Characteristic Comparison of *bmr* and Conventional Sorghum as Promising Forage Grown on *Ultisol* Soil Applied Different Levels of Organic Fertilizer

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ABSTRACT

As promising cereal plant for forage sources, sorghum was grown easily on most of Indonesian soils and produce high number of biomass. Sorghum utilization for ruminant feed purpose still using conventional sorghum, it's not designed specify for forage source and it's have limiting factor about high lignin content which can reduce fiber digestibility. Mutation breeding techniques produced promising sorghum mutant line for forage with low lignin content and high nutrition forage quality. Brown Midrib (*bmr*) sorghum was obtained by gamma ray irradiation at 250 *Gy* for producing sorghum mutant lines containing low lignin, which is possible to be used for forage sources in animal livestock feed. A serial research was conducted to compare the *bmr* lines sorghum (PATIR 3.2 and 3.5) and conventional sweet sorghum varieties (Numbu and CTY-33) on marginal Ultisol soil applied with different levels (0, 10, 20, and 40 ton ha^{-1}) of organic fertilizer. The research parameters were Viability, Pest Disturbance Intensity (PDI), Stem Diameter, Stem Height, Stem °brix, and forage Crude Protein Content. Research result showed that *bmr* line sorghum have similar average of Viability (91.90 vs. 93.30%), and forage Crude Protein Content (7.49 vs. 7.45%) Generally, *bmr* sorghum lines have bigger on stem diameter but shorter on stem height. The superiority of *bmr* lines were lower on PDI (13.84 vs. 31.33%) and higher on Stem °brix content (12.77 vs. 12.30°brix) compare with conventional ones. Based on the characteristics, *bmr* lines sorghum (PATIR 3.2 and 3.5) could be considered its utilization for forage source in marginal soil to replace conventional sorghum varieties which not design for feed source purpose.

Keywords: Sorghum, Brown Midrib, Forage, Marginal Soil, Characteristic.

INTRODUCTION

Sorghum was known as one of potential plant to cultivate for forage source. Beside of its high biomass, easy adapt on marginal environment soil could be as a consideration to use it as future potential forage source in Indonesia. So far, sorghum utilization as forage in Indonesia still uses conventional (sweet) sorghum which was not specialized for forage source. It has effect on produced forage quality, especially on lignin content which could reduce it digestibility on ruminant digestion system. Sorghum plant breeding has been directed to created new brown midrib (*bmr*) line, which known has lower lignin content, and can be well utilized as ruminant feed. These *bmr* line was created within 250 Gy gamma ray radiation process. Serial research was conducted to evaluate *bmr* sorghum ability with grown it on marginal soil and applied organic fertilizer and compare with conventional sweet sorghum which named as one of National Release Variety and for the time has been used as forage source.

MATERIALS AND METHODS

Cultivation. Research was conducted on September 2013 until March 2014 started with sorghum cultivation in Lalowiu, South Konawe Residence, Southeast Sulawesi Province. The location latitude was 4°07’366” SL and 122°48’104” WL with altitude ±51.6 ASL. The geographic position of research site located on tropic area with annual rainfall recorded as 1816.13 ml year^{-1}, relative humidity 84% (minimum 35% and maximum 98%) and daily temperature 20°C up to 38°C. Cultivation location was former swamp area which was drained and categorized as ultisol soil and analyzed result show high acidity (4.5) and aluminum (Al^{3+} 2.04 cmol$_c$ kg^{-1}) content soil. Four organic fertilizer levels (0 ton ha^{-1}, 10 ton ha^{-1}, 20 ton ha^{-1}, and 40 ton ha^{-1}) became one of two research treatment beside sorghum varieties/ lines (Numbu, CTY-33, PATIR3.2, PATIR3.5) as second factors. Numbu and CTY-33 varieties were conventional sweet sorghum and it were National Released, while PATIR3.2 and PATIR3.5 lines were *bmr* sorghum. The sorghum seed were obtained from SEAMEO Biotrop. Basic fertilization with NPK applied on 15 and 30 DAS during research period with comparison N:P:K equal with 4:3:2 (g/g). The harvesting held on 80% population blooming with assumed best nutrition and production phase of sorghum as forage source.

Evaluation. The observation was conducted on fourth day after sowing (DAS), while sorghum seed starting emerged. Every single sorghum shoots in each plots were counted and compared with totally seed hole planted (200 holes) to obtain sorghum seed viability. On fifth DAS, occurred pest/ insect attack (grasshopper and cricket) on field, attacked shoots were counted and compare with total shoot to obtain the percentage. Stem diameter and height were obtained on the harvesting day by measure using caliper on stem bottom part, meanwhile plant length was measured by straighten/ uncurl plant and measured from bottom until highest part. Stem/ leaf ratio obtained by separately weighing sorghum stem and leaf parts on harvesting day. The harvesting age was noted as long sorghum cultivate until blooming phase of 80% population. Stem °brix content was measured stem juice sugar content by using ATAGO® commercial refractometer, while crude protein content was measured by proximate analysis.

RESULTS AND DISCUSSION

Seed Viability and Pest Disturbances Intensity. Germination is complex process where the seed should recover its physically quickly from drying, and continue metabolism intensity, finishing others important cellular activities to allow the plant embryo emerge, and prepare for germ growing later (Nonogaki *et al*. 2010). It is important to observe on field sorghum seed viability due to initial step to evaluate its adaptation ability on every environment. After germination occur, sorghum shoot very susceptible on pest disturbances, and naturally they have mechanism to defending itself.

Research result on Tabel 1 showed that there was no significant effect (P>0.05) of organic fertilizer on all sorghum viability. The average viability on this research was 92%. This high viability indicating that seed using on this research have good vigor category which can well adapt on new environment. Research field environment temperature recorded as 20 - 38ºC. High sorghum seed viability obtained on temperature around to 32 - 40ºC for medium seed, while big one was 32 - 42ºC (Mortlock and Vanderlip 1989). The factors which were affecting germination processes were moisture content, oxygen, temperature, and internal factor. Seed should be fulfilling genetic, physic, and physiologic requirement. The soluble oxygen on water between kernels has significant effect on vegetative growth of sorghum early germination phase (Pflugfelder and Rooney 1986). It was mean that planted sorghum seeds have fulfilled good genetic, physic and physiologic requirements.

Table 1. Sorghum Viability and Pest Disturbances Intensity (PDI)

Varieties/ Lines		Organic Fertilizer Levels (ton ha^{-1}) 0	10	20	40	Average
Numbu	Viability (%)	94.67±2.36	95.67±2.25	93.67±2.36	94.83±3.06	94.71±2.28
	PDI (%)	32.00±7.21	21.67±09.50	34.00±3.61	31.67±8.33	29.83±8.12^{b}
CTY-33	Viability (%)	92.33±2.52	91.17±6.11	90.83±3.82	93.17±1.53	91.88±3.46
	PDI (%)	34.00±12.17	29.67±04.62	29.33±7.09	38.33±7.57	32.83±8.07^{b}
PATIR3.2	Viability (%)	94.00±2.65	91.17±5.01	93.00±3.04	90.83±4.16	92.25±3.54
	PDI (%)	13.00±1.73	13.67±02.08	15.33±6.51	17.67±12.50	14.92±6.40^{a}
PATIR3.5	Viability (%)	90.33±7.97	91.17±5.35	91.67±1.26	93.00±2.29	91.54±4.36
	PDI (%)	15.00±03.46	12.33±04.93	7.00±04.57	16.67±08.50	12.75±6.18a
Viability Average (%)		92.83±8.50	92.29±9.30	92.29±5.28	92.96±5.81	
PDI Average (%)		23.50±11.77	19.33±08.85	21.42±12.25	26.08±12.55	

Number which followed by different letter on same column and row of each parameters show significant different ($p<0.05$)

Pest disturbances intensity was significant affected ($p<0.05$) by sorghum varieties/ lines (Table 1). Table 1 showed that Numbu and CTY-33 varieties were easier pest attacked compare than PATIR3.2, and 3.5 lines. Numbu and CTY-33 disturbance intensity attain to 29.83 and 32.83%, while PATIR 3.2 and 3.5 on 14.92 and 12.75%. Therefore PATIR 3.2 and 3.5 were less preferred by insect, such as cricket, grasshopper, and caterpillar on research site. Naturally, plant has defence mechanism through insect disturb. Young plant which susceptible to any disturbances and environment dangerous has any defence mechanism. Fractionation of 15 days sorghum leaf indicated some phenol acid, which allegedly have ability to inhibit grasshopper (*Locusta*) disturbances (Woodhead dan Driver 1979). Therefore *bmr* lines phenol compound was more effective to suppress insect disturbances on early age sorghum cultivation, although there was need advance research to confirm it.

Stem Height and Diameter. Plant height and plant blooming age can be used as genotypic selection character of sweet sorghum with high fresh biomass potential production (Efendi *et al*. 2013).

Table 2. Sorghum Stem Height and Diameter

Varieties/ Lines		Organic Fertilizer Levels (ton ha^{-1}) 0	10	20	40	Average
Numbu	Height (cm)	267.95±28.03^{bc}	262.33±38.30^{c}	279.46±19.28^{ab}	264.98±18.15^{c}	268.60±27.47
	Diameter (cm)	1.40±0.24	1.43±0.28	1.52±0.22	1.55±0.28	1.48±0.26^{z}
CTY-33	Height (cm)	265.23±24.97^{c}	284.78±13.60^{a}	277.89±17.39^{ab}	281.40±19.71^{a}	277.26±20.55
	Diameter (cm)	1.44±0.23	1.64±0.25	1.49±0.27	1.73±0.31	1.58±0.29^{y}
PATIR3.2	Height (cm)	220.72±16.66^{efg}	228.01±10.35^{de}	215.14±35.03^{fg}	236.63±10.81^{d}	225.16±22.09
	Diameter (cm)	1.74±0.24	1.83±0.23	1.79±0.30	1.99±0.29	1.84±0.28^{x}
PATIR3.5	Height (cm)	223.65±13.70^{ef}	226.21±14.95^{def}	209.29±24.84^{e}	225.26±23.36^{def}	221.01±20.90
	Diameter (cm)	1.79±0.22	1.83±0.32	1.75±0.31	1.99±0.28	1.84±0.30^{x}
Stem Height Average (cm)		245.34±31.08	250.44±32.99	245.43±41.60	252.43±28.93	
Stem Diameter Average (cm)		1.59±0.29^{c}	1.69±0.31^{b}	1.64±0.30b^{c}	1.81±0.34^{a}	

Number which followed by different letter on same column and row of each parameters show significant different ($p<0.05$)

Plant height was one of several indications to understand plant biomass quantity. Silungwe (2011) indicated strong positive correlation between plant height and sorghum biomass yield. Research result indicated interaction ($p<0.05$) between organic fertilizer adding levels and sorghum varieties/ lines on plant height, but it there was not on stem diameter ($p>0.05$). CTY-33 variety has high consistency of highest plant height on every organic fertilizer adding levels (Table 2.). Sweet sorghums have consistency higher of plant height if compared with *bmr* lines. PATIR 3.2 and 3.5 have highest plant height on 40 ton h^{-1} organic fertilizer adding level, also control level for PATIR 3.5. Sorghum plant height on this research was more influenced by genetic traits, which *bmr* lines were have lower plant height compared with sweet sorghum varieties. The common character of *bmr* lines were reducing of dry matter production, post harvest re-growth ability, biomass weight, and longer age to get blooming phase (Pedersen 2005).

Stem Sugar and Plant Crude Protein (CP) Content. Sorghum stem's sugar content stated in °brix value. °brix could be important parameter to selecting sorghum genotype which has high sucrose accumulation (Kawahigashi *et al*. 2013). Sorghum sweetness levels should become an important objective to sorghum as feed source development, in addition to its leaf proportion and softness (Bian 2006).

Table 3. Sorghum Stem Sugar (°brix) and Plant Crude Protein Content (%)

Varieties/ Lines		Organic Fertilizer Levels (ton ha^{-1})				Average
		0	10	20	40	
Numbu	Sugar (°brix)	11.78±1.98	12.31±2.59	12.48±1.80	13.03±1.88	12.40±2.12^{b}
	Crude Protein (%)	8.77±2.93	5.79±0.47	8.14±1.05	7.43±1.67	7.53±1.91
CTY-33	Sugar (°brix)	12.53±2.26	11.89±2.00	12.23±1.77	12.10±1.61	12.19±1.93^{b}
	Crude Protein (%)	7.04±2.43	8.09±1.63	6.97±1.17	7.38±0.86	7.37±1.05
PATIR3.2	Sugar (°brix)	13.00±2.12	11.71±1.93	13.00±2.18	12.25±1.65	12.49±2.05^{b}
	Crude Protein (%)	7.47±1.87	8.09±0.56	7.29±2.04	8.32±0.36	7.79±1.29
PATIR3.5	Sugar (°brix)	13.14±2.06	12.71±1.53	13.08±2.09	13.25±2.87	13.05±2.20^{a}
	Crude Protein (%)	7.36±1.17	8.22±0.95	6.67±1.34	6.45±2.15	7.18±1.45
	Sugar Average (°brix)	12.61±2.17	12.16±2.08	12.70±1.99	12.66±2.11	
	Crude Protein Average (%)	7.66±1.85	7.55±1.18	7.27±1.37	7.39±1.41	

Number which followed by different letter on same column and row of each parameters show significant different ($p<0.05$)

Research result (Table 3.) showed that organic fertilizer adding levels didn't gave significant effect ($p>0.05$) on sorghum stem °brix value, while varieties/ lines have significant effect ($p<0.05$) on it. PATIR3.5 line has the highest °brix value (13.05) compare to the others. Sorghum stem °brix value has proportional value on sucrose concentration total sugar, which reached about 75% of total sugar content in more than 15 °brix value's varieties (Kawahigashi *et al.* 2013). The higher °brix value on physiology maturity phase could indicate the sorghum stem total sugar accumulation. °brix value increase on blooming until physiology maturity phases which allegedly due to the reducing of stem moisture content (Gadakh *et al.* 2013).

Crude protein content of several sorghum varieties on other field research in various years according Bean *et al.* (2013) recorded between 5.4 until 7.8% with consistency *bmr* have lower content. Crude protein content on this research was 5.79 to 8.77%. Table 3 showed that organic fertilizer adding levels didn't gave significant effect ($p>0.05$) crude protein content. The indifference of crude protein content possibility due to stem and leaf proportion. Decreasing of stem and leaf proportion and the increasing of stem percentage would lower forage quality, because crude protein mostly found on leaf portion and leaf was more edible if compare to stem portion (Silungwe 2011). Kurniawan *et al*. (2014) indicated that there was no significant difference between sweet and *bmr* sorghum on leaf and stem proportion, although harvested in difference age.

The presumption of soil fertility effect on forage quality (especially crude protein content) could be explained by the utility of soil nitrogen. Nitrogen was important element of protein formation process, which mainly located in chlorophyll for photosynthetic reaction. Adequate N supply would be associated with high rate photosynthetic activity, good vegetative growth, and dark green leaf color (Havlin *et al*. 2005).

CONCLUSIONS

Based on the characteristics comparison between *bmr* lines and sweet sorghum, there are many equal yield and productivity of them, that's make *bmr* lines sorghum (PATIR 3.2 and 3.5) could be considered its utilization for forage source in marginal soil to replace conventional sorghum varieties which not design for feed source purpose. Nevertheless, it's still need an advance research to determining *bmr* lines become variety which have stable performance.

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