Development and Utilization of High Mineral Beans in Combination with Quality Protein Maize as a Nutritional Intervention in Southwestern Colombia

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Introduction

Iron deficiency anemia and other micronutrient deficiencies affect large number of people worldwide and in Colombia. Legumes are a good source of iron (often >50 ppm) and other essential micronutrients that are found only in low amounts in the cereals or root crops (Fe > 10 ppm). Unlike many cereals that are polished before eating, resulting in a significant loss of nutrients, beans and other grain legumes are usually consumed whole, thus conserving their nutritional content. The protein contribution of grain legumes is often of primary importance in the diets of the urban and rural poor.

Framework

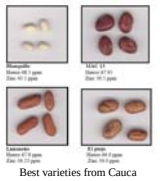
This project addresses issues of nutrient malnutrition via a multi-disciplinary team that includes agronomists, plant breeders, extensionists, nutritionists and public health workers. The project builds on locally existing crop diversity and the introduction and testing of improved germplasm with better nutritional quality and grain characteristics preferred by the Colombian consumer (white maize; large- seeded, red- mottled beans). Multiple-location testing of germplasm both on experiment stations and with farmers is used to evaluate genotype adaptation. The most promising varieties have been tested with soil and foliar micronutrient fertilization to evaluate their influence on seed mineral accumulation. *In vitro* bioavailability tests have been performed with cooked samples of 12 varieties of beans to determine the role of tannins in nutritional quality. Seed supply and grain multiplication has been carried out through a non-governmental organization (NGO) and farmer groups. A bioefficacy trial is being implemented with pre-school children in seven urban daycare centers. Results are being disseminated nationally and regionally through national agricultural research system researchers and NGOs in Bolivia and Venezuela.

Objectives

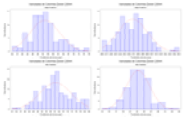
Biofortification of common beans is offered as a potential solution to micronutrient deficiencies in rural and urban populations of southwest region of Colombia, where beans along with maize are important components of the diet. The principal goal of this project was to develop beans with high Fe and Zn content and measure their affect on the nutritional status of children consuming them in combination with high-tryptophan/lysine, quality protein maize (QPM). Specific objectives were to 1) characterize nutritional quality in regional and improved varieties of beans; 2) evaluate the agronomic adaptation of both crops; and 3) develop a bioefficacy testing strategy for the combined diet of high mineral beans and QPM.

Activity Highlights

1. Bean Improvement



Best varieties from Cauca



Fe/Zn distribution – Colombian varieties

One of the goals of the project has been to characterize local bean landraces from Colombia for their nutritional quality. Currently the following germplasm has been evaluated:

• A total of 48 farmer-grown varieties of various seed types were collected by FIDAR in the departments of Cauca and Nariño and were tested for iron and zinc content which ranged from 44 to 69 ppm and 25 to 44 ppm, respectively.

• The landraces were compared to 40 mostly red-mottled or large-red released varieties from the national program of Colombia (CORPOICA series). Iron and zinc content was measured for grain grown at two P fertilization levels and averaged 54 ppm and 24 ppm, respectively.

2. Agronomic Evaluations

NUA 45 NUA 35

QPM and non-QPM

Various experiments were conducted to evaluate the agronomic performance of the biofortified beans as described below:

• Experiment 1 –red-mottled and large-red advanced lines (NUA, BIF series)
• Experiment 2 – Effect of Fe/Zn foliar sprays – small grain (2 sites)
• Experiment 3 – Effect of Fe/Zn foliar sprays – large grain (2 sites)
• Experiment 4 – Participatory varietal selection (Nariño, Cauca, Valle)
• On-farm trials: NUA35 and NUA45, both high iron lines, were grown by farmer groups across more than 10 sites.

In parallel, 36 advanced lines of yellow and white QPM maize were also evaluated.

3. Bioefficacy Trial

Anthropometry

Recipe preparation

Human bioefficacy testing of biofortified beans (NUA lines) in combination with QPM maize is being conducted among pre-school children in seven daycare centers in Cali, Colombia with three treatment groups as outlined below. Anthropometric measurements and recipe evaluations have been completed as has *in vitro* bio-availability testing of raw bean samples.

Trt 1	Trt 2	Trt 3
Low-Fe beans Non-QPM maiz	High-Fe beans QPM maiz	Fe Supplement
N=120	N=120	N=120

Trial period: 8 months

Results

The most important bean improvement results have been the development of biofortified advanced lines for higher iron content such as NUA35 and NUA45 which have commercial seed color, are acceptable to farmers in participatory evaluation and consistently produce grain with 50% more iron than check genotypes such as the red mottled genotype CAL96. Local landraces and released varieties in comparison tend to have iron and zinc content similar to the check genotypes although some higher iron landraces were identified.

In terms of agronomic evaluations, the extent of genotype x environment interaction effects on yield has been evaluated for over 100 advanced lines of red mottled and large red beans and 36 advanced lines and hybrids of white and yellow maize. The best seven maize genotypes have been identified and testing of the biofortified beans is continuing. In addition, the effect of foliar fertilization with iron and zinc chelates has been evaluated on both small and large-seeded beans under different soil types across three departments of Southwest Colombia.

Previous to conducting the bioefficacy trial a test period was used to determine the best recipes for the high and low iron beans as well as for the maize and for carrying out food surveys for the children with their parents and with the daycare staff. In the pilot study, there were no preference differences between high and low iron beans (nor between normal and quality protein maize), however consumption of beans at the daycare centers was found to be no more than two times per week. Consumption rates were determined to be 60 grams of cooked beans per meal for children aged 2 to 3 years old and 90 grams for children that were 3 to 5 years old which allowed us to set the supplementation treatment at 7.3 mg iron/week.

For the bioefficacy trial, base-line data and anthropometrical analysis showed that the 366 children in the population had a Z score for height to weight that was near 0 indicating adequate nutritional status of the study group overall. The average range of hemoglobin, red blood cells, and hemocue were considered normal. A total of 26 children had Hb concentrations <12 g/dL and 11 children had Hb concentrations <11,5g/dL but the majority were in the range of 12.1 to >13 g/dL. Zinc status measurements are underway.

Expected outcomes

The following outcomes have been achieved or are expected from this project: 1) Local varieties with higher nutritional quality identified. 2) Biofortified beans or QPM found to be locally adapted. 3) Seed/grain multiplication carried out. 4) Uptake of nutritionally improved varieties by farmers. 5) Bioavailability and bioefficacy studies determine anti-nutrient levels and potential nutritional impact of new varieties. To date results are promising that the biofortified bean varieties and QPM are locally adapted and acceptable to farmers. Results of the bioefficacy trial will be completed by the end of 2007.