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RELATIONSHIP AMONG GRAIN CHARACTERISTICS AND  
COUSCOUS YIELD IN PEARL MILLET

S.C. Gupta, A.T. Ndoye and H.M. Mbengue

# RELATIONSHIP AMONG GRAIN CHARACTERISTICS AND COUSCOUS YIELD IN PEARL MILLET

S.C. Gupta<sup>1</sup>, A.T. Ndiaye<sup>2</sup>, and H.M. Mbengue<sup>3</sup>

Pearl millet (Pennisetum americanum (L.) Link) is one of the man's most drought - tolerant food crop and it is grown principally in the semi-arid regions of Africa and the Indian sub-continent. It is among the six leading cereals in the world in providing calories and proteins for human consumption (Evans 1975). In Senegal, pearl millet is the most important cereal crop, both in terms of surface area covered and production. The grain is used for human consumption primarily as couscous, a steamed granulated product made from dehulled flour.

At "Centre National de Recherches Agronomiques de Bambey (CNRA)" the important selection criterias in pearl millet breeding program are grain yield, disease resistance, grain size, and evident grain quality characteristics such as grain colour and appearance. Recently little emphasis was given on estimating the protein content, basic amino acid content and the couscous yield in newly developed varieties.

Before placing a strong emphasis on breeding for protein content, basic amino acid content and the yield of the end product - couscous, the relationships that exist among grain yield, grain size, protein content, basic amino acid content, couscous yield and the characteristics affecting couscous yield such as dehulling percentage, extraction rate and flour percentage were investigated on a diverse range of material developed at Bambey and introduced from different millet growing regions of Africa and India.

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1. Pearl Millet Breeder, ICRISAT, B.P. 3340, Dakar, Senegal

2. Pearl Millet Breeder and Coordinator, ISRA, CNRA, Bambey, B.P. 53, Senegal

3. Post Harvest Technologist, ISRA, CNRA, Bambey. B.P. 53, Senegal

## MATERIALS AND METHODS

### a) Seed Material

The seed stocks used for this study included two different types of material :

- Advanced yield trial : A trial of 10 entries - 4 progeny varieties, 3 synthetics, 1 experimental variety and 2 checks, Seuna III and farmers local was conducted at 4 locations in Senegal during rainy season 1983. All the entries (Table 1) in this trial were developed at CNRA Bambey. The trial was grown in randomized block design, 6 replications and with a net plot size of 15.36 m<sup>2</sup>. The plots were over planted and thinned to single plant per hill after 15 days with a spacing of 40 cm between plants in rows 80 cm apart. At harvest grain yield per net plot was recorded and converted into kilogram per hectare. The open - pollinated seed of individual plots from Bambey location was utilized to estimate other characteristics.
- Geographical diverse material : Ten entries from different geographical regions of Africa and India were multiplied at ICRISAT Center, Patancheru, India, during the off-season 1982-83. The open-pollinated seed of these ten entries alongwith two checks (Table 3) was utilized for this study.

### b) Protein Content, DBC/Protein and Thousand-Grain Weight

The open-pollinated seeds of individual plots from advanced yield trial were used to determine protein content and DBC/Protein. Grain protein content was estimated (N x 6.25) using a technique Auto-analyser (Singh and Jambunathan 1980). Basic amino acid content was estimated using the Udy Dye - Binding capacity (DBC) technique with an amount of flour that contained 80 mg of protein, value being expressed as DBC/Protein (Jambunathan 1980).

In advanced yield trial, the mean of two - 1000 grain weights measured on a Mumugal seed counter was recorded for each plot. In other trial, thousand grain weight recorded on four samples for each of the entry.

### 2) Dehulling, Flour and Couscous Characteristics

Couscous was prepared by women in a traditional way. In advanced yield trial, couscous was prepared for the entire replication by same woman to avoid woman to woman variation in a replication. In second experiment couscous was prepared by two different teams for each entry from the same seed stock. In each team, one woman carried out only one operation for all the entries. The grain lots were dried at 60°C for 24 hours before weighing on electrical balance (Mettler P 10 N). The initial grain weight (AA) varied from 1530 g to 2580 g per sample in advanced yield trial, and 500 to 1500 g in another trial. In advanced yield trial, the dehulling, extraction rate, and flour content were based only on humid samples where as in geographical diverse material all the estimates were made on humid as well as on dry matter basis.

Water was added 15 % by weight for dehulling the grain. The grains of millet were pounded in a mortar with a pestle for 17 - 20 minutes. The bran was separated from grain. Total bran and dehulled grain were weighed separately. Dehulling percentage - humid was obtained by dividing the weight of dehulled grain with dehulled grain plus bran. In second experiment, the total bran from each sample was dried at 60°C for 24 hours and weighed. Dehulling percentage (dry) was derived as  $1 - (\text{Weight of dry bran} / \text{AA})$ .

After dehulling, the dehulled grains were washed with water and dried in shade for 30 minutes. Each sample of dehulled grain was weighed (BB) before pounding in a mortar with a pestle for another 25 to 30 minutes to produce the flour. The fine flour was sieved with 1 mm-mesh and the remainder was again pounded and sieved. The flour was weighed (CC). Extraction rate (DD) was obtained as  $\text{CC} / \text{BB}$ . In second experiment 100 g of flour was dried at 60 °C for 24 hours to determine the moisture content. Dried flour was weighed (EE). Flour (%) was obtained by multiplying DD with dehulling (%). Percent of dry flour was obtained as  $(\text{CC} \times \text{EE}) / (\text{AA} \times 100)$ .

The flour is then mixed with water and the mixture is stirred constantly, being careful to stir all around the recipient for ten minutes. Amount of water was added in such a way that the mixture was neither too wet and nor too dry. The mixture was forced through a sieve with 1.5 mm-mesh openings and then placed into a container with a bottom perforated with several small holes. The container was placed on a pot of boiling water. The cooking took about 25 to 30 minutes for each sample. Couscous was weighed and 500 g from each sample was dried in oven at 60 °C for 48 hours to determine the moisture content. Couscous (%) was a ratio between total weight of couscous and the initial grain weight. Dry couscous (%) was obtained as total weight of dry couscous divided by adjusted initial grain weight (AA - EE). All the estimates were multiplied by 100 to express in percentages. Acceptability test was carried out on all samples but excluded due to high coefficient of variation.

#### d) Statistical Analysis

Analysis of variance were computed by the method described in Cochran and Cox (1964) and the correlations (based on mean over replications) by the method given in Senedecor and Cochran (1967).

### RESULTS

#### a) Advanced Yield Trial

Mean performance of advanced yield trial entries at Bamby for seven characters is presented in Table 1. The mean squares for entries were significant for all the characters except grain yield, DBC/protein and extraction rate. The entries were diverse in genetical background but with similar yields did not exhibit large variation even for characters such as protein content, thousand - grain weight, flour content and dehulling (%). Protein content ranged from 13.5 to 14.9 %, the thousand grain weight from 6.59 to 7.85 g, flour content from 76.0 to 80.0 % and dehulling from 83.7 to 88.9 %.

The correlation coefficients of grain yield with thousand-grain weight and DBC/protein were positive and significant, where as with protein content was negative and significant (Table 2). Protein content was strongly negatively correlated with DBC/Protein and the correlation between DBC/Protein and the flour content was positive and significant. Dehulling was strongly correlated and positive with flour content. Thousand-grain weight was positively correlated with DBC/Protein, dehulling, flour, and extraction rate but non-significant.

#### b) Geographically Diverse Material

The mean squares were significant for all the eight characters - thousand grain weight, dehulling (based on humid and dry), extraction rate, flour content, flour content based on initial grain weight, couscous and dry couscous yield expressed in percentages. Mean performance for eight characters are presented in Table 3. There was large variation for all the characters except extraction rate. Thousand grain weight varied from 7.0 to 10.8 g and dehulling percentage (dry) ranged from 82.4 to 91.0. Flour content based on initial grain weight ranged from 73.8 (K13, Upper Volta) to 89.7 % (DSA 74, Ghana). DSA 74 produced highest couscous yield (12 % more than Bamby local) and the lowest was from K 13.

The correlation coefficient of thousand-grain weight with all other characters except extraction rate was positive, and significant for dry flour content (Table 4). Dehulling and flour content based on humid were strongly and positively correlated with dehulling based on dry sample and dry flour content respectively. Both dehulling percentages were strongly and positively correlated with flour and couscous characteristics. Both flour characteristics were strongly and positively correlated with couscous and dry couscous. Couscous yield was strongly and positively correlated with dry couscous yield.

#### DISCUSSION

In advanced yield trial, the differences among entries were significant for thousand grain weight, protein content, dehulling and flour percentages. However, there was not large

variation where as in geographically diverse material large variation among entries was found for all the characters except for extraction rate. The relationship between grain yield and protein content was significant and negative as demonstrated in sorghum (Crook and Casady 1974), wheat (Mattern et al 1968) and in maize (Dudly et al 1971). However, the results were not in agreement with Kumar et al (1983) in pearl millet. They reported non-significant relationship between grain yield and protein content. The present results should be considered with caution as the material did not have large variation for grain yield and protein content. Our findings suggest a positive and significant association between grain yield and DBC/Protein, where as Deesthale et al (1971) and Kumar et al (1983) reported negative and non-significant association between these two characters. The relationship between protein content and DBC/Protein was strongly negative indicating that the selection for increased protein content may lead to a reduced level of basic amino acids. The present findings are in agreement with Kumar et al (1983). The relationship between grain yield and grain size was positive and significant indicating thereby that the improvement in grain size may lead to increase in grain yield production.

The relationship of thousand-grain weight with dehulling, flour and couscous characteristics was positive and generally non-significant indicating thereby that there is a possibility of improving seed size and couscous yield simultaneously. The strong and positive association between the estimates on humid and dry matter for dehulling, flour and couscous yield suggest that in breeding material, the differences among varieties can be found for dehulled grain, flour and couscous yield on humid basis. Couscous yield was strongly and positively related with dehulling and meaning thereby that the large breeding material could be screened for couscous yield by estimating the dehulling percentage. All the varieties were acceptable in tests except Fakiyabad a variety from Sudan.

These results suggest that in pearl millet it should be possible to select for increased grain weight, basic amino acid content, couscous yield and grain yield simultaneously though with detrimental effect on protein content.

## SUMMARY

Pearl millet is the most important cereal crop, both in terms of surface area covered and production in Senegal. The grain is used for human consumption primarily as couscous. Before selecting genotypes for grain characteristics, such as grain yield, grain size, protein content and DBC/Protein, it is important to know how such selection will affect couscous yield. Using a diverse range of elite material grown at Bambey (Senegal), the relationships that exist between grain yield, grain size, protein content, dye binding capacity (DBC) per unit protein (an estimate of basic amino acids in protein), dehulled grain, extraction rate, flour content and couscous yield in pearl millet (Pennisetum americanum (L.) Link) were investigated. Protein content was estimated as total N  $\times$  6.25, total N being measured with an Technicon automatic analyzer. Basic amino acid content was estimated using the Udy DBC technique.

The relationship among couscous yield, flour content and dehulled grain was positive and strongly correlated. The relationship of thousand grain weight with dehulling, flour and couscous characters was positive but generally non-significant. Flour content and protein content were significantly negatively correlated, and the relationship between flour content and DBC/Protein was significant and positive. Grain yield and protein content were significantly correlated and negative, and the relationship between grain yield and DBC/Protein was significant and positive. These results suggest that in pearl millet it should be possible to select for increased couscous yield, basic amino acid content, grain yield, grain weight simultaneously, though with detrimental effect on protein content.

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Table 1. Mean performance of advanced yield trial entries at Bamby for several traits in pearl millet during rainy season 1983.

No	Entry	Grain yield (kg/ha)	Thousand grain weight (g)	Protein (%)	DRC/g protein	Dehulling (%)	Extraction (%)	Flour (%)
1	IBV 8001	2101	7.51	13.5	5.46	85.3	91.7	79.1
2	IBV 8004	2086	7.52	13.6	5.13	88.9	90.0	80.8
3	IBV 7019	1756	7.53	14.9	5.01	83.7	90.7	76.0
4	PS 90-2	1737	7.37	14.3	5.22	84.9	90.1	76.4
5	H7-66	2100	7.72	13.5	5.44	85.0	91.7	78.0
6	H9-127	1690	7.89	14.4	5.18	86.3	91.4	78.0
7	H23-38	1786	7.53	13.7	5.44	85.3	91.1	80.7
8	3/3 HK-878 (I)	1759	6.76	14.4	5.18	85.7	91.1	78.4
9	Suma III	2056	7.39	14.2	5.26	85.0	90.9	79.9
10	Bamby Local	1680	6.59	14.0	5.20	86.7	89.3	77.3
	Mean	1886	7.34	14.0	5.20	85.0	91.4	78.6
	SE $\pm$	164	0.19	0.3	0.10	0.8	0.2	1.1
	LSD 0.05	469	0.55	0.9	0.30	2.2	2.7	3.2
	C.V. %	21.4	6.49	5.5	5.00	2.2	2.5	3.4

a. Sample size for dehulling grain was 1500 to 2500 g. Dehulling (%) is based on humid dehulled grain and bran.

Table 2. Linear correlation coefficients among seven characters in advanced yield trial at Bambeý during rainy season 1983.

Character	Thousand grain weight (g)	Protein (%)	DBC/ g protein	Dehulling (%)	Extraction rate (%)	Flour (%)
Grain yield	0.72*	- 0.68*	0.61*	0.10	- 0.61	0.45
Thousand grain weight	---	- 0.60	0.44	0.16	0.51	0.33
Protein	---	---	- 0.99**	- 0.53	0.15	- 0.61*
DBC/Protein	---	---	---	0.56	0.10	0.63*
Dehulling	---	---	---	---	- 0.10	0.03**
Extraction rate	---	---	---	---	---	0.40

\*,\*\* Correlation coefficients significant at the 5 and 1 % levels of probability respectively.

Table 3. Mean performance of 12 varieties for eight grain, flour and couscous characters in pearl millet.

No	Entry	Thousand grain weight (g)	Dehulling (%) <sup>a</sup>		Extraction rate (%)	Flour (%)	Dry flour (%)	Couscous (%)	Dry couscous (%)
			Humid	Dry					
1	DSA 74	10.6	87.5	91.0	97.1	89.0	85.7	115.1	86.8
2	Souna	7.2	86.1	87.6	98.3	86.6	84.0	104.7	83.4
3	Togo	10.4	86.5	88.6	98.0	86.8	88.6	115.2	85.6
4	Nigerian Composite	8.2	84.3	85.8	98.0	84.1	82.7	121.4	81.6
5	CIVT II	9.0	81.7	84.4	97.4	82.2	80.1	122.5	79.7
6	Fakiyabad	10.7	85.8	88.1	97.4	85.0	84.4	131.9	82.3
7	SAD 448	7.4	87.2	88.9	97.3	86.5	82.5	126.8	83.1
8	Mossi Local	9.5	85.8	88.3	97.0	85.6	85.9	121.1	83.4
9	ICMS 7703	7.5	85.4	88.0	97.0	85.1	79.3	122.6	78.8
10	K13	7.0	80.1	82.4	97.3	80.8	73.8	118.0	75.8
11	IBV 3001	10.5	87.1	88.9	98.2	87.2	82.6	126.6	81.0
12	Bambay	8.5	86.6	88.8	97.2	86.5	82.4	125.2	80.2
	Mean	8.9	85.4	87.6	97.6	85.5	83.0	127.0	81.6
	SE ±	0.2	1.5	1.5	0.2	1.5	1.2	2.0	2.0
	LSD 0.05	0.4	3.3	3.4	0.5	3.4	2.7	4.3	4.4
	C.V. %	3.1	1.8	1.8	0.2	1.8	1.5	1.5	2.5

a. Based on initial grain weight - 1500 g for first eight entries, 900 g for 9th and 10th entries and 500 g for 11th and 12th entries.

Table 4. Linear correlation coefficients among eight characters in 12 geographical diverse pearl millet genotypes.

Characters	Dehulling (%)		Extraction rate (%)	Flour (%)	Dry flour (%)	Couscous (%)	Dry couscous (%)
	humid	dry					
Thousand grain weight	0.42	0.52	0.50	0.51	0.69*	0.95	0.54
Dehulling-humid		0.97*	0.5	0.97**	0.75**	0.75**	0.75**
Dehulling-dry	---	---	0.06	0.98**	0.79**	0.75**	0.78**
Extraction rate	---	---	---	0.14	0.15	0.32	0.20
Flour	---	---	---	---	0.82***	0.32**	0.82**
Dry flour	---	---	---	---	---	0.87**	0.94**
Couscous	---	---	---	---	---	---	0.94**

\*,\*\* Correlation coefficients significant at the 5 and 1 % levels of probability respectively.