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Characterization of biomass sorghum cultivars aiming to generate energy for the north region of Mato Grosso, Brazil

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ABSTRACT: Biomass sorghum has high lignocellulosic biomass production, emerging as a cultivation alternative for renewable energy production. The objective of this study was to characterize biomass sorghum cultivars aiming to generate energy for the north of Mato Grosso. To this end, an experiment in the randomized block design with three replications, consisting of 36 sorghum genotypes (34 biomass and two forage) was implanted in 12/04/2014 in Sinop/Mato Grosso. The evaluated characteristics were: flowering, plants height, lodged plants, finishing, plants population, green mass production, dry matter production, dry matter percentage and humidity. Data were subjected to analysis of variance, and the averages of the genotypes were grouped by the Scott-Knott test. Forage materials flourished on average after 77 days, whereas the biomass genotypes flourished from 101 to 130 days. While the best forage genotype (Volumax) produced 11.6 t ha^{-1} dry matter, 15 genotypes of sorghum biomass produced on average 24 t, each one. Demonstrating being a potential for cultivating in the region. The dry matter produced by biomass sorghum genotypes associated with its calorific has demonstrated the potential of culture for renewable energy production.

Keywords: *Sorghum bicolor*, renewable energy, bioenergy.

Caracterização de cultivares de sorgo biomassa visando a geração de energia para a região norte de Mato Grosso

RESUMO: O sorgo biomassa possui elevada produção de biomassa lignocelulósica, surgindo como alternativa de cultivo visando produção de energia renovável. O objetivo deste trabalho foi caracterizar cultivares de sorgo biomassa visando a geração de energia para região Norte de MT. Para tal, implantou-se em 04/12/2014, em Sinop-MT, um experimento no delineamento em blocos casualizados, com três repetições, composto por 36 genótipos de sorgo (34 biomassas e 2 forrageiros). As características avaliadas foram: florescimento, altura de plantas, acamamento, população de plantas, produção de massa verde, produção de massa seca, porcentagem de massa seca e umidade. Os dados foram submetidos a análise de variância e as médias dos genótipos foram agrupadas pelo teste de Scott-Knott. Os materiais forrageiros floresceram, em média, aos 77 dias, enquanto que os genótipos de biomassa floresceram dos 101 aos 130 dias. Enquanto o melhor genótipo forrageiro (Volumax) produziu 11,6 t de massa seca ha^{-1}, 15 genótipos de sorgo biomassa produziram, em média, 24 t. Demonstrando estes serem os de maior interesse de cultivo na região de estudo. A matéria seca produzida pelos genótipos de sorgo biomassa associado a seu poder calorífico demonstram potencial da cultura para produção de energia renovável.

Palavras-chave: *Sorghum bicolor*, energia renovável, bioenergia.

1. INTRODUCTION

Biomass sorghum, *Sorghum bicolor* (L.) Moench, similar to elephant grasses and Napier grass, emerges as one of the renewable energy sources to the growing energy problem. According to Parrela et al. (2011), Brazil and several other countries visualized the importance of production and use of biomass for power generation.

Since 2001, the use of hydroelectric energy generation in its total capacity has decreased mainly by drought in recent years, making electricity cogeneration by burning biomass (bagasse) in a very attractive thermoelectric business (MOURA et al., 2015).

About 6.4% of the Brazilian matrix of power generation is from sugarcane burning bagasse, black liquor, wood, biogas, rice husk, which commercialize the exceed energy (Conab, 2011).

In this context, Parrela et al. (2011) point out that the sorghum biomass is a promising raw material due to its high-energy yield per hectare and short cycle. Schuck et al. (2014) cite that sorghum biomass is a culture that allows mechanization from crop planting, and its planting was done by seeds, with the capacity to produce large amounts of biomass per hectare in a cycle of approximately six months.

The genetic improvement program of Embrapa Maize and Sorghum developed hybrid sorghum biomass, sensitive to the photoperiod, with high yield potential per cycle (6 months) for dry matter, about 50 t.ha^{-1} (PARRELA et al., 2011).

This study aimed to characterize the agronomic potential of biomass sorghum cultivars aiming to generate power for the north region of Mato Grosso.

2. MATERIAL AND METHODS

Thirty three experimental cultivars of sorghum biomass were evaluated in the 2014/15 harvest, in the municipality of Sinop/Mato Grosso, (201429B001, 201429B002, 201429B003, 201429B004, 201429B005, 201429B006, 201429B007, 201429B008, 201429B009, 201429B010, 201429B011, 201429B012, 201429B013, 201429B014 , 201429B015, 201429B016, 201429B017, 201429B018, 201429B019, 201429B020, 201429B021, 201429B022, 201429B023, 201429B024, 201429B025, 201429B026, 201429B027, 201429B028, 201429B029, 201429B030, 201429B031, 201429B032, 201429B033), from the genetic improvement program Embrapa Maize and Sorghum, 1 commercial cultivar of sorghum biomass (BRS 716), 2 commercial cultivars of forage sorghum (BRS 655 and Volumax), the last three considered as samples. The experimental design was by randomized blocks, with 3 repetitions. The experimental parts were constituted by four rows of five meters, spaced at 0.7 m, and the two central rows were considered useful.

The evaluated characteristics were: Flowering (FLOW): days from planting to flowering of at least 50% of the plants in the experimental parts; Plant height (PH): average height in meters, measured from the ground surface to the apex of panicle plant after its physiological maturity; Bedding (BEDD): quantity of broken plants or with an inclination level less than 30° related to the vertical in the experimental part at the harvesting, extrapolating this value for one thousand plants ha^{-1}; Population (POP): number of plants in the experimental part at harvest, with extrapolated value for plants ha^{-1}; Green Mass Production (GMP): mass of the air part of all plants from the useful experimental part, harvested at physiological maturity of grain, converting data to t ha^{-1}; Dry Mass Production (DMP): determined in t ha^{-1} by multiplying the GMP by the percentage of dry matter of this biomass; Percentage of dry matter (%DM): ratio between the dry matter yield and green mass of a biomass sample of each part after drying in a forced ventilation oven at 65 °C for 72 h, converted to percentage; Humidity (HUM%) determined in percentage (%) through percentage difference of dry mass (%DM) and the total mass percentage.

Data were submitted to variance analysis, and the means of the characteristics of different genotypes were grouped by the Scott-Knott test ($P<0.05$). These statistical analyses were performed using the computational resources of the GENES program (Cruz, 2009).

3. RESULTS AND DISCUSSION

The variance analysis showed significant differences ($p<0.05$) among the genotypes for all evaluated characteristics, showing a genetic variability between genotypes and the possibility of selection of those with superior attributes for cultivation in the study region. Tables 1 and 2 shows the average values of the evaluated characteristics in the different genotypes and the coefficient of variation (CV) related to them. The FLOW ranged from 75 to 130 days, PH from 2.50 to 5.92 m, BEDD from 0 to 10476 plants ha^{-1}, the POP from 74,286 to 136,667 thousand plants ha^{-1}, the GMP from 27.6 to 84.4 t ha^{-1}, DMP from 6.346 to 28.793 t ha^{-1}; DM% from 23.17 to 36.61% and HUM% with values between 63.39 to 76.83%.

Table 1. Average of different characteristics obtained in 36 sorghum genotypes grown in Sinop, MT, Brazil, in 2014/15 crop.

Tabela 1. Média de diferentes características obtidas em 36 genótipos de sorgo cultivados em Sinop, MT, Brasil, na safra 2014/15.

Genotypes	Characteristics/1							
	FLOR (days)		ALT (m)		ACAM (plants ha^{-1})		POP (mil plantas ha^{-1})	
201429B001	130	a	5.62	a	7143	a	136.667	a
201429B005	128	a	5.23	b	5714	a	100.476	b
201429B015	128	a	5.15	b	4762	a	111.905	a
BRS 716	128	a	5.53	a	27143	a	96.190	b
201429B013	127	a	5.40	a	10000	a	111.905	a
201429B010	125	a	5.06	b	47619	a	104.762	b
201429B008	124	a	5.14	b	5714	a	99.048	b
201429B006	123	a	5.15	b	42857	a	113.810	a
201429B017	123	a	4.77	b	8571	a	119.048	a
201429B032	122	a	5.49	a	52381	a	74.286	b
201429B033	122	a	5.50	a	19524	a	100.476	b
201429B012	121	a	5.18	b	6667	a	95.238	b
201429B031	121	a	5.76	a	15238	a	93.809	b
201429B020	119	a	5.57	a	10952	a	88.571	b
201429B026	118	b	5.80	a	19048	a	113.809	a
201429B014	117	b	4.68	b	4762	a	124.286	a
201429B018	117	b	5.00	b	40476	a	96.667	b
201429B030	117	b	5.34	a	4762	a	96.191	b
201429B002	116	b	5.21	b	10476	a	134.762	a
201429B022	116	b	5.92	a	24286	a	85.238	b
201429B029	116	b	5.48	a	38095	a	113.809	a
201429B009	115	b	5.25	b	20476	a	89.524	b
201429B016	115	b	4.91	b	31905	a	131.905	a
201429B003	114	b	5.17	b	0	a	98.571	b
201429B004	114	b	5.13	b	4762	a	86.190	b
201429B023	114	b	5.54	a	15238	a	118.571	a
201429B007	112	c	4.92	b	1429	a	100.952	b
201429B019	111	c	4.51	b	7143	a	107.143	b
201429B024	111	c	5.26	b	6667	a	93.809	b
201429B011	110	c	4.81	b	9524	a	113.333	a
201429B021	110	c	5.00	b	8571	a	86.667	b
201429B025	110	c	5.31	b	18571	a	120.476	a
201429B027	110	c	5.78	a	10000	a	100.476	b
201429B028	101	d	4.93	b	3333	a	89.524	b
Volumax	79	e	3.07	c	0	a	105.714	b
BRS655	75	e	2.49	d	3810	a	89.048	b
CV	3.82		5.83		158.57		19.28	

1/FLOWER = flowering (days), PH = plant height (m), BEDD = bedding, POP = Population of one thousand plants.

Table 2. Average of different characteristics obtained in 36 sorghum genotypes grown in Sinop, MT, Brazil, in 2014/15 crop.
Tabela 2. Média de diferentes características obtidas em 36 genótipos de sorgo cultivados em Sinop, MT, Brasil na safra 2014/15.

Genotypes	Characteristcs/1							
	GMP (t ha^{-1})		DMP (t ha^{-1})		%DM		%HUM	
201429B026	84.400	a	28.793	a	34.1	a	65.9	c
201429B001	83.305	a	27.119	a	32.7	a	67.3	c
BRS 716	76.257	a	25.482	a	33.1	a	66.9	c
201429B031	76.971	a	25.237	a	33.0	a	67.0	c
201429B002	83.686	a	25.201	a	30.1	b	69.9	b
201429B013	80.210	a	24.799	a	30.7	b	69.3	b
201429B020	74.114	a	23.813	a	32.3	a	67.7	c
201429B022	75.686	a	23.086	a	30.6	b	69.4	b
201429B033	75.447	a	22.907	a	30.4	b	69.6	b
201429B030	61.257	b	22.644	a	36.6	a	63.4	c
201429B014	74.781	a	22.607	a	30.3	b	69.7	b
201429B029	69.924	a	22.562	a	32.2	a	67.8	c
201429B012	60.733	b	22.225	a	36.4	a	63.6	c
201429B017	76.829	a	22.160	a	28.8	b	71.2	b
201429B005	72.162	a	21.935	a	30.4	b	69.6	b
201429B015	73.591	a	21.610	b	29.4	b	70.6	b
201429B023	74.590	a	21.229	b	28.5	b	71.5	b
201429B016	71.019	a	20.870	b	29.3	b	70.7	b
201429B025	63.590	b	20.318	b	32.2	a	67.8	c
201429B004	64.781	b	20.143	b	31.1	b	68.9	b
201429B008	64.543	b	20.115	b	31.2	b	68.8	b
201429B009	66.495	a	20.026	b	30.1	b	69.9	b
201429B027	61.448	b	19.627	b	32.0	a	68.0	c
201429B007	56.495	b	19.623	b	34.7	a	65.3	c
201429B021	58.924	b	19.212	b	33.1	a	66.9	c
201429B024	56.828	b	18.823	b	33.1	a	66.9	c
201429B006	67.257	a	18.789	b	28.1	b	71.9	b
201429B032	59.781	b	18.783	b	31.5	a	68.5	c
201429B003	61.114	b	18.682	b	30.7	b	69.3	b
201429B018	58.019	b	17.437	b	30.1	b	69.9	b
201429B010	62.257	b	17.017	b	27.1	c	72.9	a
201429B028	46.543	b	14.393	c	31.0	b	69.0	b
201429B011	48.114	b	14.322	c	29.8	b	70.2	b
201429B019	49.495	b	12.038	c	24.4	c	75.6	a
Volumax	39.543	b	11.556	c	29.1	b	70.9	b
BRS655	27.257	b	6.346	d	23.2	c	76.8	a
CV	11.82		15.13		8.96		4.00	

1/GMP = green mass production (t.ha^{-1}), DMP = dry matter production (t ha^{-1}), %DM = percentage of dry matter (%) and %HUM = humidity (%).

Five flowering groups were observed on average, and the feed materials were the earliest flowering, on average after 77 days, whereas the biomass genotypes flourished from 101 to 130 days.

According to Parrela et al. (2013), the sensitivity of sorghum biomass to photoperiod has an effect on their growth cycle. This larger cycle may be an explanation of their greater potential for dry matter production (DMP).

While the best forage genotype (Volumax) produced 11.6 t DM ha^{-1}, there were 15 genotypes of sorghum biomass forming the group of the most productive with an average production of 24 t MS ha^{-1}, where the 201429B026 genotype is emphasized by the DMP in an absolute value of 28.793 t ha^{-1} (Table 1b).

The planting of the experiment took place on 12.04.14, and the harvest was six months later. In the study of Schuck et al. (2014), where the planting occurred on 11.19.13, it could be observed that the BEDD varied from 113 to 136 days, inferring on the sensitivity to the photoperiod and vegetative cycle, while the DMP had an average of 36 t ha^{-1}, with the more productive genotype reaching an average of 47.35 t ha^{-1}.

In the study of Parrella et al. (2013), four locations were evaluated (Capivari/São Paulo, Nova Porteirinha/Minas Gerais, Piracicaba/São Paulo and Sete Lagoas/Minas Gerais), where the lowest average for the assessed characteristics are due to late sowing, making shorter the growing season.

Data from this literature show that the productivity of the evaluated genotypes may be better in plantations at the beginning of the rainy season, that is, late October or early November for Mato Grosso, tending to increase their growing seasons and enhancing their fixing capabilities of dry matter (DM).

As the calorific value of DM sorghum biomass, Schuck et al. (2014) estimated the DM gross calorific value (GCV) of 14 genotypes, finding no significant differences between them, and the average value obtained per DM kg of 4,423 Kcal. Considering this value, the 201429B026 genotype in the current study would produce, 127.35 Gcal ha^{-1} on average, during a cycle of six months. This data resemble the eucalyptus culture with a dry matter production of 30 t ha^{-1} year^{-1}, generating 138 Gcal ha^{-1} per year, considering the GCV of eucalyptus of 4,600 Kcal Kg^{-1} of DM.

4. CONCLUSIONS

The dry matter produced by biomass sorghum genotypes associated with its calorific power demonstrate the potential of culture for renewable energy production.

The identification and use of genotypes adapted to the growing region are important for a productive success.

Further tests are necessary with cultivars in different planting seasons, locations and years for the validation of a sorghum biomass crop production system in the north of Mato Grosso.

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6. REFERENCES

CONAB. Companhia Nacional de Abastecimento. **A geração termelétrica com a queima do bagaço de cana-de-açúcar no Brasil: análise do desempenho da safra 2009-2010**. Brasília, 2011. 157 p.

CRUZ, C.D. **Programa GENES - aplicativo computacional em genética e estatística**. Viçosa: UFV, 2009. Disponível em:<http://www.ufv.br/dbg/genes/genes.htm>. Acesso em: 14 jul. 2015.

MOURA, L. M; OLIVEIRA, I. C. M; SILVA, K. J; DUARTE, D. D; SILVA, R. A; PARELLA, R. A. C; OLIVEIRA, N. A; DURÃES, N. N. L. Caracterização de Híbridos de Sorgo Biomassa. In: CONGRESSO BRASILEIRO DE MELHORAMENTO DE PLANTAS, 8, 2015, Goiânia. **Anais...** Viçosa: Sociedade Brasileira de Melhoramento de Plantas, 2015.

PARELLA, R. A. C. **Desempenho agronômico de híbridos de sorgo biomassa**. Brasília: EMBRAPA/CNPMS-MG, 2011. 19 p. (Boletim de Pesquisa e Desenvolvimento,41).

PARRELLA, R. A. C. Cultivares. In: MAY, A.; SILVA, D. D.; SANTOS, F.C. **Cultivo do sorgo biomassa para cogeração de energia elétrica**. Sete Lagoas: Embrapa Milho e Sorgo, 2013. 65 p. (EMBRAPA/CNPMS-MG. Documentos, 152).

SCHUCK, D. A; TARDIN, F. D; SCHANFRANSKI, N. O; DIEL, F. A; MORALES, M. M; SILVA, V. Q. R. da; PARELLA, R. A. C; SILVA, A. F. da. Productive behavior of biomass sorghum hybrids (Sorghum bicolor) for energy production in Sinop - MT. In: GENETICS AND PLANT BREEDING MEETING OF RIO DE JANEIRO, 2., 2014, Campos Goytacazes. Abstracts. [S.I]: SBMP: UENF, 2014. p. 57.