Research Application Summary

Characterisation of micronutrient (zinc and iron), dense tropical maize hybrids grown in two different environments in Zambia

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Abstract

Iron and zinc deficiencies that are prevalent in most sub-Saharan African countries have been attributed to the low grain micronutrient levels in local varieties. The study characterised micronutrient (iron and zinc) dense maize germplasm so as to identify promising inbred lines to introduce to maize breeding in Zambia. The study was conducted in two locations. Locations were different for kernel zinc levels with National Irrigation Research Station (NIRS) having 19.2 mg/kg and Golden Valley Agricultural Research Trust (GART) 18.7 mg/kg. No differences were observed among locations and entries, and neither were there any significant interactions with regards to kernel iron levels, though the levels were within acceptable range of 13.6 mg/kg for genotype 07C04592B and 17.9 mg/kg for genotype 07C04602B. Differential responses for grain yield were observed among genotypes from one location to another. Differences in plant growth and development parameters observed among entries were due to the growing conditions and the soils found at the two locations. Three high yielding entries were identified; 07C04602B, 07C04568B and 07C04578B. They also contained high kernel iron and zinc levels.

Keywords: Iron, maize, micronutrient, Zambia, zinc

Résumé

Les carences en fer et en zinc qui sont répandues dans la plupart des pays de l’Afrique sub-saharienne ont été attribuées à des faibles niveaux de micronutriments des grains dans les variétés locales. L’étude a caractérisé le germoplasme du maïs dense en micronutriments (fer et zinc) afin d’identifier les lignées prometteuses à introduire pour la reproduction du maïs en Zambie. L’étude a été menée en deux endroits. Les emplacements ont été différents pour les niveaux intérieurs de zinc avec « National Irrigation Research Station (NIRS) » ayant 19,2 mg / kg et « Golden Valley Agricultural Research Trust (GART) » 18,7 mg / kg. Aucune différence n’a été observée entre les sites et les entrées, ni des interactions significatives en ce qui concerne les niveaux intérieurs de fer, bien que les niveaux étaient dans la fourchette acceptable de 13,6 mg / kg pour le génotype 07C04592B et 17,9 mg / kg pour le génotype 07C04602B. Les réponses différentielles pour le rendement en grain ont été observées entre les génotypes d'un endroit à un autre. Les différences dans la croissance des plantes et les paramètres de développement observés parmi les entrées sont dues aux conditions de croissance et les sols trouvés dans les deux sites. Trois entrées de haut rendement ont été identifiées : 07C04602B, 07C04568B et 07C04578B. Ils comportaient aussi des niveaux élevés intérieurs de fer et de zinc.

Mots clés: Fer, maïs, micronutriment, Zambie, zinc

Background

Most of the maize genotypes grown in sub-Saharan Africa lack adequate micro-nutrients thereby posing a serious threat to the health of the people who subsist on maize. This is especially alarming in Zambia where maize is a staple food for more than 70% of the population (CSO, 2009). In this study, Iron and Zinc were singled out due to their being among the top ten major risks contributing to the prevalence of disease in the world (Ronaghy, 1987; Welch, 2001; Long *et al.*, 2004). Micronutrient deficiencies have been associated with the maize based diets among the resource poor households. Biofortification (the breeding of micronutrient dense cereals using conventional breeding and biotechnology) is a new initiative that has been coined to help combat micronutrient deficiency among resource poor people who subsist on maize and other cereals (Nestle *et al.*, 2006). It is a seed based technology which can compliment current intervention methods like supplementation and fortification of foods which are consumed daily.

Literature Summary

Cereals are naturally low in minerals, vitamins and protein but they are good calorie sources (Pfeiffer and McClafferty, 2007). Due to rising food prices, people's diets have become more cereal based cutting out other foods that are rich in micronutrients like legumes and fruits, thus narrowing diet diversity which is the long term mitigating factor for micronutrient deficiencies. Micronutrient enrichment traits are available within the genomes of the major staple crops that could permit substantial increases in Iron, Zinc and pro-vitamin A carotenoids without negatively impacting yield (Welch and Graham, 2002).

Study Description

Ten high zinc and iron maize hybrids were evaluated during the 2008/09 growing season in two locations, National Irrigation

Research Station (NIRS) and Golden Valley Agricultural Research Trust (GART), using the randomised complete block design. Soil samples were collected from the locations and analysed. Data on several plant growth and development parameters were also collected including disease score, plant height, ear height, ears per plant, ear position, grain yield, and anthesis date. Kernel iron and zinc levels were determined using Inductively Coupled Plasma Optic Electrical Spectrometry (Galicia, 2008).

Research Application

Locations were different for kernel zinc levels, averaging 19.2 mg/kg at NIRS and 18.7 mg/kg at GART. Despite the non significant entry kernel iron levels observed, the levels were within acceptable range of 13.6 mg/kg for 07C04592B and 17.9 mg/kg for 07C04602B. Plants were taller at NIRS (207.6 cm) than at GART (186.5 cm). Higher grain yields were obtained at NIRS (6.6 t/ha) than at GART (2.9 t/ha). Differential responses for grain yield were observed among genotypes from one location to another.

Plant growth and development parameters can be used to identify promising hybrids that are high yielding and whose kernels contain high iron and zinc concentration. The non-significant differences observed for location, entries and their interactions with regards to kernel micronutrient levels suggest that breeding for high iron and zinc dense maize is feasible and should therefore, ensure wide diversity of germplasm, use of numerous locations and sampling of several seasons. Additionally, locations should be chosen for similarity in seasonal temperatures and soil types so as to get data representative of the adaptability of varieties to different environments in the country.

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References

Central Statistics Office, 2009. National Food Balance for Zambia for the 2009/2010 Agricultural marketing season. Based on the 2008/2009 MACO/CSO Crop forecasting

Survey and MACO/Private Sector Utilization estimates (Metric tonnes).

Long, J.K., Banzinger, M. and Smith, M.E. 2004. Diallel analysis of grain iron and zinc density in Southern African- adapted maize inbreds. *Crop Science* 44:2019-2026.

Nestel, P., Bouis, H.E., Meenakshi, J.V. and Pfeiffer, W. 2006. Biofortification of staple food crops, symposium: Food fortification in developing countries. *J. Nutr.* 136:1064-1067

Pfeiffer, W.H. and McClafferty, B. 2007. HarvestPlus: Breeding crops for better nutrition. *Crop Science* 47: 88-105.

Ronaghy, H.A. 1987. The role of zinc in human nutrition. *World Rev. Nutr. Diet* 54: 237–254.

Welch, R.M. 2001. Micronutrients, agriculture, and nutrition: Linkages for improved health and well-being. In: Singh, K., Mori, S. and Welch, R.M. (Eds.). Perspectives on the micronutrient nutrition of crops. Jodhpur, India: Scientific Publishers. pp. 247–289.

Welch, R.M. and Graham, R.D. 2002. Breeding crops for enhanced micronutrient content. *Plant and Soil* 245:205-214.

Welch, R.M. and Graham, R.D. 2004. Breeding for micronutrients in staple food crops from a human perspective. *Journal of Experimental Botany* 55(396):353-364.