Evaluation of genetic diversity in quality-related traits of cowpea genetic resources for the development of an open access database

Cowpea [*Vigna unguiculata* (L.) Walp.], a traditionally important grain crop in sub-Saharan Africa, is an affordable source of protein and minerals as well as cash income, especially for small-scale farmers who have limited options for food and cash crops. It also retains tremendous potential for improving nutritional balance and livelihoods in the region. Africa has been experiencing rapid economic growth in recent years; thus, in addition to improving "quantity" in the production, more attention would be placed on "quality" to boost utilization and consumption, and to further promote the crop through "value addition". In this study, we sought possible strategies for value-addition using the rich genetic resources available, and we evaluated the genetic diversity especially in various grain quality-related traits and the relationships among these traits in cowpea.

Wide genetic variation and strong correlations among crude protein and Fe and Zn contents suggest the possibility of improving the concentrations of these nutritional factors simultaneously in 240 accessions evaluated (Table 1). Also, low associations among physical and nutritional properties of grain indicate the possibility of introgressing favorable traits utilizing identified genetic resources.

From these 240 accessions, a set of 20 accessions retaining the diversity in physical and basic nutritional properties were selected and further analyzed to create a detailed profile of the grain’s physical, nutritional/anti-nutritional, and functional properties (Table 2). Based on the observed narrow variation in amino acid (AA) composition, a reliable nitrogen-to-protein conversion factor of 5.45 was proposed for the estimation of crude protein content. We identified several improved breeding lines, such as IT93K-452-1, IT90K-277-2, and IT98K-205-8, with low concentrations of flatulence-causing oligosaccharides together with various favorable agronomic traits and nutrient contents. Also, TVu-12802 and TVu-467 were nominated as potential parental lines due to their high amounts of micronutrients and low phytic acid/Fe and phytic acid/Zn molar ratios.

The obtained results were organized into an open access "EDITS-Cowpea" database (http://www.jircas.go.jp/database/edits-cowpea) that enables all cowpea breeders and researchers to identify the potential germplasm resources to use to facilitate their work.

These findings suggest potential and possible uses of identified genetic resources with key quality-related traits which may stimulate breeding activities towards promotion and value-addition of the crop. Also, the developed open access database will enhance the utilization of cowpea’s wide genetic diversity. These outputs are expected to link the primal elements needed for grain quality improvement, and facilitate the development and deployment of cowpea varieties with improved nutrition and quality that meet the needs of farmers and consumers. This, in turn, should enhance cowpea consumption and production in the region.

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Table 1. Phenotypic (upper diagonal) and genotypic (lower diagonal) correlations among major agronomic traits and physical and nutritional properties

	Dflow[a]	Dharv[b]	Byield[c]	Gyield[d]	CP[e]	Fe	Zn	Mn	Cu	Gweight[f]
Dflow		0.45 *	0.30 *	0.02	0.05	0.02	−0.01	0.08 *	−0.14 *	0.08
Dharv	0.44 *		0.10 *	0.09 *	−0.10 *	−0.13 *	−0.10 *	0.15 *	0.12 *	0.44 *
Byield	0.57 *	0.19 *		0.49 *	0.22 *	0.17 *	−0.01	−0.09 *	−0.15 *	0.04
Gyield	0.10	0.32 *	0.57 *		0.07	0.03	−0.23 *	−0.05	−0.01	0.17 *
CP	0.10	−0.15	0.25 *	−0.11		0.47 *	0.36 *	−0.02	0.07	−0.19 *
Fe	0.05	−0.22 *	0.16	−0.23 *	0.70 *		0.33 *	−0.03	0.04	−0.24 *
Zn	0.00	−0.25 *	−0.07	−0.38 *	0.70 *	0.68 *		0.05	0.13 *	−0.14 *
Mn	0.24 *	0.42 *	0.32 *	0.53 *	0.13	0.04	0.18		0.19 *	0.15
Cu	−0.30 *	0.17 *	−0.27 *	0.02	0.11	0.06	0.16	0.22		0.00
Gweight	0.13	0.53 *	0.06	0.35 *	−0.28 *	−0.39 *	−0.25 *	0.07	0.00	

* indicates *P<0.05*

[a] Dflow=Days to 50% flowring; [b] Dharv=Days to harvest; [c] Byield=Biomass yield;
[d] Gyield=Grain yield; [e] CP=Crude protein; [f] Gweight=100-grain weight

Table 2. Profile of the grain's physical, nutritional/ anti-nutritional and functional properties

Traits	Average	Highest	Lowest	S.D.
Grain size[a)]				
100 seed wt (g)	11.7	18.7	4.0	2.9
Width (mm)	5.3	6.8	3.7	0.6
Length(mm)	7.2	9.7	4.8	0.9
Protein (%)[a,b)]	20.4	24.1	17.0	1.3
Micronutrient (mg/kg)[a)]				
Fe	53.1	66.3	41.4	5.0
Zn	39.6	47.3	32.1	2.9
Mn	25.3	39.4	14.7	3.8
Cu	4.8	7.3	3.4	0.7
Dietary fibre (g/100g)[c)]				
Insolble	15.7	20.6	9.0	2.7
Solble	1.2	3.4	N.D.	0.9
Oligosaccharide (mg/g)[c)]				
Stachyose	31.5	43.8	24.1	3.9
Sucrose	15.4	39.3	9.2	7.8
Raffinose	3.4	4.5	1.7	0.7
Phytic acid (mg/g)[c)]	28.3	37.0	21.8	4.6
Polyphenol (mg/g)[c)]	4.4	48.8	0.1	10.7
DPPH IC_{50} (mg/g)[c)]	416.7	1403.9	28.8	376.8
Cooking time (min)[c,d)]	97.0	160.0	60.0	23.9

[a)] Data obtained in 240 genotypes
[b)] Calculated with N-P conversion factor of 5.45
[c)] Data obtained in selected 20 genotypes
[d)] Time to reach adequate hardness (2 - 4 N) as boiled bean

Fig. 1. Various cowpea grains

Fig. 2. Relationship between grain nitrogen and grain crude protein contents