CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

CG FARRAPO: a sudangrass cultivar with high biomass and grain yields

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Abstract: *The new sudangrass cultivar [Sorghum sudanense (Piper) Stapf.] was developed by the method of selection of individual plants with progeny testing. The most important traits are high biomass yield with high grain yield.*

Key words: *Sorghum sudanense (Piper) Stapf., plant breeding, forage traits, grain yield.*

INTRODUCTION

The diversification of annual summer crops for forage production is highly desirable, since production costs of conventional crops, such as maize (*Zea mays* L.) and sorghum [*Sorghum bicolor* (L.) Moench] are high (Neumann et al. 2010). In animal production, the reduction of costs allied to yield and to forage quality are basic requirements for the success of livestock activities. Thus, the employment of physiologically most efficient plants in the use of light, nutrients and water is highly desirable (Penna et al. 2010). Sudangrass [*Sorghum sudanense* (Piper) Stapf.] is reported for having great ability in tolerance to drought, to high soil acidity and lower fertility, to heat, to foliar diseases and it has great competitive ability over weeds. Therefore, it is highly adapted to hot and dry climates, presents high biomass production, and its recovery after cutting of grazing is superior to most annual grasses (Bibi et al. 2010).

In silage production, maize is considered the standard species. However, its production and quality are uncertain due to the strong sensitivity to water stress (Martin et al. 2012). On the other hand, sorghum has shown production similar to maize, especially in regions where low rainfall is observed, which may facilitate the replacement of maize by sorghum in silage processing (O'Kennedy et al. 2006). Cultivation of sorghum or sudangrass evidences lower costs with seeds; lower production cost; high biomass yield, and the nutrition value of the produced forage is equivalent to 85 to 90% of maize silage, without the need of any additive to improve fermentation (Von Pinho et al. 2007). According to Neumann et al. (2004), the use of dual-purpose sorghum to replace maize in confined animal feeding does not alter the consumption of the dry matter, the weight gain and the feed conversion. Forage sorghum and/or sudangrass are of great importance for animal production, evidencing the high productive potential. Their quality is recognized as a source of energy for animal feeding, either as silage, cutting or direct grazing (Montagner et al. 2005). It should be highlighted that the proportion of grains is a determinant factor for the quality

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of the silage, and it is the largest available energetic fraction of this plant (Oliveira et al. 2005). Thus, in the production of a good silage, besides the high biomass yield, the high participation of grains in the ensiled mass is decisive for the quality of the elaborate product (Zopollatto et al. 2009). Also, it has been verified that the inclusion of dual-purpose sorghum silage with high participation of grains in the ensiled mass in animal's diet has provided greater net income per confined animal (Neumann et al. 2004).

PEDIGREE AND BREEDING METHODS

The cultivar CG FARRAPO was obtained by the method of selection of individual plants within the "common" original population with subsequent progeny test (tests of value of cultivation and use - VCU). In the year of 2009, three populations of "common" sudangrass, originated from different edaphoclimatic regions, were sown in the field, evidencing great genetic variability within and between populations. Two populations were collected in the fields of Cegil Agro Seeds company, in São Borja - Rio Grande do Sul, and in Campos de Júlio - Mato Grosso, and another one was collected by farmers in the municipality of Melo (province of Cerro Largo, Uruguay). Seeds of each population were sown 0.45 m between plants and between rows, on a density of three to four seeds per pit-hole. The established order sought to force competition between plants in the pit-hole, and the one which expressed greater competitive ability in the vegetative stage would remain. There was selection pressure of approximately 3% in 1272 of the plants obtained from three populations, based on forage traits (produced biomass) and grain yield, such as length, infertility, weight of panicle, number and grain weight per panicle. In the field, the main trait of analysis was tillering, and it was selected plants, which had at least 10 fertile tillers (viable panicles). These plants were cut close to the soil surface at the physiological maturity of seeds, separating the panicles for kiln drying (40 °C) until seed moisture reached close to 13%, and the rest of the genotype of each plant was weighed in order to assume the potential for biomass production. Before cutting, the main panicle of each plant was identified, harvested and packed in paper bags for drying, and were directly taken to the laboratory for analysis of traits related to the inflorescence components, such as panicle length,

Table 1. Agronomic Performance of forage cultivars of the trials of value for cultivation and use, carried out in 2011, in three different soil and climatic regions

Genotype	Year 2011 - Augusto Pestana/RS												
	TFM*	FML	FMS	TDM	DML	DMS	GY	TFM	TDM	GY	TFM	TDM	GY
	(kg ha $^{-1}$)							% about JUMBO			% about SUDAN		
CG FARRAPO	51892	23191	28701	12246	5307	6939	4200	130	121	111	129	128	275
AG 2501C	41645	20417	21228	11218	5364	5854	3820	104	111	101	103	117	250
JUMBO	39957	19875	20082	10107	4828	5279	3794	100	100	100	99	106	248
SUDAN	40269	16405	23864	9562	3750	5812	1530	101	95	40	100	100	100
ADR500	33314	14859	18455	7456	3119	4337	800	83	74	21	83	78	52
Genotype	Year 2011 - São Borja/RS												
	TFM	FML	FMS	TDM	DML	DMS	GY	TFM	TDM	GY	TFM	TDM	GY
	(kg ha $^{-1}$)							% about JUMBO			% about SUDAN		
CG FARRAPO	52321	23557	28764	13121	5579	7542	3642	129	114	103	137	146	178
AG 2501C	41147	20104	21043	12079	5677	6402	3760	101	105	107	108	134	184
JUMBO	40549	19884	20665	11468	5504	5964	3529	100	100	100	106	128	173
SUDAN	38269	15112	23157	8990	3441	5549	2045	94	78	58	100	100	100
ADR500	31751	13735	18016	6990	3007	3983	1462	78	61	41	83	78	71
Genotype	Year 2011 - São José do Cedro/SC												
	TFM	FML	FMS	TDM	DML	DMS	GY	TFM	TDM	GY	TFM	TDM	GY
	(kg ha $^{-1}$)							% about JUMBO			% about SUDAN		
CG FARRAPO	46379	20115	26264	11107	4983	6124	3814	112	89	135	123	122	189
AG 2501C	40981	19452	21529	11882	5435	6447	3111	99	96	110	109	130	154
JUMBO	41436	20094	21342	12438	5886	6552	2830	100	100	100	110	137	140
SUDAN	37685	15746	21939	9110	3947	5163	2021	91	73	71	100	100	100
ADR500	31114	15147	15967	6892	3013	3879	1484	75	55	52	83	76	73

* TFM= Total Fresh Matter; FML= Fresh Matter of Leaves; FMS= Fresh Matter of Stalks; TDM= Total Dry Matter; DML= Dry Matter of Leaves; DMS= Dry Matter of Stalks; GY= Grain Yield.

panicle weight, number of panicle grains, weight of panicle grains, fertility, and panicle harvest index. Thus, after the analysis of the selected genotypes, plants with higher performance for the simultaneous production of forage and seeds were sown in the field, in 2010, in individual plots. In that year, selection occurred between plots, and the selected plots needed to present great uniformity and superior performance. The selected plots were submitted to VCU tests in the following years. The cultivar was called CG 393AR09 in the field.

PERFORMANCE

Due to its great potential in biomass yield and grain, in the years of 2011 and 2012, the line CG 393AR09 was tested in VCU tests carried out at three different locations: Augusto Pestana (lat 28º 28' 51'' S, long 53º 58' 07'' W, alt 385 m asl) and São Borja (lat 28º 54' 40'' S, long 55º 29' 06'' W, alt 137 m asl) in the state of Rio Grande do Sul, and in São José do Cedro (lat 26º 27' 46'' S, long 53º 32' 53'' W, alt 627 m asl) in the state of Santa Catarina. Tests were carried out in a randomized block design with four replications. Each experimental unit, which included a genotype to be tested, consisted of five 5 m rows spaced 0.20 m apart, in order to compose a 5 m² plot. Seeding rate was 25 kg ha^{-1} of seeds for cultivars of sudangrass and pearl millet, and 12 kg ha^{-1} of seeds for sorghum cultivars. The evaluated traits were the total production of fresh matter (TFM) by 1 m^2 cutting of each plot, every time plants reached 60-65 cm height, leaving a 10 cm residue above the soil. Samples of each genotype were weighed to obtain the TFM, and then, 100 grams were used for botanical separation. Therefore, it was analyzed the fresh matter of leaves (FML) and the fresh matter of stalks (FMS), and after that, they were converted to kg ha^{-1}. Subsequently, samples were placed to dry in an oven with forced air circulation at 65 °C until constant weight, for another analysis, and to obtain estimates of total dry matter (TDM), dry matter of leaves (DML), and dry matter of stalks (DMS).

For analysis of grain yield, another experiment was carried out in order to obtain greater reliability of selection applied on the components of grain yield of the cultivar. Thus, the experiment was carried out in randomized block design with three replications. Each experimental unit, which included a genotype to be tested, consisted of five 5m rows spaced

Table 2. Agronomic Performance of forage cultivars of the trials of value for cultivation and use, carried in 2012, in three different soil and climatic regions

Year 2012 - Augusto Pestana/RS													
Genotype	TFM*	FML	FMS	TDM	DML	DMS	GY	TFM	TDM	GY	TFM	TDM	GY
	(kg ha $^{-1}$)							% about JUMBO			% about SUDAN		
CG FARRAPO	136603	65569	71034	23913	10638	13275	3900	113	111	160	127	123	225
AG 2501C	113573	52244	61329	19830	9849	9981	2693	94	92	111	105	102	155
JUMBO	121333	54600	66733	21507	11884	9623	2431	100	100	100	112	111	140
SUDAN	107983	50752	57231	19367	8746	10621	1736	89	90	71	100	100	100
ADR500	96930	39741	57189	17327	7911	9416	620	80	81	26	90	89	36
Year 2012 - São Borja/RS													
Genotype	TFM	FML	FMS	TDM	DML	DMS	GY	TFM	TDM	GY	TFM	TDM	GY
	(kg ha $^{-1}$)							% about JUMBO			% about SUDAN		
CG FARRAPO	111960	50382	61578	17623	8111	9512	3523	117	110	126	125	119	189
AG 2501C	91293	42908	48385	14193	7263	6930	2971	95	89	106	102	96	159
JUMBO	96061	45149	50912	15993	9031	6962	2794	100	100	100	107	108	150
SUDAN	89482	38477	51005	14810	6807	8003	1864	93	93	67	100	100	100
ADR500	81004	32402	48602	13200	6295	6905	756	84	83	27	91	89	41
Year 2012 - São José do Cedro/SC													
Genotype	TFM	FML	FMS	TDM	DML	DMS	GY	TFM	TDM	GY	TFM	TDM	GY
	(kg ha $^{-1}$)							% about JUMBO			% about SUDAN		
CG FARRAPO	106893	50240	56653	16647	7753	8894	4118	102	103	118	116	121	184
AG 2501C	99836	44926	54910	15347	7781	7566	3251	95	95	93	108	112	145
JUMBO	105197	47339	57858	16096	8887	7209	3494	100	100	100	114	117	156
SUDAN	92203	40569	51634	13723	6270	7453	2243	88	85	64	100	100	100
ADR500	82572	34680	47892	12062	5634	6428	1114	78	75	32	90	88	50

* TFM= Total Fresh Matter; FML= Fresh Matter of Leaves; FMS= Fresh Matter of Stalks; TDM= Total Dry Matter; DML= Dry Matter of Leaves; DMS= Dry Matter of Stalks; GY= Grain Yield.

0.20 m apart, in order to compose a 5 m² plot. Seeding rate was 25 kg ha^{-1} of seeds for cultivars of sudangrass and pearl millet, and 12 kg ha^{-1} of seeds for sorghum cultivars. To estimate grain yield, it was carried out harvesting of the three central rows of each plot, comprising an area of 3 m^2, as soon as seeds reached the stage of physiological maturity. Panicles were weighed and threshed with values estimated in kg ha^{-1}. For not having available seeds of this cultivar (IPA Sudan 4202) registered at the Ministry of Agriculture, Livestock and Supply-MAPA when the study was carried out, it was used as control, in both experiments, one pearl millet (ADR 500 - "SuperMassa"), two hybrid forage sorghum cultivars (AG2501C and JUMBO), and the sudangrass "common" population. In these same years, in Augusto Pestana, the experiment was carried out with the purpose of doing the DHS (Differentiation, Homogeneity and Stability) tests, comparing with the same control cultivars.

In table 1, which shows the comparison between the cultivars in relation to forage and grain yield in 2011, the cultivar CG FARRAPO presented greater prominence, surpassing the traits total fresh matter, fresh matter of leaves, and stalks, when comparing to all the controls in the three evaluation sites. In the evaluation of the total dry matter and dry matter of stalks, the superiority of the cultivar CG FARRAPO was also observed in the environments Augusto Pestana and São Borja. Moreover, in São José do Cedro, thsorghum he ybrid JUMBO was the most productive. For dry matter of leaves, the hybrid AG2501C was superior in the environments of Rio Grande do Sul; however, in Santa Catarina, the cultivar JUMBO obtained the highest production of dry matter of leaves per hectare. It should be highlighted, for the

Table 3. Mean agronomic performance of forage cultivars of the trials of value for cultivation and use, carried out in the years of 2011 and 2012, in three different soil and climatic regions

Augusto Pestana/RS Mean													
Genotype	TFM*	FML	FMS	TDM	DML	DMS	GY	TFM	TDM	GY	TFM	TDM	GY
	(kg ha $^{-1}$)							% about JUMBO			% about SUDAN		
CG FARRAPO	94248	44380	49867	18079	7973	10107	4050	117	114	130	127	125	248
AG 2501C	77609	36330	41279	15524	7607	7918	3257	96	98	105	105	107	199
JUMBO	80645	37237	43408	15807	8356	7451	3113	100	100	100	109	109	191
SUDAN	74126	33579	40547	14465	6248	8217	1633	92	92	52	100	100	100
ADR500	65122	27300	37822	12391	5515	6877	710	81	78	23	88	86	43
São Borja/RS Mean													
Genotype	TFM	FML	FMS	TDM	DML	DMS	GY	TFM	TDM	GY	TFM	TDM	GY
	(kg ha $^{-1}$)							% about JUMBO			% about SUDAN		
CG FARRAPO	82141	36970	45171	15372	6845	8527	3583	120	112	113	129	129	183
AG 2501C	66220	31506	34714	13136	6470	6666	3366	97	96	106	104	110	172
JUMBO	68305	32516	35789	13731	7268	6463	3162	100	100	100	107	115	162
SUDAN	63876	26795	37081	11900	5124	6776	1955	94	87	62	100	100	100
ADR500	56378	23068	33309	10095	4651	5444	1109	83	74	35	88	85	57
São José do Cedro/SC Mean													
Genotype	TFM	FML	FMS	TDM	DML	DMS	GY	TFM	TDM	GY	TFM	TDM	GY
	(kg ha $^{-1}$)							% about JUMBO			% about SUDAN		
CG FARRAPO	76636	35177	41459	13877	6368	7509	3966	105	97	125	118	122	186
AG 2501C	70409	32189	38219	13615	6608	7007	3181	96	95	101	108	119	149
JUMBO	73317	33716	39600	14267	7387	6881	3162	100	100	100	113	125	148
SUDAN	64944	28158	36786	11417	5109	6308	2132	89	80	67	100	100	100
ADR500	56843	24914	31929	9477	4324	5154	1299	78	66	41	88	83	61
Overall Mean (Years + Sites)													
Genotype	TFM	FML	FMS	TDM	DML	DMS	GY	TFM	TDM	GY	TFM	TDM	GY
	(kg ha $^{-1}$)							% about JUMBO			% about SUDAN		
CG FARRAPO	84341	38842	45499	15776	7062	8714	3866	114	108	123	125	125	203
AG 2501C	71413	33342	38071	14092	6895	7197	3268	96	97	104	106	112	171
JUMBO	74089	34490	39599	14602	7670	6932	3145	100	100	100	110	116	165
SUDAN	67648	29510	38138	12594	5494	7100	1907	91	86	61	100	100	100
ADR500	59447	25094	34353	10654	4830	5825	1039	80	73	33	88	85	55

* TFM= Total Fresh Matter; FML= Fresh Matter of Leaves; FMS= Fresh Matter of Stalks; TDM= Total Dry Matter; DML= Dry Matter of Leaves; DMS= Dry Matter of Stalks; GY= Grain Yield.

expression of grain yield, that only in the municipality of São Borja, RS, the cultivar CG FARRAPO did not achieve the highest performance. In the year of 2011, the pearl millet cultivar ADR 500 was inferior to the other genotypes for all traits. In the second year of evaluation of the VCU tests, CG FARRAPO stood out again for the highest productions both in the main forage traits and in grain yield, surpassing the control in all the evaluation sites (Table 2). In the year of 2012, due to climate favoring, all genotypes presented higher yields than the previous year, when the cultivar CG FARRAPO proved its great performance, and surpassed the forage hybrids mostly used by farmers in southern Brazil.

Table 3 presents the mean yield values of forage traits and grain yield in the two years at each site and the overall mean of both years in all of the sites. Thus, it is noted that the environment Augusto Pestana was the most favorable, while the environment São José do Cedro was the most restrictive. In this sense, the cultivar CG FARRAPO showed superiority for grain yield and for the main forage traits, when compared to the best controls, except for the total dry matter production in São José do Cedro, where the hybrid JUMBO achieved the best performance. Moreover, the high genetic gain obtained in the selection process of the new cultivar of sudangrass, with yield of fresh and total dry matter in 25% more than "common cultivar", increasing from 67648 and 12594 kg ha^{-1} to 84341 and 15776 kg ha^{-1}, respectively. Moreover, it doubled grain yield, from 1907 kg ha^{-1} to 3866 kg ha^{-1} (Table 3). Cultivar CG FARRAPO surpassed the best control, cultivar JUMBO, in 14 and 8% in total fresh matter and total dry matter, respectively, besides producing on average 23% more grain per hectare.

SEED MAINTENANCE AND DISTRIBUTION

CG FARRAPO is registered in the Ministry of Agriculture, Livestock and Food Supply, under the register number 32395 (MAPA 2014). Cegil Agro Seeds (Celso L. Arenhardt & Cia Ltda.) is responsible for maintaining the cultivar genetics and basic seeds. Seeds are sold to producers accredited by the company.

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