ENHANCING THE QUALITY AND QUANTITY OF SWEET SORGUM SAP FOR BIOETANOL

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Abstract

Sweet sorghum is one of renewable bioethanol raw materials as an alternative energy substitution to fossil fuel which its existence is increasingly depleted. Several studies have been done to improve the quality and quantity of sweet sorghum stem sap. The research is conducted from 2013 to 2016. The result of initial study in 2013 shows that the dosage variation of mycorrhizal has an effect on the quality of stem rods i.e. stem weights and stem sap content. A second study (2014) shows an interaction between genotypes with husk-charcoal mycorrhizae in the sap sugar content (%) with the highest value obtained in a combination of a 30 g / plant-HZ-30 (P3G1) husk-charcoal treatment of 7.6144%. The third study (2015) gives the result that there is an interaction between varieties and the combination of inorganic fertilizer, organic fertilizer and husk-charcoal on the parameters of stem sap content (ml), sweetness level of sap (briks), and sap sugar content (%). The fourth research (2016) obtains a result that there is an interaction between treatment of varieties and the dosage of organic fertilizer on the weight of sorghum stem, starch content of sorghum stem, total sugar content of sorghum stem, and carbohydrate content of sorghum stem.

Keywords: quality, quantity, stem sap, sweet sorghum

I. Introduction

Sorghum *(Sorghum bicolor L. Moench)* is a grain cereal crop that belongs to the Graminaea family or grass. In Indonesia, currently sorghum plants provide opportunities to be developed as food crops, feed and bioethanol (bioenergy). Some countries, such as the United States, India and China have been using sardines from sorghum as raw material for bioethanol manufacture (Sukmadi, 2010). As a raw material for bioethanol, sweet sorghum does not compete with food crops or animal feed. Some of the reasons that support this include botanically most bioethanol is produced by the stem, while the seeds can be processed into bioethanol or for food and animal feed. These dual benefits make sweet sorghum a crop which capable to fulfill the needs of food, animal feed, and energy in a single dimension of space and time (Rajvanshi, 1989; Yudiarto, 2006 in Anonymous, 2013)

Sorghum is a plant that has big enough prospect to be developed as raw material of ethanol. Sweet sorghum stems, *bagase* (squeezed juice) and seeds can be processed into ethanol after under going through the extraction process. The high ethanol production per unit area of sweet sorghum stem sap besides influenced by ethanol content per kg of stem is also much determined by the production of biomass stems of each variety (Anonymous, 2011).

In the cultivation of sweet sorghum plants, the problem is the level of production which is still low for both quantity and quality. This is partly due to the use of fertilizers that have not been in accordance with the needs, soil poor nutrients, pest and disease control that has not been effective, agroclimate factors and lack of technical mastery of farming by farmers. To increase the production of sweet sorghum, various ways can be done through improvement of cultivation technology such as the use of superior varieties, fertilizer with organic and biological fertilizer, pest and disease control with biological pesticide, and post harvest improvement (Sukmadi, 2010).

To improve the yield of sweet sorghum biomass in addition to the use of superior varieties can also be done with the addition of arbuscular mycorrhizal fungi. Arbuscular mycorrhizal fungi are beneficial for plants in increasing nutrient uptake, especially phosphorus (P) and other nutrients such as zinc (Zn), molybdenum (Mo), copper (Cu) and potassium (K). In addition to nutritional improvements, arbuscular mycorrhizal fungi are also known to protect plants from drought and have the ability to increase plant resistance to root pathogens (Sukmadi, 2010; Kusnadi, 2010; and Yuwono, 2006).

Arbuscular mycorrhizal fungi as biological fertilizers can also be combined with husk charcoal as a soil enhancer. Husk charcoal as a soil enhancer, can bind carbon and improve soil function, help the soil to retain nutrients and water, improve soil moisture, reduce evaporation of soil water, suppress the development of certain plant diseases, create good habitat for symbiotic microorganisms and improve water quality and quantity (Kurnia Adhi, 2013; Nurida et al., 2015). The results of Nurbaity et al. (2011) demonstrates that a mixture consisting of inoculant fungi of arbuscular mycorrhizal mixed with husk charcoal and zeolite media (1: 3) gives better sorghum yield than inoculant fungi of arbuscular mycorrhizal mixed with only zeolite media.

The improvement of cultivation technology can also be done by adding combination of organic fertilizer, inorganic and husk charcoal as soil enhancer. Organic fertilizers apart of providing nutrients for plants also improve the soil physical properties. Inorganic fertilizers alone can provide nutrients for plants relatively faster than organic fertilizers.

II. Arbuscular Mikorisa Fungus

Biological fertilizer (biofertilizer) is a living microbial substance given to the plant to increase the ability of plant roots to absorb nutrients from the soil. Microbes help to decompose the elements present in the soil into compounds that can be absorbed by plant roots. According to Goenadi

(2006) in Sukmadi (2010) biological fertilizer in principle is a microbe that can improve or enhance the availability of nutrients for plants. Due to the reduction of chemical fertilizer consumption, the technology of biological fertilizer is believed to be an important part in sustainable agriculture system (Sukmadi, 2010).

One type of microbe that can be utilized as a biofertilizer is arbuscular mycorrhizal fungi (AMF). AMF will grow on the roots of the plant as long as the plant is alive, so its application is only require once in a plant lifetime. AMF is a mutually-symbiotic fungus with plant roots that play an important role in the nutritional cycle in the ecosystem (Suhardi, 1990 in Sukmadi, 2010). Biofertilizer has been considered as an alternative input production in the cultivation of plants, especially those concerning fertilization activities. Biofertilizer formulated from microbial active ingredients plays an important role in the process of nutrient dissolution in the soil which is needed for plant growth, and can overcome the low carrying capacity of soil due to low microbial activity. This type of fertilizer does not contain N, P, K or other elements, but the microbes in it can increase the efficiency of fertilizer. Therefore, apart of the application of biofertilizer technology is needed to support land rehabilitation activities, it also improves biodiversity of microorganisms (Sukmadi, 2010).

Biofertilizer arbuscular mycorrhizal fungi is one form of biofertilizer that can be applied to almost all types of plants. This fungus can increase the productivity of plants without damaging the environment because its natural provenance. Biofertilizer AMF also plays a role in maintaining the nutritional status of soil and soil aggregate stability by the presence of hyphae threads that continue to develop in the soil. It is therefore very appropriate to use AMF biofertilizer as an alternative to reduce the negative impact of chemical fertilizers and pesticides on environmental damage (Sukmadi, 2010).

Nurngaini and Riyati (2013), applying mycorrhizae to four genotypes of sweet sorghum and obtain the following results: Variation of dose of mycorrhizal shows no significant effect on plant vegetative growth, but significantly effects on the quality of sorghum stem i.e. stem weights and stem sap content. The comprehensive results can be seen in tables 1 and 2.

Giving of mycorrhizae was able to produce average stem weight of HZ-30 Varieties (255,600 g), Patir 3 (224,580 g) and Patir 9 (208,280 g) (table 1); with the average content of sweet sorghum juice of HZ-30 varieties (120,330 ml), Patir 3 (106,220 ml) and Patir 9 (95,560 ml) (table 2).

Table 1. Weight of the sorghum stem (g) in the treatment of genotype and dosage of mycorrhiza

Dosage of mycorrhizae	Genotypes				Average
	G1(HZ-30)	G2 (Mandau)	G3 (Patir 9)	G4 (Patir 3)	
D1 (0 g)	274,830 ab	92,730 e	173,130 cde	217,970 abc	189,670
D2 (5 g)	186,430 bcde	116,200 de	208,200 abcd	237,700 abc	187,130
D3 (10 g)	305,570 a	104,130 e	243,500 abc	218,070 abc	217,820
Average	255,600	104,360	208,280	224,580	(+)

Note: Figures followed by the same letter means that it is not significantly different according to the Duncant 5%

Sign (+) : There is an interaction

Souce: analysis of primary data

Table 2. Sorghum stem juice content (ml) on the treatment of genotype and dose of mycorrhizal

Dosage of mycorrhizae	Genotypes				Average
	G1(HZ-30)	G2 (Mandau)	G3 (Patir 9)	G4 (Patir 3)	
D1 (0 g)	130,670 ab	41,000 d	74,330 bcd	98,000 abcd	86,000
D2 (5 g)	76,670 bcd	67,000 cd	95,670 abcd	114,670 abc	88,500
D3 (10 g)	153,670 a	38,670 d	116,670 abc	106,000 abc	103,750
Average	120,330	48,890	95,560	106,220	(+)

Note: Figures followed by the same letter means that it is not significantly different according to the Duncant 5%

Sign (+) : There is an interaction

Souce: analysis of primary data

Sukmadi research (2010), showed that the application of biofilm biological fertilizers and biological pesticides Trichoderma sp. is able to increase the productivity of the sorghum plant, and it is best combined with both organic fertilizer as well as with inorganic fertilizers. Meanwhile, sorghum cultivation with application of organic fertilizer, biological fertilizer and biological pesticide can produce the highest dry seed weight amounting 30 g per plant or equivalent to 3.42 ton/ha; stem weight 134,17 g/stem; and 725 ml sap content (54%) .

III. Charcoal charcoal

Activated charcoal (biochar) is a pyrolysis of charcoal at high temperature. The active material used comes from agricultural waste, such as wood waste, bamboo, rice husk, rice straw, corncobs, corn stalks, coconut husk, coconut shell, empty bunches and palm shells (Harsanti and Adiwinata, 2011). The addition of charcoal is possible in order to restore the soil fertility. This is due to the effective pore in charcoal is able for binding and storing soil nutrients that will be released slowly according to plant consumption needs (slow release).

Besides, charcoal is hygroscopic material making the nutrients in the soil are not easily washed and the land is always ready to be utilized. The thorough benefits of charcoal in agricultural purposes include: improving soil structure by maintaining nutrient availability, decreasing soil acidity and improving soil conditions, increasing groundwater flow, boosting plant root growth, absorbing pesticide residues and excess fertilizer in soil, increasing soil bacteria and as micro organisms media for symbiosis, preventing certain diseases, and improving the taste of fruit and production (Anonimus, 2002 in Gusmailiana et al., 2015; Nurida et al., 2015).

Furthermore, it was stated that in the plantation began to be developed bioactive compost charcoal (Arkoba). Arkoba is an advanced product of charcoal, a mixture of charcoal and compost from the composting process with the help of lignocellulolytic microbes that remain alive in the compost. Microbes have the ability as a biofungisida, which protects the plant from the attack of root disease and therefore it is called bioactive. The purpose of adding charcoal to the composting process apart from improving the quality of the compost, will also increase the number and activity of microorganisms that play a role, hence the decomposition process can be completed quicker. Charcoal also createas a neutral atmosphere on the process, charcoal pores become a place where microbes live and therefore the process becomes optimal. Wood charcoal, coconut shell, rice husk and sawdust charcoal can be used as additional sources of plant nutrients and they also have other advantages as soil enhancer (Soemeinaboedhy and Tejowulan, 2007; Gusmailiana et al., 2015).

Table 3. Sorghum stem weights in the treatment of husk-charcoal mycorrhizae and (g)

Husk-charcoal mycorrhizae	Genotypes				Average
	G1(HZ-30)	G2(Mandau)	G3(Patir 9)	G4(Patir 3)	
P1(mycorrhizae 10 g)	197.16667	167.63333	235.7	293.93333	**223.6083 a**
P2(mycorrhizae 10 g + Husk-charcoal 30 g)	217.16667	100.16667	157.96667	181.93333	**164.3083 a**
P3(Husk-charcoal 30 g)	206.26667	110.06667	208.26667	204.36667	**182.2416 a**
Average	**206.8666 p**	**125.9555 q**	**200.6444 p**	**226.7444 p**	-

Note: Figures followed by the same letter means that it is not significantly different according to the Duncant 5%, (-) : no interraction
Souce: analysis of primary data

The results of Nurngaini and Riyati research (2014), shows that the mycorrhizal treatment combined with husk charcoal gives average of sorghum rod weight of HZ-30 varieties of 206.8666 g, Patir 9 of 200.6444 g and Patir 3 of 226.7444 g (table 3); average sap content of varieties HZ-30 (85.3333 ml), Patir 3 (97.3333 ml) and Patir 9 (82,5555 ml) (table 4).

Table 4. The content of sorghum stems in mycorrhizal treatment-husk charcoal and genotype (ml)

Husk-charcoal mycorrhizae	Genotypes				
	G1(HZ-30)	G2(Mandau)	G3(Patir 9)	G4(Patir 3)	Average
P1(mycorrhizae 10 g)	79.6666	63.6666	99.0000	108.3333	**87.6666 a**
P2(mycorrhizae 10 g + Husk-charcoal 30 g)	91.6666	41.3333	58.6666	81.6666	**68.3333 a**
P3(Husk-charcoal 30 g)	84.6666	36.3333	90.0000	102.0000	**78.2500 a**
Average	**85.3333 p**	**47.1111 q**	**82.5555 p**	**97.3333 p**	-

Note: Figures followed by the same letter means that it is not significantly different according to the Duncant 5%, (-) : no interraction

Souce: analysis of primary data

IV. Organic Fertilizer

According to Agriculture Ministry Regulation Number 2 year 2006 organic fertilizers are defined as fertilizers that are partly or wholly derived from plants and or animals that have been through engineering processes, in the form of solid or liquid, used to supply organic materials to improve the physical, chemical and biological properties of the soil (Sutanto , 2002 and Risnandar,?). Organic fertilizers have various types and variants. The types of organic fertilizers are distinguished from the raw materials, methods of manufacture and form. In terms of raw materials, some are made of manure, forage or a mixture of both. By the method of manufacture there are many varieties of fertilizers such as aerob compost, bokashi, and so forth. While in terms of form there are powder, liquid, granule or tablet.

The technology of organic fertilizer today is growing rapidly. This development can not be separated from the impact of the use of chemical fertilizers which cause various problems, ranging from the destruction of ecosystems, the loss of soil fertility, health problems, and also up to the problem of farmers' dependence on chemical fertilizers. Therefore, the use of organic fertilizers is again encouraged to overcome various problems (Sutanto, 2002 and Risnandar,?). Organic fertilizer is the best soil enhancer than any other ingredient. N, P and K nutrients contained in organic fertilizers are generally low and highly variable, but also contain micro nutrients (Sutanto, 2002).

One type of organic fertilizer is Petroganik. Indrati research results (2009) show that Petroganik super organic fertilizer has a significant effect on the weight of 100 seeds of corn. Moreover, the results of research by Wisardja (2011), the treatment of super organic fertilizer Petroganik gives very significant effect on dry weight of 1000 seeds of corn BISI-16 and also have a significant effect on the weight of the corn kernels per plant.

Table 5. sorghum stem weight (g) on the treatment of organic fertilizer and varieties dosage

Dosage of fertilize	Varieties			Average
	V1(Patir 3)	V2 (Samurai 2)	V3 (Mandau)	
D1 (20 g/plant)	170,2222 b	194,4444 a	99,1444 e	154,6037
D2 (40 g/ plant)	195,8222 a	166,4000 b	76,2222 e	146,1481
D3 (60 g/ plant)	204,8889 a	147,2000 c	117,555 d	156,5481
Average	190,3111	169,3481	97,6407	+

Note: Figures followed by the same letter means that it is not significantly different according to the Duncant 5%, (+) : there is an interraction

Souce: analysis of primary data

Nurngaini and Riyati (2016) apply Petroganik on three varieties of sweet sorghum yielded average yield of Patir 3 varieties of 190,3111 g, Samurai 2 varieties of 169,3481 g and Mandau varieties of 97.6407 g (table 5). Medium average volume of stirred varieties Patri 3 varieties of 48.8888 ml, Samurai 2 varieties of 38,0000 ml and Mandau varieties of 22.7037 ml (table 6).

Table 6. sorghum stem volume (ml) on the treatment of organic fertilizer and varieties dosage

Dosage of fertilizer	Varieties			Average
	V1(Patir 3)	V2 (Samurai 2)	V3 (Mandau)	
D1 (20 g/plant)	47,7777	44,1111	21,8888	37,9259 a
D2 (40 g/plant)	50,2222	30,4444	20,7777	33,8148 a
D3 (60 g/plant)	48,6666	39,4444	25,4444	37,8518 a
Average	48,8888 p	38,0000 q	22,7037 r	-

Note: Figures followed by the same letter (p,q,r) on the line and (a, b, c) in the same column means that there is no significant difference according to the Duncant 5%, (-) : no interraction

Souce: analysis of primary data

V. Conclusion

Efforts to improve the quality and quantity of sweet sorghum sap have been done in various ways, either by utilizing microorganisms, charcoal addition, and the use of organic fertilizers that provide mixed results in some varieties of sweet sorghum treated. Variation of doses of mycorrhizae significantly affect the quality of sorghum stem i.e. stem weights and sap content. There is an interaction between genotypes with husk-charcoal mycorrhiza on sap sugar content (%) with the highest value obtained in a combination of husk-charcoal treatment 30 g/plant-HZ-30 (P3G1) of 7.6144%. There is an interaction between varieties with the combination of inorganic, organic and husk-charcoal on the parameters of sorghum stem content (ml), sap sweetness level (briks), and sap sugar level (%). There is an interaction between the treatment of varieties and the doses of organic fertilizer on the stem sorghum weight, sorghum stem starch content, total sugar content, and carbohydrate content. Fertilization with arbuscular mycorrhizal fungi (AMF) can increase the weight of sweet sorghum stem and sap content. The addition of husk-charcoal is able to improve soil conditions resulting in increased yield of sweet sorghum on the parameters of stem weights and stem sap contents. Fertilization with super Petroganik has not been able to improve the results and the quality of sweet sorghum.

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