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Mini-Review

Grain Protein Content Versus Yield in Cowpea

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Mini Review

Pulses are the primary source of dietary protein for a large part of the population, especially in marginal areas for agriculture, where soils are deficient in nutrients and frequent environmental stresses, mainly in Asia, Africa, and South America. Among them, Cowpea [*Vigna unguiculata* (L) Walp.] is an important pulse crop that serves multiple purposes for human food and animal feed, especially in parts of the world where other pulse crops cannot be cultivated due to environmental constraints [1]. Cowpea is one of the critical low-cost protein sources in the world's arid, semi-arid, and tropical parts. It provides protein for millions of people, especially in developing countries [2]. The crop is efficient at biological nitrogen fixation and is one of the pulses best adapted to environmental stresses [1]. Generally, family farming in low-input agriculture produces Cowpea without fertilization or irrigation [2]. Therefore, as population growth increases, especially in these marginal regions, the primary demand seems likely to outpace food production [2]. Cowpea shows an average yield of 527 kg ha^{-1} because it is mainly produced by small farmers in low-input agriculture, using traditional local genotypes [2]. These local genotypes will have a lower yield in optimal conditions but are better adapted to abiotic stresses so frequent in these areas [1]. In the semi-arid region of Senegal, EPACE 10, a Brazilian traditional local genotype not inoculated, did symbiosis with native *Rhizobium* strains and yielded 850 Kg. ha^{-1} with only 44% of the crop evapotranspiration (ETc) [4]. This yield is well below the crop's potential, approximately 6000 kg ha^{-1}, attained only in high-input agriculture, with modern commercial genotypes that depend more on fertilization, pesticides, and irrigation [2]. However, these modern cultivars are not adapted to the wide range of local environmental conditions in marginal areas for agriculture; thus, they tend to be more vulnerable to biotic and abiotic stresses, which reduces their yield severely in these areas [2]. Among 18 genotypes studied [3], the total grain protein content ranged from 21% to 29% of grain weight. Cowpea proteins contain higher amounts of amino acid lysine than sulfur-containing amino acids, such as methionine and cysteine. Consequently, it complements cereals proteins, which have low amounts of lysine but are richer in methionine and cysteine [1,3]. Among the grain proteins, globulins contain up to 52% of essential amino acids, albumins contain up to 44%, glutelins contain around 30%, and prolamins contain up to 22% [5]. Prolamins and glutelins are the principal grain proteins in cereals, whereas, in pulses, globulins and albumins are in more significant quantity [5]. Therefore, a pulse mixture with cereals is considered well equilibrated in amino acids for food safety [1]. To verify the differences between local genotypes (EPACE-10 and Paulistinha) and new commercial genotypes (Novaera and Gurguéia), two experiments in a greenhouse were conducted to compare grain protein content and yield of these four genotypes in the first one. The second experiment evaluated two contrasting genotypes (Novaera and EPACE-10) under six treatments. These treatments were: (EI) EPACE-10 only inoculated; (EMAP) EPACE-10 inoculated + Mono Ammonium Phosphate (MAP) applied at the pollination stage; (EU) EPACE-10 inoculated + urea ((NH2)2CO) applied at the pollination stage; (NI) BRS Novaera only inoculated; (NMAP) BRS Novaera inoculated + Mono Ammonium Phosphate (MAP) applied at the pollination stage, (NU) BRS Novaera inoculated + urea applied at the pollination stage. The pollination stage is the most sensitive stage to environmental stresses [6], and for common beans, it is recommended that a complement of nutrients increase yield [6]. In the first experiment, among the four genotypes evaluated (Table 1), the local genotypes, Paulistinha and EPACE-10, showed higher total grain protein content than the two commercials genotypes, Novaera and Gurguéia. However, the yield of these two local genotypes (Table 2), Paulistinha and EPACE-10, were lower than for the two commercial genotypes, Novaera and Gurguéia, as expected, because the metabolic cost for protein synthesis is higher than for starch [3,5]. Otherwise, in marginal areas for agriculture, submitted to environmental stresses, the commercial genotypes have lower yield (grain weight per plant) than the local genotypes, which are more adapted to these stresses [1]. Among the commercial ones, Novaera showed a high Globulin and Albumin content than Gurguéia and a higher Albumin content than the local genotypes, Paulistinha and EPACE-10 (Table 1).

In the second experiment, for all the three treatments applied to the two genotypes, EPACE-10 and Novaera, the total grain proteins of EPACE-10, the local genotype, were higher than for Novaera, the commercial one (Table 3). However, in this second experiment, the Globulins and Albumins contents were the same for both genotypes in all treatments. Neverthless, in this second experiment, the treatments with MAP and Urea for EPACE-10 increased its yield (grain weight per plant) compared to the only inoculated treatment (Table 4). This increase in yield shown by the fertilization at the pre-flowering stage of EPACE-10, the local genotype, did not happen with the commercial one, Novaera (Table 4). Therefore, it can be concluded that the local genotypes studied had a higher grain protein content but lower yield than the commercial ones studied, Novaera and Gurguéia. In addition, the treatments with MAP or Urea at the pre-flowering stage increased the Albumin content and yield of EPACE-10, but not for the commercial one, Novaera. Thus, the increase in yield due to the fertilization was genotypic-specific.

Table 1: Total grain protein contents and their fractions on four genotypes of Cowpea

Protein Fractions	Genotypes			
	Novaera	Gurguéia	Paulistinha	EPACE-10
Globulins (mg $100mg^{-1}$)	15.5a	13.3b	15.6a	16.4a
Albumins (mg $100mg^{-1}$)	0.6a	0.4b	0.4c	0.4c
Prolamins (mg $100mg^{-1}$)	0.2c	0.3b	0.3b	0.4a
acid Glutelins (mg $100mg^{-1}$)	0.9c	0.9c	1.0b	1.4a
alkali Glutelins (mg $100mg^{-1}$)	2.8c	4.0b	5.7a	5.9a
Total grain protein (mg $100mg^{-1}$)	20.0b	18.9b	23.0a	24.3a

Means followed by the same letters in the same line are not significantly different by the SNK test at the P=0.05 probability level.

Table 2: Yield components of four genotypes of Cowpea.

Genotype	Number of Pods Per Plant	Number of Grains Per Plant	Grain Weight Per Plant (g)
Novaera	6.00 a	33.75 b	8.622 a
Gurguéia	6.75 a	70.50 a	6.892 a
Paulistinha	3.75 a	28.00 b	4.727 b
EPACE-10	4.25 a	33.00 b	3.800 b

Means followed by the same letters in the same column are not significantly different by the SNK test at the P=0.05 probability level.

Table 3: Total grain protein contents and their fractions on four genotypes of Cowpea under six treatments: (EI) EPACE-10 only inoculated; (EMAP) EPACE-10 inoculated + Mono Ammonium Phosphate (MAP) applied at the pollination stage; (EU) EPACE-10 inoculated + urea applied at the pollination stage; (NI) BRS Novaera only inoculated; (NMAP) BRS Novaera inoculated + Mono Ammonium Phosphate (MAP) applied at the Pollination stage, (NU) BRS Novaera inoculated + urea applied at the pollination stage.

Protein fractions	Treatments					
	EI	EMAP	EU	NI	NMAP	NU
Globulins (mg $3mL^{-1}$)	18,08a	19,20a	19,74a	19,67a	19,76a	19,33a
Albumins (mg $2mL^{-1}$)	0,84a	0,84a	0,90a	0,78a	0,80a	0,82a
Prolamins (mg $0,5mL^{-1}$)	0,31a	0,26ab	0,28ab	0,19b	0,20ab	0,22ab
Acid Glutelins (mg $1mL^{-1}$)	0,94a	0,74ab	0,75ab	0,61b	0,45b	0,58b
Alkali Glutelins (mg $1mL^{-1}$)	6,09a	5,05b	5,28ab	1,56c	1,21c	1,58c
Total grain proteins (mg $100mL^{-1}$)	26,26a	26,09a	26,94a	22,81b	22,43b	22,52b

Means followed by the same letters in the same column are not significantly different by the SNK test at the P=0.05 probability level.

Table 4: Yield components of four genotypes of Cowpea, under the six treatments EI, EMAP, EU, NI, NMAP, and NU.

Genotype	Number of Pods Per Plant	Number of Grains Per Plant	Grain Weight Per Plant (g)
EI	2,17b	15,33ab	2,35b
EMAP	3,17b	30,67a	5,48a
EU	2,83b	27,50a	5,01a
NI	5,67a	22,67ab	5,14a
NMAP	3,33b	11,50b	3,26ab
NU	3,76b	22,17ab	4,59a

Means followed by the same letters in the same column are not significantly different by the SNK test at the P=0.05 probability level.

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