Dry land sustainable agriculture with application of sorgaab to improve brix sugar content and crop yield in two sorghum varieties

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Abstract. Sorgaab is an extract of Sorghum bicolor plant which can be used as a natural bioherbicide. This research aims to evaluate the effects of sorgaab application on brix sugar content and crop yield of two Sorghum varieties. Sorghum is a potential crop to be developed in Indonesia because it is beneficial for food, feed, energy, and sources of fiber. Sorghum can also live on marginal or dry land so that can adapt well to extreme agro-climate conditions. The research was conducted on dry land at Tambakan, Nguter, Sukoharjo, Indonesia with Vertisol soil type, using a Randomized Complete Block in Split Plot Design with 2 treatment factors: (1) Sorgaab concentration (S0 = control, S1 = 25%, S2 = 50%, S3 = 75%; and (2) Sorghum varieties (V1 = Numbu varieties, and V2 = Kawali varieties). Analysis of variance using F test 5%, continued with The Duncan Multiple Range Test. The relationships between variables using a correlation test. The application 75% of sorgaab showed the highest level of brix sugar content in Numbu varieties which is 16.73% brix per plant and showed the highest level of 1000 grain weight in Kawali varieties which is 31.889 grams. There is positive correlation between variables which the increase of sorgaab application followed by the increase of brix sugar content and crop yield of both two Sorghum varieties.

1. Introduction

The use of dry land which has low soil moisture content often reflects the structure of the lower economic class and is identical with poverty. This is because dry land has low productivity due to reduced harvest intensity and has a high risk of crop failure due to high exposure to plant pests. Dry land is also very potential for weed growth. The presence of weeds in plants is not expected because they compete for nutrients, light, and space to grow. Giving herbicides is one solution that can be done to suppress weed growth. However, the continuous use of chemical herbicides can disrupt the land ecosystem and potentially threaten the environment.

Natural herbicides that can reduce the cost of farming and promote environmental sustainability are needed as an alternative to weed control. Sorgaab which is an extract (soaking water) of the Sorghum bicolor plant can be used as a bioherbicide [1] which is natural and safe for the environment. All parts of the sorghum plant such as roots, leaves, stems, and seed sprouts have phytotoxicity that can release...
allelopathic compounds as phyto-inhibitors that suppress weed growth [2]. Sorgaab is produced from sorghum plant, which is a drought-resistant cereal with high productivity even though it is planted in water deficit stress conditions [3]. Therefore, sorghum has a great opportunity to be developed in Indonesia because it can live in marginal lands and in extreme agro-climatic conditions but is still useful for food, feed, energy, and a source of fiber [4], even sorghum stalks are often used as raw materials for making liquid sugar (syrup), jaggery (a kind of brown sugar), and bioethanol [5]. Sorgaab produced from the sorghum plant contains an allelopathic compound called sorgoleone which can inhibit weeds. In addition, the previous research results also stated that bioherbicides from sorgaab can increase yields of wheat, maize and soybeans [6, 7]. The treatment of sorgaab at 30 WAS and 40 WAS was the most effective application in reducing weed density and biomass by 22% and 46% respectively, and increasing the yield by 21% over control [8]. Seeing the results of previous research, the application of sorgaab to sorghum plant is potential to increase crop yields, including the sugar content of sorghum stems as an act to manage dry land. This research aims to evaluate the effects of sorgaab application on brix sugar content and crop yield of two Sorghum varieties.

2. Material and Methods

The research was conducted in Tambakan Village, Nguter District, Sukoharjo Regency on dry land with Vertisol soil type at 110 m above sea level. Meanwhile, the analysis of sorghum stem sugar content and crop yields was carried out at the Physiology and Biotechnology Laboratory, also Ecology and Plant Production Management Laboratory Faculty of Agriculture, Sebelas Maret University. This study was conducted from May to September 2019.

This study used two varieties of sorghum, Numbu and Kawali which were obtained from Balai Besar Serelia Maros. The research was conducted using a completely randomized block design (RAKL) separate plot (Split Plot) with 3 replications. The main plot factor is a variety of sorghum which consists of 2 types, Numbu Varieties (V1) and Kawali Varieties (V2). While the sub-plot factor is the concentration of sorgaab consisting of 4 levels, 0%; 25%; 50%; and 75%. Based on this design, 8 treatment combinations were obtained and were repeated 3 times to obtain 24 experimental units.

The sorgaab solution used is the result of root extraction of the sorghum plant. Extraction of sorghum roots to obtain a sorgaab solution follows the guidelines of the Cheema and Khaliq method [8]. Sorghum roots are dried and then washed clean of impurities and the remaining soil that is still attached. The clean roots are wind dried and then cut into small pieces (2-3 cm) and crushed with a mortar and pestle. After that it was immersed in water at 10% (W/V) for 24 hours at room temperature. The ingredients are squeezed while filtering to get 100% extract. The sorghum root extract becomes a 100% sorgaab stock solution which can then be diluted according to the treatment to be used, namely 25%, 50%, and 75%. Meanwhile, the application of sorgaab is done when the plants are 6 WAS, 8 WAS, and 10 WAS. Apply using a sprayer with a concentration according to treatment in the morning after the dew is gone. While the observation of stem sugar levels was carried out by squeezing the fresh stems of the sorghum plant until 5 ml of fresh juice was obtained and then measured using a hand refractometer.

3. Result and Discussion

Sorgaab application at the levels of 25%, 50% and 75% had a significant effect on both the brix sugar content of sorghum stems and crop yields. The results of the application of sorgaab at the level of 25%, 50% and 75% have significantly affected compared to the level of 0% or without the gift of sorgaab. However, in the treatment of sorgaab application with levels of 25%, 50%, and 75% the average results of brix sugar content did not show significantly different results (Table 1).

The possible reason for the increase in brix sugar content of sorghum stem along with the increase in the application of sorgaab is the allelopathic effect that exhibits inhibitory potential on seed germination and growth of weed. This weed control treatment might be attributed to increased availability of nutrients and reduced competition which stimulated vegetative growth. Good vegetative growth will produce optimal photosynthetic assimilation in the process of growing plant stems and leaves [9].

In terms of varieties, the Numbu Variety (V1) had a higher level of brix sugar content from sorghum stems, in the application 75% of sorgaab which is 16.73% brix, compared to Kawali variety (V2) which was 13.10% brix at 75% application of sorgaab (Figure 1). The differences between these
varieties are very likely to occur considering that each variety has a different genetic background and genetic constitution depending on its different origins [10].

| Sorgaab Concentration (%) | Sugar Content (% Brix) |
|---------------------------|------------------------|
| 0                         | 11.5778 a              |
| 25                        | 14.2333 b              |
| 50                        | 13.4389 b              |
| 75                        | 14.9222 b              |

**Table 1.** Level of brix sugar content

Figure 1. Brix sugar content in two shorgum varieties. S0 = 0%, S1= 25%, S2=50%, S3=75% of sorgaab application

The positive correlation was seen in the crop yield of sorghum plant including wet and dry weight, as well as 1000 grain weight. The results showed that the treatment of sorgaab application at a concentration of 50% and 75% significantly affect the highest yield of wet weight at 75% concentration of sorgaab solution, which is 656.29 g. The highest dry weight is also at a concentration of 75% sorgaab solution, which is 279.15 g (Table 2).

The same result was seen on variable of 1000 grain weight that application of 75% sorgaab solution has the most significant effect for the highest yield of 1000 grain weight of sorghum, which is 32.5817 gr. The increase in 1000 grain weight in the application of sorgaab at the 75% level might be due to the presence of essentials nutrients from sorgaab which improves soil organic matter. Previous research stated that plant water extracts successfully enhanced grain weight of rice [11]. Similar results were also found that sorghum extract increased grain weight in paddy yield [12]. Meanwhile, the Kawali variety has a greater average of 1000 grain weight than the Numbu variety with an average value of 31.889 g (Table 4).

| Sorgaab Concentration (%) | Wet Weight (gram) | Dry Weight (gram) |
|---------------------------|------------------|------------------|
| 0                         | 384.43 a         | 1.6908 a         |
| 25                        | 501.28 b         | 2.2170 b         |
| 50                        | 6.2815 c         | 2.5406 bc        |
| 75                        | 6.5629 c         | 2.7915 c         |

Table 2. Level of brix sugar content

From these results, it shows that there is a relationship between the variables of wet and dry plant weight, stem sugar content, and the 1000 grain weight from the application of sorgaab solution. The
highest yield was seen in the treatment of sorgaab application with a concentration of 75%. This is very possible because the allelochemical sorgoleone contained in sorgaab has enormous potential as an herbicide due to its high activity against various weed species. Sorgoleone decreasing activity of that enzyme affects ion uptake and water balance by decreasing water uptake and affecting weed growth [13].

| Varieties | Mean  | Std. Error | 95% Confidence Interval |
|-----------|-------|------------|------------------------|
|           |       |            | Lower Bound | Upper Bound |
| V1 Numbu  | 30.048| .388       | 29.098      | 30.997      |
| V2 Kawali | 31.889| .388       | 30.940      | 32.839      |

The results of research by Dayan et al. [14] stated that the application of sorgaab (sorghum soaking water) which produced sorgoleone compounds was able to suppress the growth of *Echinocloa crus-galli* L. weeds by up to 40% in cotton, soybean, wheat, and rice crops. Besides suppressing weed growth, sorgaab application also has a positive impact on physical and biological soil characteristics, as well as adding nutrients to the soil [15].

These results show that all yield components were higher in plants treated with sorgaab than in control. The possible reason is that application of sorgaab solution as weed control treatment might be attributed to increased availability of nutrients and reduced competition which stimulated vegetative growth so that it increases the yield of sorghum stem sugar content, wet and dry plant weight, and weight of 1000 grains. These results are similar to those of Wazir et al. [16] and Jensen et al. [17] which also conducted such allelopathic studies on rice.

4. Conclusions

Based on this research, there is a positive correlation between variables which the increase of sorgaab application followed by the increase of brix sugar content and crop yield of both two Sorghum varieties. The application 75% of sorgaab showed the highest level of brix sugar content in Numbu varieties which is 16.73% brix per plant and showed the highest level of 1000 grain weight in Kawali varieties which is 31,889 grams. The possible reason is that application of sorgaab solution as bioherbicide might be attributed to increased availability of nutrients and reduced competition with the weed which stimulated growth of the Sorghum plant. Meanwhile, the difference in yield in the two varieties is possible due to different genetic backgrounds and genetic constitutions.

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