

Importance of Iron in Maize (*Zea mays* L.) genotypes and quantification of iron content by Atomic Absorption Spectrophotometry



Biology

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ABSTRACT

Nutritional deficiencies (e.g. iron, zinc, vitamin A etc.) account for almost two-thirds of childhood death worldwide. Most of these afflicted are dependent on staple crops such as rice, wheat and maize for their sustenance. Thus, micronutrient enrichment, i.e. biofortification of staple food crops has been considered a sustainable strategy to tackle the problem of micronutrient deficiencies. Maize is the one of the most important staple food grain in the diets of a large population of humans. Apart from carbohydrates, it is also a good source of proteins and micronutrients. The present study was conceptualized and executed for screening maize genotypes for iron content with micronutrient content in maize genotypes. Fourteen maize genotypes were obtained from the Maize Research Centre, ARI, ANGRAU, Hyderabad. The samples analyzed for grain iron content by Atomic Absorption Spectrophotometer, were grouped under high, medium and low categories. The iron content of the maize genotypes ranged from 9.81 to 80.47 mg / kg of grain and four genotypes had high iron content, six genotypes possessed medium iron content and four genotypes exhibited low iron content.

INTRODUCTION

Maize (*Zea mays* L.) is a major cereal crop widely consumed in developing countries, which have a high prevalence of anemia due to iron (Fe) deficiency. Iron deficiency may affect as many as 3000 million people in the world (Underwood, 2000). The major cause of iron deficiency in these countries is inadequate intake of bioavailable iron, where poverty is a major factor. Therefore, biofortification of maize by increasing iron concentration and / or bioavailability has great potential to alleviate this deficiency. Biofortification is the process of breeding food crops that are rich in bioavailable micronutrients. These crops fortify themselves by loading high levels of minerals and vitamins in different plant parts. Both conventional and molecular breeding approaches can be used for selection of high micronutrient and low anti-nutrient lines. Parental lines are normally screened for nutrient content and closely linked DNA markers will be identified in marker assisted selection. A better understanding of iron homeostasis, involving knowledge of the basic physiological processes of iron absorption, distribution and storage in plants, can serve as a starting point for the biotechnological manipulation of crops (Grusak, 2002 and Grotz and Guerinet, 2002). Maize is also a model system for genomic research and thus allows the opportunity for gene discovery (Hoekenga *et al.*, 2007).

MATERIAL AND METHODS

Materials

Fourteen popular maize genotypes were used for screening studies on iron content and identification of Simple Sequence Repeats (SSR) DNA markers closely linked with high and low iron content. The details of the maize genotypes selected are given in Table 1.(10 page)

Methods

Screening of maize genotypes for micronutrient (iron) content

The maize genotypes were collected from Maize Research Centre, Agricultural Research Institute (ARI), ANGRAU, Rajendranagar. These samples were analyzed for iron content by Atomic Absorption Spectrophotometry.

The plant parts were digested to convert organic form of nutrient to inorganic form before actual analysis is carried out.

Wet digestion

Wet digestion method was used for digesting the powdered maize samples for analysis of mineral contents. This method subjects the food sample to acid digestion.

Preparation of sample The seed sample was dried in shade, powdered with the help of a mechanical grinder and preserved in a paper bag.

Digestion and Distillation

The concentrated acid mixture used for digestion includes HNO_3 , H_2SO_4 , and HCl in a ratio of 9:4:1. This mixture is called digestion/Triacid mixture. In a 150ml conical flask exactly 1g of seed sample was weighed and 10 -12ml of triacid mixture was added and allowed for cold digestion for about 24 hrs. Then hot digestion was done by heating the contents at 250°C. A funnel was placed on the conical flask. At the end of digestion, if a clear solution is not obtained and the digested sample is dark in color, 3-4 ml of HNO_3 was added after cooling. Digestion was continued till a clear solution was observed. After cooling the flask and transferring the contents to a 100ml volumetric flask by using a funnel with repeated washings, the volume was made up. If a white precipitate is observed, filtration is done after volume is made up and used for analysis in the AAS.

Atomic Absorption Spectrophotometer

In the "excited state", as the number of atoms in the light path increase, the amount of light absorbed also increases. By measuring the amount of light absorbed, a quantitative determination of the amount of analyte can be made. The use of special light sources and careful selections of wavelengths allow the specific determination of individual elements.

INSTRUMENTATION OF AAS

There are five basic components of an atomic absorption instrument:

1. The light source (hollow cathode lamp / Electrode less discharge lamp) that emits the spectrum of the element of interest.
2. An absorption cell in which atoms of the sample are produced (flame, graphite furnace).
3. A Monochromator for light dispersion.
4. A detector which measures the light intensity and amplifies the signal.
5. A display that shows the reading after it has been processed by the instrument's electronics.

Atomic Absorption Spectrophotometer, model (Varian 240 FS, Australia) was used for analysis of iron in maize grains.

Fourteen popular maize genotypes including seven inbred lines (BML-6, BML-7 and BML-10, CM-118, CM-119, CM-130 and CM-211), one pop corn (Amber popcorn), two sweet corn (Madhuri and Priya) and four quality protein maize lines (QPM-91-2, QPM-66, QPM-66-2 and QPM-266-2) were collected from Maize Research Centre, Agricultural Research Institute (ARI), ANGRAU, Hyderabad. The iron content of grain samples of these maize genotypes were estimated by Atomic Absorption Spec-

trophotometer (Varian 240 FS, Australia). Based on grain iron content, the genotypes with less than 20 mg / kg were categorized as low iron containing genotypes, while those with iron content between 20-40 mg / kg were classified as medium and those with more than 40 mg / kg iron content as high iron containing genotypes.

RESULTS AND DISCUSSION

The present investigation was undertaken to screen fourteen maize genotypes for micronutrient (Fe) content

SCREENING OF MAIZE CULTIVARS FOR MICRONUTRIENT (IRON) CONTENT

Fourteen maize genotypes were collected from Maize Research Station (ARI), Rajendranagar. From the following fourteen maize cultivars, 1g of the grain of each maize cultivar was weighed, and powdered at micronutrient Lab (ARI, Rajendranagar, and Hyderabad).

The powdered yellow maize samples were then estimated for iron content by Atomic Absorption Spectrophotometry. The results for iron content of the following maize genotypes arranged in descending order of concentration are presented in the Table 2.(10 page).

Based on the results obtained on iron content, the maize genotypes were classified under high, medium and low categories. Out of the fourteen maize samples used in the study, the iron content of different maize genotypes ranged from 9.81 to 80.47 mg / kg. Four genotypes had high iron content ranging from 42.08 to 80.47 mg / kg. Around six genotypes had medium iron content ranging from 22.01 to 26.08 mg /kg and the remaining four genotypes had low iron content ranging from 9.81 to 19.85 mg / kg.

The iron content of different maize genotypes ranged from 9.81 to 80.47 mg / kg (Table 2). Four genotypes had high iron content ranging from 42.08 to 80.47 mg / kg, while six genotypes showed medium iron content ranging from 22.01 to 26.08 mg / kg and the remaining four genotypes exhibited low iron content ranging from 9.81 to 19.85 mg / kg.

CONCLUSION

Maize is important feed and industrial crop. It plays an important role in human and animal nutrition. It is grown in tropical, subtropical and temperate countries. It is grown primarily as a food grain crop to meet the food demand for humans and animals.

Biofortification is development of the micronutrient dense staple food crop using the best traditional breeding practices and biotechnology. The present study was conceptualized and executed for screening maize genotypes for micronutrient (iron) content. The powdered yellow maize seeds were estimated for iron content by Atomic Absorption Spectrophotometry. Based on the results obtained, the maize genotypes were grouped under high, medium and low categories for iron content. Among the fourteen maize samples used for the study, the iron content of the maize genotypes ranged from 9.81 to 80.47 mg / kg of grain. Four genotypes had high iron content ranging from 42.08 to 80.47 mg / kg. Six genotypes had medium iron content ranging from 22.01 to 26.08 mg / kg and four genotypes had low iron content ranging from 9.81 to 19.85 mg / kg.

The genotypes identified in the present study could be used as a tool for identifying and mapping of new genes for high and low iron contents. Additional biochemical methods may be surveyed in the targeted region in an attempt to find genotypes closely flanking the genes governing high iron and low iron contents in the maize grains.

Table 1: Maize genotypes selected for the study

S. No.	Genotypes	characters
1.	BML - 6	-
2.	BML -7	-
3.	BML -10	Inbred lines
4.	CM -118	-
5.	CM -119	-
6.	CM -130	-
7.	CM -211	Dent types
8.	Amber popcorn	Popcorn
9.	Madhuri	-
10.	Priya	Sweet corn
11.	QPM -91-2 WS	-
12.	QPM - 66 WS	-
13.	QPM - 66-2WS	-
14.	QPM -266-2 WS	QPM lines

Table 2: Iron content (mg / kg) of maize genotypes

S. No.	Genotypes	Iron Content (mg / 1000g)
1.	QPM - 91 - 2	80.47
2.	Amber popcorn	46.08
3.	BML - 7	45.06
4.	CM - 119	42.08
5.	CM - 130	26.08
6.	BML - 10	26.06
7.	CM - 211	24.75
8.	BML - 6	24.51
9.	QPM - 66	24.04
10.	QPM - 66 - 2	22.01
11.	Priya	19.85
12.	Madhuri	19.12
13.	CM - 118	19.05
14.	QPM - 266 - 2	9.81

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