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Correlations Between Stability Statistics of Forage Production in Elephant Grass

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Abstract

Elephant grass (*Pennisetum purpureum* Schum.) is an important forage plant in the tropics and the potential of genotypes depends on the genotype × environment interaction effects. The objective of this study was to evaluate and compare different stability methods of forage production of 53 elephant grass genotypes, in Campos dos Goytacazes, Rio de Janeiro State, Brazil. The experiment lasted two years, a total of ten cuts with randomized block experimental design with two replications. The analysis of variance was applied to data from dry matter production (DMP), subjected to stability analysis using the following methods: Yates and Cochran, Plaisted and Peterson, ecovalence Wrickie, Kang and Phan, Lin and Bins, and Annicchiarico. The Yates and Cochran method showed more stable genotypes but being less productive. Plaisted and Peterson and ecovalence Wrickie methods presented a Spearman correlation equal to 1, so it is not recommended to implement them concurrently. Lin and Bins showed a strong negative correlation with the average being a method that indicates the genotype also very stable and productive. This method correlates with Annicchiarico, which also indicates productive genotypes by the confidence index. The genotypes most stable among the methods were: Pusa Napier 2, Taiwan A-143 and Merckeron Comum.

Keywords: breeding, dry matter production, G×E interaction, *Pennisetum*, spearman

1. Introduction

The forage productions obtained in pastures originate largely the competitiveness of Brazilian cattle industry (Barcellos et al., 2008). The elephant grass (*Pennisetum purpureum* Schum.) because of its high yield potential and quality is one of the most suitable forage for intensive systems of milk production in pasture (Cóser et al., 2008).

The cattle raising is a common activity on the properties of North of Rio de Janeiro State, Brazil, thus having great importance in the economy and sustainability of municipalities in the region. In the municipality of Campos dos Goytacazes, RJ, about 40% of farms have livestock as their main activity (Souza et al., 2009). Like most of the country, in northern Fluminense, the intensive rearing system has fodder as its main source of feed for cattle.

The efficient use of forage and pasture for animal feed is one of the surest ways to increase productivity, thereby reducing production costs. Whereas the cost of deploying and maintaining an elephant grass plantation depend on the cultivar used in planting, selection of clones of higher productivity, improved nutritional value and higher stability make it more economical exploration activity of dairy cattle, providing a greater margin of profit for the producer. The selection of new genotypes of elephant grass more adapted to soil and climatic conditions of North

Fluminense may result in an increase in forage supply, especially in the dry season, thus mitigating the effects of seasonality on production.

The elephant grass is used prominently in the Brazilian dairy livestock (Moreira et al., 2008). There is a need of developing new varieties for the production of milk by means of plant breeding (Leão et al., 2012). Enhanced cultivars are a common need to dairy farmers across the country, and the demand for new forage cultivars adapted to different ecosystems is intense. Stability is the response predictability in different environmental conditions (Viana et al., 2014). Studies of stability parameters are important because they allow us to identify genotypes with predictable behavior and responding to environmental variations (Cruz et al., 2012).

The method of Yates and Cochran (1938) consists in the joint analysis of experiments, in which the variation of the environment within each genotype is used for an estimate of stability. The Plaisted and Peterson (1959) method, besides quantifying, identifies the most stable genotypes. The stability parameter in Wricke's method is called ecovalence and presents as advantages and disadvantages of the method proposed by Plaisted and Peterson (1959) (Cruz et al., 2012).

The method by Lin and Binns (1988) is a nonparametric test that evaluates the deviation of cultivars behavior in the environments and, therefore, estimates a stability. The method also considers a genotype test and behavior of a hypothetical genotype, or a measure of adaptability (Murakami et al., 2004). Annicchiarico's (1992) methodology is also used to study adaptability and stability (Schmildt & Cruz, 2005).

Therefore, the objective of this study was to evaluate and compare different stability statistics of the forage production of 53 genotypes of elephant grass in successive cuts made over time at conditions of Campos dos Goytacazes, RJ, Brazil.

2. Materials and Methods

The experiment was conducted at the State Center for Research on Bioenergy and Waste Recovery, located in the city of Campos dos Goytacazes, Rio de Janeiro State, Brazil (Coordinates: 21°19′23″S latitude and 41°19′40″W longitude; elevation of 20 to 30 m) in the area of the Unit for Research Support of the Center for Agricultural Sciences and Technology (CCTA/UENF).

The experiment was composed of fifty-three genotypes of elephant grass (treatments) from the Active Germplasm Bank of Elephant grass of Universidade Estadual do Norte Fluminense Darcy Ribeiro (UENF), identified in Table 1.

Table 1. Identification of fifty-three genotypes of elephant grass

Identification	Genotype	Identification	Genotype
1	Elefante da Colômbia	28	Mole de Volta Grande
2	Mercker	29	Porto Rico
3	Três Rios	30	Napier
4	Napier Volta Grande	31	Merckeron Comum
5	Mercker Santa Rita	32	Teresópolis
6	Pusa Napier nº 2	33	Taiwan A-26
7	Gigante de Pinda	34	Duro de Volta Grande
8	Napier Goiano	35	Mercker Comum de Pinda
9	Mercker S.E.A	36	Turrialba
10	Taiwan A-148	37	Taiwan A-146
11	Porto Rico 534-B	38	Cameroon-Piracicaba
12	Taiwan A-25	39	Taiwan A-121
13	Albano	40	Vrukwona
14	Híbrido Gigante da Colômbia	41	T241-Piracicaba
15	Pusa Gigante Napier	42	IAC-Campinas
16	Elefante Híbrido 534-A	43	Elefante Cachoeiro de Itapemirim
17	Costa Rica	44	Capim-Cana D'África
18	Cubano de Pinda	45	Gramafante
19	Merckeron de Pinda	46	Roxo
20	Merckeron Pinda México	47	Guaçu/IZ.2
21	Mercker 86 México	48	Cuba-116
22	Taiwan A-144	49	King Grass
23	Napier S.E.A	50	Vruckwona Africano
24	Taiwan A-143	51	Cameroon
25	Pusa Napier nº 1	52	IJ 7141 cv EMPASC 306
26	Elefante de Pinda	53	Pasto Panamá
27	Mineiro		

Planting was performed on April 25, 2008 by distributing whole stems into the furrows, positionated with their base in contact with the apex of the next plant in the bottom of the groove, in spaced lines at 50 cm in 10 cm deep, followed by 100 kg ha^{-1} P_2O_5. After 50 days of planting, fertilization was complemented with coverage of 25 kg ha^{-1} N.

The experimental design was a randomized block design with two replications. The experimental unit consisted of two rows spaced three meters by 0.5 meters between rows and 3 m between plots and are considered useful only 1.5 m of the lines, totaling 2,625 m^2, neglecting the ends of each row.

After the establishment phase, all genotypes were cut close to the ground in October 3, 2008. After each cut was made coverage fertilization with 60 kg ha^{-1} of K_2O and 50 kg ha^{-1} of N, beginning the phase of data collection. The ten evaluation cuts occurred on the following dates: 5/12/08; 04/02/09, 14/04/09, 18/07/09, 15/10/09, 15/12/09; 08/03/10, 12/05/10, 17/09/10 and 03/12/10.

The trait evaluated was dry matter production (DMP). Plants that were 1.5 m within each plot were weighed immediately after cutting. Then, sub-samples collected, chopped and conditioned in paper bags identified, weighed and placed in an oven at 65 °C for 72 hours. Then the samples were weighed again to obtain the air-dried sample (ADS), according to the methodology described by Silva and Queiroz (2004).

Individual variance analysis was performed, followed by joint variance analysis. The stability methods employed were Yates and Cochran (1938), Plaisted and Peterson (1959), Wricke (1965), Lin and Binns (1988), Annicchiarico (1992) and Kang and Phan (1991). In this work, the weights of Kang and Phan (1991) were made in relation to methods Yates and Cochran (1938), Plaisted and Peterson (1959) and Wricke (1965). For the comparison between the methods was performed by Spearman rank correlation (Steel et al., 1997). For this analysis all statistics were classified according to the descending order. Statistical analyzes used in this work were performed using the program GENES-Computer Application in Genetics and Statistics (Cruz, 2013).

3. Results and Discussion

The values of mean squares, averages and coefficients of experimental variation obtained by individual variance analysis, involving the elephant grass genotypes in Campos dos Goytacazes, in ten cuts are shown in Table 2. Significant differences among treatments were observed ($P < 0.05$) for most of the cuts except the first and the sixth cut which were not significant and significant ($P < 0.05$), respectively. The average dry matter production was 6.53 t ha^{-1}, and ranged from 4.18 to 9.32 t ha^{-1}, covering the seventh and first cut, respectively (Table 2). The DM yields obtained in this study were similar to those described by Meinerz et al. (2011), where it evaluated the genotype Merckeron Pinda in two planting systems, agroecologico and convercional. The average of 6 t ha^{-1} cuts in total of eight in the convecional system in this study was observed. According Lista (2008) in his study in Campos dos Goytacazes, RJ, Brazil, to evaluate the potential of 10 genotypes and two cultivars of elephant grass under irrigation found average of about 15 t ha^{-1} of dry matter in cut times 42, 56 and 70 days. Lima et al. (2007) evaluated for 9 months, 12 elephant grass genotypes in North Fluminense, and these DM yield by cutting ranged from 7.3 to 14.5 t ha^{-1}.

Table 2. Mean squares, means and coefficients of variation of dry matter production obtained from the analysis of variance, involving fifty-three elephant grass genotypes, in the ten cuts evaluated

SV	Cut										General
	1	2	3	4	5	6	7	8	9	10	
GMS	12.50ns	4.16*	9.59*	9.27*	3.56*	1.96***	2.80*	2.13*	3.07*	6.26*	
RMS	15.21	2.464	5.19	4.98	1.935	1.36	1.706	1.334	1.901	3.313	
Mean	9.32	7.13	9.15	7.34	4.95	5.30	4.18	5.65	5.34	7.00	6.536
CV(%)	41.86	22.00	24.91	30.43	28.08	22.04	31.26	20.46	25.8	25.99	27.283

Note. ***, ** and * significant at the level of 10, 1 and 5 % of probability by F test, respectively [1/] Mean square values multiplied by 10^3.

DMP: Dry matter production; SV: Source of variation; Degree of freedon of Genotype SV = 52; Degree of freedon of Residue SV = 52; GMS: Genotype Mean Square; RMS: Residue Mean Square; CV: Coefficient of variation.

The values of residual mean squares (RMS) obtained from individual variance analysis (for environment) of dry matter production (DMP) (Table 2) resulted in a relation between the largest and the smallest value of RMS equal to 11.40, indicating a high degree of heterogeneity of variance in individually evaluated environments , thereby precluding the inclusion of all environments in joint variance analysis. Considering an acceptable proportion 7:1 (Pimentel Gomes, 2009) discarding the first cut was performed, then obtaining the ratio of 3.89 between the highest and lowest value of RMS for others nine environments (cuts) indicating relative homogeneity of variances enabling the use of these environments in the joint analysis of variance (Table 3).

Table 3. Summary of joint variance analysis for the trait dry matter production (DMP) involving 53 genotypes in 9 cuts

SV	DF	DMP (Mean squares)
Block	1	31.5176
Genotype	52	13.576*
Error A	52	7.7487
Cut	8	251.4040**
Error B	8	3.3148
G × C	416	3.6581**
Error C	416	2.0555
CV error a(%)		44.702
CV error b(%)		98.096
CV error c(%)		23.023

Note. ** and * significant at the level of 1 and 5 % of probability by F test, respectively.

Significant differences by the F test for the sources of variation genotype, cut and genotype × cut were observed. The significance of the interaction suggests the study of stability, in order to indicate genotypes with predictable behavior and exhibit productive genotypes.

With respect to the method of Yates and Cochran (1938), it was found that genotypes had the lowest mean squared estimation (Table 4) were 49, 34, 33, 2, 31, 10, 46, 43, 3, 5 , 15, 30, 40, 32, 18, 44, 4, 7, 21 and 24. Considering the ranking of general average productivity (Table 4), the genotype 49, which is the most stable, occupied 48th among 53 positions, far below the overall average. The genotypes, 6, 31 and 24, the latter two being in accordance with the results of Yates and Cochran method, occupied positions 18th, 5th and 19th in the ranking of the most productive, respectively.

Table 4. Values of average dry matter production and stability parameters of Yates and Cochran (Y&C), Plaisted and Peterson (θ%), Wricke (ωi %), Lin and Binns (LB), Annicchiarico (Ann %) and Kang and Phan associated with Yates and Cochran (K+Y&C); Plaisted and Peterson (K+θ%) and Wricke (K+Wi) methods

Genotype	Average	Y&C	θ (%)	ωi (%)	LB	Ann (%)	K+Y&C	K+θ (%)	K+Wi
1	6.5256	15.96	3.76	3.53	8.75	96.39	66	66	66
2	4.7942	2.24	0.22	0.43	15.61	76.11	55	53	53
3	4.4685	3.43	1.94	1.93	18.5	68.4	62	85	85
4	6.1642	4.86	0.83	0.96	9.2	95.36	45	44	44
5	5.8994	3.56	0.54	0.71	10.27	92.68	46	44	44
6	6.4967	6.53	0.41	0.59	7.62	101.11	42	24	24
7	6.6862	4.95	2.52	2.44	7.69	103.49	34	56	56
8	5.6259	5.37	0.74	0.88	11.46	85.35	62	54	53
9	5.1786	8.28	0.94	1.06	13.81	76.58	80	65	65
10	4.6793	2.31	0.84	0.97	16.6	72.98	58	69	69
11	6.3005	5.64	0.68	0.83	8.71	97.72	47	35	35
12	6.734	8.28	3.03	2.89	8.32	102.58	49	58	58
13	5.9784	11.12	1.2	1.29	9.48	89.51	76	58	58
14	5.4596	8.27	0.57	0.73	12.1	82.11	75	52	52
15	5.4022	3.86	1.82	1.83	13	83.78	56	75	75
16	6.78	8.8	1.27	1.35	6.84	102.67	50	39	39
17	6.9976	27.24	7.03	6.39	7.29	98.58	62	62	62
18	6.0599	4.51	0.1	0.32	9.39	94.84	48	34	34
19	6.4342	13.4	3.73	3.5	9.3	95.42	66	69	69
20	5.4046	15.81	3.86	3.62	13.7	76.87	92	94	94
21	4.8715	5.28	1.51	1.56	15.9	72.68	68	76	76
22	8.4387	10.63	3.21	3.05	2.75	129.02	41	46	47
23	6.9138	15.65	3.11	2.96	6.74	100.84	58	55	55
24	6.4676	5.32	1.04	1.14	7.87	100.16	39	39	39
25	6.102	15.21	3.66	3.44	10.31	90.23	77	78	78
26	5.3934	9.93	0.8	0.94	12.19	79.42	84	60	61
27	6.9958	6.64	2.47	2.4	6.47	108.08	35	49	49
28	7.1369	9.42	1.63	1.67	5.81	109.33	43	34	34
29	8.2813	12.09	1.33	1.4	2.39	128.56	44	28	28
30	6.2293	4.08	2.33	2.27	9.81	96.32	38	63	63
31	7.1412	2.25	0.97	1.08	5.76	112.73	10	24	24
32	5.6122	4.46	0.33	0.52	11.5	87.06	56	46	46
33	6.7856	2.19	2.45	2.38	7.8	105.59	16	51	51
34	5.7126	1.96	1.25	1.33	11.79	89.76	41	63	63
35	6.8517	7.74	1.91	1.91	7.34	105.28	41	43	43
36	6.0839	24.65	5.37	4.94	10.27	84.44	84	83	83
37	6.3783	6.35	1.07	1.17	8.3	98.27	46	45	45
38	6.3859	18.98	6.25	5.71	9.34	91.26	73	74	74
39	6.4553	17.18	3.21	3.04	8.72	93.71	70	66	65

40	6.1203	4.17	0.73	0.88	9.19	95.39	42	41	42
41	5.845	8.75	2.06	2.04	10.73	86.99	72	70	70
42	5.6884	7.6	0.41	0.6	10.85	85.13	68	47	47
43	6.1086	3.06	2.16	2.13	10.27	95.78	38	64	64
44	5.7454	4.84	1.04	1.15	10.86	88.83	54	59	59
45	7.1106	12.1	2.62	2.53	6.21	106.83	50	48	48
46	4.8054	2.62	0.29	0.48	15.53	75.32	57	53	53
47	7.0409	10.33	2.22	2.18	6.07	106.56	47	43	43
48	6.345	6.65	0.69	0.84	8.17	97.47	50	35	35
49	5.1384	1.35	0.8	0.93	14.24	81.3	49	63	62
50	7.3348	12.7	2.31	2.26	4.74	110.93	48	40	40
51	6.1728	7.37	2.67	2.58	10.01	93.71	54	69	69
52	6.0575	7.82	0.34	0.53	9.1	93.03	65	39	39
53	8.2193	7.81	1.73	1.75	2.95	127.22	33	32	32

Among the other stable genotypes, 33, 31, 7 and 24 occupied positions 13th, 5th, 16th and 19th in the productivity ranking, respectively. The last-place ranking of mean squares, *i.e.*, the less stable genotype was 17, but that was positioned in the top 10 in productive performance, occupying the 9th position.

Other authors to also use the methodology of Yates and Cochran (1938), found that the most stable genotypes, were among the less productive, while the most productive were found to be the most unstable (Cargnelutti et al., 2007). This method values the stability in the biological sense, and some authors report not be advantageous to use this methodology because genotypes with that kind of stability are generally not productive (Cruz et al., 2012). Thus, using this methodology, it can be concluded that more stable cultivars are indicated, but associated with lower productivity.

Regarding the Plaisted and Peterson (1959) method, the genotype which has lower estimate θ (%) is considered the most stable. As results shown in Table 4, the 20 genotypes were more stable in ascending order: 18, 2, 46, 32, 52, 6, 42, 5, 14, 11, 48, 40, 8, 49, 26, 4, 10, 9, 31 and 24. The most stable genotype by this method was 18, which in the productivity ranking was in 33rd place (Table 4), with an average below the overall average. Daher et al. (2003), for genotypes 27 and 37 of this study, they found estimates θ (%) 4.67% and 14.40%, respectively. They also concluded that the genotypes with highest yield had little stability.

It was observed generally that classification for stability is not highly related with the worst production as in method Yates and Cochran, occurring alternate genotypes with good yields and stability, with low production genotypes, and good stability. Also identified genotypes with low yield and stability values. In Silva et al. (2017) evaluated the stability of the production of 40 elephant grass genotypes and found that the Mercker 86-México genotype presented the second best yield (30.65 t ha^{-1}), but it was the most unstable according to the Yates and Cochran method, corroborating with the results obtained in the study in relation to this method.

The Wrickie (1965) method, like the previous one (Plaisted and Peterson) agreed that the most stable genotype has lower estimated ωi (%). Methods Plaisted and Peterson and Wricke showed a perfect correlation between them (r = 1) (Table 6) and therefore identical correlations with the other methods. Thus, the findings obtained by these two methods are the same. This similarity results from the fact that both use the decomposition of the sum of squares of GE interaction in the derivation of their stability parameters (Cruz et al., 2012).

The method proposed by Lin and Binns (1988) quantifies how the genotype is close to ideal performance, referred to as a genotype with the highest yield in each of the environments studied. The lower the value of the parameter Pi for a given genotype, it is evident that it was close to the maximum achieved in each of the cuts (Daher et al., 2003). According to Table 5, the 20 genotypes showed the lowest Pi values in ascending order were: 29, 22, 53, 50, 31, 28, 47, 45, 27, 23, 16, 17, 35, 6, 7, 33, 24, 48, 37 and 12.

Table 5. Estimate stability parameters for dry matter production by means of Yates and Cochran (Y&C), Plaisted and Peterson (θ%), Wricke (ωi %), Lin and Binns (LB), Annicchiarico (Ann %) and Kang and Phan associated with Yates and Cochran (K+Y&C); Plaisted and Peterson (K+θ%) and Wricke (K+Wi) methods

Genotype	Average	Y&C	θ (%)	ωi (%)	LB	Ann(%)	K+Y&C	K+θ (%)	K+Wi
1	17	49	49	49	23	22	40	41	42
2	51	4	2	2	50	49	30	26	26
3	53	9	32	32	53	53	36	52	52
4	28	17	16	16	26	27	16	16	16
5	36	10	8	8	33	32	17	17	17
6	18	24	6	6	14	15	12	1	1
7	16	18	40	40	15	12	4	30	30
8	41	21	13	13	40	40	37	28	27
9	47	33	18	18	47	48	50	40	40
10	52	6	17	17	52	51	34	43	43
11	25	22	10	10	21	20	19	7	7
12	15	34	43	43	20	14	23	31	31
13	35	41	23	23	30	36	48	32	32
14	43	32	9	9	43	44	47	25	25
15	45	11	30	30	45	43	31	48	48
16	14	36	25	25	11	13	25	9	9
17	9	53	53	53	12	18	38	35	35
18	33	15	1	1	29	28	21	5	5
19	21	45	48	48	27	25	41	44	44
20	44	48	50	50	46	47	53	53	53
21	49	19	27	27	51	52	42	49	49
22	1	40	46	46	2	1	9	19	20
23	11	47	44	44	10	16	35	29	29
24	19	20	20	20	17	17	8	10	10
25	31	46	47	47	36	34	49	50	50
26	46	38	15	15	44	46	51	34	34
27	10	25	39	39	9	7	5	23	23
28	6	37	28	28	6	6	14	6	6
29	2	42	26	26	1	2	15	3	3
30	26	12	37	37	31	23	6	36	37
31	5	5	19	19	5	4	1	2	2
32	42	14	4	4	41	38	32	20	19
33	13	3	38	38	16	10	2	24	24
34	39	2	24	24	42	35	10	37	38
35	12	29	31	31	13	11	11	14	14
36	32	52	51	51	34	42	52	51	51
37	23	23	22	22	19	19	18	18	18
38	22	51	52	52	28	33	46	47	47
39	20	50	45	45	22	29	44	42	41
40	29	13	12	12	25	26	13	13	13
41	37	35	33	33	37	39	45	46	46
42	40	28	7	7	38	41	43	21	21
43	30	8	34	34	35	24	7	39	39
44	38	16	21	21	39	37	28	33	33
45	7	43	41	41	8	8	26	22	22
46	50	7	3	3	49	50	33	27	28
47	8	39	35	35	7	9	20	15	15
48	24	26	11	11	18	21	27	8	8
49	48	1	14	14	48	45	24	38	36
50	4	44	36	36	4	5	22	12	12
51	27	27	42	42	32	30	29	45	45
52	34	31	5	5	24	31	39	11	11
53	3	30	29	29	3	3	3	4	4

Table 6. Estimates of Spearman correlation coefficients among average dry matter production and stability parameters

	Y&C	θ (%)	Wi	Pi	Ann (%)	K+Y&C	K+θ (%)	K+Wi
Average	0.43**	0.46**	0.46**	-0.98**	0.97**	-0.54**	-0.51**	-0.51**
Y&C		0.60**	0.60**	-0.38**	0.24ns	0.50**	0.14^{ns}	0.14^{ns}
θ (%)			1.00**	-0.31*	0.30*	0.11ns	0.51**	0.51**
Wi				-0.31*	0.30*	0.11ns	0.51**	0.51**
Pi					-0.97**	0.56**	0.64**	0.64**
Ann						-0.69**	-0.63**	-0.63**
K+Y&C							0.60**	0.60**
K+θ (%)								1.00**

Note. (Y&C) = Yates and Cochran; (θ%) = Plaisted and Peterson; (ωi %) = Wricke, Lin and Binns (LB), Annicchiarico (Ann %) and Kang and Phan associated with Yates and Cochran (K+Y&C); Plaisted and Peterson (K+θ%) and Wricke (K+Wi) methods. ** and * significant at the level of 1 and 5 % of probability by F test, respectively.

Annicchiarico (1992) considers that all agriculture involves the occurrence of a certain event that is independent of the breeder's will, and that this can be measured to assist in decision making about the use of cultivars. For this, the author proposed a method of estimating a measure of stability called confidence index (I). The higher the index, the greater the confidence in the recommendation of the cultivar. The genotypes with the highest estimates I were 22, 29, 53, 31, 50, 28, 27, 45, 47, 33, 35, 7, 16, 12, 6, 23, 24 (Table 5). They presented the stability parameter above 100%, indicating that would yield above ambient average. A total of 17 genotypes, all of them are among the 20 most productive. The more is produced, the greater the confidence index.

The results obtained by the Annicchiarico (1992) methodology were very similar to those obtained by the Lin and Binns (1988) model, which was expected. Both are designed to measure the superior genotypes: the first takes as a reference the performance of the best genotypes in each environment and the second the average of each of the environments.

In this work, the weighting of Kang and Phan (1991) was made in relation to Yates and Cochran (1938); Plaisted and Peterson (1959) and Wricke (1965) methods. Kang and Phan method associated with the traditional method showed the genotypes 31, 33, 53, 7, 27, 30, 43, 24, 22, 34, 35, 6, 40, 28, 29, 4, 5, 37, 11 and 47 as the 20 most stable. Among them, 12 are among the 20 most productive. Genotype 31 comes in 1st position according to this method, and is the 5th place among the most productive (Table 5).

All correlation methods were correlated with DMP. However, correlation coefficients indicate that a relationship differs between methods. Stability parameters of Kang and Phan (1991) associated with Plaisted and Peterson (1959) and Wrickie (1965) methods indicated as top 20 the genotypes: 6, 31, 29, 53, 18, 28, 11, 48, 16, 24, 52, 50, 40, 35, 47, 4, 5, 37, 32 and 22. Among them, 11 were between the 20 most productive. The results for the methods are the same, they have perfect correlation with each other. Daher et al., 2003 using the same method with 14 clones and three cultivars, and the genotypes 27 (Mineiro) and 37 (Taiwan A-146) were also among them presenting a high value of Kang and Phan "ranks". In this work the genotypes 27 and 37 were between the top 25 among the 53 genotypes.

Phan and Kang (1991) associated with Plaisted and Peterson (1959) method was correlated with the average productivity and all methods ($P < 0.01$), except the method of Yates and Cochran (1938). The same can be concluded with the method of Kang and Phan (1991) associated with Wrickie (1965) method, both of which have a correlation coefficient equal to 1.

According to the estimates of the Spearman correlation coefficients (Table 6), the method of Yates and Cochran (1938), or traditional, showed a positive correlation ($r = 0.43$) with the average level of 1% significance, indicating a weak tendency of individuals with little variation over the cuts have low production.

Correlations between the method of Yates and Cochran (1938) with Plaisted and Peterson, Wrickie, Lin and Bins and Kang and Phan method associated with this method (Yates and Cochran) were significant at 1% (r = 0.6; 0.6; -0.38 and 0.5), respectively. On the other hand, the correlations with the methods of Annicchiarico and Kang and Phan associated with Peterson and Plaisted and Wrickie methods were not significant (r = 0.24; 0.14; 0.14), respectively.

The Plaisted and Peterson (1959) method was positively correlated (P < 0.01) to yield (r = 0.43), with Wrickie (r = 1), and the Kang and Phan weights associated with Plaisted and Peterson method and Wrickie (r = 0:51) according to Table 6, and also correlated with the Annicchiarico method (r = 0.30) (P < 0.05). However, the correlation with Kang and Phan method associated with the Yates and Cochran (r = 0.11) was not significant (P > 0.05) and with the method of Lin and Bins was negatively correlated (r = -0.31) (P < 0.05).

The methods Plaisted and Peterson and Wricke presented a perfect correlation between them (r = 1), thus exhibit the same correlation with the other methods. Regarding the correlation between the method Wrickie (1965) and crop productivity in this work it was found r = 043, similar to that found for Scapim et al. (2010) (r = 0.36), according to Table 6.

The method of Linn and Bins (Pi indices) presented high correlation with the average productivity of the genotypes, revealing estimate of r = -0.98, similar to that found by Scapim et al. (2010) (r = -0.99). According to these same authors, the correlation values between the present method and the Wrickie (1965) was -0.35, also in agreement with the value found in this study (r = -0.31).

The Annicchiarico method presented strong agreement with the average productivity, with correlation of 0.97 (P < 0.01). The more is produced, the greater the confidence index. The results obtained by the methodology of Annicchiarico (1992) were very similar to those obtained by the model Lin and Binns (1988). The Spearman correlation between Pi and Annicchiarico index was -0.97 (Table 6). These results are in agreement with those obtained by Mora et al. (2007), who also found concordant results in the two models to cotton productivity.

By using the Kang and Phan (1991) methodology, the method of Yates and Cochran (1938) was negatively correlated (P < 0.01) with the average (r = -0.54), and the Plaisted and Peterson (1959) and Wricke (1965) methods found a correlation (r = 0.11) that was not significant (P > 0.05). Still on consideration of the effect of the Kang and Phan weights associated with Yates and Cochran (1938) method, a positive correlation was observed (r = 0.56) (P < 0.01) with the Lin and Binns (1988) stability parameters as well as there was a positive correlation with a weighting of Kang and Phan (1991) with methods Plaisted and Peterson (1959) and Wrickie (1965) and hence r = 0.6 for both.

The use of Kang and Phan methodology (1991) associated with the method of Plaisted and Peterson (1959) presented correlation coefficient with an average of -0.51 (P < 0.01), in agreement with Scapim et al. (2010) that found value -0.57. The weighting Kang and Phan (1991) associated with the method of Plaisted and Peterson (1959) was correlated with the average productivity and all methods in the 1% level, except for the method of Yates and Cochran (1938). The same may be concluded with Kang and Phan's (1991) method associated with Wrickie method (1965), both of which have a correlation coefficient equal to 1.

4. Conclusions

The most productive genotypes showed greater stability at Lin and Binns method, as in Annicchiarico method. These methods show a strong association between themselves and produced similar genotypic classifications on the phenotypic stability, recommending be used either.

The methods Plaisted and Peterson (1959), and Wrickie (1965) showed Spearman correlation equal to 1 indicating same stable genotypes.

Based among 20 genotypes of higher productivity and good stability parameters, it is concluded that the genotypes were more promising for feed use was Pusa Napier 2, Taiwan, A-143 and Merckeron Comum.

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