

PATTERN OF TRAITS ASSOCIATION IN GRAIN SORGHUM

POLA HUBUNGAN ANTAR SIFAT PADA SORGHUM

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ABSTRACT

Factor analysis was employed to reveal the pattern of traits association in sorghum as indicated by simple correlation analysis. Experiment was conducted in 2006 and 2007, involved 17 and 16 genotypes, respectively. Factor extraction had resulted three common factors that accounted for more than 90% of variability existing in the correlation structure. Factor I was consisted of vegetative traits (plant height, stalk diameter, leaf number and area, dry weight of stalk, root, and leaf), panicle length, and grain yield per plant. Factor II was consisted of heading date and maturity date, and Factor III was consisted of 1000-grain weight. The results suggested that vegetative performances were main criteria in the selection process for increasing sorghum grain yield.

Key words: sorghum, correlation, factor analysis

ABSTRAK

Analisis faktor digunakan untuk mengungkap pola hubungan sifat pada tanaman sorgum yang dihasilkan dari analisis korelasi sederhana. Percobaan dilaksanakan pada tahun 2006 dan 2007, yang masing-masing melibatkan 17 genotipe dan 16 genotipe. Hasil ekstraksi menunjukkan bahwa matriks korelasi dapat dikelompokkan ke dalam tiga faktor, yang secara kumulatif menerangkan lebih dari 90% keragaman yang terdapat pada struktur korelasi. Faktor I tersusun dari sifat-sifat vegetative (tinggi tanaman, diameter batang, jumlah dan luas daun, bobot kering batang, akar dan daun), panjang malai, dan bobot biji per tanaman (hasil). Faktor II tersusun dari umur berbunga dan umur panen, dan Faktor III hanya tersusun dari bobot 1000 biji. Hasil analisis faktor memperlihatkan bahwa penampilan sifat-sifat vegetative tanaman merupakan kriteria penting dalam proses seleksi untuk meningkatkan hasil biji sorgum

Kata kunci : sorgum, korelasi, faktor analisis

INTRODUCTION

Grain yield of sorghum (*Sorghum bicolor* L. Moench) is the manifestation of the preceding growth and development processes, which to some greater extent are affected by environment fluctuations. This notion implies that yield is a quantitative in nature and depends upon several other traits. Sorghum grain yield has been reported to have low heritability (Bello *et al.*, 2007) and, consequently, indirect selection via yield related characters with high heritability might be more effective than the direct selection for yield.

Therefore, if the grain yield improvement is the primary objective in a sorghum breeding program, the study of association among traits becomes a prerequisite in developing comprehensive selection criteria for reaching this objective (Ezeaku and Mohammed, 2006). By determining the inter-relationships among grain yield components, a better understanding on the plant types that produce higher yield can be established and effective selection can be attained.

Correlation analysis is traditionally used to determine the degree of traits association which, in turn, it is used to determine the yield criteria for

indirect selection. However, there are certain limitations inherent in the correlation analysis as to the interpretation of complex interrelated traits. To overcome such problems, a factor analysis is often employed to simplify the dimensionality of the data in a set of variables based on structural relationships among them, thus providing a more interpretable association. Factor analysis is a multivariate technique for reduction of a large number of correlated variables into a new set of a smaller number of uncorrelated variables, called underlying factors (Johnson, 1998). Factor analysis has been used in study on soybean (Bramel *et al.*, 1984), guar (Seiler and Stafford, 1985), dry bean (Aquaah *et al.*, 1992), peanut (Chozin, 1997), rice (Yanbo *et al.*, 1999), linseed (Khan *et al.*, 2000), and wheat (Heidari *et al.*, 2008) for identification of dependent relationship among characters associated with seed yield in several crops. The objective of this study was to evaluate the pattern of association among traits using factor analysis and for determination of the best criteria for the screening of high yielding sorghum genotypes.

MATERIAL AND METHOD

The study was conducted in 2006 and 2007 at Bengkulu University Agriculture Experiment Station, Tanjung Terdana, North Bengkulu. Seventy sorghum genotypes procured from Cereal Research Station at Maros, South Sulawesi and Gajah Mada University Agriculture Research Station, Yogyakarta were used in 2006 trial and sixteen genotypes from National Nuclear Agency (BATAN) were used in 2007 trial. Each genotype was row planted on 4 m long row and arranged in a randomized complete block design with three replications. Planting was done with 20 cm intra and 80 cm inter row spacing. Blocks were separated from each other using 100 cm spacing. Basal fertilizers (equivalent to 19.16 kg N, 34.5 kg P₂O₅, 45 kg K₂O ha⁻¹) were applied at a distance of 10 cm from the planting holes and additional 38.33 kg N ha⁻¹ was applied at 42 day after planting (dap). Hand weeding was done weekly and neither insecticide nor fungicide was

applied as there was no significant pest or disease infestation.

Observations were made on the individual plant basis for plant height (cm), leaves number, stalk diameter (mm), leaf area (cm²), root dry weight(g), stalk dry weight (g), leaves dry weight(g), heading date (dap), maturity date (dap), panicle length (cm), 1000-grain weight (g), and plant grain yield(g). The plant height, leaves number, stalk diameter, leaf area, heading date, and maturity date were measured prior to harvesting. Panicle length, grain yield per plant, 1000-grain weight, leaf dry weight, root dry weight, and stalk dry weight were measured after harvesting. The dry weights were measured after the plant materials were dried at 80 °C for three days. The collected data were averaged on each experimental unit and subjected to statistical analysis using SAS system for windows version 8 (SAS Institute Inc., 2001). The FACTOR procedure was performed on Pearson correlation coefficients. After several methods were employed to analyze the interrelationship among the observed traits, the maximum likelihood method was adopted for the factor extraction and three factors were retained. The array of communality, the amount of the variance of a variable accounted by the common factors together, was estimated using the squared multiple correlation (smc) of a given variable to all other variables. The varimax rotation (Kaiser, 1958) was carried out to make each factor uniquely defined as a distinct cluster of inter-correlated variables.

RESULT AND DISCUSSION

The correlation between all the pairs of traits in 2006 and 2007 are shown in Table 1. The vegetative traits (plant height, leaves number, stalk diameter, leaf area, root dry weight, stalk dry weight, and leaves dry weight), were highly correlated to each other and to grain yield. These finding are in agreement with those reported by Asthana *et al.* (1997). Exception was indicated by plant height in 2006, where its associations with the other vegetative traits and grain yield were mostly moderate (<0.5). Similarly, most vegetative

traits had low to moderate correlation to plant maturity traits (heading and maturity dates), panicle length and 1000-grain weight, and grain yield. High correlations were observed in some pairs but they were inconsistent across year. Heading date was only highly correlated to maturity date, but not to other reproductive traits (panicle length, 1000-grain weight, and grain yield). In addition, panicle length and 1000-grain weight were observed to have low correlation to grain yield in 2006 but not in 2007.

Table 2 presents the matrices of rotated

factor in 2006 and 2007 experiments. The three factors were found to adequately explain the correlation of 12 sorghum traits that accounted for 95 % and 94 % in both years, respectively. Factor loading indicates the correlation of a given trait to its corresponding factor (Cliff, 1987) and represent the characteristic of the factor. For purpose of interpretation, however, the characteristic of each factor was determined by factor loadings 0.5 or higher (Seiler and Stafford, 1995).

Table 1. Correlation coefficient matrix of 12 traits in sorghum (upper diagonal 2006, lower diagonal 2007)

Trait	Trait number											
	1	2	3	4	5	6	7	8	9	10	11	12
1. Plant height	-	0.33	0.38	0.57	-0.04	0.44	0.38	0.14	0.29	-0.28	0.13	0.39
2. Stalk diameter	0.78	-	0.89	0.73	0.68	0.55	0.70	-0.12	0.25	0.24	-0.17	0.81
3. Leaves number	0.60	0.76	-	0.85	0.63	0.61	0.78	0.21	0.49	0.48	-0.21	0.80
4. Leaf area	0.81	0.81	0.50	-	0.46	0.76	0.80	0.33	0.61	0.27	0.01	0.85
5. Root dry weight	0.53	0.56	0.59	0.64	-	0.61	0.62	-0.03	0.29	0.24	0.18	0.67
6. Stalk dry weight	0.82	0.68	0.60	0.75	0.77	-	0.82	0.41	0.72	-0.05	0.29	0.73
7. Leaf dry weight	0.81	0.74	0.68	0.74	0.83	0.89	-	0.34	0.64	0.17	0.15	0.76
8. Heading date	-0.17	-0.30	-0.31	0.02	0.31	0.13	0.08	-	0.90	0.19	0.03	0.01
9. Maturity date	-0.23	-0.42	-0.38	-0.03	0.26	0.05	0.05	0.92	-	0.12	0.13	0.35
10. Panicle length	0.60	0.61	0.46	0.71	0.50	0.49	0.69	-0.08	0.06	-	-0.53	0.29
11. 1000-grain weight	0.54	0.15	-0.20	0.49	0.13	0.42	0.27	0.14	0.19	0.25	-	0.10
12. Plant grain yield	0.88	0.68	0.51	0.86	0.58	0.78	0.73	-0.03	0.01	0.72	0.66	-

Table 2. Pattern of rotated factors for 12 traits in sorghum

Trait	2006					2007				
	Factor			Communality		Factor			Communality	
	I	II	III	Initial	Final	I	II	III	Initial	Final
Plant height	0.44	0.16	-0.07	0.73	0.23	0.76	-0.25	0.53	0.96	0.92
Stalk diameter	0.91	-0.12	0.26	0.95	0.90	0.82	-0.41	0.14	0.95	0.86
Leaves number	0.87	0.19	0.45	0.97	1.00	0.82	-0.33	-0.22	0.90	0.83
Leaf area	0.83	0.34	0.13	0.92	0.82	0.77	-0.04	0.47	0.92	0.81
Root dry weight	0.74	-0.01	-0.03	0.84	0.55	0.85	0.29	-0.03	0.87	0.80
Stalk dry weight	0.77	0.45	-0.35	0.92	0.92	0.85	0.06	0.32	0.92	0.82
Leaf dry weight	0.83	0.36	-0.03	0.82	0.82	0.93	0.07	0.16	0.97	0.90
Heading date	-0.02	1.00	0.08	0.97	1.00	0.03	0.93	0.01	0.97	0.86
Maturity date	0.38	0.91	-0.03	0.98	0.98	-0.04	1.00	0.08	0.98	1.00
Panicle length	0.15	0.13	0.72	0.90	0.56	0.67	0.07	0.28	0.93	0.53
1000-grain weight	0.07	0.09	-0.66	0.71	0.44	0.10	0.12	0.93	0.91	0.89
Plant grain yield	0.90	0.03	0.01	0.93	0.81	0.72	-0.02	0.64	0.97	0.92
			Total	10.63	9.03			Total	11.24	10.14
Eigenvalue	111.67	54.77	14.11			129.26	82.08	17.76		
% to initial communality	0.59	0.29	0.07	0.95		0.53	0.34	0.07	0.94	

In both years, the vegetative traits and grain yield had characterized Factor I and accounted for more than half of the total variability present in the dependence structure. As suggested in the correlation matrix (Table 1), 1000-grain weight would not be in the same group with grain yield. Similarly, panicle length would be in the same group with grain yield only in 2007. The sign of factor loading for the traits that characterize Factor I was all positive, indicating that those traits exhibit the same direction and may be controlled by the same gen(s).

Factor II accounted for about one third of the total variability present in the dependence structure and was strongly associated with heading and maturity dates. Both traits had positive loading on Factor II and strongly correlated to each other with $r = 0.9$ in 2006 and $r = 0.98$ in 2007. Factor III had an inconsistent characteristic. In 2006, it was inconsistently determined by panicle length and 1000-grain weight but in 2007 it was characterized by plant height, 1000-grain weight, and grain yield. As the contribution of Factor III was only 7% to the total variability in the dependence structure, it possibly has less practical implication in the breeding program.

The present study demonstrates the use of factor analysis for elucidating the multivariate pattern of trait associations in sorghum revealed by the simple correlation analysis. The breeder would thus have available information for determining the plant type that potentially capable of producing high yield. Although there were small inconsistency results across years, the general pattern indicates that selection on the basis of the overall vegetative performances would be the most effective way of increasing the sorghum grain yield.

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