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Analysis of Glucose Contents in Sorghum (*Sorghum bicolor* (L) Moench) Varieties: Local, Superior, and Introduced

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Abstract
Fossil energy as a fuel source in the world is decreasing. This research aims to provide bioenergy as an alternative renewable energy source, namely sweet sorghum (Sorghum bicolor (L.) Moench), which is cheaper, safer, and reduces air pollution. The specific objectives to be achieved were to identify sorghum varieties containing high stem glucose content (%brix) among several local, superior, and introduced varieties and to obtain the best panicle pruning percentage.
The research was conducted by selecting several local, superior, and introduced sorghum varieties against panicle pruning. The design used was a group design with two treatment factors arranged factorially. The first factor was the type of variety consisting of 5 levels: Sorghum variety (V): Lokal Putih NTT (V1), Super 1 (V2), Kawali (V3), Numbu (V4), and Introduced Sweet-Sorghum (Kotobun sorgo/FS501) (V5) The second factor was panicle pruning time (P) which consisted of 4 levels: development stage (50% of a plot had swollen stems) (P1), flowering stage (100% of a plot had flowers (P2), seed filling stage (50% in a plot had seed filling phase) (P3) , and not pruned (Control) (P0).
The results of this study showed that sorghum varieties on the variable production of stem juice (sap) in the Kawali variety, which was the highest at 6.28 ton/ha^{-1}, gave a very significantly different effect ($P<0.01$) compared to the other four sorghum varieties, namely Numbu (4.94 ton/ha^{-1}), Super 1 (4.88 ton/ha^{-1}), FS501 (4.83 ton/ha^{-1}), and Lokal Putih NTT (4,04 ton/ha^{-1}). The highest stem glucose content of sorghum varieties fell to Kawali and Super 1, with 11.00% brix compared to the other three sorghum varieties, namely Lokal Putih NTT (10.00% brix), FS501 (9.53% brix), and Numbu (9.00% brix). The two variables of stem glucose content (%brix) and stem juice production (ml/kg) had a positive correlation (r = 43%). This will affect the result of bioethanol content. The glucose content in the stem juice of sweet sorghum varies by variety (Almodares et al., 1994). This is in line with the results of research by Sepahi (1996) and Almodares et al. (1997), which stated that the duration of sucrose accumulation in the stem varied among cultivars.
In the treatment of panicle pruning on the production of stem juice (sap), there were various outcomes ($P<0.01$), with the highest results in (P2) 2.20 ml compared to (P1) 2.09 ml, (P3) 1.93 ml, and (P0) 1.85 ml. This is in accordance with the research of Almodares et al. (2008) that in sorghum stalks, the content of unstructured carbohydrates increases during the pre-boot (before the development stage) and reaches a maximum level near thepost-anthesis.

Keywords: *sorghum varieties, panicle pruning, glucose contents, stem juice (sap)production.*

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I. Introduction

Fossil energy as a fuel source in the world is decreasing. This research aims to provide bioenergy as an alternative renewable energy source, namely sweet sorghum (*Sorghum bicolor* (L.) Moench), which is cheaper, safer, and reduces air pollution.

Research by Almodares and Sepahi (1996) found that sweet sorghum's glucose content (brix) ranged from 14.32-22.35%. Meanwhile, Shiringani and Friedt (2009) obtained total glucose from sweet sorghum stem juice (sap) ranging from 5.67-22.67%. The high glucose content in sorghum stems can be used as raw ethanol. Mangena et al. (2018) analyzed the feasibility of sorghum ethanol production. They concluded that sweet sorghum could be used as an ethanol feedstock if all cellulosic glucose could be hydrolyzed efficiently and then converted to ethanol. According to Almodares and Sepahi (1996), the rate of glucose accumulation in sorghum stems varies based on the cultivar, nonstructural carbohydrate content, temperature, and time effects (Almodares et al., 2000), maturity, branching, fertilization, and spacing (Almodares et al., 2008).

The response of glucose and ethanol levels to panicle pruning in sorghum is still sporadic; no one may have studied it. The production of stem glucose levels produced by the KCS 105 variety was 2.6 tons/ha, the ethanol content of sorghum stems was 94.1% (Agung et al., 2013), and ethanol productivity was 1.44g/l (Rolz et al., 2019). In corn, pruning male flowers can increase seed yield and seed quality. The interaction of leaf pruning and male flower pruning may also affect the distribution of assimilates between reproductive and vegetative organs (Heidari, 2013).

Surtinah's research (2005) showed that trimmed male flowers of corn plants gave higher production compared to untrimmed male flowers of corn plants. The increase in yield due to male flower pruning is due to the loss of plant shoots so that existing phytohormones will be directed to the growth of the stem and cob, which is a modification of the corn plant stem. The increase can also be caused by the cessation of assimilating delivery to the male flowers because the male flowers are no longer present, so the existing assimilate will only be sent to the generative parts that need it, namely seeds, and stored in the stems of the corn plant. Based on the research on corn, it is suspected that pruning panicles will increase stem glucose levels in sweet sorghum.

The problem is that there has been no research on panicle pruning affecting glucose levels in several sorghum plants. Therefore, it is necessary to conduct research that examines and analyzes glucose levels in several varieties of local, superior, and introduction sorghum plants.

II. Methods and Materials

This research was conducted in the Padanggalak area, Sanur Village, Denpasar City, from April 17 to August 17, 2015. This research was conducted by using several local, superior, and introduced sorghum varieties to panicle pruning. The design used was Group Design with two treatment factors arranged factorially and repeated three times. The first factor was the type of variety consisting of 5 levels: Sorghum variety (V): Local White NTT (V_1), Super 1 (V_2), Kawali (V_3), Numbu (V_4), and Introduction-Sweet-Sorghum (*Kotobun sorgo*/FS501) (V_5). The second factor is panicle pruning time (P), which consists of 4 levels: development stage (50% of a plot had swollen stems) (P_1), flowering stage (100% of a plot had flowers (P_2), seed filling stage (50% in a plot had seed filling phase) (P_3), and not pruned (Control) (P_0). The plot area was 3.5 m x 1.5 m or 5.25 m2. The distance between plots was 0.5 m, and the distance between replicates was 1 m.

Harvesting was done when the plants reached 105 days of age or were physiologically ripe and adjusted to the harvesting age of each variety. The materials used in this study were some seeds of introduction sweet sorghum varieties, leading sorghum varieties, local sorghum varieties, organic fertilizers, and pesticides. The tools used were a tractor/hoe to cultivate the soil, hand sprayers for spraying plants, measuring tapes to measure planting distance and plant height, wooden planks & bamboos for execution boards, plastics, raffia strings, papers for plant samples, refractometer, spectrophotometer, Whatman no. 42 filter paper, sugarcane squeezer, and labels.

The data collected were then analyzed statistically with variance analysis (Anova.) SAS-26 computer software was used to compare the mean values of variables. If there is significantly different data, it is continued with Duncan's multiple area tests.

III. Results and Discussion

The results of the analysis of variance showed that the interaction of sorghum varieties and panicle pruning in phase I research had a real effect ($P>0.05$) on stem diameter and a genuine effect ($P>0.01$) on stem glucose levels (%brix). The treatment of varieties had a very significant effect ($P < 0.01$) on the number of seeds that grew 7 days after planting, plant height at 52 days after planting, stem glucose content, stem glucose production, and stem juice (sap) production. Meanwhile, the effect of panicle pruning time had a very significant effect ($P < 0.01$) on stem glucose content and production (Table 1).

The results of this study showed that sorghum varieties on the variable production of stem juice (sap) in the Kawali variety, which was the highest at 6.28 ton/ha^{-1}, gave a very significantly different effect ($P<0.01$) compared to the other four sorghum varieties, namely Numbu (4.94 ton/ha^{-1}), Super 1 (4.88 ton/ha^{-1}), FS501 (4.83 ton/ha^{-1}), and Lokal Putih NTT (4,04 ton/ha^{-1}). The highest stem glucose content of sorghum varieties fell to Kawali and Super 1, with 11.00% brix compared to the other three sorghum varieties, namely Lokal Putih NTT (10.00% brix), FS501 (9.53% brix), and Numbu (9.00% brix). The two variables of stem glucose content ($^{\%}$brix) and stem juice production (ml/kg) had a positive correlation (r = 43%). This will affect the result of bioethanol content. The glucose content in the stem juice of sweet sorghum varies by variety (Almodares et al., 1994). This is in line with the results of research by Sepahi (1996) and Almodares et al. (1997), which stated that the duration of sucrose accumulation in the stem varied among cultivars. Almodares and Sepahi (1996) stated that brix among sweet sorghum varieties ranged from14.32-22.35%.

In the treatment of panicle pruning on the production of stem juice (sap), there were various outcomes

(P<0.01), with the highest results in (V3P3) & (V3P1) at 11.00% brix, followed by (V3P2) at 10.73% brix, and (V3P0) at 10.67% brix (Table 2). The response of glucose and ethanol levels to panicle pruning in sorghum is still sporadic; no one may have studied it. This is in accordance with the research of Almodares et al. (2008) that in sorghum stalks, the content of unstructured carbohydrates increases during the *pre-boot* (before the development stage) and reaches a maximum level near the *post-anthesis*. Pruning maize's male flowers can increase seed yield and seed quality. The interaction of leaf pruning and male flower pruning may also affect the distribution of assimilates between reproductive and vegetative organs (Heidari, 2013). Research by Clerget et al. (2008) showed a potentially negative interaction between stem development and sweet sorghum seed yield. This is in stark contrast to grain sorghum accessions, where carbohydrate accumulation is carried out for grain, whereas sweet sorghum accessions are characterized by carbohydrate accumulation within their juicy stems.

IV. Conclusion

The treatment of pruning sorghum panicles on the production of stem juice (sap) in the Kawali variety gave the highest results (6.28 ton ha^{-1}) compared to the other four sorghum varieties. Kawali and Super 1 sorghum varieties produced the highest stem glucose content (11.00% brix) compared to the other three sorghum varieties. The Kawalivariety can be considered raw material for bioethanol in further research.

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Table 1.

Effect of varietal treatment and panicle pruning on the number of seeds grown at 7 daysafter planting, plant height at 52 days after planting, stem juice production (sap)

Treatment	Number of seeds sprouted 7 days after planting from 30 seedlings	Plant height at 52 days after planting (cm)	Stem juice production/sap (ton/ha)
Variety			
V1	14.58b	165.08b	4.04c
V2	14.08b	210.22a	4.88b
V3	17.83a	157.44b	6.28a
V4	15.50ab	142.36c	4.94b
V5	17.58a	213.17a	4.83b

Panicle Pruning			
P_0	15.20a	174.67a	4.05d
P_1	15.67a	173.93a	5.97a
P_2	16.47a	175.02a	4.55c
P_3	16.33a	186.99a	5.40b

Note: numbers followed by the same letter in each factor are not significantly different atthe 5% Duncan Multiple Range Test

Table 2.

Duncan's Multiple Range Test 5% on the interaction of varieties (V) and panicle pruning (P) on stem glucose levels

Variety / Pruning	V_1	V_2	V_3	V_4	V_5
P_0	8.00b	9.20b	10.67b	6.80c	8.13c
P_1	6.93c	10.00a	11.00a	8.33bc	9.07b
P_2	7.87b	9.67a	10.73b	8.67b	9.53a
P_3	8.80a	8.73c	11.00a	9.00a	9.47a
LSR 5% V	**0.37**	**0.38**	**0.39**	**0.40**	
LSR 5% P	**0.33**	**0.34**	**0.35**		