Biofortified Bean Genotypes under Integrated Soil Fertility Soil Management in the humid mid-highlands of Democratic Republic of Congo (DRC)

Kanyenga Lubobo Antoine [1&3*], G. Amzati Sefu[2], P. Bukeni Mbate[2], Mukalayi Mwamba[3], Kasongo Lenge[3], Kizungu Vumiliya[4], Kalonji Mbuyi[4] and Paul Kimani[5]

[1] CIAT - HarvestPlus , [2] Université Evangélique en Afrique UEA, [3] Université de Lubumbashi UNILU, [4] Université de Kinshasa UNIKIN, [5]University of Nairobi UoN

*Corresponding author: Kanyenga Lubobo Antoine (PhD), CIAT/HarvestPlus -DRC, P.O. Box 1860, Bukavu; Email – a.k.lubobo@cgiar.org

Introduction

• Bean (*Phaseolus vulgaris L*) is an important crop for more than 20 millions people in Eastern , Southern and Western D.R. Congo, where its consumption can supply 60 % of dietary protein for rural and urban people with an estimated consumption of 60 kg per year and per person. It is the most grown legume that provides daily metabolic needs, on carbohydrates, proteins, and micronutrient.

•Despite high bean consumption , the malnutrition in general and malnutrition due to iron and zinc deficiency remains high and almost chronic within bean production areas and the prevalence of anemia due to iron deficiency is very high (53 % among pregnant women in North and South Kivu).

•Bean production level depends on many factors : yield potential, biotic and abiotic constraints and farming practices. Yield is always the first trait for famers and evidence for bio fortification breeding shows that high micronutrient concentration can be combined with yield , pests and diseases resistance.

•Although identification of best genotypes (through plant breeding), understanding of trait expression to the optimal levels requires exploring environmental conditions and elucidating genotype-by-environment interactions (G x E). Soil is one of most components of the environment which can be influenced by farming practices such as ISFM .

• The main objective of this study was to investigate the contribution of ISFM options (in addition to breeding) on yield, micronutrient content, Pests and diseases resistance of bean genotypes in Multi-Environment Trials (MET), by assessing cultivar's response and stability across environment (locations x years) in relationship with ISFM.

Methods

• Field experiment in *Split Plots Design* was carried out , where 8 bush bean genotypes from INERA , PABRA and CIAT were main plots and 7 ISFM options :2.5 tons/ha of lime, 10 tons/ha of farm manure, 150 kg/ha of mineral fertilizer(NPK 10-20-10) used single or combined +1 check plot were secondary plots

•This experiment was implemented in 8 sites representing 5 main agro ecological zones of D.R.Congo (figure 1) : Lohutu , Kingi and Kibututu in North Kivu, Mulungu, Bitese and Luvungi in South Kivu, and Kipopo and Kaniama in Katanga.

• Data referring to soil properties , rainfall , yield components, pests and diseases incidence and micronutrient level in seed were collected and analyzed

• For micronutrient (Fe and Zn) content, seed were harvested, threshed , grinded and analyzed using XRF Spectrometer (figure 2) and following Stangoulis protocol (2010).

Figure 1: Experimental sites in North Kivu, South Kivu and Katanga,

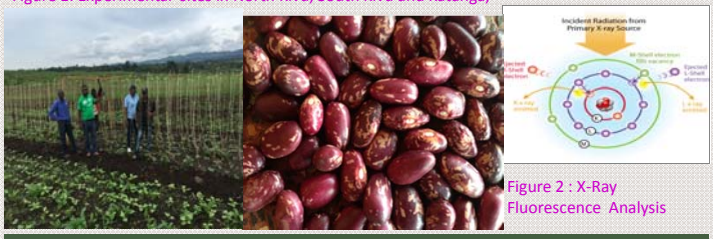

Figure 2 : X-Ray Fluorescence Analysis

Results

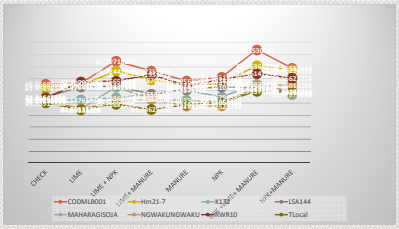

Figure 3: Response of Bean Genotypes under ISFM Main Effect on Iron Content (ppm)

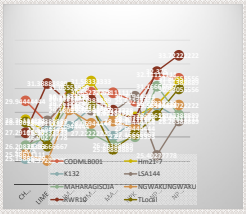

Figure 4:Response of Bean Genotypes under ISFM Main Effect on Zinc Content (ppm)

• Significant difference (P<0.001) was found between bean genotypes, locations and years both for yield, iron and zinc content and their interactions.

• Iron content (Figure 3) was influenced by the combination of lime + farm manure+ chemical fertilizer and CODMLB001 showed the highest content 94 ppm compared to 67 ppm without any application . It was followed by lime + chemical fertilizer

•Whereas , for zinc content (Figure 4), the combination of lime + farm manure and chemical fertilizer induced a good response with the same bean genotype CODMLB001. Good response was also observed with genotype Hm 21-7 under The combination of lime + chemical fertilizer and under lime applied alone.

•Yield (figure 5) was highly influenced also by the same combination of lime+farm manure+fertilizer , and highly correlated to iron content (r= 0.72) , due especially to the change of soil PH and C/N status after ISFM application in all locations . Zinc content was slightly correlated to yield (r= 0.29) under lime application , a part in the acidic soil of Luvungi (Ruzizi Plain) with a PH of 4.1. however, the correlation between Iron and zinc (r= 0.31)

•Performing and Stable bean genotypes for micronutrients (figure 6) across 8 sites, 3 years and under the best ISFM Option were CODMLB001 and Hm 21-7 out of all genotypes. From the biplots AMMI analysis, with the PCA1; genotypes contribute with 56.7 % to yield, 53.3 % to iron content and with 67.8 % to zinc content.

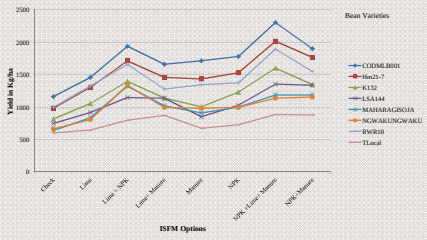

Figure 5: Yield of Bean Genotypes under Main Effect of ISFM Options in 8 Locations in North Kivu, South Kivu and Katanga

Results (continued)

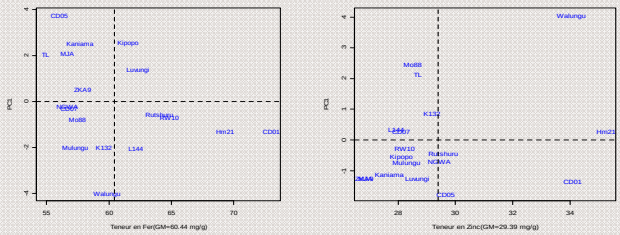

Figure 6: Performed and Stable Genotypes for micronutrients across Sites and Years in D.R.C.

Conclusion and Recommendations

• Related to ISFM options applied, the combination of lime, farm manure and chemical fertilizer improve yield of bio fortified bean up to 87.3 % (**yield range:827-1549 kg/ha**), Fe content up to 27.1 % (**55.3-70.3 ppm**) and 11.8 % for Zn (**27.1-30.3 ppm**) . But this depend mostly on the bean genotypes responses, followed by soils properties , then rainfall during micronutrients uptakes.

•The same combination contributes to reduce severity of Bean Rot Roots (BRR) with 17.8 %, Angular Leaf Spots (ALS) with 15.8 % and Bean Steam Maggot (BSM) with 17.4 % .

• Bean genotypes (breeding contribution in the G x E x ISFM interactions) contributed with 56.7 % to yield , 53.3 % to iron and with 67.8% to zinc .

•Lime contributed to increase more Zn content than Fe content in same areas than others depending on the typology of acidity .

•ISFM technologies induced high productivity, improved pest and diseases resistance and increase bean micronutrients content , but need further investigation on others components such as foliar bio fertilizer and inoculums /*Rhizobium* in synergy or antagonism with other microorganisms involved in soil activity and especially iron and phosphorus

Acknowledgements

We are grateful to HarvestPlus for financial support , CIAT , INERA , Local NGOs and CBOs for technical support and to UNILU for Scientific and Academic support which facilitated this research