Development of *Megathyrsus maximus* genotypes for intensification of cattle rearing in Brazil

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Abstract
Megathyrsus maximus is a forage species used over 30 million hectares in Brazil and in the surrounding countries for intensification of the cattle production systems. Due to the large area and distinct biomes in which it is used, there is a need to continuously develop more productive and adapted cultivars to each biome and use. Three apomictic accessions were crossed with five sexual plants at Embrapa Beef Cattle in Campo Grande, MS, Brazil in 2014. More than 1100 hybrids were planted in a spaced-plant field and evaluated visually for regrowth after cuts and for disease and pest damage. In 2016, the best 154 hybrids together with the parentals and standards were planted in small plots with replication, and evaluated for two years for forage production and quality under a harvest cutting regime. From the nine harvests performed, the best twenty-three hybrids and four standards were planted to a field on 12 m^2 plots with three replications on February 2019. These genotypes were evaluated under cuts every 35 days in the rainy season and at the end of the dry season in a total of 10 harvests. Leaf dry matter yield varied from 6.0 to 15.1 tons ha^{-1} with a dry season percentage of 5.7 to 12.8%. Leaf percentage varied from 59 to 92% and seed yield from 50 to 158 kg ha^{-1}. The genotypes were grouped taking into account production, quality and morphological characteristics. Selection of the best ones is presented and discussed viewing evaluation under grazing before release in the market.

Introduction
Brazil has the second largest cattle herd in the world, with 196.47 million heads, which corresponds to 11.7% of the world´s herd, and is the second beef producer in the world, which corresponds to 13.6% of the world´s beef production (Abiec, 2022). Brazil is also the largest exporter of beef. In 2021, 25.5% of the slaughtered heads were exported. Brazil has a competitive advantage since all the cattle are reared on pastures and only 17.9% were terminated on feed lots in 2021. To sustain all the livestock, pastures occupy the largest area of cultivation in Brazil, 163.1 million hectares. With the exception of the two southernmost states in the country, which correspond to 5% of the pasture area and may be sown mostly to temperate pasture species, the rest of 95% of the country is based on tropical pasture species. Brachiaria species are the main forages used, mainly for extensive exploitation, and *Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L.Jacobs (Panicum maximum Jacq.) are used on around 30 million hectares of more intensive exploitation. Other forage species are also very important and cover less area.

Thus, for a country with such an extension as Brazil, and which covers five very distinct biomes, forage breeding and cultivar development programs are of utmost importance. Embrapa is the main institution with complete solid programs which have already released innumerous cultivars in the market. In fact, up to date, 57% and 76% of the *Brachiaria* and *Panicum* seed, respectively, commercialized in the country are from Embrapa cultivars (Unipasto, personal communication).

Embrapa Beef Cattle is responsible for the *P. maximum* breeding and cultivar development program since 1982. The program follows an evaluation scheme (Jank et al., 2014) which involves crosses between selected parents, hybrid evaluation in small plots, evaluation in network trials and evaluation under grazing.

This paper reports the results of a two-year evaluation of twenty-three hybrids in a network trial conducted at Embrapa Beef Cattle.

Methods
Three apomictic accessions were crossed with five sexual plants at Embrapa Beef Cattle in Campo Grande, MS, Brazil in 2014. Seeds from the sexual plants were harvested in May 2015. They were put to germinate in a tray with sand:soil 1:1. Seedlings were transplanted to tubes. More than 1100 hybrids were planted in a spaced-plant field and evaluated visually for type of plant, vigor, regrowth after cuts and for disease and pest damage. In 2016, the best 154 hybrids together with the parents and checks were planted in small plots with replication, and evaluated for two years for forage production and quality under a harvest cutting regime. From the nine harvests performed, the best twenty-three hybrids were planted to a field on 12

m^2 plots with four standards and three replications on February 2019. The standards were cvs. Mombaça, Massai, Paredão and Gatton Panic. All genotypes and cultivars were harvested every 35 days in the rainy season and at the end of the dry season in a total of 10 harvests.

The harvests were done at a height of 20 cm from the soil, the harvested forage was weighed in the field and a subsample of around 200-300 grams was taken, weighed in the laboratory and separated into leaves, stems and dead matter. They were then dried for 72 hours at 65ºC, ground with a Wiley Mill and sieved in a 1 mm sieve, for determination of quality through NIRS (Near Infrared Spectroscopy).

Data was analysed with the use of SAS and means were grouped with Scott-Knott (Canteri et al., 2001).

Results and Discussion

Annual leaf dry matter yield of 27 *P. maximum* genotypes evaluated in Campo Grande, MS, Brazil, varied from 6 to 15.1 t/ha/yr and from 0.7 to 1.4 t/ha in the dry season (Table 1). These values are compatible with the values obtained in the State of Acre (Valentim et al., 2006) in a previous network experiment, with the same plot size. In Acre, annual LDMY varied from 3.9 to 14.15 t/ha and cv. Mombaça presented between 9.2 and 11.9 t/ha, similar to our 12.4 t/ha. In the dry season, however, cv. Mombaça produced between 2.4 and 2.8 t/ha LDMY in Acre, almost double our 1.6 t/ha. This is expected since Acre lies in an equatorial type climate, while our state is in a tropical-type climate, where a dry season is very well defined.

In Rio de Janeiro, cv. Mombaça yielded 15.4 t/ha in two years in the previous network experiment with the same plot size (Ledo et al., 2005). Thus, it yielded almost half of our annual yield per year.

Eight hybrids and cv. Paredão presented higher annual LDMY than cv. Mombaça, and 14 hybrids together with cvs. Mombaça and Paredão were the highest yielders in the dry season (Table 1). Cultivar Mombaça was the genotype with the second highest mean in the dry season (1.6 t/ha).

The leaf yield percentage in the dry season/annual yield varied from 5.7 to 12.7%, values similar to those obtained for 25 accessions evaluated in 1984-1985 in Campo Grande, MS (Savidan et al., 1990), where 5.5 – 12.1% were obtained. However, value for cv. Mombaça was higher in the present experiment (12.5% vs 10.9% - K190A in the publication). Cultivar Paredão yielded 9% in the dry season/annual yield. Cultivar Mombaça was also, one of the five genotypes whose percentage in the dry season was greater then 12%. These genotypes were not the ones with the highest annual or dry season yields. Cultivar Gatton Panic was the least productive, yet its dry season percent was above 12%. We were surprised with the fact that cv. Gatton Panic produced only little in the dry season, since it is widely used in the arid regions of North Argentina. Other climate factors such as temperature and luminosity might have limited its production in this season.

Leaf percentage (annual mean) varied from 49 (cv. Gatton Panic) to 94% (HPM24) and from 47 (cv. Gatton Panic) to 92% (HPM24 and HPM16) in the dry season (Table 1). Only three hybrids were grouped in the first group in the annual mean. Both Mombaça (79%) and Paredão (82%) were grouped in the fourth worse group out of five. In the dry season, Mombaça was grouped in the second group (71%) and Paredão (64%) in the third group. Thus, most hybrids presented higher leaf percentages, which indicate better structure for animal grazing.

Regrowth after cuts is an important characteristic, because the tillers that regrow seven days after harvest in *P. maximum*, are the ones that will effectively contribute with the next cycle of production (Corsi, 1984). The speed of regrowth, embedded in the scale, will also contribute with a higher production in the next cycle. Of the cultivars, only Massai was grouped in the first group in the annual mean. Cultivars Paredão and Gatton Panic showed low regrowth scores, being grouped in the lowest group. Cultivar Paredão presents very thick tillers, and a low tiller regrowth density. Cultivar Gatton Panic presents many tillers, but a low regrowth speed. Despite this, yield of cv. Paredão was compensated by the good leaf production.

Pure seed production of all genotypes was rather low, varying from 10 to 158 kg/ha. The most probable explanation is that the plots were very densely planted, thus with a high competition among plants and fertilization was not enough to meet the plants requirements for a good seed production. The decision to evaluate seed production was taken when some plots had already flowered, thus the early-flowering genotypes were impaired. Nevertheless, the results obtained are important to have some indication of the seed production potential of the genotypes. In fact, Savidan et al. (1990) obtained 72 and 85 kg/ha for Mombaça and Massai, respectively, thus compatible with the present results.

Our important standards in this research are tall cv. Mombaça and short cv. Massai, two cultivars released by our group in 1993 and 2001, respectively. Cultivar Mombaça had been adopted by many cattle rearers and covers approximately 20 million hectares in the country, and is exported to many south and central American countries. A large number of hybrids evaluated in this experiment presented better performances than cv. Mombaça for most characteristics.

Table 1. Annual and dry season leaf dry matter yield (LDMY, t/ha/yr), leaf percentage (Leaf, %), regrowth after cuts (Regrowth, scale 1 – 5 much) and pure seed production (PSP, kg/ha) of 23 hybrids and 4 cultivars of *Panicum maximum* in Campo Grande, MS, Brazil.

	LDMY (t/ha/yr)			Leaf %		Regrowth		PSP (kg/ha)
	Annual	Dry	% Dry*	Annual	Dry	Annual	Dry	
HPM10	15.1 a**	1.4 a	9.4	88 b	79 b	2.9 a	3.0 a	158
HPM 20	14.0 a	1.4 a	10.3	79 d	59 c	2.7 b	2.0 b	57
HPM 3	13.8 a	1.8 a	12.7	85 c	72 b	3.5 a	3.3 a	50
HPM 24	13.8 a	1.4 a	10.3	94 a	92 a	3.5 a	3.3 a	72
HPM 9	13.5 a	1.3 a	9.4	85 c	76 b	2.7 b	3.0 a	121
Paredão	13.1 a	1.2 a	9	82 d	64 c	1.8 c	1.3 c	58
HPM 8	13.0 a	1.3 a	10.1	87 b	74 b	2.3 b	2.0 b	69
HPM 15	13.0 a	1.3 a	9.6	87 b	87 a	3.4 a	2.7 a	51
HPM 22	12.8 a	1.0 b	7.7	89 b	86 a	3.5 a	3.0 a	94
HPM 16	12.5 b	1.3 a	10	89 b	92 a	3.8 a	3.3 a	46
Mombaça	12.4 b	1.6 a	12.5	79 d	71 b	2.6 b	2.3 b	70
HPM6	12.2 b	1.3 a	10.5	86 c	73 b	3.0 a	2.3 b	87
HPM19	12.2 b	1.3 a	10.6	85 c	75 b	2.4 b	1.7 c	120
HPM 13	12.1 b	1.2 a	9.8	88 b	90 a	3.5 a	4.3 a	97
HPM 5	12.1 b	1.1 b	9.0	85 b	77 b	2.8 a	2.3 b	56
HPM 14	11.9 b	1.5 a	12.8	82 d	80 a	3.3 a	3.3 a	105
HPM 17	11.8 b	1.1 b	9.2	84 c	90 a	3.1 a	3.3 a	135
HPM 23	11.7 b	1.4 a	11.6	86 b	74 b	2.9 a	3.0 a	82
HPM 2	11.6 b	0.9 b	7.5	92 a	91 a	3.8 a	3.3 a	123
HPM 21	11.4 b	1.1 b	9.6	83 c	76 b	2.9 a	3.0 a	126
Massai	11.0 c	0.6 b	5.7	84 c	70 b	3.3 a	2.0 b	65
HPM 18	10.7 c	1.3 a	12.0	82 d	78 b	2.8 a	2.3 b	51
HPM 11	10.4 c	1.0 b	10.0	89 b	84 a	3.1 a	3.0 a	34
HPM 4	10.3 c	1.0 b	9.6	92 a	91 a	2.9 a	3.0 a	10
HPM 7	9.9 c	1.1 b	10.9	86 b	79 b	2.2 a	1.3 c	52
HPM 12	9.6 c	0.8 b	8.3	88 b	86 a	2.9 a	2.7 a	45
Gatton Panic	6.0 c	0.7 b	12.2	49 e	47 d	1.3 c	0.7 c	41

*Percentage of yield in the dry season/annual yield

**Distinct letters within a column represent distinct groupings by Scoll-Knott testa at 5% probability.

Hybrid HPM10 is interesting because it presented the highest forage and seed productions, high leaf percentage and adequate regrowth after the harvests. The hybrid HPM3 was outstanding for its dry season production and percent production in the dry season in relation to the year-round production. The hybrid HPM24 showed high LDMY, and the highest leaf percentage and regrowth after harvests. Other promising hybrids are HPM16 (high leaf percentage and regrowth), HPM13 and HPM14 (high regrowth and seed production). The latter presented the highest percent growth in the dry/annual season.

For the selection of the hybrid that will follow the evaluation scheme and thus be evaluated under grazing, further statistical analysis has to be made, and the morphological data and visual merit in the field has to be taken into account. The data and the visual field observations (not shown) are very promising.

Conclusions and/or Implications

Many of the hybrids here evaluated are promising, and after selection should be evaluated under grazing and then released as new cultivars in the market.

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