Crop Breeding and Applied Biotechnology 5:99-104, 2005
Brazilian Society of Plant Breeding. Printed in Brazil

Selection of interspecific *Brachiaria* hybrids to intensify milk production on pastures

Antonio Vander Pereira[1*], Fausto de Souza Sobrinho[1], Cacilda Borges do Valle[2], Francisco José da Silva Lédo[1], Milton de Andrade Botrel[1], Jackson Silva e Oliveira[1], and Deise Ferreira Xavier[1]

Received 21 December 2004

Accepted 4 April 2005

ABSTRACT - *Milk production in Brazil is largely based on pasture utilization which represents an inexpensive feed compared to processed or conserved forages.* Brachiaria brizantha *and* B. decumbens *are prevalent in Brazil owing to their high yield potential and good adaptation to acid and infertile soils. Their forage quality is however considered low in view of the nutritional needs of animals of high genetic potential for milk production. Fortunately there is intra and interspecific variation for forage quality in* Brachiaria *germplasm to be exploited in the development of new cultivars.This paper reports on the evaluation of 47 interspecific hybrids between* B. ruziziensis *(R) x* B. brizantha *(B) and R x* B. decumbens *(D), with the objective of selecting potential new cultivars that combine high yield and forage quality. The experiment was arranged in a completely randomized design with two replicates and two common cultivars as controls. Data of the total dry matter yield, dry matter percentage, plant height and regrowth vigor of six cuts were collected. Samples from the third cut were analyzed for nutritive value using near infrared spectroscopy (NIRS). Results confirmed the existence of variability for the majority of the traits analyzed so high quality and productive hybrids can be selected.*

Key words: *Brachiaria decumbens*, *B. brizantha*, *B. ruziziensis*, breeding, forage quality, pastures.

INTRODUCTION

Pastures play a key role in animal production in Brazil since the area occupied with forages covers three fourths (approximately 180 million hectares) of the total agricultural surface in the country (Vilela and Bressan 2002). They further represent the main feed source for the herds in Brazil. Exclusive pasture use is responsible for almost 90% of the meat and for the bulk of the 23 billion liters of milk produced nationwide annually. The productivity indexes are still low though, due to several factors such as the low nutritional value of the forages under the pasture management employed and the lack of genotypes well adapted to the prevalent acid and low fertility Brazilian soils.

Among the tropical forages planted in Brazil, *Brachiaria*, *Panicum*, *Paspalum*, *Pennisetum*, and *Andropogon* are the most important. Species of the *Brachiaria* genus are those that occupy the vastest extension of land, approximately 84 million hectares (Pereira et al. 1998), due to the good tolerance of the few available cultivars to the poor and acid tropical soils and

---

[1] Embrapa Gado de Leite, Rua Eugênio do Nascimento 610, Bairro Dom Bosco, 36.038-330, Juiz de Fora, MG, Brasil. *E-mail: avanderp@cnpgl.embrapa.br
[2] Embrapa Gado de Corte, BR 262, km 4, C. P. 154, 79.002-970, Campo Grande, MS, Brasil

the reasonable forage value. The most widely used species are *B. decumbens* (D), *B. brizantha* (B), *B. ruziziensis* (R), and *B. humidicola* (Renvoize et al. 1996) and all available cultivars present specific limitations such as susceptibility to spittlebug – the major insect pest on *Brachiaria* pastures – or no tolerance to poorly drained soils. This points to the need to combine traits in novel cultivars through interspecific breeding (Miles et al. 2004).

In *Brachiaria*, apomixis and polyploidy prevail and among the widely cultivated species in Brazil only (R) is diploid and completely sexual (Darlington and Wylie 1955, Ferguson and Crowder 1974). The commercial cultivars of (B) and (D) are tetraploids and reproduce by a type of apomixis called apospory of the *Panicum* type. Breeding of this genus began in 1988, both at Embrapa Beef Cattle Center and CIAT (International Center for Tropical Agriculture) based on crosses and schemes proposed by Gobbe et al. (1983) to improve apomictic cultivars (Miles et al. 2004). Crosses were launched using artificially tetraploidized (R) genotypes as mother plants pollinated by natural apomictic genotypes of (D) or (B) (CIAT 1992, Miles and Valle 1996, Miles et al. 2004). Interspecific apomictic and sexual hybrids were obtained and tested for agronomical performance (Valle et al. 2000). The best were advanced to regional trials following the process of cultivar development and this paper reports on the evaluation for yield and nutritional value of the selected ones.

MATERIAL AND METHODS

The trial was conducted at the 'Santa Mônica' Experimental Station of the Embrapa Dairy Cattle Center, in Valença, state of Rio de Janeiro, involving 47 interspecific (apomictic and sexual) hybrids and two commercial cultivars of *Brachiaria*, Basilisk (D) and Marandu (B). These hybrids are part of the breeding program of the Embrapa Beef Cattle Center and were obtained from crosses between (R) x (D) or (R) x (B) since 1990. Individual plants were selected from progenies considering general morphology, leaf content and persistence from 1998 to 1999. Then they were evaluated from 1999 to 2000 for agronomic performance and regrowth ability in vegetatively propagated plots under cuts. The best were included in this trial which was planted by vegetative propagation on December 20, 2001.

A completely randomized design with two replications was used. The experimental plots consisted of 4.5 m rows, using the central 3.5 m for sampling. The spacing between rows was 1.0 m and 0.5 m between plants in a row.

The first cut occurred on March 13, 2002 followed by five other cuts from April 2002 to January 2003. At each sampling date the total green matter yield, plant height (cm) and vigor (scale from 1= low to 5=high) were evaluated. Sub-samples were taken to evaluate dry matter percentage (DM) and calculate yield data on a dry matter basis (DMY).

The third cut at the end of the dry season was sub-sampled for an evaluation of the forage quality. Crude protein (CP), in vitro organic matter digestibility (IVOMD), neutral (NDF) and acid (ADF) detergent fiber, cellulose (Cel) and lignin (Lig) percentages were determined using near infrared spectrometry (NIRS) at the Laboratory of the Embrapa Beef Cattle Center.

Univariate statistical analyses were realized for each of the six cuts using a completely randomized design model for each of the evaluated traits. Afterwards a compiled analysis was performed considering cuts as repeated samples in time in a model using hybrids as the main plot and cuts in the subplots (Ramalho et al. 2000). Means were compared using the Scott and Knott test (1974). Means for DMY (t ha^{-1}), DM (%), plant height and vigor in each cut were used to estimate parameters that evaluate the stability through the Annicchiarico (1992) procedure.

RESULTS AND DISCUSSION

There were significant differences between hybrids for plant height, vigor and dry matter yield but not for dry matter percentage in the univariate analysis (by cuts) indicating wide variability created by interspecific hybridization in *Brachiaria* for yield-related traits. The joint analyses also detected differences between hybrids and cuts for all four traits mentioned above. The treatment x cut interaction was also significant, indicating that the behavior of the hybrids at the different sampling dates was not consistent.

Mean yield at each cut was 2.5 t ha^{-1} cut^{-1}, with an amplitude of 2.0 t ha^{-1} (Table 1). The Scott and Knott test divided the treatments in two groups, with the elite group containing 21 hybrids and cv. Basilisk (T_1). Rao et al. (1998) evaluated 53 *Brachiaria* genotypes, 43 of which were interspecific hybrids, for acid soil tolerance and found a variability ranging from 59 to 343 g per plant for dry matter yield. Some hybrids were very productive under acid soil conditions both in the dry and wet seasons corroborating the potential of interspecific hybridization for generating valuable genotypes.

Table 1. Performance means per cut of hybrid genotypes of the dry matter yield (DMY), dry matter percentage (DM), plant height (H), vigor of regrowth (V), acid detergent fiber (ADF), neutral detergent fiber (NDF), lignin (Lig) and cellulose (Cel) percentages and general data means

Hybrid	**DMY** t ha^{-1}	**DM** %	**H** cm	**V**	**ADF** %	**NDF** %	**Lig** %	**Cel** %
1	2.3^{b}	22.8^{b}	33.0^{e}	2.9^{a}	31.4	67.5^{a}	7.8^{a}	19.7^{a}
2	2.4^{b}	24.0^{b}	23.6^{d}	2.0^{b}	33.0	67.7^{a}	7.5^{a}	20.6^{a}
3	2.8^{a}	25.6^{a}	41.7^{b}	3.4^{a}	36.3	71.7^{a}	7.8^{a}	24.5^{c}
4	2.2^{b}	25.2^{a}	36.2^{c}	3.1^{a}	36.4	70.6^{a}	7.7^{a}	23.3^{b}
5	3.0^{a}	21.9^{b}	42.6^{b}	3.8^{a}	36.8	72.1^{a}	8.4^{a}	24.7^{c}
6	3.4^{a}	26.4^{a}	36.2^{c}	3.7^{a}	38.1	74.8^{b}	8.2^{a}	26.1^{c}
7	2.0^{b}	25.8^{a}	28.6^{e}	2.3^{b}	39.5	70.3^{a}	9.9^{b}	24.5^{c}
8	3.4^{a}	22.5^{b}	50.5^{a}	4.3^{a}	37.2	71.3^{a}	7.7^{a}	24.6^{c}
9	2.4^{b}	23.2^{b}	20.0^{d}	2.2^{b}	37.5	73.5^{b}	9.1^{b}	23.1^{b}
10	2.6^{a}	25.6^{a}	42.0^{b}	3.0^{a}	37.9	72.2^{a}	8.3^{a}	25.2^{c}
11	3.5^{a}	23.4^{b}	55.0^{a}	4.7^{a}	34.8	70.8^{a}	6.9^{a}	22.9^{b}
12	2.2^{b}	25.4^{a}	27.5^{e}	2.4^{b}	33.5	66.9^{a}	7.1^{a}	21.1^{a}
13	2.8^{a}	23.2^{b}	44.0^{b}	3.6^{a}	39.2	74.2^{b}	9.0^{b}	26.3^{c}
14	3.4^{a}	25.7^{a}	41.6^{b}	3.6^{a}	33.5	69.8^{a}	7.2^{a}	21.2^{a}
15	2.3^{b}	25.5^{a}	26.5^{e}	2.2^{b}	36.5	72.8^{b}	8.8^{b}	23.4^{b}
16	2.1^{b}	23.3^{b}	22.2^{d}	2.0^{b}	37.9	72.1^{a}	9.0^{b}	23.3^{b}
17	3.1^{a}	25.0^{a}	30.0^{e}	2.4^{b}	38.8	74.2^{b}	9.4^{b}	25.3^{c}
18	2.7^{a}	21.0^{b}	42.0^{b}	3.4^{a}	36.8	71.4^{a}	8.3^{a}	24.1^{c}
19	2.5^{b}	25.0^{a}	31.2^{e}	2.6^{b}	38.1	74.8^{b}	9.1^{b}	26.4^{c}
20	2.9^{a}	24.6^{a}	44.7^{b}	3.4^{a}	40.0	74.1^{b}	9.3^{b}	27.0^{c}
21	2.3^{b}	25.2^{a}	35.5^{c}	3.2^{a}	35.2	71.5^{a}	7.8^{a}	22.2^{b}
22	2.0^{b}	25.1^{a}	21.8^{d}	1.4^{b}	38.8	71.4^{a}	9.6^{b}	23.5^{b}
23	2.4^{b}	21.3^{b}	27.6^{e}	1.9^{b}	41.2	71.6^{a}	11.1^{b}	23.3^{b}
24	1.5^{b}	25.1^{a}	29.5^{e}	2.0^{b}	33.2	69.9^{a}	7.9^{a}	21.4^{a}
25	3.5^{a}	24.3^{b}	40.6^{b}	3.7^{a}	37.4	73.7^{b}	8.7^{b}	25.8^{c}
26	3.2^{a}	22.6^{b}	43.6^{b}	3.8^{a}	34.9	72.6^{a}	7.9^{a}	23.1^{b}
27	2.2^{b}	25.1^{a}	21.7^{d}	2.3^{b}	40.1	75.3^{b}	10.3^{b}	26.0^{c}
28	2.3^{b}	26.5^{a}	39.7^{b}	3.2^{a}	37.2	72.7^{a}	9.3^{b}	23.7^{b}
29	2.3^{b}	23.9^{b}	18.5^{d}	1.7^{b}	36.1	72.2^{a}	9.3^{b}	22.7^{b}
30	2.2^{b}	23.7^{b}	24.6^{d}	2.0^{b}	32.9	67.8^{a}	8.9^{b}	19.1^{a}
31	2.7^{a}	25.9^{a}	36.5^{c}	3.1^{a}	35.4	70.8^{a}	7.9^{a}	22.0^{a}
32	1.6^{b}	25.4^{a}	16.7^{d}	1.6^{b}	39.1	72.0^{a}	10.0^{b}	23.9^{b}
33	1.8^{b}	26.9^{a}	31.3^{e}	2.2^{b}	37.8	71.0^{a}	8.2^{a}	23.6^{b}
34	1.8^{b}	25.2^{a}	23.8^{d}	1.4^{b}	36.8	75.0^{b}	9.3^{b}	23.8^{b}
35	2.1^{b}	26.2^{a}	25.9^{e}	2.2^{b}	39.7	72.5^{a}	9.9^{b}	24.1^{c}
36	3.3^{a}	24.2^{b}	41.0^{b}	3.4^{a}	37.3	74.9^{b}	9.0^{b}	25.9^{c}
37	1.8^{b}	26.5^{a}	32.8^{e}	2.4^{b}	37.0	73.3^{b}	8.0^{a}	23.7^{b}
38	3.0^{a}	24.0^{a}	27.4^{e}	2.6^{b}	36.8	70.2^{a}	9.4^{b}	22.2^{b}
39	2.6^{a}	24.5^{a}	44.5^{b}	3.5^{a}	37.7	71.7^{a}	8.1^{a}	23.7^{b}
40	1.9^{b}	26.2^{a}	35.4^{c}	2.8^{a}	39.2	74.3^{b}	8.3^{a}	26.8^{c}
41	1.6^{b}	26.0^{a}	16.1^{d}	1.5^{b}	37.4	75.2^{b}	10.0^{b}	22.9^{b}
42	3.5^{a}	25.7^{a}	50.5^{a}	4.1^{a}	42.1	77.6^{b}	9.3^{b}	28.2^{c}
43	3.1^{a}	24.1^{b}	42.0^{b}	3.5^{a}	39.0	76.2^{b}	9.7^{b}	25.8^{c}
44	2.1^{b}	25.0^{a}	39.4^{b}	2.9^{a}	39.7	74.3^{b}	8.8^{b}	26.2^{c}
45	2.2^{b}	26.4^{a}	35.5^{c}	2.9^{a}	41.5	77.7^{b}	9.8^{b}	27.1^{c}
46	2.7^{a}	25.1^{a}	29.6^{e}	2.4^{b}	37.5	73.1^{b}	8.2^{a}	24.5^{c}
47	3.5^{a}	23.4^{b}	40.0^{b}	3.6^{a}	37.8	72.5^{a}	8.9^{b}	22.3^{b}
Basilisk	3.0^{a}	26.0^{a}	26.4^{e}	2.6^{b}	36.2	71.4^{a}	8.9^{b}	21.8^{a}
Marandu	2.6^{b}	25.4^{a}	28.8^{e}	2.5^{b}	34.5	70.1^{a}	8.3^{a}	21.2^{a}
Mean	**2.5**	**24.7**	**33.6**	**2.8**	**35.6**	**72.3**	**8.7**	**23.8**

[1] Values followed by different letters in the same column are statistically different by the Scott and Knott (1974) test at 5% probability

There was a variation of 5.85 percentage points in DM among hybrids. The 30 best of the 47 hybrids evaluated displayed DM similar to the checks. The hybrids were grouped in five clusters for plant height with 38.8 cm amplitude in values: hybrids 8, 42 and 11 were the highest, with means 88.5% higher than the checks. Considering the vigor of regrowth, 25 hybrids were grouped as statistically better than the rest (Table 1).

The forage quality of the hybrids was significantly different when the NDF, ADF, lignin and cellulose percentages were considered. Interestingly, no significant difference was found for the other traits by the analysis of variance. Despite the variability detected in the analysis of variance for ADF, the Scott and Knott test could not separate the hybrids into distinct clusters at a probability level of 5%. This apparently contradictory result may be explained by the high number of genotypes involved. The procedures for multiple comparisons or simply tests of means are affected, among other aspects, by the difference among means but also by the number of contrasts to test. The Tukey test for example, has only 50% chance of detecting differences of six standard errors between means with 100 treatments whereas with 5 treatments the chances increase to 88% (Ramalho et al. 2000). Similar results have been reported for the Scott and Knott test by Silva et al. (1999).

Results for the NDF content separated the hybrids into two groups; the one with the lower fiber percentage grouped 28 hybrids and the two checks (Table 1). The range of lignin content was 4.14 percentage points among the hybrids. The cellulose contents of the hybrids 31, 24, 14, 12, 2 and 1 plus the two checks were the lowest among the three groups detected by the variance analysis.

Hughes et al. (2000) evaluated accessions of different *Brachiaria* species and also found significant differences for most of the quality traits analyzed: the protein content varied from 8.4% in *B. humidicola* - H13 to 14.8% in *B. ruziziensis* - R128. The amplitudes of variation for NDF, ADF and lignin were 16.6; 12.0 and 2.0%, respectively. The possibilities to select for quality among products of hybridization are therefore far-ranging (Hughes et al. 2000).

Considerable forage potential was detected in some hybrids when analyzing agronomical traits associated to the nutritive value. Hybrids 14 and 31, for example, combine high DMY, plant height, vigor and DM with reduced NDF, lignin and cellulose contents. Thus, the possibility of selecting hybrids with yield and quality combined through selection of interspecific hybrids between *B. brizantha x B. ruziziensis* and *B. decumbens x B. ruziziensis* exists.

The estimate of the confidence index (CI) of Annicchiarico (1992) for DMY ($t\ ha^{-1}$), dry matter percentage (DM), plant height and vigor of regrowth of

Table 2. Annicchiarico Confidence Index for dry matter yield (DMY), DM percentage (DM), plant height (H), vigor of regrowth (V) in *Brachiaria* hybrids

	Confidence Index %			
Hybrids	**DMY**	**DM**	**H**	**V**
1	85.24	91.19	95.26	97.79
2	86.55	95.97	69.19	65.78
3	103.56	102.39	121.76	117.61
4	84.19	100.68	108.11	108.92
5	111.73	86.95	125.55	130.53
6	130.11	105.56	108.70	126.44
7	70.61	101.84	82.44	77.37
8	122.99	90.30	138.90	148.89
9	85.22	93.44	59.51	77.41
10	98.96	102.85	124.22	103.08
11	132.04	92.97	167.16	164.90
12	85.20	100.68	78.09	82.79
13	104.62	93.04	131.36	123.56
14	131.01	102.80	122.93	121.93
15	79.24	100.48	75.81	73.40
16	73.23	92.75	61.75	68.47
17	114.98	98.91	83.01	82.28
18	95.28	81.12	121.96	115.89
19	95.71	99.98	92.87	90.71
20	103.92	98.29	130.95	117.54
21	86.02	99.27	100.29	107.23
22	72.96	100.37	53.75	45.42
23	81.25	80.36	65.15	61.95
24	55.98	99.83	79.52	68.38
25	133.58	96.22	109.88	126.89
26	115.88	90.22	125.12	132.77
27	82.55	99.47	65.83	80.80
28	84.57	105.06	117.45	110.03
29	78.86	95.84	54.19	53.96
30	77.06	94.66	69.40	67.90
31	100.00	103.86	101.96	104.95
32	59.15	100.94	48.82	51.34
33	64.42	106.28	92.39	72.20
34	67.03	100.54	57.37	45.18
35	75.17	104.68	74.95	75.50
36	121.21	96.25	111.70	118.28
37	70.11	104.11	92.66	83.40
38	107.36	96.50	79.75	85.71
39	97.23	98.07	125.16	120.00
40	74.40	104.63	105.95	97.91
41	58.92	103.28	47.99	48.80
42	127.98	101.93	152.64	138.19
43	119.58	96.79	113.21	120.52
44	73.76	99.10	115.50	98.75
45	85.65	105.35	104.87	99.78
46	100.08	99.78	84.27	80.25
47	136.35	92.46	116.55	121.09
B. decumbens (Basilisk)	109.22	102.89	75.71	84.85
B. brizantha (Marandu)	94.80	100.05	81.42	84.08

the hybrids are presented in Table 2. For DMY (t ha^{-1}), 10 hybrids were superior to the best control (*B. decumbens* cv. Basilisk), especially hybrids 6, 8, 11, 14, 25, 36, and 42 with CI estimates over 120%, which means they were 20% better than the evaluated population, considering all sampling cuts. The risk associated with the use of such hybrids can thus be considered small since their yields were high and consistent throughout the evaluation period. The performance of cv. Marandu is noteworthy with an estimate CI of 94.8%. Despite its widespread use in Brazil (an area estimated at 30 million hectares by the amount of seed commercialized each year – Miles and Valle, 1996) it displayed a certain (5.2%) risk of producing less than the mean of the tested hybrid population. This result attests to the potential advantage of using interspecific hybridization in a Brachiaria breeding program with the aim of releasing promising genotypes for pasture yield.

Considering DM, eight hybrids had higher CI estimates than the best control but the magnitude of this superiority was much smaller than for DMY. Hybrid 45 demonstrated the lowest risk of adoption (CI = 105.35%) whereas 18 had the greatest (CI = 81.12%).

The greatest differences in CI estimates between the hybrids and controls were observed for plant height and vigor (Table 2). For vigor of regrowth, an essential trait in forages under grazing, the controls were in the mean at least 15% inferior to the hybrids. Hybrid 11, for example, was 64.9% better than the overall mean over all cuts.

Considering all evaluated traits, the possibility for selection of hybrids with consistent performance throughout the seasons, combining high DM and DMY with adequate plant height and regrowth vigor is unequivocal. Hybrids 3, 6, 14, 31 and 42 presented the highest CI estimates (over 100%), which means that in the worst situation they would still perform at least as well as the mean of the others. Some other well-performing hybrids were 8, 11, 25 and 26, which presented superior DMY and regrowth vigor in spite of their below-average CI values for DM (CI< 100); they should therefore not be discarded. These nine cited hybrids will be further evaluated for resistance to grazing and animal performance during the process of cultivar development.

Hybrids 8 and 31, mentioned earlier as combining forage quantity and quality also demonstrated performance stability during the evaluation period. These types of forage grasses should contribute greatly to an increase in efficiency in animal yield on pastures due to their high forage yield with good nutritive values and consistent performance.

CONCLUSIONS

Variability was detected amongst interspecific hybrids of *Brachiaria* for most of the evaluated traits.

It is possible to select hybrids that combine high DM yield with good forage quality.

Seleção de híbridos interespecíficos de *Brachiaria* para intensificação da produção de leite a pasto

RESUMO - *A produção brasileira de leite está baseada na utilização de pastagens, sendo que* Bachiaria brizantha *and* B. decumbens *representam as forrageiras com maior área cultivada. Embora, a qualidade das cultivares disponíveis seja considerada deficiente, existe variabilidade intra and interespecífica para qualidade de forragem em* Brachiaria *e que pode ser aproveitada no desenvolvimento de novas cultivares. O objetivo deste trabalho foi avaliar híbridos interespecíficos de* Brachiaria *com base na produtividade e qualidade nutricional da forragem. Foram avaliados 47 híbridos oriundos dos cruzamentos entre* B. brizantha x B. ruziziensis *e* B. decumbens x B. ruziziensis*, juntamente com duas testemunhas, utilizando o delineamento de blocos casualizados. Foram realizados seis cortes, sendo avaliados: produção de matéria seca, porcentagem de matéria seca, altura de plantas e vigor da rebrota. Procedeu-se, também, a avaliação da qualidade de forragem, por meio de análises laboratoriais (NIR's). Os resultados demonstraram a existência de variabilidade para a maioria das características avaliadas, evidenciando a possibilidade de identificação de híbridos com alta produção e qualidade da forragem. Constata-se, portanto, a viabilidade da estratégia de hibridações interespecíficas para o melhoramento da* Brachiaria.

autor tam 8 esp 9,6

Palavras-chave: *Brachiaria decumbens*, *B. brizantha*, *B. ruziziensis*, melhoramento genético, qualidade de forragem, pastagem.

REFERENCES

Annicchiarico P (1992) Cultivar adaptations and recommendation from alfalfa trials in Northern Italy. **Journal of Genetics & Breeding 46**: 269-278.

Centro Internacional de Agricultura Tropical (1992) **Pastures for the tropical lowlands: CIAT's contribution**. CIAT, Cali, 238p.

Darlington CD and Wylie AP (1955) **Chromosome atlas of flowering plants**. Allen & Unwin, London, 243p.

Ferguson JE and Crowder LV (1974) Cytology and breeding behavior of *Brachiaria ruziziensis* Germain et Evrard. **Crop Science 14**: 893-895.

Gobbe J, Longly B and Louant B (1983) Apomixie, sexualité et amélioration des graminée tropicales. **Tropicultura 1**: 5-9.

Hughes NRG, Valle CB, Sabatel V, Boock J, Jessop NS and Herrero M (2000) Shearing strength as an additional selection criterion for quality in *Brachiaria* pasture ecotypes. **Journal of Agricultural Science 135**: 123-130.

Miles JW and Valle CB (1996) Manipulation of apomixis in *Brachiaria* breeding. In: Miles JW, Maass BL, Valle CB (eds.) ***Brachiaria*: biology, agronomy and improvement**. Centro Internacional de Agricultura Tropical - CIAT/Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA, Cali, p.164-177 (CIAT Publication nr 259).

Miles JW, Valle CB, Rao IM and Euclides VPB (2004) Brachiariagrasses. In: Sollenberger LE, Moser L and Burson B (eds.) **Warm-season (C4) grasses**. Agronomy monograph 45. ASA- CSSA-SSSA, Madison, p. 745-783.

Pereira AV (1998) Melhoramento genético de plantas forrageiras. In: **2th Simpósio sobre atualização em genética e melhoramento de plantas**. UFLA/FAEPE, Lavras, p.135-162.

Ramalho MAP, Ferreira DF and Oliveira AC (2000) **Experimentação em genética e melhoramento de plantas**. UFLA, Lavras, 326p.

Rao IM, Miles JW and Granobles JC (1998) Differences in tolerance to infertilie acid soils stress among germplasm accessions and genetic recombinant of the tropical forage grass genus *Brachiaria*. **Field Crops Research 59**: 42-52.

Renvoize SA, Clayton WD and Kabuye CHS (1996) Morphology, taxonomy and natural distribution of *Brachiaria* (Trin.) Griseb. In: Miles JW, Maass BL and Valle CB (eds.) ***Brachiaria*: biology, agronomy and improvement.** Centro Internacional de Agricultura Tropical - CIAT/Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA, Cali, p. 1-15. (CIAT Publication nr 259).

Scott AJ and Knott MA (1974) A cluster analysis method for grouping means in the analysis of variance. **Biometrics 30**: 507-512.

Silva EC, Ferreira DF and Bearzoti E (1999) Avaliação do poder e taxas de erro tipo I do teste de Scott-Knott por meio do método de Monte Carlo. **Ciência e Agrotecnologia 23**: 687-696.

Valle CB, Macedo MCM and Calixto S (2000) Avaliação agronômica de híbridos de *Brachiaria*. In: **37th Anais da reunião anual da Sociedade Brasileiro de Zootecnia**. Sociedade Brasileira de Zootecnia, Viçosa (Trabalho n.º 0383, CD-Rom)

Vilela D and Bressan M (2002) **Anais do projeto plataforma tecnológica do leite - fase 2**. Embrapa Gado de Leite, MCT/CNPq, Juiz de Fora, 130p. (Documentos 86).