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Correlation Studies among Nutritional Quality Parameters of Baby Corn

Sapna[1,2]*, S K Chauhan[3], D P Chaudhary[1], Z A Dar[4], R Z Sayyed[5] and H A El Enshasy[6,7]

[1]ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana–141 004, India
[2]Presently ICAR-National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi 110012, India
[3]Horticulture Division (ICAR), KAB-II, Pusa Campus, New Delhi-110 012, India
[4]Dryland Agriculture Research Station, SKUAST, Kashmir-190 001, India
[5]Department of Microbiology, PSGVP Mandal's Arts, Science, and Commerce College, SHAHADA, Maharashtra 425 409, India
[6]Institute of Bioproduct Development (IBD), Universiti Teknologi Malaysia (UTM), Johor Bahru, Malaysia
[7]City of Scientific Research and Technology Applications, New Burg Al Arab, Alexandria, Egypt

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Correlation studies made with nineteen diverse genotypes of baby corn (*Zea mays* L.) for seven nutritional quality parameters, viz., sugar, protein, potassium, ascorbic acid, phosphorus, iron and calcium contents revealed the positive association of protein content with ascorbic acid, sugar and calcium and negative with potassium and phosphorus. Ascorbic acid got a positive correlation with all the quality parameters under experiment except iron. Calcium showed a negative trend with sugar, phosphorous and potassium and positive with remaining parameters. There existed a positive and highly significant correlation between phosphorous and potassium. Iron content showed a positive correlation with potassium and calcium and negative with other parameters. This suggests that breeding for high protein content will lead to simultaneous improvement in ascorbic acid, sugar, and calcium. Similarly, selection for high iron content will simultaneously enhance potassium and calcium.

Keywords: Ascorbic acid, Calcium, Iron, Phosphorus, Potassium

Introduction

Baby corn is the young unfertilized ear of maize (*Zea mays* L.) harvested before silk emerges.[1] Maize is the third major crop of India and staple food to the poor people in many parts of the world.[2–5] China and Thailand are the major producers of baby corn globally. In India, its cultivation is now picking up in states like Western UP, Meghalaya, Haryana, Karnataka, Maharashtra, Andhra Pradesh and Punjab.[6] Corn is considered to be the most "safe" vegetable as eatable because it contains no residual effects of pesticides and insecticide as the young unfertilized cob is fully wrapped up with husk and therefore, protected from insects and diseases.[7–9] Baby corn is used in a variety of ways such as salad, chutney, pakora, candy, mixed vegetables, murabba, pickles, halwa, kheer, raita etc. Nutritionally, it is highly enriched and its nutritional quality is approximately equal or even superior to many seasonal vegetables.[10] Nutritional quality of food plays a very important role in maintaining the physiological balance of the humans and animals. As we know that, protein is one the major bio-molecule of the body, functioning as the major building block of the body. Sugars or the carbohydrates are the principal source of energy.[11] Minerals often serve as an important co-factor of enzymes and involved in biological reactions. Calcium and phosphorous are the minerals and major constituents of bones and teeth in the body. Potassium, is a mineral that serves as an electrolyte with other essential functions like assisting in balance of blood pressure, nerve impulse etc. Iron is part of haemoglobin and an essential mineral for humans. Ascorbic acid (Vitamin C) is the natural water-soluble vitamin and fights in detoxification of the body. Besides protein, potassium, vitamin B_6, sugar, riboflavin, vitamin C, and iron, baby corn is one of the richest sources of phosphorus. It is enriched with fibrous protein and easy to digest.[12] Despite very high nutritive value, very little efforts have been put on the improvement of its nutritional quality.[13] Hence, the present investigations were undertaken to seek out the correlation among seven nutritional quality traits of

*Author for Correspondence
E-mail: sapna@icar.gov.in

baby corn and explore possibilities of genetic improvement in these parameters.

Materials and Methods

The experimental material consisted of 19 genetically diverse genotypes of maize used for baby corn cultivation. The samples were oven-dried to reduce the moisture level to meet the accuracy of the results. The samples were ground to powder by using coarse and then fine grinding and de-fatted by using petroleum ether and finally kept in desiccators for analysis of various nutritional quality parameters. Protein content was determined by the Micro-Kjeldahl method of A.O.A.C.[14] Moisture content was determined by the oven drying method. Ascorbic acid (Vitamin-C) was estimated based on the fact that vitamin-C (L-ascorbic acid) gets oxidized to its dehydro form by air, especially in alkaline pH but stable in acidic medium by the method of AOAC.[14] Total sugars content was estimated according to the method of Nelson-Somogyi.[15] Total phosphorous content of baby corn was determined by the venadomolybdophosphoric acid yellow color method. The total potassium was calculated by using a flame photometer. Estimation of calcium was done by complexometric titration using EDTA.[16] Iron content was determined according to the method of Lindsay and Norvell.[17] All the samples were analyzed in triplicates.

Statistical Analysis

Analysis of variance (ANOVA), covariance, and correlations was carried out using standard procedure. ANOVA and correlation analysis were done by using statistical analysis software (SAS 9.2 English) whereas Loading plot and Scatter Plot Matrix were plotted by using SAS Enterprise Guide 4.2 version.

Pearson Correlation Coefficient |r|

A Pearson Correlation Coefficient |r| among 19 maize varieties was calculated by taking Prob > |r| under (Null Hypothesis) H0: Rho=0 by the formula given below:

$$r = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{n}\right)\left(\sum Y^2 - \frac{(\sum Y)^2}{n}\right)}}$$

Results and Discussion

The analysis of variance was significant for all the seven nutritional quality parameters indicating the presence of genetic variability in the material used for the study (Table 1). Protein content exhibited a positive correlation with ascorbic acid, sugar, and calcium, and negative with potassium and phosphorus. A positive relationship of protein and sugars indicates that nitrogen, the major building block of protein facilitates the production and use of sugars whereas a positive relationship of protein and calcium reveals its involvement in protein synthesis mechanism. Our results are in full agreement with the report of Saleem *et al.*[18] Ascorbic acid got a positive correlation with all the nutritional traits but iron. Calcium showed a negative correlation with sugar, phosphorous, and potassium whereas a positive correlation with protein, Iron and ascorbic acid. The correlation between phosphorous and potassium was positive and highly significant. Iron content showed a positive correlation with calcium and potassium and negative with other traits.

Protein gives non-significant negative correlation with potassium and phosphorous indicating the fact that higher levels of potassium and phosphorous do not contribute towards the protein synthesis despite the universal fact that potassium is essential for this process. Calcium facilitates the regulation of different cellular functions as hormone does in plants; for instance, it regulates the protein pump which in turn regulates the movement of various nutrients from root to the plant body. Adequate calcium is needed at root level as it stimulates the protein channel for uptake of nutrient. Both protein and sugar are limited to endosperm part of the seed only. The protein content

Table1 — ANOVA table of baby corn nutritional quality parameters

Parameters	Degree of Freedom	Mean Square	F-Ratio	CD (5%)	Coefficient of Variance
Moisture	18	7.19	1.75	NS	2.49
Protein	18	0.98	2.92	1.21	19.56
Sugar	18	6.22	11.39	1.54	9.45
Ascorbic Acid	18	0.45	0.9	NS	15.81
Potassium	18	294914.7	35021.11	6.07	0.13
Phosphorous	18	28944	2988.78	6.51	0.47
Calcium	18	3928.51	632.89	5.21	1.83
Iron	18	1.97	1.48	NS	23.51

is one of the most important parts of maize kernel and therefore it has been studied extensively. Similarly, a positive correlation between protein and vitamin C is another important finding which shows that breeding for high protein will lead to simultaneous enhancement in vitamin C content. There exists a non-significant inverse relationship of sugar with iron and calcium making it difficult to improve all the parameters simultaneously. Ascorbic acid got a positive correlation with all the quality traits but iron. It is a water-soluble vitamin found abundantly in baby corn and plays a variety of roles like strengthening of blood vessels, speed up healing reactions and facilitates the iron absorption. Humans, primates and guinea pigs depend on the dietary ascorbic acid due to loss of a functional form of the last enzyme (l-gulono-1, 4- lactone oxidase) of the biosynthesis pathway. A significant positive relationship between sugar and vitamin C might be because D-glucose is the precursor for vitamin C biosynthesis.

The positive and highly significant correlation between phosphorous and potassium is reported in this study. Potassium is very important for maintaining nerve function, muscle control, and blood pressure and phosphorous for other biochemical reactions occurring in the plant and animal cells. Therefore breeding programs for both will finally result in a nutritionally enriched kernel composition. Calcium showed a negative correlation with potassium, sugars, and phosphorous whereas positive with rest of four quality traits. Iron content exhibited a positive association with calcium and potassium whereas negative with the rest revealing that breeding for high protein and sugar will adversely affect the iron content possibly indicating the fact why iron deficiency is so abundant and resulted into the most common nutritional disorder i.e. Iron Deficiency Anemia (IDA) severely affects 4–5 billion people in the world and among these half of the population belongs to developing countries.[19] Iron related deficiencies can have a negative effect on body starting from cognitive development to reproductive efficiency.[20–23] Approximately 70% of the children (less than five years) are anemic in India.[24,25]

The principal component analysis (PCA) was done to ensure the extent of the importance of various parameters and shown by the loading plot in an effective way (Fig 1). Results showed that phosphorous is the major component followed by potassium and ascorbic acid. Phosphorous abundance can be explained as it is part of nucleic acids in the cell. Principal component analysis variable loadings, percentage of variance explained with cumulative variance are given in Table 2. A total of 81% of the

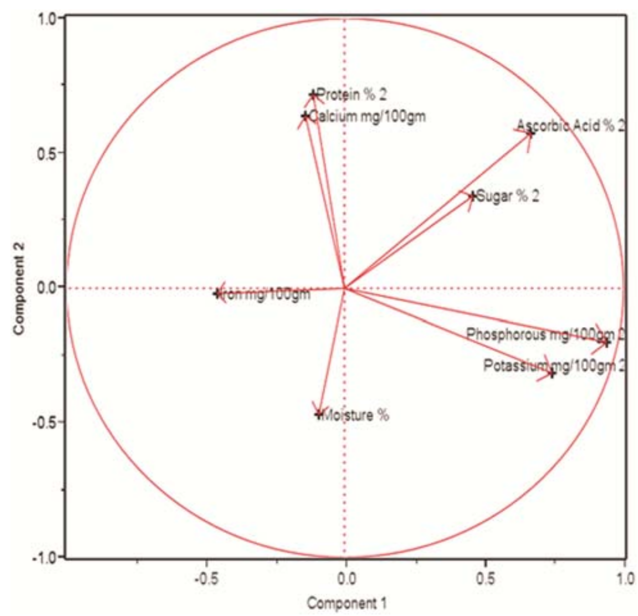

Fig. 1 — Loading plot for nutritional quality parameters of baby corn

Table 2 — Factor loading of the nutritional quality parameters of baby corn for the first four principal components analysis (PCA) and the percentage variance

Parameters	PCA1	PCA2	PCA3	PCA4
Moisture (%)	−.061	−0.35	0.64	−0.02
Protein (%)	−.073	0.54	0.19	0.10
Sugar (%)	0.30	0.25	−0.41	−0.27
Ascorbic acid(%)	0.43	0.43	0.10	−0.10
Potassium (mg/100g)	0.48	−0.24	0.00	0.53
Phosphorous (mg//100g)	0.61	−0.15	0.05	0.16
Calcium (mg//100g)	−0.09	0.48	0.38	0.44
Iron (mg//100g)	−0.29	−0.01	−0.46	0.62
Variance (%) proportion	29.36	21.47	15.99	13.76
Variance (%) cumulative	29.36	50.82	66.81	80.57

Table 3 — Correlation coefficients of nutritional quality parameters of baby corn

	Moisture (%)	Protein (%)	Sugar (%)	Ascorbic acid (%)	Potassium (mg/100g)	Phosphorous(mg/100g)	Calcium (mg/100g)	Iron (mg/100g)
Moisture (%)	1.00	−0.19	−0.26	−0.24	0.03	0.02	0.07	−0.21
		0.42	0.26	0.30	0.88	0.91	0.76	0.36
Protein (%)	−0.19	1.00	0.01	0.15	−0.17	−0.11	0.39	−0.04
	0.42		0.95	0.53	0.46	0.62	0.09	0.83
Sugar (%)	−0.26	0.01	1.00	0.39	0.05	0.26	−0.07	−0.06
	0.26	0.95		0.09	0.81	0.26	0.76	0.80
Ascorbic acid (%)	−0.24	0.15	0.39	1.00	0.20	0.45	0.30	−0.39
	0.30	0.53	0.09		0.40	0.05	0.20	0.09
Potassium	0.03	−0.17	0.05	0.20	1.00	0.86	−0.07	0.00
(mg/100g)	0.88	0.46	0.81	0.40		<.0001	0.76	0.99
Phosphorous	0.02	−0.11	0.26	0.45	0.86	1.00	−0.20	−0.35
(mg/100g)	0.91	0.62	0.26	0.05	<.0001		0.40	0.13
Calcium	0.07	0.39	−0.07	0.30	−0.07	−0.20	1.00	0.14
(mg/100g)	0.76	0.09	0.76	0.20	0.76	0.40		0.55
Iron	−0.21	−0.04	−0.06	-0.39	0.00	−0.35	0.14	1.00
(mg/100g)	0.36	0.83	0.80	0.09	0.99	0.13	0.55	

Pearson Correlation Coefficients, N = 20 Prob > |r| under H0: Rho=0

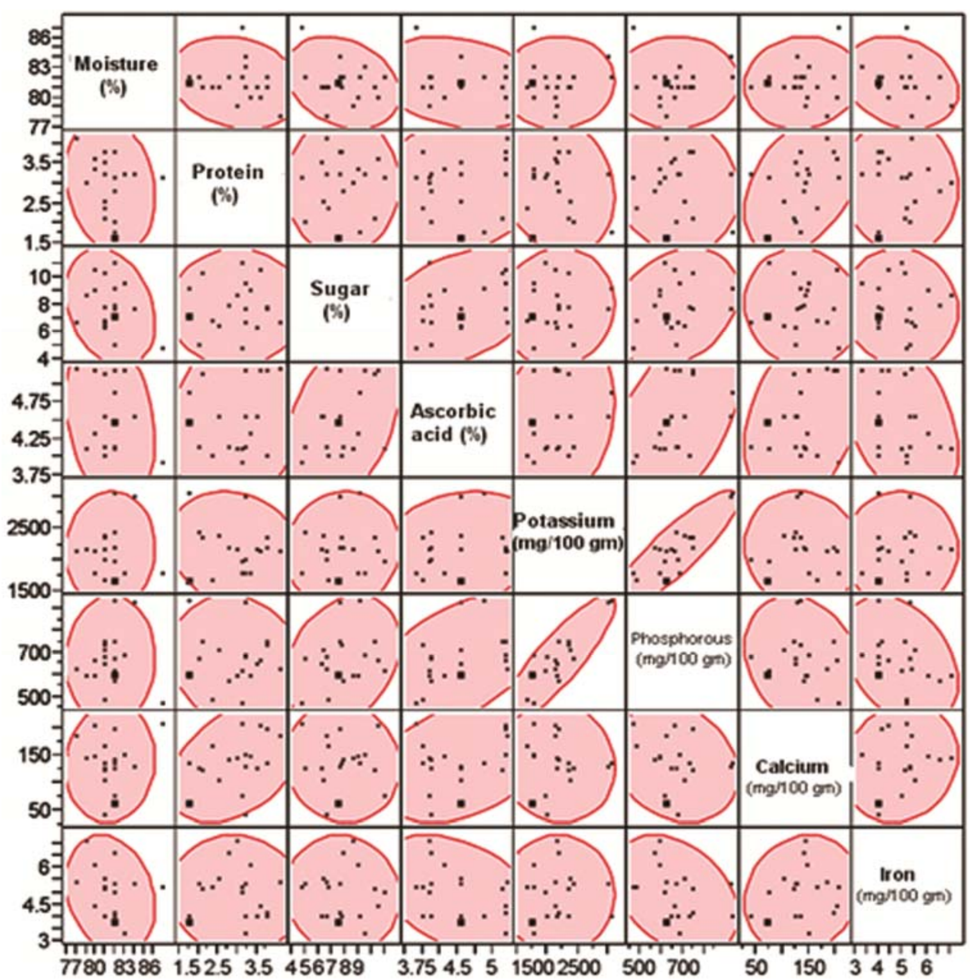

Fig. 2 — Scatterplot matrix of nutritional quality parameters of baby corn

variance is contributed by the first four principal components and 29.36% is contributed by principal component 1 (PCA 1) only having parameters like ascorbic acid, potassium, phosphorous. PCA 1 distinguished all the genotypes which have a higher content of the above-mentioned parameters. All the parameters contributed positively towards PCA 1 except moisture, protein, calcium, and iron. Principal component 2 (PCA 2) contributed 21.47% to the total variance having characters like protein, ascorbic acid, and calcium and distinguish the genotypes for these characters. Principal component 3 (PCA 3) and principal component 4 (PCA 4) accounted for 15.99% and 13.76% respectively to the total variance. This is a very efficient tool for grouping genotypes and to understand the variability for genotypic selection for crop improvement.[26,27] Correlation coefficients among various traits such as moisture, protein, ascorbic acid, sugar, phosphorous, potassium, iron and calcium, are given in Table 3 and Fig 2.

Conclusions

The present study suggests that breeding for high protein content will lead to simultaneous improvement in ascorbic acid, sugar, and calcium. Similarly, selection for high iron content will simultaneously enhance potassium and calcium. This will help in breeding improved hybrids of baby corn for nutritional quality and alleviating the "Nutritional Hunger" as well.

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