Acta Scientiarum. Agronomy
ISSN: 1679-9275
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Universidade Estadual de Maringá
Brasil

Fritsche-Neto, Roberto; Vieira, Rafael Augusto; Scapim, Carlos Alberto; Vieira Miranda, Glauco; Moreira Rezende, Luciano
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Acta Scientiarum. Agronomy, vol. 34, núm. 1, enero-marzo, 2012, pp. 99-101
Universidade Estadual de Maringá
Maringá, Brasil

Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1679-9275
ISSN on-line: 1807-8621
Doi: 10.4025/actasciagron.v34i1.13115

Updating the ranking of the coefficients of variation from maize experiments

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ABSTRACT. The objective of this study was to update the ranking of the coefficients of variation (CVs) from maize experiments and evaluate the accuracy of the data from the latest Brazilian publications. We rank-ordered the CVs for grain yield, plant and ear heights, number of ears per plant, and weight of commercial ears, except for the weight of 100 grains. The data were obtained from 143 scientific papers published from 2005 to 2010. The classification was based on the average (m) and standard deviation (SD) and the CVs were ranked as low, intermediate, high and very high. All of the random variables had the CVs normally distributed. For most of the traits, we observed a large difference between the ranks from Scapim and Pimentel Gomes. In summary, the coefficients of variation have to be classified for each variable, significant improvement occurred in the accuracy of the national maize experiments in the last 15 years, and they still require periodic updating.

Keywords: experimental precision, experimental design.

Atualização da proposta de classificação dos coeficientes de variação para a cultura do milho

RESUMO. O objetivo desse trabalho foi fazer a atualização na proposta de classificação dos coeficientes de variação (CV) para a cultura do milho e avaliar a qualidade dos dados dos artigos mais recentes publicados no Brasil. Os CV das diferentes variáveis aleatórias foram obtidos a partir da consulta de 143 artigos científicos publicados de 2005 e 2010. As faixas de classificação dos (CV) foram baseadas na média (m) e no desvio-padrão (DP) da seguinte forma: baixo; médio; alto; muito alto. Todos os cv das variáveis aleatórias apresentaram distribuição normal. Foi possível observar que para a maioria dos caracteres avaliados houve uma grande diferença entre a classificação proposta e a de Pimentel-Gomes. Houve melhoria significativa na qualidade experimental na cultura do milho para os principais caracteres produtividade de grãos, alturas de planta e espiga, número de espigas por planta e peso de espigas comerciais, sendo a única exceção o peso de 100 grãos. Conclui-se que as faixas de classificação de coeficientes de variação têm que ser específica para cada variável, é necessária atualização periódica da classificação dos coeficientes de variação e nos últimos 15 anos, no Brasil, a qualidade da experimentação com cultura do milho teve uma melhora significativa.

Palavras-chave: precisão experimental, delineamento experimental.

Introduction

The accuracy in predicting the responses of agronomic traits is crucial for the success of plant breeding programmes. The experimental error, quantified by the CV, represents the ratio of the standard deviation to the mean. The CV is highly important to comment the analyses of agriculture experiments because it represents the level of variation from random variables that follow the Normal distribution. Higher the error term, lower is the power of a test to discriminate the treatments (COSTA et al., 2002). This dimensionless statistics permits to the researchers compare the accuracy of experiments despite the different units of measurements (PIMENTEL-GOMES, 2000).

Ranking is fundamental to make inferences about the similarities between two different experiments or about the significant of effects on the sources of variation (SCAPIM et al., 1995). Pimentel-Gomes (1984) based on field experiments to classify the order of these coefficients for all the agronomic traits in the same ranking. He classified all of them as low for values lower than 10%, intermediate for values from 10 to 20%, high for values higher than 20 and maximum of 30% and very high for values higher than 30%. The field practices, however, showed that the wide inclusion

of all traits in the same classification does not take into account the specific characteristics of the crops and each of them (AMARAL et al., 1997; CARVALHO et al., 2003; COSTA et al., 2002; GARCIA, 1989; SANTOS et al., 1998; SCAPIM et al., 1995). The new ranking proposed by Scapim et al. (1995) surpassed the recommendation of Pimentel-Gomes (1984) because significant improvements in the experimental designs and the use of modern genotypes have affected positively the experimental precision during the last 15 years.

The present study was carried out to update the CV ranking from maize experiments and document the accuracy of the latest national experiments.

Material and methods

In the current experiment, the sources of CVs were the 143 national articles about maize plant breeding carried out from 2005 to 2010, published in indexed scientific magazines from 2007 to 2009 as B1, B2 and B3 by the Capes (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior), and accessed through the Scientific Electronic Library on Line - Scielo. We surveyed CV data from grain yield, plant and ear height, ear diameter, number of spikes per plant, weight of commercial ears, weight of 100 seeds, lodging and broken plants, days to silking and effective digestibility because these are the most significant traits currently investigated in plant breeding programmes. The classification was based on reports of Garcia (1989), who ranked the CV as low, intermediate, high, and very high. The goodness of fit to the Normal distribution was evaluated by the Kolmogorov-Smirnov test modified by Lilliefors (1967).

In the present report, the experimental design was not considered because Estefanel (1987 apud COSTA et al., 2002) stated that the design does not have any influence on the CV value because it aims to attenuate the experimental error.

Results and discussion

All the data followed the Normal distribution as verified by the Lilliefors test for all the random variables (Table 1). Previously, the number of ears per plant and the weight of 100 grains had distribution close to the Normal (SCAPIM et al., 1995). These responses may have been affected the confidence intervals, and therefore the rank of these traits.

The amplitude between and within the traits was very large because of the influence from numerous factors that contribute to the error.

Table 1. Variables recorded in maize experiments showing the significance level of the Lilliefors test, the mean (M) and the standard deviation (SD) of the CVs.

Traits	N	M	SD	Lilliefors
Grain yield	245	11.87	3.62	0.05ns
Plant height	109	5.90	2.35	0.06ns
Ear height	75	7.68	3.09	0.09ns
Ear diameter	27	8.80	4.97	>0.15ns
Ears per plant	42	12.70	6.56	0.12ns
Weight of commercial ears	36	13.92	3.45	0.09ns
Weight of 100 grain	23	12.43	7.61	>0.15ns
Lodging and broken stalks	11	48.81	23.80	>0.15ns
Days to silking	9	2.07	1.51	0.13ns
Effective digestibility	16	4.76	1.55	>0.15ns

[n]number of experiments; [ns]nonsignificant by Lilliefors test.

The ranges between and within the ranks was affected by the traits (Table 2).

Table 2. Current ranges of CV data (%) for the most common traits evaluated in maize experimentation.

Traits	Low	intermediate		high		very high
	LS	LI	LS	LI	LS	LI
Grain yield	8.24	8.25	15.49	15.50	19.11	19.12
Plant height	3.55	3.56	8.25	8.26	10.60	10.61
Ear height	4.58	4.59	10.76	10.77	13.85	13.86
Ear diameter	3.82	3.83	13.78	13.79	18.75	18.76
Ears per plant	6.13	6.14	19.26	19.27	25.81	25.82
Weight of commercial ears	10.46	10.47	17.37	17.38	20.82	20.83
Weight of 100 grain	4.81	4.82	20.04	20.05	27.66	27.67
Lodging and broken stalks	7.01	7.02	19.60	19.61	25.88	25.89
Days to silking	25.00	25.01	72.60	72.61	96.40	96.41
Effective digestibility	3.20	3.21	6.30	6.31	7.85	7.86

[LI, LS]Lower and upper limit of the CV intervals, respectively.

Large differences were detected between the current recommendation and the Pimentel-Gomes rank (PIMENTEL-GOMES, 1984) for most of the traits, except for grain yield, ears per plant and weight of commercial ears. The explanation for these traits responses can be the data distribution close to the Normal unlike observed in the other traits because the Lilliefors test has some limitations.

The data distribution within the current rank was similar of Scapim et al. (1995) (Table 3), and reinforces the report of Scapim et al. (1995), where none specific variable was well-fitted to the Pimentel-Gomes rank. Therefore, the CVs need a classification for every trait as the lodging and broken plants, plant and ear height, ear diameter, days to silking and effective digestibility.

Table 3. Distribution of maize experiments (%) in the current rank.

Traits	low	intermediate	high	very high
Grain yield	15.51	68.57	10.20	5.71
Plant height	18.35	63.30	14.68	4.59
Ear height	13.33	64.00	20.00	2.67
Ear diameter	18.52	66.67	7.41	7.41
Ears per plant	14.29	76.19	4.76	4.76
Weight of commercial ears	13.89	72.22	8.33	5.56
Weight of 100 grain	8.70	78.26	8.70	4.35
Lodging and broken stalks	18.18	63.64	9.09	9.09
Days to silking	20.00	70.00	10.00	0.00
Effective digestibility	12.50	68.75	12.50	6.25

Otherwise, the data distribution within the ranking of Pimentel-Gomes was different (Table 4).

Table 4. Distribution of experiments (%) in the Pimentel-Gomes rank.

Trait	low	intermediate	high	very high
Grain yield	33.06	64.08	2.86	0.00
Plant height	92.66	7.34	0.00	0.00
Ear height	74.67	25.33	0.00	0.00
Ear diameter	62.96	29.63	7.41	0.00
Ears per plant	28.57	59.52	9.52	2.38
Weight of commercial ears	8.33	86.11	5.56	0.00
Weight of 100 grain	43.48	43.48	8.70	4.35
Lodging and broken stalks	0.00	0.00	27.27	72.73
Days to silking	100.00	0.00	0.00	0.00
Effective digestibility	100.00	0.00	0.00	0.00
Expected frequency	15.86	68.27	13.59	2.28

Traits less affected by environmental conditions as days to flowering, plant and ear height, ear diameter and effective digestibility had the ranking similar to Scapim et al. (1995) unlike observed from the rank of Pimentel-Gomes (1984). Similarly, this last effect was observed for lodging and broken plants that has high CV values because of the nature of these data (HALLAUER; MIRANDA FILHO, 1988).

The quality of the experimental responses from maize trials evaluating grain yield, plant and ear height, ears per plant and the weight of commercial ears were improved along these 15 years, except the weight of 100 grain (Table 5). The CV from grain yield was reduced by 25%, for example, and reinforces the necessity of periodic updating in the ranking of the CVs.

Table 5. Estimates (m) of CVs for the most common traits evaluated in the current study, Scapim et al. (1995), and the differences between them (%).

Traits	Scapim et al. (1995)	Current estimates (2010)	Difference %
Crop yield	16.02	11.87	- 25.9
Plant height	6.64	5.90	- 11.1
Ear height	9.71	7.68	- 20.9
Ears per plant	13.86	12.70	- 8.4
Commercial ear weight	16.22	13.92	- 14.1
Weight of 100 grains	7.7	12.43	+ 161.4

Conclusion

The ranking of the CVs from maize experiments have to be established for every trait. The CV ranks have to be update periodically. In the last 15 years, there was significant reduction in the experimental error of the national maize experiments.

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Received on April 8, 2011.
Accepted on April 18, 2011.