Screening for Zn & Fe content and its bioavailability in Common bean (Phaseolus vulgaris L.)

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Abstract

Common bean is one of the most important legume crops grown worldwide. Micronutrients like Zinc and Iron are among the important minerals that are required in the diet to fulfill the nutritional needs of people. Therefore, present study was conducted to identify lines showing higher content for micronutrients in common bean. A set of 96 lines were collected and evaluated for a variety of morphological traits and based on the preliminary trait evaluations and phenotyped for nutrient content using Diacid method of Zn and Fe estimation. The lines showed a normal distribution with significance level (p-value) greater than 0.05. The ANOVA analysis for the 96 bean accessions revealed significant difference for all parameters, (p ≤ 0.01), the mineral content for both Fe and Zn has shown significant difference among the Common bean lines, described diversity of micronutrient content in dry seeds was found among the common bean lines with a high level of diversity for each, but several accessions with lower levels of nutrients were also identified. A high variation of Fe content was identified in the genotypes and a good normal distribution for Zn content was observed in germplasm. The screening deciphered the mean values identifying cultivars with high amounts of Fe and Zn could contribute significantly to improvements of micronutrient of people depending on the common bean as major component of their diet and the germplasm identified can be used as breeding lines for varietal improvement. The current estimation, therefore, was conducted to evaluate variability of iron and zinc concentrations among common bean germplasm grown at SKUAST-J, Jammu & Kashmir.

Keywords: Common bean, Germplasm, micronutrients, Diacid

Introduction

Common bean (Phaseolus vulgaris L.) is an annual legume crop and is suitable for consumption purpose, as dry beans provide a major source of quality protein consists of high lysine and therefore complements most cereals. In addition, beans are high in carbohydrates, fibre, and minerals (calcium, potassium, phosphorus, iron, zinc and magnesium). In terms of nutritional importance legumes provide complementary nourishment in the form of proteins, lipids (oil), and minerals. Important mineral (Ca, Fe, Mg, P, K, Na, Zn, Mn) levels are higher in legumes than in cereals. Common bean is high in starch, protein and dietary fibre and is an excellent source of iron, potassium, selenium, molybdenum, thiamine, vitamin B6, and folate. Therefore, beans are sometimes also called as “poor man’s meat” as it has high proteins and rich content of other nutrients like iron, zinc and vitamins (Beebe et al. 2000) and complement the non-vegetarian diets of people. Whereas it also complements cereals and other carbohydrate rich foods in providing near perfect nutrition to people of all ages and helps to lower cholesterol and cancer risks (Singh, 2000). However, the concentrations will vary in response to both genetic and environmental factors (Grusak, 2002). Recent reports indicate that Fe deficiency is the most prevalent micronutrient problem in the world affecting over 2 billion people, most of who depend on beans as staple food (Welch and Graham, 1999) and 40% of Fe intake in developing countries is derived from legumes and cereals. Other studies have identified Zn deficiencies in children depending on diets high in starchy foods (Runam, 1999). The deficiency of Zinc in human body can cause delay in growth and in sexual maturity, hypo-gonadism, hypospermia, alopecia, skin rashes, slow healing of wounds, immuno-deficiencies, behavioral disorders, night blindness and loss of appetite. In general, 1.4% of deaths are attributed to a lack of zinc (WHO, 2011). Available literature indicates existence of comparable ranges of mineral concentrations among seeds of most leguminous species (Wang et al., 2003). Thus, identifying cultivars with high amounts of Fe and Zn could contribute significantly to improvements of micronutrient of people depending on the common bean as major component of their diet. The current study
therefore, was conducted to evaluate variability of iron and zinc concentrations among common bean germplasm grown at SKUAST-J, Jammu & Kashmir.

Material & Methods

Plant Material: A set of 96 diverse common bean lines (core set) selected from a set of 429 lines based on morphological trait diversity (qualitative trait diversity) was used during the present study. The 96 lines included 54 local landraces from 11 hot-spots of state Jammu and Kashmir and 42 exotic lines belonging to 10 countries. In addition, 45 lines in the core set belongs to Mesoamerican gene pool, while as 51 lines belongs to Andean gene pool. The germplasm consists of different bean market classes possessing different shape, size and colour classes.

Trait Phenotyping: The 96 accessions were also subjected to trait phenotypic with the diacid digestion protocol (Jackson, 1973) in which 1gm of ground sample was taken and transferred into a digestion flask followed by addition of 5ml diacid mixture (Nitric acid: Perchloric acid in ratio of 3:1), Digestion of samples over the hot plate with increasing temperature up to 300 degree for about half hour so that the solution turns clear. After digestion the digestion tube was allowed to cool down, the peroxide was added to bleach the solution. The solution was again put for digestion on the hot plate, heated till the solution appears the colourless. Further readings were taken on the standardized AAS (Atomic Absorption Spectrophotometer) using standard AR grade Zinc and Iron standard 0.439g AR grade ZnSO$_4$ and and AR grade ammonium ferrous sulphate (NH$_4$)$_2$SO$_4$FeSO$_4$.6H$_2$O.

Data analysis

The descriptive statistics for the trait data treatment was performed using the software SPSS (Statistical Package for the Social Science) version 20.0 for analysis of variance for the germplasm.

Result and Discussion

Analysis of Variance for seed zinc and seed iron content:
The 96 lines have been found diverse in terms of seed morphology traits and represent all the major common bean growing regions/sites of Jammu & Kashmir (India) and nearly one dozen countries (Russia, Sweden, USA, Turkey, Iran, Syria, Ukraine, Portugal, Norway and Denmark) of the world excluding India. Therefore, this diverse set of 96 lines was evaluated for seed Zn and seed Fe content. A descriptive statistical analysis was made for each (Zn & Fe) parameter. One-way ANOVA was applied to evaluate the variance of mineral parameters. Seeds samples of the selected accessions were analyzed for their mineral traits. Nutritional composition of common beans can vary as a result of the influence of genetic diversity as well as environmental conditions including temperature, soil and fertilization (nutrients) Singh et al. 1991, Kigel et al. (1999). This portion of subject was to evaluate if crop diversity as in Freitas et al. (2011) influences the variability of nutritional and mineral composition presented in Table 1.

Table 1: The Mean and Standard error values of proximate mineral (Fe) & (Zn) composition performed on 96 bean accessions are

<table>
<thead>
<tr>
<th>Source</th>
<th>Zinc</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.S</td>
<td>2185.18*</td>
<td>71.51*</td>
</tr>
<tr>
<td>Error</td>
<td>6.43</td>
<td>44.70</td>
</tr>
<tr>
<td>CD</td>
<td>5.042</td>
<td>13.293</td>
</tr>
<tr>
<td>SE(d)</td>
<td>2.536</td>
<td>6.686</td>
</tr>
<tr>
<td>SE(m)</td>
<td>1.793</td>
<td>4.728</td>
</tr>
<tr>
<td>CV</td>
<td>4.178</td>
<td>12.540</td>
</tr>
</tbody>
</table>

Fig 1a: Distribution of mean values of Fe content
All parameters showed a normal distribution with significance level (p-value) greater than 0.05. The ANOVA analysis for the 96 bean accessions revealed significant difference for all parameters, (p<0.01), the mineral content for both Fe and Zn has shown significant difference among the Common bean lines, describes diversity of micronutrient content in dry grains was found among the common bean lines, particularly high level of diversity for: Fe and Zn, but several accessions with lower levels of nutrients were also identified. The mineral content for both Fe and Zn has shown significant difference among the Common bean lines, described diversity of micronutrient content in dry seeds was found among the common bean lines with a high level of diversity for each, but several accessions with lower levels of nutrients were also identified. A high variation of Fe content was identified in the genotypes PBG-578, PBG-581, WB-947, WB-665, WB-792 having mean values 117.410, 129.705, 161.485, 128.875, 122.320 respectively. And for Zn it has shown EC-13096, EC-21753 and Local-2 with their mean value 135.670, 126.020, 150.920, the difference among them observed to be significant. Whereas line WB-970 has shown both optimum Fe and Zn content with average mean values 97.990 and 90.290 respectively. According to reported data by Samman et al. (1999) [10], on six varieties of bean, range of variation for, Fe (9 to 18 mg/100g) and Zn (2.5 to 4 mg/100g). Our findings are similar. While regarding to Cabrera et al. (2003), Higher results for micronutrients were reported by Paredes et al. (2009) [8], Fe (68.9 to 152.4 mg kg-1) and Zn (27.9 to 40.7 mg kg-1). In an analysis of some accessions at CIAT*, the range for Fe was (34 to 89 mg kg-1), and for Zn (21 to 54 mg kg-1), while the content of Fe and Zn in our study of CBL was also similar in results reported by Islam et al. (2002) [3]. The detection of differences within the lines for respected nutrient content was observed as shown in Figure 1a & 2a. In present study nutrients have shown variability within the germplasm in comparison to Zn content distribution as shown in Figure 1a.

Conclusions

The evaluated common bean landraces represent a good variability for the analysed micronutrients. In terms of micronutrient content of common bean landraces, there was found optimum content of micronutrients Zn & Fe compared to previously published researches. The differences among germplasm were significant for Fe and Zn. The genetic diversity among landraces makes them a valuable resource as potential donors of genes for plant breeding.. Finally, it could be concluded that it is possible to identify genetic diversity within common bean genotypes for micronutrients as a prerequisite for breeding strategy aiming at increasing their concentrations, bioavailability and utilisation in human nutrition.

References


