UTILIZATION OF COMMON BEAN FOR IMPROVED HEALTH AND NUTRITION IN EASTERN AND CENTRAL AFRICA

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Abstract

Common beans have the potential to alleviate micronutrient malnutrition and hunger as they are rich in quality protein, fiber, micronutrients such as iron, zinc and vitamin A. Although several interventions have been implemented to alleviate micronutrient malnutrition including supplementation, fortification of foods and use of diverse micronutrient rich diets, micronutrient malnutrition has remained rampant in developing countries. This has been due to limited reach and unaffordability of the interventions by the rural and urban poor. Utilization of biofortified nutrient dense beans which is popular in the diets of many vulnerable groups offer potential and sustainable solution to malnutrition and hunger related deficiencies. The national bean research programs across ECA region developed nutrient dense bean varieties with iron and zinc contents above 70ppm and 30ppm, respectively for farmer use in the region. Twenty one micronutrient dense bean varieties have been released across the region while twenty varieties are at pre-release stage in eight countries. The national bean research programs have also developed bean based food baskets and recipes (twenty six recipes) for utilization of bean for improved health and nutrition in the region. The developed varieties and bean based food baskets are being intensively promoted through awareness creations (demonstrations, publications, trainings) for use among the vulnerable groups in EAC region for improved health and nutrition. Preliminary results from Rwanda and Uganda showed improved health and nutritional status of HIV affected communities with regular consumption of micronutrient rich beans. Therefore, improved access to micronutrient rich beans and bean-based products is likely to improve health and nutritional status of the vulnerable groups in the communities across EAC.

Background

Chronic hunger and micro-nutrient malnutrition or hidden hunger is rampant in most parts of the world especially developing countries. The lack of micronutrients such as vitamin A, zinc and iron affect at least a half of the world’s population (Nestel et al., 2006). It affects mostly infants below five years and women of the reproductive age group, leading to anemia, general body morbidity and mortality, mental impairment; and still births or low child birth weight, blindness and infant mortality. Iron deficiency anemia is estimated at 65% and 34% among infants and pregnant women in Uganda, respectively (MAAIF/MoH, 2005). In Rwanda, anemia was estimated at 59% among infants, 33% and 29% among women of aged 15 – 49 years and men, respectively (CIAT, Harvest Plus Program, 2009), while protein and calorie malnutrition stood at 13 and 24%, respectively (MINECOFIN, 2008). At 53% and 71% among women and children, malnutrition is one of the highest in the region (IFPRI, 2005). Malnutrition and malnutrition related sicknesses contributes to over a third of child deaths in the world (Horton, 2008) while micro-nutrient hunger and related
effects accounts for more than half of the daily infant mortality in sub-Saharan Africa (Caulfield et al., 2006).

Several interventions such as supplementation, fortification of foods and promoting use of diverse micronutrient rich diets (leafy vegetables, fruits, and animal and poultry products) have been used to mitigate malnutrition in developing countries. However, these interventions have limited effect, especially among the vulnerable majority rural poor that makes about 80 – 90% of the populations in the Sub-Saharan Africa countries, since they are unfamiliar, inaccessible and/or unaffordable to them. Therefore, developing and promoting low cost and user-friendly interventions that target the most vulnerable rural households become very critical and essential in order to alleviate hunger and malnutrition. Utilization of biofortified crops such as common beans that are popular in daily diets of the rural and urban populations offer potential solution to combat malnutrition and hunger with the related deficiencies and deaths more effectively and sustainably (Kimani et al, 2006).

Common beans (Phaseolus vulgaris L.) have the potential to alleviate malnutrition and hunger related problems as they are rich in quality globulin protein (20-28%), energy (32%), fibre (56%) and micronutrients especially iron (70 mg/kg) and zinc (33 mg/kg) and vitamin A. Previous studies have suggested that high genetic diversity among bean genotypes for micronutrient densities exists (Beebe et al., 2000; Tryphone and Nichumbi-Msolla, 2010) Where daily bean consumption is high, it provides significant amount of proteins, calories and micronutrients to avoid the consequences of malnutrition and hunger (Valdernio and Whitaker, 1982). At 40 – 60 kg per capita (compared with 17 kg for Africa) bean consumption in eastern and central Africa is one of the highest in the world. They are are consumed by over 50 million persons of all social and wealth categories in diverse recipes as green or fresh leaves, pods, grain and as dry grain in daily diets by as many as 99% of the population in some of the countries such as Burundi and Rwanda. They are popular complements of the largely starchy cereals and tuber-based diets as they become more available alternative to the rare and expensive animal sources of proteins among the resource poor rural and urban consumers. Protein intake from beans can reach 65% of both plants and animals origin in Burundi and Rwanda (Sperling, 1992). Bean proteins have high digestibility with significant nutritional and health advantages for consumers. As a legume, bean consumption is highly correlated with low incidence of coronary heart diseases and death (Menotti et al., 1999; Demardi-Blacberry et al., 2004) and has been reported to be important in controlling non-communicable diseases such as diabetes, and obesity. Beans are thus called the vegetarians’ meat for the rich (Schneider, 2002) and meat for the poor (MINAGRI, 1988). Thus consumption of beans is very essential among all classes of consumers: the wealthy and the poor, infants, teens, pregnant and nursing women as a unique remedy to prevalent micronutrient malnutrition and the associated physical and mental development impairments.

In order to improve the food, nutrition and health security benefits from beans, there is need to increase access to improved micronutrient rich bean varieties and bean based products especially among the rural and urban poor. There is adequate information on nutrient rich bean genotypes
and bean-based products which can be disseminated to the vulnerable groups across the region. This paper therefore, describes the approaches the national bean research programs in eastern and central Africa (Burundi, Democratic republic of Congo, Kenya, Rwanda, Tanzania and Uganda) have adopted to reduce micronutrient malnutrition and hidden hunger and other related side effects of malnutrition among the rural and urban poor and at the same time improve their food security and income.

**Methodology**

**Biofortification: breeding for micronutrient rich bean varieties**

The national bean research programs were involved collection of germplasm to identify superior parental lines (genotypes) with high micronutrient densities (over 70 mg/kg for iron and 30 mg/kg for zinc). The programs used these parental lines to develop new varieties combining high iron and zinc contents, marketable traits and high yield potential with resistance to pests and diseases and tolerance to low soil fertility using conventional breeding and marker assisted selection procedures. The developed genotypes were evaluated across agro-ecologies to assess mineral stability and genotype x environment (GXE) interactions. The genotypes were grown in replicated complete block design in plots ranging from 2-4m x 1.5-3m depending on the sites. A number of the genotypes were evaluated at preliminary, intermediate and advanced yield trials and on-farm trials through participatory approach involving many stakeholders, and the best performing genotypes with desired traits (high yielding, resistance to diseases, desired growth habits, desired pod characteristics, attractive seed color and size, short cooking time, desired market classes and) and rich in micronutrients were eventually released for farmer use. Levels of iron and zinc micronutrient contents were determined by XRF machines or AAS facilities at specialized laboratories at Waite Analytical Services (WAS) of Adelaide University of Australia and at the Department of Food Science and Nutrition of the University of Nairobi (UoN), Kenya.

The developed and released nutrient dense bean varieties were disseminated through (a) increased production of breeder and foundation seeds by research institutes and seed companies; (b) increased multiplication and sale of certified and quality declared seeds by the formal and informal seed producers, respectively; (c) setting of demonstrations and holding field days to create awareness; (d) training of trainers in various aspects of seed and grain production; and developed and implemented appropriate information dissemination and communication approaches.

**Development of nutrient rich bean products, bean-based food baskets and recipes**

Nutritionists from the national bean research programs in collaboration with Universities identified and developed suitable bean based food basket combinations. They also developed recipe procedures and recipe development manuals for snap and dry beans and modified them as recipe books for snap and dry beans. Analysis of culinary properties, sensory characteristics (colour, texture, taste and flavor) and consumer acceptability of improved bean varieties were carried out.
Results and discussion

Biofortification of beans (development of nutrient rich bean varieties)

The national bean research programs in east and central Africa (Kenya, DRC, Rwanda, Burundi, Tanzania and Uganda) through the ASARECA based network (ECABREN) and other development partners such as AGRA have over the years developed high yielding micronutrient rich bean varieties for integration in the diets of the consumers. Up to 960 bean populations were developed and identified as high in Iron (above 70 mg/kg) and Zinc (above 30 mg/kg) above the average nutrient content for beans of 50ppm and 20ppm of Fe and Zn, respectively. About forty locally collected or bred bush or climbing bean varieties with Fe and Zn content beyond the target levels of 80 mg/kg and 30mg/kg Fe and Zn, respectively were identified, released or at the pre-release stages by the national programs across the region (Table 1). These new varieties have 80% or more iron and 50% more zinc compared to ordinary varieties. Many of these varieties combine the high micronutrient content with high yield, resistance or tolerance to pests and diseases and low soil fertility as well as culinary and market preferences by the farmers thus being suitable for food and nutrition and income security for the farmers and the vulnerable groups. To date a total of 21 micronutrient rich varieties have been released across eight countries while 20 lines are at the pre-release stage in eight countries. Preliminary results on consumption of nutrient dense beans regularly from Rwanda and Uganda showed that micronutrient rich beans can significantly improve the health and nutrition status of HIV affected communities (PABRA Annual Report, 2009/2010) This was corroborated by Bennink (2010) who noted that consumption of beans on a regular basis increases intake of dietary fiber essential for the control of blood glucose concentrations in the body that reduces rampant incidence of Type II diabetes, heart disease and high blood pressure and other non-communicable diseases thus reducing the cost of medication among the wealthy. He also observed that consuming beans, improve glycemic index control, reducing serum cholesterol and body weight gain that improved HIV conditions.

In order to improve access of nutrient rich bean varieties by the farming communities, both the formal seed systems through registered seed companies and the informal community-based seed systems are used. The national research programs produce the breeder seeds while the formal seed sector produces foundation seeds and certified seeds for sale to the farming communities. The formal seed sector has stockists distributed all over the country but mostly in urban areas who sell improved bean seeds to the communities and other seed users.

Areas far removed from urban centers in most cases do not benefit from the improved seeds. The informal seed system of community-based seed production is used. This is where farmer groups are organized into seed producers. They work closely with researchers, extension agents and NGOs to produce quality declared seeds which are commercially acceptable. The groups produce the seeds as a business and sell to the farming communities especially the hard to reach areas. The farmer groups’ capacity to produce quality declared seeds is enhanced by technical experts. They are
Table 1: Characteristics of some iron (Fe) and zinc (Zn) micro-nutrient dense released and pre-release bush and climbing bean genotypes

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Origin</th>
<th>Growth Type</th>
<th>Fe mg/kg</th>
<th>Zn mg/kg</th>
<th>Laboratory</th>
<th>Seed type</th>
<th>Yield Kg/ha</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nakaja</td>
<td>Uganda</td>
<td>Bush</td>
<td>144</td>
<td>44</td>
<td>UoN</td>
<td>Small</td>
<td>1,500</td>
<td>Evaluation</td>
</tr>
<tr>
<td>MLB 49-98A</td>
<td>DRC</td>
<td>Bush</td>
<td>124</td>
<td>55</td>
<td>UoN</td>
<td>Small black</td>
<td>2,000</td>
<td>Released</td>
</tr>
<tr>
<td>AND 620</td>
<td>DRC</td>
<td>Bush</td>
<td>147</td>
<td>38</td>
<td>UoN</td>
<td>Large red mottled</td>
<td>1,500</td>
<td>Released</td>
</tr>
<tr>
<td>RWR 2245</td>
<td>Rwanda</td>
<td>Bush</td>
<td>75</td>
<td>37</td>
<td>WAS</td>
<td>Large red mottled</td>
<td>2,500</td>
<td>Released</td>
</tr>
<tr>
<td>RWR 2154</td>
<td>Rwanda</td>
<td>Bush</td>
<td>75</td>
<td>34</td>
<td>WAS</td>
<td>Large sugar</td>
<td>2,000</td>
<td>Released</td>
</tr>
<tr>
<td>RWRV 1129</td>
<td>Rwanda</td>
<td>Climber</td>
<td>81</td>
<td>34</td>
<td>WAS</td>
<td>Large kaki</td>
<td>4,500</td>
<td>Released</td>
</tr>
<tr>
<td>Mac 44</td>
<td>Rwanda</td>
<td>Climber</td>
<td>78</td>
<td>31</td>
<td>WAS</td>
<td>Large red mottled</td>
<td>4,000</td>
<td>Released</td>
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<tr>
<td>CAB 2</td>
<td>Rwanda</td>
<td>Climber</td>
<td>85</td>
<td>37</td>
<td>WAS</td>
<td>Large white</td>
<td>5,000</td>
<td>Released</td>
</tr>
<tr>
<td>NABE 9C</td>
<td>Uganda</td>
<td>Climber</td>
<td>106</td>
<td>24</td>
<td>WAS</td>
<td>Large red</td>
<td>3,500</td>
<td>Released</td>
</tr>
<tr>
<td>RWRV 2361</td>
<td>Rwanda</td>
<td>Climber</td>
<td>79</td>
<td>29</td>
<td>WAS</td>
<td>Large red mottled</td>
<td>3,500</td>
<td>Released</td>
</tr>
<tr>
<td>RWRV 3006</td>
<td>Rwanda</td>
<td>Climber</td>
<td>76</td>
<td>36</td>
<td>WAS</td>
<td>Large white</td>
<td>3,600</td>
<td>Pre-released</td>
</tr>
<tr>
<td>Maharagi Soja</td>
<td>DRC</td>
<td>Bush</td>
<td>92</td>
<td>29</td>
<td>UoN</td>
<td>Small cream</td>
<td>1,250</td>
<td>Released</td>
</tr>
<tr>
<td>Gofta</td>
<td>Ethiopia</td>
<td>Bush</td>
<td>79</td>
<td>35</td>
<td>UoN</td>
<td>Medium cream</td>
<td>1,250</td>
<td>Released</td>
</tr>
<tr>
<td>HRS 545</td>
<td>Sudan</td>
<td>Bush</td>
<td>75</td>
<td>45</td>
<td>UoN</td>
<td>Small white</td>
<td>1,200</td>
<td>Released</td>
</tr>
<tr>
<td>Minimum Target</td>
<td>-</td>
<td>-</td>
<td>70</td>
<td>30</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

trained in seed production (crop, pest, disease, soil fertility and water management), post-harvest handling, institutional and organizational development, entrepreneurship skills, negotiation skills, book keeping, processing and marketing and investments and savings. In Uganda, Community
Enterprise Development Organization (CEDO) working closely with over 300 farmer groups has produced over 3 tons of nutrient dense bean lines (AND 620, MLB-49-89A, Roba 1 and G59/1-2). Similarly, more production of biofortified beans (over 3 tons of NUA 45, 6, 1, Gofta, Roba1 and Maharagi Soja) was undertaken in Western Kenya by the Ministry of Health Nutrition Department in the last year. In Rwanda more than 15 tons of micro-nutrient dense bush and climbing beans was multiplied and distributed to the farmers. A similar initiative is being undertaken in Burundi, DRC and Ethiopia. For example, the informal seed sector in Uganda recorded an average total gross margin of UGX 549,451 (USD 220) per hectare per season (Survey Report on Small Scale Seed Enterprises in Uganda, 2011; AGRA 2008 PASS 018 Final Project Report, 2011). This indicates that the informal seed system can be viable and sustainable over time period. This approach therefore, supplements the conventional seed system further increasing access to improved seeds by the rural and urban poor and also improves the income of the participating farmer groups. The seeds are packed in small packages for easy selling, wider reach and affordability by a large number of community members. Rather than pack seeds in larger packages of say 5kg or more, seeds were packed in more affordable sizes of 0.25 kg, 0.5 kg, 1.0 kg and 2.0 kg. The smaller packed quantities although costs more are more affordable to the farmers. The informal seed system has been successfully implemented in Uganda, DRC, Burundi and Rwanda and will give farmers more access to biofortified bean varieties for better nutrition and health especially of the vulnerable groups.

**Development and commercialization of nutrient rich bean products, bean-based food baskets and recipes**

A survey carried out by Pan African Bean Research Alliance (PABRA) and its collaborating national programs to identify who the malnourished are and what they eat in east and central Africa (Uganda, Kenya, DRC, Ethiopia, Tanzania and Burundi) indicated the prevalence of malnutrition ranging from chronic hunger (lack of adequate food over a long period of time) to short durations of starvation due to seasonal variation in access to food. In eastern DRC, the prevalence of malnutrition was high in children under 5 years with 5-10% being moderately malnourished and over 20% at risk of malnutrition. These were mainly due to iron and protein deficiencies which stem from poor quality diets with heavy dependence on starchy-carbohydrates foods with little consumption of animal and fish products, legume products, fruits and vegetables. Therefore, there is need to develop biofortified beans and nutrient rich bean based foods which can be more easily affordable to the less privileged communities and the vulnerable groups who are more prone to malnutrition and chronic hunger.

Dietary combinations and cooking techniques that enhance nutrient availability and promote nutrient retention were highlighted. Focus was on home preparation and community-based processing such as using processed bean products to enrich local recipes, fermentation, germination and food-to-food fortification. Bean-based products have been developed by the national programs in collaboration with Universities and other food processing industries. Bean-based composite flours formulated to meet nutritional needs of infants and adults have been
developed. Two of the products (bean based processed flours and composite-complementary flours like bean/grain amaranth flours) developed by Makerere University’s Food Science Department are already being marketed in supermarkets in Kampala. NARO’ Food Science Unit is working closely with East Africa Basic Foods to facilitate the commercial marketing of bean-processed flour and products. Other bean-based products with high nutritive values developed and evaluated together with consumers include snacks such as samosas, bean finger rolls, bagia, bread, madazi, and many others (Figure 1). Recipe booklets for making of these products have been developed for consumer and community use.

Figure 1: Farmers and other consumers participate in bean-based product and recipe development (1a); a range of prepared products are displayed including bean samosa, bagiya, bean finger rolls, cakes and biscuits (1b); and participating farmers/consumers evaluate a range of the developed products.
The various national programs have also developed snap beans based products of high nutritive values including sources (snap beans mixed with other foods such as fish, groundnuts/sesame paste, okra, beef, chicken and mixed vegetables), stir-fried dishes, salads and snacks (fresh green bean fritters, soup) (Figure 2). Up to 26 recipe types have been developed and documented into recipe books for use. All these products are more attractive to all generations especially the young stars and in line with the changing dietary habits of this generation. The products and recipes are more attractive and create more interest in the consumption of beans for better health and nutrition. The major challenge is to design the best dissemination strategies so that the products can effectively reach all communities especially the hard to reach communities who are the majority and more prone to under nutrition and malnutrition.

**Dissemination of information and innovations (nutrient rich bean varieties and bean-based food products and recipes)**

National Bean Research Programs have over the years designed and implemented dissemination strategies for wider reach of information to a wider set of stakeholders in order to create awareness and improve uptake of technologies (varieties and management technologies). Each year various national programs produced varied quantities of posters, leaflets and production guides in various languages for dissemination to stakeholders. These information tools include variety descriptions and seed and grain production guides. Each national program in collaboration with other partners (NGOs, CBOs, government extension agents) encouraged the setting of demonstrations and holding of field days to aid in dissemination of information to stakeholders.

**Lessons learnt**
The following were lessons learnt from the regional research projects on bean for health and nutrition: (a) Wide germplasm base is key to bean variety development progress; (b) Germplasm exchange among participating member countries and institutions within ASARECA is the backbone of regional progress; (c) Participatory methods which involve a wide range of stakeholders in research process is key to technology development and adoption; (d) Networking and regionality is key to efficiency and progress and avoids duplication of research work across the region; (e) Sharing of information, technologies and innovations among the countries within the region is made possible through such collaborative research activities; (f) Regular skill upgrading of researchers is essential for capacity building and quality research results; (g) Technical staff are key to research program continuity and collection of quality research data; (h) Exchange visits among farmers is useful in exchange of ideas and information; and (i) Children can be good at disseminating information on beans to their parents and other colleagues.

Future Interventions

Future interventions to improve on utilization of beans for nutritional and health benefit will include the following activities: (a) baseline survey on nutrition and dietary assessment and identification of target populations, (b) evaluation of nutrient retention in micronutrient rich bean-based foods, (c) development and selection from new populations for high iron and zinc contents (screen bean genotypes and germplasm for breeding), (d) regional evaluation of biofortified nutrient dense bean lines for Genotype x Environment through participatory variety selection (PVS) procedure, (e) training of trainers in the communities and setting up demonstration gardens, (f) promotion of marketing and consumption of nutrient rich bean varieties and products (biofortified beans and bean products), (g) assessment of improvement of nutrition status with specific products of target population or communities and lastly, creating a favorable environment for farmer access to improved nutrient dense bean seeds in the region and (h) Creating a favorable environment for farmer access to improved nutrient dense bean seeds in the region.

Conclusion

Beans have been proved to be a very healthy food for the vulnerable groups especially for rural and urban poor who are unable to afford animal and fish sources and depend a lot on beans as sources of protein and micronutrients. With the development of nutrient dense bean genotypes (biofortification), there is high hope of making micronutrients especially iron and zinc more easily accessible and available to the vulnerable groups and therefore reducing on micronutrient malnutrition and hidden hunger. Since beans are easy to grow and more easily accessible by a wider community than supplementation and fortified foods, there is hope that malnutrition among the vulnerable groups will be solved through consumption of biofortified beans and nutrient rich bean based foods.

The dissemination efforts in place coupled with training is to create awareness of the needs to consume biofortified beans and nutrient enriched bean based food baskets. The strong
collaboration among national programs allowed for exchange of information and innovations and strengthened partnership which encouraged exploitation of synergies for more efficient production of results.

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References


IFPRI 2005.


Sperling 1992
