sorghum has 4.3 tons/ha dry matter production, while Super-2 is 5.75 ton/ha. Miller and Stroup (2003) stated lignin content of BMR also is lower (3.6%) than non-BMR (4.4%).

Harvesting time greatly affects to the production and prussic acid content. The older the harvesting time, the production of dry and organic matter, also reduce prussic acid content in sorghum. Prussic acid content in sorghum is a limiting factor in forage quality. Excessive prussic acid content will cause poisoning in cattle where hemoglobin cannot bind oxygen in the blood. The content of prussic acid is above 1,000 mg/kg of dry matter (Simili *et al*., 2013). The purpose of this study was to determine the effect of sorghum varieties and harvesting time of sorghum planted in stylosanthes pastures base on growth, production and prussic acid content.

## Materials and Methods

### Material

This research was done for 6 months, from January until June 2018. The process of planting was carried out in the field of Laboratory of Forage and Pasture. Chemical analysis was conducted at the Laboratory of Forage and Pasture, Faculty of Animal Science, Universitas Gadjah Mada. The materials used were seeds of sorghum of brown midrib resistance (BMR) and Super-2, *Stylosanthes guianensis* seeds, SP36 fertilizer (30% $P_2O_5$), KCl fertilizer (50% $K_2O$), urea fertilizer (46% $N_2$), organic compost and materials for analysis prussic acid. The equipment used are tractors, hoes, sickles, rulers, digital scales, ovens 55ºC, ovens 105ºC, tanur 550ºC, analytical scales with sensitivity 0.0001 g, willey mill and prussic acid analyzers.

### Method

The land was spilled out using a tractor to loosen the soil, then given organic compost as much as 5 tons/ha, KCl 100 kg/ha and SP36 100 kg/ha. The land divided into 18 plots with the size of each plot was 2x3 m. The seeds of stylosanthes are moved to the field at the age of 2 weeks. Stylosanthes seeds are transplanted to the land with the depth of planting holes between 5 to 10 cm with a spacing of 25x25 cm. Sorghum seeds are planted into land with a spacing of 75x 25 cm after the stylosanthes reach 2 weeks. Urea fertilization was done twice, the first application was done at two weeks (40%), and four weeks (60%) after defoliation with total dose of 200 kg/ha. Fertilizers are given by top dressing. Sorghum plant were cut 8 weeks after planting to synchronized the plant growth. Data collected was at the first regrowth (ratoon). Harvesting was done at 6, 8 and 10 weeks by cutting the stems about 5 to 10 cm above the ground. Data collected were from BMR, and super-2 sorghum, and stylosanthes pasture. The variables observed were growth (plant height); productivity (production of dry and organic matter); prussic acid content. Determination of dry matter (DM) and organic matter (OM) according to AOAC (2005) method. Determination of prussic acid content was done according to method from Egan *et al*. (1997).

### Data analysis

The results were analyzed statistically according to analysis of variance based on split plot design 2x3. Main plot was sorghum variety and sub plot was harvesting time and the significant differences between treatments was tested using Duncan's Multiple Range Test (DMRT) (Astuti, 1980).

## Result and Discussion

### Plant height

Sorghum varieties had a significant effect ($P<0.05$) on plant height (cm). The result in Table 1 showed that brown midrib resistance (BMR) sorghum variety had higher plant height (215.33 cm) ($P<0.05$) compared to Super-2 (202.17 cm). This is because super-2 has low regrowth ability compared to BMR. The low rate of regrowth ability causes lower fresh production as well. Fresh production is positively correlated with plant height. The fresh production of super-2 was lower (10.92 tons/ha) than that BMR (13.92 tons/ha). Efendi *et al*. (2014) stated that sweet sorghum (*Sorghum bicolor* (L.) Moench) has low regrowth ability with annual growth rate was 33 to 44%. Fresh biomass production is positively correlated to plant height and age of flowering plants. The plant height of sweet sorghum at first ratoon was about 194 to 280 cm, while BMR was about 215 to 277 cm (Efendi *et al*., 2014; Kurniawan, 2014). Plant height is one indication of the quantity of plant biomass. Silungwe (2011) showed that there is a strongly positive correlation between plant height and yield of sorghum plant biomass. Harvesting time had a significant ($P<0.05$) effect on the plant height when sorghum was harvested in the first ratoon. Harvesting time of 10-weeks had significantly ($P<0.05$) higher plant height compared to 8 and 6 weeks (235.80 cm

Table 1. The plants height (cm) of BMR and super-2 sorghum varieties at different harvesting time in the first ratoon

| Sorghum varieties | Harvesting time (week) | | | Mean |
|---|---|---|---|---|
| | 6 | 8 | 10 | |
| BMR | 162.83±6.45 | 244.67±4.73 | 238.50±1.80 | 215.33±39.67$^{q}$ |
| Super | 131.00±4.95 | 227.00±3.46 | 249.00±1.50 | 202.17±54.27$^{p}$ |
| Mean | 146.92±18.17$^{a}$ | 235.8±10.36$^{b}$ | 245.50±5.67$^{c}$ | |

$^{p,q}$ : Different superscripts at the same column indicate significant differences ($P<0.05$).
$^{a,b,c}$ : Different superscripts at the same row indicate significant differences ($P<0.05$).

and 146.92 cm). Afzal *et al*. (2012) showed that the height of sweet sorghum plants (*Sorghum bicolor* (L.) Moench) recieved 100 kg of urea/ha and be harvested in 14 weeks had about 192 to 195 cm of plant height.

**Production**

Table 2 showed that sorghum varieties had a significant effect (P<0.05) on dry matter production (tons/ha). Dry matter production is a reference to determine plants productivity. Factors affecting plant growth and productivity are genetic and environmental agronomic and management. The production of dry matter of sorghum and mixed pasture plants in this study was calculated in the form of tons per hectare (ton/ha). Sorghum BMR had significantly (P<0.05) a higher dry matter production (4.27 tons/ha) compared to super sorghum (3.09 tons/ha). The high dry matter production in BMR sorghum is due to plant height and higher number of shoots compared to super-2 sorghum. The number of shoots and the plant height increased dry matter production. Kurniawan (2014) stated that grass biomass is influenced by the number of shoots and plant height. Based on the data in Table 3 showed that stylosanthes pastures under BMR and Super sorghum do not have a significant effect on dry matter production (tons/ha).

There were no significant effect on dry matter production of stylosanthes pasture integrated with BMR and super-2 sorghum plants that were respectively 3.47 and 3.33 tons/ha. Integrated pastures of BMR sorghum and stylosanthes pasture) and of super-2 sorghum and stylosanthes pasture had no effect on stylosanthes pasture production. The presence of stylosanthes in sorghum plantation will increase dry matter production and nutrient quality. However harvesting time affected significantly (P<0.05) on stylosanthes production. The dry matter production harvested at 16 and 18 weeks (3.75 and 4.21 ton/ha) was significantly higher (P<0.05) compared to 14 weeks, and the dry matter production of 16 and 18 weeks was not significantly different.

The dry matter production from 6 weeks harvesting time was significantly different (P<0.05) with 8 and 10 weeks, however the dry matter production from 8 weeks cutting time was not significantly different. The high dry matter production at the 10weeks harvesting time is due to the high dry matter content. Dry matter production is inversely proportional to the ratio of stem and leaf. The older harvesting time increase dry matter production, but decrease the ratio of leaf stems. Kurniawan (2014) stated that dry matter production of BMR sorghum was 7.57 tons/ha, while sweet sorghum was 6.60 tons/ha. The dry matter production of sorghum was lower than the literature, this because the sorghum used in the first year so that the dry matter production had decreased. The difference in sorghum varieties (BMR and super) and harvesting time had a significant effect (P<0.05) on dry matter production (tons/ha). The BMR sorghum harvested at 6, 8, and 10 harvesting time had a dry matter production that was not significantly different. Different with Super-2 sorghum where dry matter production is increasing (P<0.05) with older harvesting time. Organic matter production is calculated by multiplying the organic matter content with dry matter production. Table 5 shows that sorghum varieties have a significant effect (P<0.05) on organic matter production (tons/ha).

Table 2. The dry matter production (tons/ha) of BMR and super-2 sorghum varieties at different harvesting time in the first ratoon

| Sorghum varieties | Harvesting time (week) | | | Mean |
|---|---|---|---|---|
| | 6 | 8 | 10 | |
| BMR | 3.96±0.26$^{h}$ | 4.85±0.14$^{h}$ | 3.98±0.22$^{h}$ | 4.27±0.48$^{q}$ |
| Super | 2.05±0.33$^{f}$ | 2.99±0.68$^{g}$ | 4.24±0.83$^{h}$ | 3.09±1.10$^{p}$ |
| M*ean* | 3.01±1.08$^{a}$ | 3.92±1.11$^{b}$ | 4.11±0.55$^{b}$ | |

$^{p,q}$ :Different superscripts at the same column indicate significant differences (P<0.05)).
$^{a,b}$ :Different superscripts at the same row indicate significant differences (P<0.05)).
$^{f,g,h}$ :Different superscripts at the same row and column indicate significant differences (P<0.05)).

Table 3. The dry matter production (ton/ha) of the stylosanthes pasture at different harvesting time that was integrated with sorghum plant of varieties BMR and super-2

| Varieties | Harvesting time (week) | | | Mean$^{ns}$ |
|---|---|---|---|---|
| | 14 | 16 | 18 | |
| S. guianensis pasture under BMR sorghum plant | 2.21±0.04 | 4.11±0.14 | 4.09±0.43 | 3.47±0.97 |
| S. guianensis pasture under super sorghum plant | 2.27±0.12 | 3.39±0.71 | 4.33±0.43 | 3.33±0.96 |
| Rerata *(mean)* | 2.24±0.08$^{a}$ | 3.75±0.59$^{b}$ | 4.21±0.30$^{b}$ | |

$^{a,b}$ Different superscripts at the same row indicate significant differences (P<0.05).
$^{ns}$ Nonsignificant.

Table 4. The mean of dry matter production (ton/ha) of the mix pasture with different harvesting time

| Varieties | Harvesting time *(week)* | | | Mean |
|---|---|---|---|---|
| | 6 | 8 | 10 | |
| BMR + stylosanthes pasture | 6.18±0.29$^{g}$ | 8.96±0.27$^{h}$ | 8.07±0.31$^{h}$ | 7.73±1.25$^{q}$ |
| Super + stylosanthes pasture | 4.32±0.21$^{f}$ | 6.38±1.22$^{g}$ | 8.57±0.83$^{h}$ | 6.43±1.99$^{p}$ |
| Mean | 5.25±1.04$^{a}$ | 7.67±1.62$^{b}$ | 8.32±0.62$^{b}$ | |

$^{p,q}$ Different superscripts at the same column indicate significant differences (P<0.05).
$^{a,b}$ Different superscripts at the same row indicate significant differences (P<0.05).
$^{f,g,h}$ Different superscripts at the same row and column indicate significant differences (P<0.05).

Table 5. The mean of organic matter production (ton/ha) of two varieties of the sorghum with different harvesting time planted in stylosanthes pasture

| Sorghum varieties | Harvesting time (week) | | | Mean |
|---|---|---|---|---|
| | 6 | 8 | 10 | |
| BMR | 3.49±0.22$^{h}$ | 4.38±0.12$^{i}$ | 3.62±0.21$^{hi}$ | 3.83±0.45$^{q}$ |
| Super | 1.79±0.28$^{f}$ | 2.67±0.61$^{g}$ | 3.86±0.73$^{hi}$ | 2.77±1.03$^{p}$ |
| Mean | 2.64±0.95$^{a}$ | 3.53±1.01$^{b}$ | 3.75±0.49$^{b}$ | |

p,q Different superscripts at the same column indicate significant differences (P<0.05).
a,b Different superscripts at the same row indicate significant differences (P<0.05).

Table 6. The mean of organic matter production (ton/ha) of the stylosanthes pasture with different harvesting time

| Varieties | Harvesting time (week) | | | Mean $^{ns}$ |
|---|---|---|---|---|
| | 14 | 16 | 18 | |
| Stylosanthes pasture under BMR sorghum. | 2.03±0.11 | 3.75±0.14 | 3.77±0.45 | 3.18±0.89 |
| Stylosanthes pasture under super sorghum | 2.07±0.12 | 3.09±0.64 | 3.99±0.50 | 3.05±0.89 |
| Mean | 2.06±0.08$^{a}$ | 3.42±0.55$^{b}$ | 3.88±0.31$^{c}$ | |

a,b,c Different superscripts at the same row indicate significant differences (P<0.05).
ns Nonsignificant.

Table 7. The mean of organic matter production (ton/ha) of the mixed pasture with different harvesting time

| Varieties | Harvesting time (week) | | | Mean |
|---|---|---|---|---|
| | 6 | 8 | 10 | |
| BMR + stylosanthes pasture | 5.53±0.23$^{g}$ | 8.13±0.25$^{h}$ | 7.39±0.32$^{h}$ | 7.02±1.18$^{q}$ |
| Super +stylosanthes pasture | 3.87±0.17$^{f}$ | 5.77±1.10$^{g}$ | 7.86±0.73$^{h}$ | 5.83±1.85$^{p}$ |
| Mean | 4.70±0.93$^{a}$ | 6.95±1.47$^{b}$ | 7.63±0.56$^{b}$ | |

p,q Different superscripts at the same column indicate significant differences (P<0.05).
a,b Different superscripts at the same row indicate significant differences (P<0.05).

Organic matter production of BMR (3.83 tons/ha) was higher (P<0.05) compared to Super-2 (2.77 tons/ha). The difference in organic matter production in line with dry matter production which also shows that BMR was higher than Super-2. Koten *et al*. (2012) stated that organic matter production of *Sorghum bicolor* (L.) Moench is about 1.02 to 4.32 tons/ha. Data in Table 6 shows that stylosanthes pasture under the BMR and super sorghum plants did not have a significant effect on organic matter production (tons/ha).

The average dry matter production of Stylosanthes under BMR and Super-2 sorghum plantation was 3.18 tons/ha and 3.05 tons/ha respectively. Mixed pastures of BMR+ Stylosanthes and Super-2+ stylosanthes show a significant different (P<0.05) on organic matter production. This is by organic matter content of BMR was higher than Super-2, thus contributing to the organic matter production of mixed pasture. Harvesting time shows significantly different (P<0.05) on the organic matter production of sorghum+stylosanthes in mixed pasture (Table 7).

Organic matter production was increased in line with different harvesting time. Sorghum BMR and mixed pastures (BMR and super) produce significantly different organic matter production between harvesting time 6 to 8 and 10, but at harvesting time 8 and 10 are not significantly different. Koten *et al*. (2012) stated that *Sorghum bicolor* (L.) Moench with harvesting time of 50, 70 and 90 days gave organic matter production which continued to increase in line with the age of cutting, namely 1.16 tons/ha, 2.36 tons/ha and 3.48 tons/ha.

**Prussic acid content**

The prussic acid content of the two first ratoon sorghum varieties with different harvesting time can be seen in Table 8. The data in Table 8 shows that both BMR and Super-2 significantly different (P<0.05) on Super-2 has prussic acid content 591.74 mg/kg that is higher (P<0.05) than BMR that has prussic acid content 412.89 mg/kg. The differences caused by Super-2 has higher leaf percentage compared to BMR. Prussic acid content acumulated in leaves, so the lower the ratio of stems and leaves, the higher the prussic acid. The ratio of Super-2 stems and leaves was 1.96, while BMR was 2.74. Simili *et al.* (2013) stated that sorghum is cut when plant height is between 90 to 100 cm, with a stem and leaf ratio of 0.8 to 1.5 and a low prussic acid content. The results of statistical analysis showed that harvesting time had a significant effect (P<0.05) on the prussic acid content. The content of prussic acid with a 10 weeks harvesting (241.71 mg/kg) was lower (P<0.05) compared to 6 and 8 weeks (727.34 mg/kg and 537.90 mg/kg). The prussic acid content of sorghum with 8 weeks harvesting time (537.90 mg/kg) was lower (P<0.05) compared to 6

Tabel 8. The mean of prussic acid (mg/kg) of two varieties of the sorghum with different harvesting time

| Sorghum varieties | Harvesting time (week) | | | Mean |
|---|---|---|---|---|
| | 6 | 8 | 10 | |
| BMR | 567.00±16.97$^{i}$ | 454.71±45.63$^{h}$ | 217.97±6.14$^{f}$ | 412.89±156.14$^{p}$ |
| Super | 887.68±38.16$^{k}$ | 622.08±5.31$^{j}$ | 265.42±12.94$^{g}$ | 591.74±271.15$^{q}$ |
| Mean | 727.34±177.62$^{c}$ | 537.90±96.69$^{b}$ | 241.71±27.54$^{a}$ | |

p,q Different superscripts at the same column indicate significant differences (P<0.05).
a,b,c Different superscripts at the same raw indicate significant differences (P<0.05).

weeks (727.34 mg/kg). The older cutting age, the lower the prussic acid content. This is because the older the plant contain lower the percentage of leaves. Simili *et al*. (2013), stated that *Sorghum bicolor* at 70 days of cutting has a prussic acid content about 487 mg/kg and decreases at 100 days of cut which has 200 mg/kg. 1,000 mg/kg dry matter of prussic acid content is dangerous for livestock because it will cause poisoning. Thomas *et al*. (2013) stated, the amount of prussic acid content is higher in young plants than the older plants and the prussic acid content in leaves is higher than in stems. Prussic acid content will decrease with age and height of sorghum plants.

## Conclusions

Based on result and discussion it can be concluded that BMR sorghum has higher in plant height, dry and organic matter production compared to Super-2. The prussic acid content of BMR is lower than Super-2. Growth, dry and organic matter production increased in line with the harvesting time, but prussic acid content decrease. The first ratoon of sorghum that was harvested at 10 weeks of age has the highest growth and production with lower prussic acid content.

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