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# Variability in minerals composition of cucumber genotypes collected from Northern India

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## ABSTRACT

**Increasing the mineral contents in vegetables through breeding is considered as a suitable strategy to combat mineral deficiencies in human populations. In the present study, 21 morphologically diverse cucumber (*Cucumis sativus* L.) genotypes, comprising 19 germplasm accessions and two commercial varieties were analyzed for moisture, potassium, magnesium, iron, copper and zinc contents on a fresh weight (FW) basis. Significant differences in the mineral composition among the genotypes studied were detected. Moisture content ranged from 93.2-97.1%. The macro-minerals such as potassium and magnesium ranged from 124-161 mg and 9.76-17.6 mg/100 g FW, respectively. The micro-nutrients such as copper, iron and zinc ranged from 0.0249-0.0782 mg, 0.255-0.626 mg, and 0.0162-0.281 mg/ 100 g FW, respectively. Phenotypic co-efficient of variation and genotypic co-efficient of variation were high for the minerals studied except potassium. High broad sense heritability (83.14-99.86%) indicated the presence of additive gene effects. Three genotypes, namely, IC538155, IC538121 and IC527405 have been identified as good sources of iron, potassium and zinc. Hence, these genotypes could be utilized in breeding programmes for developing mineral rich cucumber varieties.**

**Key words:** *Cucumis sativus* L., micro-minerals, macro-minerals, variability.

## INTRODUCTION

Cucumber (*Cucumis sativus* L.; 2n = 14), one of the most important vegetables for summer, belongs to the family Cucurbitaceae. It is grown for its edible tender fruits, preferred as salad ingredient, pickles and desert fruit. It is indigenous to India and has been domesticated for at least 3,000 years (Whitaker and Davis, 14). Cucumber is often regarded as a health food because of its low calorie content and presence of vitamins and minerals. Cucumber contains 96% water that keeps body hydrated and acts as diuretic. Cucumber helps in flushing out body toxins. It's fibre-rich skin and high levels of potassium and magnesium regulates blood pressure, promotes nutrient functions, relaxes nerves and muscles and keeps blood circulating smoothly. Due to the presence of vitamins, minerals especially Mg, K, and Si, cucumber is used in skin cream, face mask, under-eye cream etc.

The recommended daily intake of Ca, Cu, Fe, Mg, Mn, K, Zn, P and Na are 1,000, 2, 18,400, 2, 1000, 15, 4000 and 2400 mg per day, respectively (DRI, 4). Vegetables hold an important place in well-balanced diets and are believed to occupy a modest place as a source of trace elements due to their high water content. However, the concentrations of Fe, Zn, and Ca are low when compared to animal food products. Therefore, increasing the content of these minerals in plant food through breeding is considered as a suitable strategy to combat mineral deficiency in human populations (Moraghan and Grafton, 8). Hence, the present study was carried out to assess variability in mineral content (potassium, magnesium, iron, copper and zinc) among cucumber genotypes and indentify the genotypes rich in mineral content.

## MATERIALS AND METHODS

A total of 21 genotypes including 19 accessions collected from northern and eastern parts of India and two commercial varieties namely Pusa Uday and Pahari Harit (Table 1) were grown in a randomized block design with three replications during rainy season of 2011 and 2012. Seeds were sown on both sides of channels on well prepared hills with a spacing of 2 m in between channels and 60 cm between hills. Five plants per genotype per replication were maintained. Fruits were harvested at commercial maturity (between 8 and 13 days after flowering), washed and cut transversely into 2 cm wide tissue discs at three positions along the length of the fruit: (a) 2 cm from the point of attachment to the plant (neck tissue); (b) midway along the length of the fruit; and (c) 3 cm from the point of style abscission. In addition, the green epidermal tissue (skin) was removed from the whole fruit. The samples were dried at 65°C in hot-air oven for 72 h until constant

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**Table 1.** Source of origin and fruit character of cucumber genotypes under study.

| Genotype | Origin | FS | FC | FL (cm) | FW (cm) | FW (g) |
|---|---|---|---|---|---|---|
| IC410617 | West Tripura, Tripura | EE | Green | 15.10 | 4.32 | 173.5 |
| IC410658 | West Tripura, Tripura | OE | Green | 19.25 | 4.57 | 308.3 |
| IC527394 | Nadia, PB | ST | Light green | 16.79 | 4.92 | 184.6 |
| IC527395 | North Parganas, PB | EE | Green | 13.48 | 4.06 | 167.0 |
| IC527400 | Nadia, PB | EE | Green | 12.95 | 3.47 | 112.5 |
| IC527402 | Murshidabad, PB | EE | Light green | 14.37 | 4.44 | 199.6 |
| IC527403 | Murshidabad, PB | EE | Light green | 19.50 | 4.74 | 268.1 |
| IC527405 | Murshidabad, PB | EE | Green | 15.52 | 4.40 | 268.0 |
| IC527410 | Burdwan, PB | OE | Green | 15.25 | 4.89 | 251.5 |
| IC527413 | Hooghly, PB | EE | Green | 16.34 | 4.45 | 141.6 |
| IC527419 | North Parganas, PB | EE | Light green | 15.31 | 4.40 | 236.3 |
| IC527423 | North Parganas, PB | OE | Light green | 16.33 | 4.61 | 293.5 |
| IC527434 | Nadia, PB | OE | Green | 13.31 | 3.81 | 150.5 |
| IC538121 | Faizabad, UP | EE | Green | 16.27 | 4.59 | 248.6 |
| IC538126 | Faizabad, UP | EE | Green | 10.35 | 2.90 | 58.3 |
| IC538145 | Sultanpur, UP | EE | Green | 13.25 | 3.14 | 98.0 |
| IC538155 | Sultanpur, UP | EE | Green | 18.91 | 4.82 | 378.6 |
| IC538186 | Gazipur, UP | EE | Light green | 16.20 | 3.65 | 147.0 |
| IC557170 | Rewari, Haryana | EE | Light green | 14.84 | 4.36 | 241.3 |
| Pahari Harit | | EE | Light green | 21.97 | 5.13 | 348.9 |
| Pusa Uday | | EE | Light green | 18.86 | 4.38 | 210.0 |

Three plants per genotype were analysed; PB = Paschim Banga, UP = Uttar Pradesh, EE = Elliptical elongate, OE = Oblong Ellipsoid, ST = Stem-end tapered.

dry weight (DW) was achieved, and then powdered and were used for the estimation of mineral content. Mineral content was estimated according to official analytical methods (AOAC, 3) with atomic absorption spectrophotometer (AAS, model-Varian Spectra AA 220 FS, Varian Australia Pty Ltd, Australia) equipped with a $D_2$ lamp background correction system, and using an air-acetylene flame (1:1).

Statistical analyses like ANOVA, simple linear correlation, principal component analysis (PCA) using correlation matrix were performed using Statistical Analysis Software, Version 9.2 (SAS, 11). The sample similarities were calculated on the basis of pair-wise Euclidean distance and the unweighted pair-group method with arithmetic averaging (UPGMA) algorithm was used for establishing cluster to search natural groupings among the genotypes for mineral content. Phenotypic (PCV) and genotypic coefficient of variation (GCV), heritability ($h^2$) in broad sense and genetic advance (GA) were estimated according to Singh and Chaudhary (12).

## RESULTS AND DISCUSSION

The results revealed that there were significant differences with wide variability among the 21 cucumber genotypes with respect to potassium, magnesium, copper, iron and zinc content (Table 2). Moisture content ranged from 93.1-97.1% with the mean value of 94.9%. In the cucumber genotypes the macro-minerals, potassium and magnesium content ranged from 123.69-160.88 mg and 9.76-17.65 mg/100 g FW, respectively. Genotypes, Pahari Harit, IC538126, IC527434, IC527405, IC538121 and IC410658 were found superior for both potassium and magnesium content compared to other genotypes analyzed. Commercial variety, Pahari Harit found to be rich in both potassium and magnesium contents compared to Pusa Uday. The values of potassium and magnesium obtained in the present study were consistent with the earlier reports (Janina *et al.*, 6; Ekholm *et al.*, 5; Rouphael *et al.*, 10). The Recommended Dietary Allowance (RDA) for potassium and magnesium are 3.2-3.7 g and 0.31- 0.34 g, respectively (Anon, 2).

**Table 2.** Moisture content (%) and macro- and micro-nutrients (mg/100 g fr. wt.) contents in 21 cucumber genotypes.

| Genotype | Moisture | K | Mg | Cu | Fe | Zn |
|---|---|---|---|---|---|---|
| | 94.1 | 140 | 11.4 | 0.0521 | 0.326 | 0.208 |
| IC410658 | 96.8 | 146 | 11.7 | 0.0366 | 0.255 | 0.193 |
| IC527394 | 95.1 | 126 | 10.8 | 0.0501 | 0.330 | 0.191 |
| IC527395 | 94.0 | 137 | 10.3 | 0.0333 | 0.501 | 0.180 |
| IC527400 | 93.5 | 132 | 10.9 | 0.0307 | 0.464 | 0.213 |
| IC527402 | 94.8 | 144 | 16.8 | 0.0385 | 0.453 | 0.235 |
| IC527403 | 95.5 | 137 | 9.76 | 0.0307 | 0.274 | 0.182 |
| IC527405 | 97.1 | 155 | 17.1 | 0.0395 | 0.626 | 0.229 |
| IC527410 | 94.1 | 128 | 12.0 | 0.0312 | 0.284 | 0.206 |
| IC527413 | 93.7 | 124 | 15.1 | 0.0399 | 0.425 | 0.195 |
| IC527419 | 93.8 | 125 | 13.9 | 0.0291 | 0.412 | 0.210 |
| IC527423 | 96.1 | 133 | 11.6 | 0.0257 | 0.353 | 0.162 |
| IC527434 | 93.2 | 155 | 17.6 | 0.0338 | 0.523 | 0.269 |
| IC538121 | 96.9 | 154 | 15.3 | 0.0437 | 0.529 | 0.281 |
| IC538126 | 96.1 | 158 | 16.2 | 0.0270 | 0.386 | 0.227 |
| IC538145 | 93.2 | 145 | 14.5 | 0.0498 | 0.457 | 0.250 |
| IC538155 | 97.1 | 142 | 11.7 | 0.0477 | 0.583 | 0.218 |
| IC538186 | 93.5 | 141 | 15.0 | 0.0782 | 0.293 | 0.175 |
| IC557170 | 95.6 | 134 | 12.6 | 0.0385 | 0.355 | 0.190 |
| Pahari Harit | 96.3 | 161 | 12.9 | 0.0249 | 0.423 | 0.213 |
| Pusa Uday | 94.6 | 136 | 10.7 | 0.0667 | 0.386 | 0.193 |
| Mean | 94.9 | 141 | 13.2 | 0.0404 | 0.411 | 0.210 |
| CV% | 1.44 | 8.01 | 18.6 | 33.5 | 25.1 | 14.4 |

Three plants per genotype were analysed and from each plant three samples were taken

Hence, intake of 100 g of cucumber could contribute 3.8- 4.39% of RDA of the potassium and 3.89-4.27% of RDA of the magnesium intake.

Among the micro-minerals studied, copper, iron and zinc content ranged from 0.0249- 0.0782, 0.255-0.626 and 0.162-0.281 mg/100 g FW, respectively, with the corresponding mean value of 0.0404, 0.411 and 0.210 mg/100 g FW. Copper and iron showed significant differences with wide variability among the genotypes studied compared to zinc. Germplasm accessions, IC527405, IC538155 and IC538121 were found to be superior for iron content among the genotypes, whereas IC538181 was found superior for both copper and zinc. Commercial variety, Pahari Harit was found to be superior for iron and zinc contents compared to Pusa Uday, which was rich in copper. The values of iron and copper contents obtained in the present study were consistent with the earlier reports (Moreno *et al.*, 9; Abulude *et al.*, 1; Rouphael *et al.*, 10). However, zinc content obtained in the present study was slightly higher than the earlier reports. Adequate dietary intake of iron, zinc, and copper is essential to human health. Intake of 100 g of cucumber could contribute 1.71-3.73% of iron, 1.5-2.14% of zinc and 2.02% of copper to the dietary intake.

All the significant correlations, *viz*., potassium with magnesium and zinc (r = 0.511 and 0.589, respectively, at $P < 0.05$), magnesium with potassium, iron and zinc (r = 0.511, 0.453 and 0.648, respectively, at $P < 0.05$) and iron with zinc (r = 0.598, at $P < 0.05$) were found to be positive (Table 3). Among the fruit characteristics, fruit length and width showed significant positive correlation with fruit weight (r = 0.788 and 0.825, respectively, at $P < 0.05$). Such correlation analysis will facilitate selection of genotype with improved nutritional quality, as selection for one trait leads to selection of genetically correlated other traits (Wricke and Weber, 15). However, correlation analysis alone could not give a complete picture of interrelations because it considers only two minerals at a time, regardless of

**Table 3.** Linear correlations (r) between the different traits in cucumber.

| | K | Mg | Cu | Fe | Zn | Fruit length | Fruit width | Fruit weight |
|---|---|---|---|---|---|---|---|---|
| Moisture | 0.442$^{ns}$ | -0.022 $^{ns}$ | 0.546$^{**}$ | 0.176 $^{ns}$ | 0.045 $^{ns}$ | 0.428 $^{ns}$ | 0.431 $^{ns}$ | 0.667$^{**}$ |
| K | | 0.511$^{**}$ | 0.128 $^{ns}$ | 0.392 $^{ns}$ | 0.589$^{**}$ | 0.004 $^{ns}$ | -0.224 $^{ns}$ | 0.078$^{ns}$ |
| Mg | | | -0.091$^{ns}$ | 0.453$^{**}$ | 0.648$^{**}$ | -0.412 $^{ns}$ | -0.363 $^{ns}$ | -0.293$^{ns}$ |
| Cu | | | | 0.380 $^{ns}$ | 0.282 $^{ns}$ | 0.470 $^{ns}$ | 0.597$^{**}$ | 0.581 $^{ns}$ |
| Fe | | | | | 0.598$^{**}$ | -0.209 $^{ns}$ | -0.124 $^{ns}$ | 0.039 $^{ns}$ |
| Zn | | | | | | -0.309 $^{ns}$ | -0.252 $^{ns}$ | -0.170 $^{ns}$ |
| Fruit length | | | | | | | 0.771$^{**}$ | 0.788$^{**}$ |
| Fruit width | | | | | | | | 0.825$^{**}$ |

the interrelationship with other minerals in the set of data. Hence, PCA was carried out using all minerals studied, to understand the underlying interrelationships in the whole set of mineral data and to select the best linear combination of minerals that explains the largest proportion of the variation in the data set.

Estimation of PCA revealed that the first three principal components (PCs) together governed 87.48% of the total variability (Table 4). PC1 and PC2 individually explained about 53.59 and 22.70 of the total variance, respectively. The Eigen values indicated that two components provide a good summary of the data, two components accounting for 76.29% of the total variance. Subsequent components contribute less than 11% each. The first component is a measure of the overall mineral content, since the first Eigen vector shows approximately equal loadings on all minerals except copper, which have less loading. The second Eigen vector has high positive loadings on copper followed by iron. Hence, it is clear that iron and copper followed by potassium contributing much towards the total variability among the cucumber studied.

The characters like minerals are generally quantitative in nature and exhibit considerable degree of interaction with gene. Thus, it becomes necessary to compute variability present in the material and its partitioning into genotypic and phenotypic effects. In the present study, the values of phenotypic coefficient of variability (PCV) were greater than the corresponding genotypic coefficient of variability (GCV) values, indicating the influence of non-additive gene action (Shukla *et al*., 13). Copper and iron followed by magnesium showed high PCV and GCV values, while potassium showed low PCV and GCV values (Table 5). The broad sense heritability for micro- and macro-minerals was more than 83% with maximum of 99.86% for zinc followed by magnesium. The expected genetic advance as percentage of mean ranged from 14.69 to 64.49%. Maximum genetic gain was observed for copper (64.49%) followed by iron (50.29%). Potassium showed low genetic gain (14.69%). High broad sense heritability values indicated the predominance of additive gene action in the expression of these traits and can be improved

**Table 4.** Eigen vectors and Eigen values for first three principal components (PC1, PC2 and PC3) in cucumber genotypes.

| Particulars | PC1 | PC2 | PC3 |
|---|---|---|---|
| Eigen value | 2.68 | 1.14 | 0.56 |
| Percentage of variance | 53.59 | 22.70 | 11.19 |
| Cumulative variance | 53.59 | 76.29 | 87.48 |
| Parameters | | Eigen vectors | |
| Potassium | 0.461 | -0.184 | 0.777 |
| Magnesium | 0.468 | -0.443 | -0.283 |
| Copper | 0.209 | 0.836 | 0.187 |
| Iron | 0.476 | 0.263 | -0.529 |
| Zinc | 0.546 | -0.014 | -0.024 |

**Table 5.** Phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (%), and genetic advance for various mineral constituents of cucumber.

| Mineral | Selection parameter | | | |
|---|---|---|---|---|
| | PCV (%) | GCV (%) | $h^2B$ (%) | GA (%) |
| Potassium | 8.58 | 7.82 | 83.14 | 14.69 |
| Magnesium | 18.70 | 18.67 | 99.69 | 38.41 |
| Copper | 32.27 | 31.79 | 97.00 | 64.49 |
| Iron | 24.49 | 24.45 | 99.67 | 50.29 |
| Zinc | 14.55 | 14.54 | 99.86 | 29.93 |

PCV = Phenotypic coefficient of variation, GCV = Genotypic coefficient of variation, $h^2B$ (%) = broad sense heritability, GA (%) = Genetic advance.

through individual plant selection. However, high heritability alone is not enough to make sufficient improvement through selection generally in advance generations unless accompanied by substantial amount of genetic advance (Johnson *et al*., 7). Heritability estimates along with genetic advance are more useful in predicting the resultant effect for the selection of the best individuals from a population. The heritability and genetic advance values were high for copper, iron followed by magnesium, suggests that these traits are under genetic control and significant improvement can be obtained for these traits.

The dendrogram generated, based on mineral contents, revealed three distinct clusters containing 13 (Cluster I), 4 (Cluster II), and 4 (Cluster III) genotypes at the linkage distance of 1.0. In general, the majority of genotypes present in Cluster I had lower amount of all the minerals studied, whereas those in Cluster II possess high amount of potassium, magnesium followed by zinc and moderate amount of iron. Genotypes in cluster III contained high amount of iron, potassium and copper and moderate amount of zinc and magnesium. The study revealed wide variability among the cucumber genotypes collected from north and eastern parts of India with respect to potassium, magnesium, copper, iron and zinc content. Iron, copper followed by potassium contributing much towards the total variability among the cucumber genotypes studied. Based on cluster analysis, three genotypes, IC538155, IC538121 and IC527405 have been identified as good sources of iron, potassium and zinc (Fig. 1). Hence, these genotypes could be utilized further in breeding programmes for developing mineral rich varieties. This could be of particular importance for developing countries like India, where iron deficiency anemia is a serious public health problem, affecting all segments of the population (50-70%), especially infants and pregnant women.

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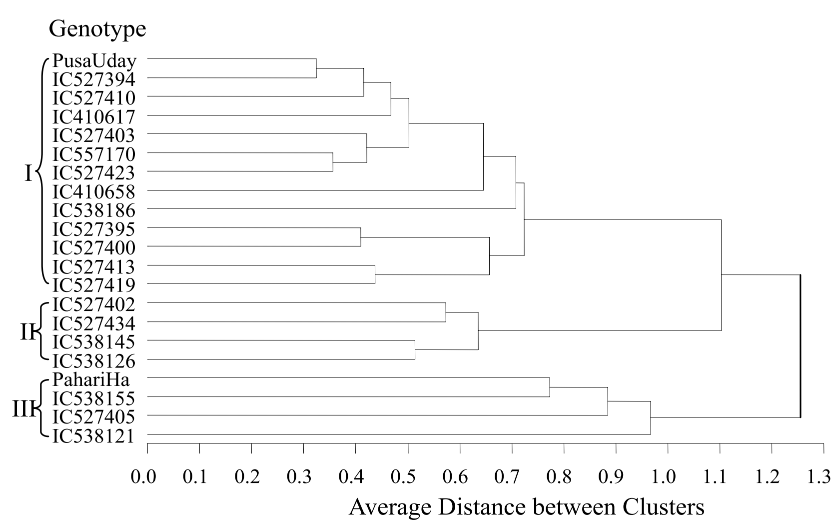


**Fig. 1.** Clustering of cucumber genotypes studied based on macro- and micro-mineral composition.

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