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SHORT RESEARCH ARTICLE

Appraising components of genetic variation and estimation of micronutrients and antinutrient parameters in black gram (*Vigna mungo* L.) genotypes

Radheshyam Kumawat*, Sanjeev Kumar and Subhash C. Kashyap

Abstract

A study was conducted to evaluate 30 black gram (*Vigna mungo* L.) genotypes for genetic variation in micronutrients and anti-nutritional factors. All the genotypes exhibited significant genetic variability for protein content (16.19–31.07%), iron (60.98–95.50 ppm), zinc (35.89–44.01 ppm), and selenium (1.12 to 19.53 ppm). Four genotypes, namely, PU-15-21 showed higher values for protein, PU-15-30 for iron, PU-KUG21 for zinc, and PU-8 for selenium contents. Phytic acid content ranged from 0.09 to 5.65 mg/g, with PU7 exhibiting the lowest. Correlation analysis indicated positive relationships between protein and seed yield iron and zinc contents. A few genotypes showed higher micronutrient levels and seed yield along with lower phytic acid, suggesting their potential for breeding aimed at enhancing micronutrient content and yield with low phytic acid levels in black gram.

Keywords: Blackgram, micronutrients, antinutrient, correlation, PCA

Blackgram (*Vigna mungo* L. Hepper), popularly known as urdbean or mash, is a short-duration grain legume and with high seed protein content (Gurumurthy et al. 2019). It is believed to have originated in India (Purseglove 1974) and is cultivated in tropical, subtropical, and temperate zones of Asia, including Bangladesh, India, Pakistan, Myanmar, Indonesia, Philippines, Sri Lanka, Nepal, China, Korea and Japan (Shanmugasundaram 2001). India is the largest producer, with area 4.50 mha and a production of 2.83 mt, and consumer of black gram (Jeberson et al. 2020). Major black gram cultivating states in India are Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, Rajasthan, and Uttar Pradesh (Bhagirath et al. 2010). Thisis the major dal favored by the consumers in the state of Jammu and Kashmir. Kumar et al. (2021a) reported that induced mutants of local landraces, e.g., Bhaderwah Local and Poonch Local, showed higher protein, iron, zinc contents and seed yield/plant. The grains also contain about 24% protein, 60% carbohydrate, 1.3% fat, and phosphoric acid (Kumar et al. 2021b). If genotypes with low grain phytic acid content show increased assimilation of nutrients helps in developing black gram varieties with higher micronutrient content. Salinity is a significant abiotic stress that reduces agricultural yield, particularly in rainfed environments. Selenium, a crucial micronutrient, is essential for reducing the negative consequences of various abiotic stressors (Jawad et al. 2020). Considering the above, the present study was conducted to identify the genotypes with higher micronutrients and other quality traits.

The material comprised of 30 diverse genotypes of black gram collected from GBPUAT-Pantnagar, including AZAD-2 from IIPR, Kanpur, Uttar Pradesh, Mash-114 from PAU, Ludhiana, Punjab and NU-1 from NDUAT, Faizabad, Uttar Pradesh. The material was planted under field conditions in a randomized complete block design with three replications of 2 rows each per genotype. After maturity, a small part of the composite sample was used for quality trait analysis. Protein content estimation was done by Micro-Kjedhal's method (Kjeldahl 1883). The nitric acid-hydrogen peroxide

Division of Plant Breeding and Genetics, SKUAST, Jammu 180 009, Jammu and Kashmir, India.

***Corresponding Author:** Radheshyam Kumawat, Division of Plant Breeding and Genetics, SKUAST, Jammu 180 009, Jammu and Kashmir, India, E-Mail:rdskumawat7@gmail.com

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digestion method (OH digestion method) was employed for Fe and Zn estimation (Mathew et al. 2011). Selenium estimation was done by laboratory method (wet digestion followed by flame-continuous AAS method), while phytic acid analysis was based on the research methodology given by (Davies and Reid 1979).

Mean performance of biochemical traits

Analysis of variance revealed significant differences in biochemical parameters (Table 1) among the black gram genotypes indicating considerable variability for these traits. The quality analyses showed that the mean performance of protein, iron, zinc, selenium, and phytic acid content was higher in some of the black gram genotypes (Table 2). Protein content ranged from 16.19 to 31.07, with PU-15-21 giving the highest value (31.07%). Similarly, the other micronutrients such as Iron content ranged from 60.98 to 95.50, with a maximum in PU-15-30 (95.50). Zinc content produced a wide range as presented in Table 2. Singh et al. (2017 reported 18.93 to 60.58 and 71.02 to 100.20 ppm iron and zinc in black gram, respectively. Selenium content ranged from 1.12 to 19.53, with PU-8(19.53) showing the highest. Phytic acid content ranged from 0.09 to 5.91, with minimum phytic acid content in PU-7 (0.09) followed by PU-15-40 (0.12), PU-IPU-2-43 (0.67) and PU-15-32 (0.83). However, in the present study, genotypes have low phytic acid content and can be used as donors for this trait.

Assessment of genetic parameters

Significant variance among the genotypes for biochemical parameters indicated sufficient genetic diversity in black gram. However, the phenotypic coefficient of variation (PCV) and genotypic coefficients of variation (GCV) for biochemical traits did not differ significantly, suggesting low environmental influence (Fig. 1). Various studies indicated moderate genotypic and phenotypic coefficient of variation for iron content in chickpea (Jayalakshmi and Reddy 2018) and protein content in chickpea. Higher GCV and PCV for black gram phytic acid content was reported earlier (Singh et al. 2017). The present study found that all the traits with high heritability along with higher genetic advance except Zinc content (Fig. 1) hence, these genotypes can be used as donor in hybridization programs for the development of varieties with suitably higher contents of micronutrients.

Correlation coefficient

The Correlations between and among the major biochemical parameters and seed yield per plant were estimated as per Pearson's method (Fig. 2). Significant positive association was observed between protein content and iron content (0.28**), while positive and non-significant relationship with seed yield per plant. It indicated no effect of protein on seed yield per plant. Iron content (ppm) is strongly positively associated with zinc content (0.38***). Zinc content correlated negatively and non-significant with selenium content and phytic acid. It indicated zinc content showed no effects on selenium and phytic acid. Phytic acid showed a negative correlation with all the biochemical traits except protein. Singh et al. (2017) also showed a positive correlation of iron with zinc but conflicting with phytic acid.

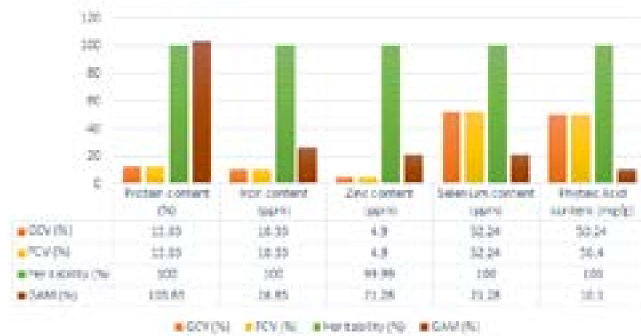

Fig. 1. Genetic variability parameters, heritability, and GAM

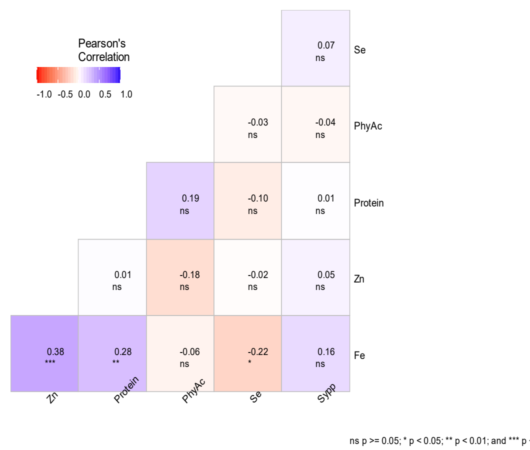

Fig. 2. Pearson's correlations for five biochemical traits

Principal component analysis

Principal component analysis (PCA) was conducted on six

Table 1. Analysis of variance (ANOVA) for five biochemical traits

Source	d.f.	Protein (%)	Iron content (ppm)	Zinc content (ppm)	Selenium content (ppm)	Phytic acid (mg/g)
Replication	2	0.129	0.013	0.0033	0.007	0.0070
Genotype	29	30.020**	175.380**	11.779**	96.356**	8.3045**
Residuals	58	0.00	0.00	0.0002	0.00	0.00

** and * indicates levels of significance at 1% and 5%, respectively

Table 2. Mean performance of biochemical traits and seed yield/plant in blackgram genotypes

Name of genotype	Protein content (%)	Iron content (ppm)	Zn content (ppm)	Selenium content (ppm)	Phytic acid (mg/g)	SY/Pl (g)	Prominent traits
AZAD-2	22.76	77.74	43.42	17.98	5.48	6.50	Zn, Se
MASH- 114	21.88	78.11	42.34	9.04	2.34	5.97	Fe, Zn, PA
NU-1	26.26	74.30	38.79	14.96	1.41	4.12	Protein, Fe, Se, PA
PU-07-7	26.26	64.72	38.91	17.32	3.64	5.22	Protein, Fe, Se
PU-10	16.19	68.76	40.18	18.97	3.59	6.21	Se
PU-13-05	22.32	69.45	38.81	11.55	4.48	8.15	Fe, Se, SY
PU-15-2	20.57	74.19	40.80	9.57	1.27	8.26	Fe, Zn, PA, SY
PU-15-21	31.07	71.77	42.48	10.34	5.91	4.20	Protein, Zn
PU-15-23	19.69	70.13	42.00	16.42	2.03	5.98	Fe, Zn, Se, PA
PU-15-26	28.01	61.04	40.01	2.93	4.84	6.04	Protein
PU-15-28	23.63	60.98	37.81	19.04	3.01	6.49	Se, PA, SY
PU-15-29	22.1	70.56	38.60	7.44	4.86	4.64	-
PU-15-30	28.01	95.50	39.93	3.25	5.58	6.32	Protein, Fe
PU-15-31	24.94	77.87	41.84	13.46	4.48	6.39	Protein, Fe, Zn, Se, SY
PU-15-32	23.63	72.84	40.51	7.74	0.83	5.14	Fe, PA
PU-15-34	20.13	72.33	39.04	7.48	2.51	5.88	Se
PU-15-35	23.01	70.53	37.76	1.12	4.48	6.40	Fe
PU-15-40	28.01	84.81	39.49	17.99	0.12	5.57	Protein, Fe and Se
PU-17-4	24.07	80.65	41.56	1.86	4.48	5.56	Fe, Zn
PU-19	27.57	88.12	40.76	14.10	5.65	7.79	Protein, Fe, Zn, Se, SY
PU-31	24.08	74.89	37.45	2.83	3.06	7.81	Fe, PA,SY
PU-35	25.82	75.94	41.23	8.12	3.23	6.56	Protein, Fe, Zn, PA, SY
PU-40	21.44	71.41	40.27	11.64	3.49	6.11	Fe, Se
PU-7	28.01	85.60	43.61	3.89	0.09	5.95	Protein, Zn,PA
PU-8	27.13	76.59	41.59	19.53	2.99	7.13	Se, SY
PU-9	27.13	63.54	35.89	13.85	4.64	6.12	Protein, Se
PU-IPU-2-43	22.32	75.36	42.65	4.88	0.67	5.74	Zn, PA
PU-KU-99-21	25.02	67.78	40.91	12.73	2.85	6.21	Protein, Zn, Se, PA
PU-KUG216	23.19	72.40	44.01	11.19	2.82	5.37	Zn, Se, PA
PU-UPU-97-1	23.67	72.34	38.66	14.12	4.09	5.28	Se
Grand Mean	24.26	74.01	40.38	10.85	3.34	6.10	-
Minimum	16.19	60.98	35.89	1.12	0.09	4.20	-
Maximum	31.07	95.50	44.01	19.53	5.91	8.26	-

Fe=Iron, Se=Selenium, Zn=Zinc, SY=Seed yield/pl, PA=Phytic acid

traits among thirty genotypes, revealing three principal components with eigenvalues exceeding one (Table 3). PC1 accounted for 26.05% of total variability with iron content (0.83) showing maximum. PC2 explained 21.10% variability, with phytic acid content contributing (0.76). PC3 captured 18.98% of variability, with the highest seed yield per plant (0.92). Genotypes rich in protein were in the first quadrant and can be utilized for protein enhancement in protein-deficient black gram genotypes. The second quadrant comprised genotypes with high phytic acid content, unsuitable for cultivation due to its anti-nutritional properties (Fig. 3). Genotypes in the third quadrant, such as NU-1, exhibited high selenium content suitable for rainfed conditions. Eight genotypes in the fourth quadrant were identified as potential donors for iron and zinc introgression and future black gram improvement programs.

The study identified superior black gram genotypes based on five parameters (Table 2). PU-15-23 displayed higher levels of Fe, Zn, Se, and seed yield per plant (SY), with lower phytic acid. With lower phytic acid, PU-KU-99-

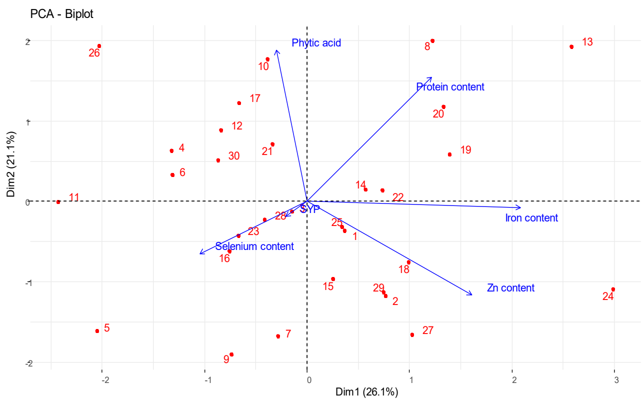

Fig. 3. Distribution of biochemical traits with seed yield per plant and 30 genotypes

Table 3. Principal component analysis for five biochemical traits

	PC1	PC2	PC3
Eigen value	1.56	1.26	1.13
Variance percent	26.05	21.10	18.98
Cumulative percent	26.05	47.15	66.14
Protein content (%)	0.48	0.62	-0.32
Iron content	0.83	-0.03	0.26
Zn content (ppm)	0.64	-0.47	-0.11
Selenium content (ppm)	-0.42	-0.26	-0.25
Phytic acid (mg/g)	-0.12	0.76	0.20
SYP	-0.08	-0.07	0.92

21 exhibited higher mean values for protein, Zn, Se, and SY. PU-35 showed higher mean values for Fe, Zn, and SY with lower phytic acid. Additionally, PU-15-32(Fe, Se, SY), PU31 (Fe, PA, SY), PU7 (Protein, Zn, PA), PU-IPU-2-43(Zn, PA) and PU-KUG216 (Zn, Se, PA) also showed higher mean value with low phytic acid content and can be used for introgression of these traits in agronomically superior varieties.

Authors' contribution

Conceptualization of research (RSK, SK); Designing of the experiments (RSK, SK); Contribution of experimental materials (RSK, SK); Execution of field/lab experiments and data collection (RSK, SK); Analysis of data and interpretation (RSK, SK); Preparation of the manuscript (RSK, SK, SCK).

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