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Participatory Evaluation of the Adoption of Bio Fortified Bean Varieties in Sheema and Ntungamo Districts, Western Uganda

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Abstract

The study focused on assessing participatory evaluation on the adoption of fortified bean varieties in Sheema and Ntungamo Districts. It was restricted to; determining the social economic factors that influence adoption of bio-fortified bean varieties, establishing farmers' perception of the selected characteristics of bio-fortified bean varieties and establishing the extent to which the interventions put in place have reached in motivating farmers to adopt biofortified bean varieties. The study employed a cross-sectional, descriptive research design and primary data was collected from 214 respondents. 193 were bean farmers randomly selected and 21 key informants were purposively selected. The study findings established the following social economic factors significantly affected the adoption of biofortified bean varieties; access to credit P=0.00 and SD= 0.00, market access P=0.00 and SD=0.02892, household size P=0.00 and SD= 0.14047, access to extension P=0.00 and SD= 0.19475, gender P=0.00 and SD= 0.30575, education level P=00 and SD=0.31439, farmers perception P=0.00 and SD=0.34305, farm size P=0.00 and SD=0.34837, farmers income P=0.39167 and farmers age was not significant since P=0.997 was greater than P=0.05 hence such factors which are significant should be put into consideration in design of any related project or programme so that malnutrition is minimized using these biofortified bean varieties. The study established that most farmers 108 (50.5%) were still growing local bean varieties since they perceived biofortified bean varieties to require additional inputs especially fertilizers and pesticides and these forced even those growing to abandon them.

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The study further established that a reasonable number of farmers 87 (40.7%) have ever grown biofortified bean varieties but only 39 (18.2%) were still growing them since the nutritional programme that used to provide seeds to them was no longer supplying and even such biofortified bean varieties were not available in the visited stores. It was established that creation of markets like promotion of school feeding programme P=0.00 to be the most significant intervention in improving the adoption of biofortified bean varieties by farmers compared to construction of storage facilities P=0.253, provision of post-harvest inputs like tarpaulins P=0.709 and strengthening farmer groups P=0.931. The study recommended that for all planting materials developed, special consideration should be taken to include all the significant social economic factors listed above and carry out assessment before in all regions for easy adoption into communities, the need to provide farmers with firsthand information on the characteristics of improved varieties and agronomic practices, the need to empower farmers to select new varieties under their own management and criteria, all research institutions developing planting materials test them in different localities, the need to involve agricultural extension service providers in making seeds available to larger numbers of farmers and ensure appropriate facilities are available including supplementary irrigation and supplementation of irrigation to demonstration farmers including training stakeholders along the value chain is critical for the sustainability of the interventions and growing of biofortified beans.

Keywords: Participatory evaluation; Biofortified bean varieties; Adoption.

1. Introduction

Common bean (*Phaseolus vulgaris* L.) is the most widely grown grain legume for direct human consumption and is highly preferred in many parts of Africa and Latin America, as well as in southern Europe [1]. It is an important source of nutrients for more than 300 million people, representing 65% of total protein consumed, 32% of energy, and a major source of micronutrients for example, iron (Fe), zinc, thiamin, and folic acid [2]. It is known as the “poor men's meat,” due to its high protein, minerals, and vitamins content [2] Fe is an essential micronutrient for almost all living organisms [3], and Iron Deficiency is the most common micronutrient deficiency worldwide, disproportionately affecting the poorest and most vulnerable populations in resource-limited settings, leading to Iron Deficiency anemia (IDA) [4]. Biofortification is considered a sustainable and cost-effective strategy to address malnutrition in developing countries because it targets staple foods that are consumed daily [5].

According to [6] nearly all rural households in East Africa including Rwanda cultivate beans. Beans are early maturity and capacity to provide a range of food products (leaves as well as, fresh pods and dry grain) also helps provide a more balanced diet to vulnerable community members (the under-five, pregnant mothers and chronically ill people). Beans are mainly grown by small scale farmers with a very minimum input use except seed.

Biofortified bean varieties represent high content in Iron (40% more iron than typical bean), high adaptability and tolerance to different variation of soil conditions and climate change and high yielding [7]. Seeds are basic agricultural input. To enhance production of biofortified beans and earning income, the farmers should within

their existing land holdings, expand proportion of land under biofortified bean production, adoption of best practices and using improved inputs, and actively participate in farmer group's activities for easier access to inputs, credit and markets [8].

Five bean varieties rich in iron and zinc were released for the first time in Uganda in 2016 by NaCRRI. These varieties included three bush and two climber growth types. The varieties, known as NAROBEAN 1, 2, 3 4C and 5C, are an excellent source of iron. Instead of buying expensive supplements, communities can now buy and grow these beans as a way of boosting nutrition and reducing anemia (a major health concern in Uganda) knowing that they will get yield despite drought [9]. Bean varieties released have different traits on which farmers' base on while selecting and adopting. Such traits include; adaptability to low soil fertility, seed size, marketability, taste, shorter cooking time, tolerance to heavy rain, resistance to common bean diseases, and shorter production cycles [9]. Despite much efforts and resources devoted in the dissemination of information on bio-fortified bean varieties in Ntungamo and Bushenyi districts in Western Uganda by MAAIF under Uganda Multi-Sectoral Food security and Nutrition programme, the concern of the preferred traits still remains unclear to majority of the farmers.

2. Statement of the problem

Common bean (*Phaseolus vulgaris* L.) is the most widely grown grain legume for direct human consumption and highly preferred in many parts of Africa [1]. It is known as the "poor men's meat," due to its high protein, minerals, vitamins content and used by most households in developing countries [2].

Researchers have developed high yielding varieties of high nutritional content of zinc and iron and FIVE BEAN varieties (NAROBEAN 1, 2, 3 4C and 5C) rich in iron and zinc were released in Uganda in 2016 by NaCRRI to boost nutrition and reduce anemia hence reducing on the costs necessary in acquiring supplements since communities can now buy and grow such beans varieties [9].

Bean varieties released had different traits on which farmers' would base on while selecting and adopting. After release the seeds were distributed to seed companies for multiplication and distribution to farmers. In Western Uganda, bio fortified been seeds are being distributed and promoted by MAAIF under UMSFSNP in the (KAZARDI) and NaCRRI in Namulonge [10]. Despite all the selected traits by farmers on the release of bio-fortified bean varieties including consideration for nutrient content, the dissemination of related information about such selected bean varieties by different stakeholders especially developers, extension workers and health workers is not uniformly done and the selected traits cannot be generalized across all districts with in the regions hence affecting their adoption. Similarly, limited access and availability of confirmed bean varieties in different input shops and limited communication channels used by extension workers in disseminating information related to yields, pest and disease resistance, marketability and nutritional contents of such bean verities is still inadequate among farmers hence forcing them to continue getting seed from informal sources. Therefore, it is against this background that this research assessed participatory evaluation on the adoption of bio fortified bean varieties in Sheema and Ntungamo Districts.

3. Materials and methods

Description of the study area

The study was conducted in Sheema and Ntungamo Districts. In Sheema District the study concentrated in the areas of Rugarama, Kigarama, Kasaana, Kyangyenyi Sub Counties and Shuuku Town Council and in Ntungamo District the study concentrated in the major bean growing areas of Nyakyera, Rweikiniro, Rugarama, Rubaare, Kibatsi and Bwongyera Sub Countries.

Study design and sampling frame

A descriptive cross-sectional survey research design was adopted with both qualitative and quantitative approaches as a way of triangulating and enhancing the quality of the findings of the study. The personal philosophical position of the researcher is that of a positivist but a qualitative approach was employed for triangulation purposes. Quantitative and qualitative data was collected from 214 respondents (bean farmers 193, 2 Agriculture officers, 2 District Agriculture Officers and District Production Officer, 6 farmer groups/ organizations, 7 produce dealers and 4 local leaders. This implies that the present study was largely quantitative. The sample unity was farmers' household heads. The sample size was derived from a formula by Anderson and his colleagues (2008) as follows:

$$N=\frac{z^2pq}{d^2}$$

Where n is the minimum sample size; Z is 1.95 at 95% confidence level; P is the population proportion i.e. assume that the proportion of bean producers in the area that is 85%. While **d** is the margin of error (acceptable error) which is assumed to be 0.05 and q is a weighting variable computed as (1-P).

$$n=\frac{1.95^2x(0.85x0.15)}{(0.05)^2}=193$$

Accordingly, a minimum sample size calculated is 193 households and other respondents appear because of their purposefulness in promotion of beans in their places of work.

Table 1: Composition of the Sample Size of the Study.

Categories of respondents	Number	Sampling techniques	Sampling method
Beans farmers	193	Random sampling	Questionnaire
Agriculture extension worker	2	Purposive sampling	Interview guide
District agriculture officers/ District production officers	2	Purposive sampling	Interview guide
Farmer groups/organizations	6	Purposive sampling	Interview guide
Produce dealers	7	Purposive sampling	Interview guide
Local leaders	4	Purposive sampling	Interview guide
Total	**214**		

Data Collection Methods

Primary data was generated from field findings and the main primary data collection methods employed were; observation, interview and through questionnaires. Through the observation method the researcher was able to directly observe and collect information on the bean fields, harvested seeds and the land coverage of planted beans in the different areas.

Data Analysis

The researcher summarized the field data collected by entering it in excel sheets, exported to SPSS version 20.0 for analysis. The researcher in determining the social economic factors that influence adoption of bio-fortified bean varieties employed linear regression analysis; the researcher further employed both descriptive statistics and linear regression analysis in establishment of farmers' perception on the selected characteristics traits and the extent to which interventions have been put in place to adopt bio-fortified bean varieties.

4. Results presentation

Table 2: Social economic factors influencing the adoption of biofortified bean varieties.

Variable	B	Std. Error	Standard deviation	Sig.
Constant	6.408	1.3021		.000
Education	2.037E-8	.02462	.31439	.000
Household size	7.412	.01147	.14047	.000
Farm size	-4.146E-8	.02664	.34837	.000
Access to extension	1.278E-8	.01574	.19475	.000
Market access	1.584E-8	.38802	.02892	.000
Farmers age	-4.004E-9	.03032	.41684	.997
Farmers perception	3.595E-8	.02631	.34305	.000
Access to credit	5.388	.0000	.000	.000
Farmer income	-9.166E-9	.02911	.39167	.000
Gender	-3.055E-8	.02388	.30575	.000

The regression coefficient of farmers income is-9.166E-9; this implies that a decrease by one 50 unit in farmer's incomes is associated with an average decrease of 9.166 E-9in the odd ratio of adopting biofortified bean varieties. Household income is necessary since it facilitates in the acquiring different materials and inputs required in the management of biofortified bean garden. Farmers with an off-farm income invested part of it to purchase farm inputs.

Education level of the farmer had a positive and significant effect on adoption of biofortified bean varieties. The probability that one would adopt at least one of the biofortified bean varieties decreased by 2.037E-8 times if a farmer had no or low education and access trainings. This is in line with [13] who pointed out that education of the household head has a positive influence on adoption of new technology.

The regression coefficient for access to extension service is 1.278E-8; this implies that an increase by one 50 unit in access to extension services is associated with an1.278E-8 increase in the adoption of biofortified bean

varieties access to extension services had a slightly positive significant effect on adoption of biofortified bean varieties. With the help of extension service the farmers can increase their productivity and income and, reduce environmental problems in their fields. The regression coefficient of farmers' age is-4.004E-9.The calculated p-value of 0.997 shows no significant relationship between farmers" age and adoption level at 5 % level of significance (P>0.05). Hence adoption of biofortified bean varieties was not in any way influenced by the farmers" age. Low adoption of biofortified bean varieties was found across farmers of different ages. This is contrary to [14] findings in West Africa that older farmers could have had preferential access to new technologies through increased contact with technology promoters and other development projects in the area thus promoting their probability of adopting new agricultural technologies and the ones from the interviews with local leaders;

Table 3: Bio-fortified bean varieties.

Parameters		**Frequency**	**Percent**
Ever grown Biofortified bean varieties	Yes	87	40.7
	No	150	59.3
	Total	**214**	**100**
Still growing Biofortified bean varieties	Yes	39	18.2
	No	175	81.8
	Total	**214**	**100**

Source: Primary Data, 2021

Table 3 above, 87(40.7) of the respondents agreed that they have ever grown biofortified bean verities although only 39 (18.2) were planting them not knowing that they are biofortified bean varieties. Therefore, according to the results not all respondents had knowledge on biofortified bean varieties.

Table 4: Bean varieties still grown by farmers.

Bean varieties mostly grown by farmers	**Frequency**	**Percent**	**Std. Deviation**	**Variance**
NABE 15	8	3.7	2.42244	5.868
NABE17	13	6.1		
NABE 4	15	7.0		
NARO BEAN 2	62	29.0		
NARO BEAN 4C	8	3.7		
LOCAL SEEDS	108	50.5		
Total	214	100.0		

Source: Primary Data, 2021

The study findings established that majority of the farmers 108 (50.5%) were still growing local bean varieties, 62 (29%) are still growing NARO BEAN 2, 15 (7%) are still growing NABE 4, 13 (6.1%) mentioned NABE17 and 8 (3.7%) mentioned NARO BEAN 4C and NABE 15. This indicates that although biofortified beans were released, most farmers are still growing local bean varieties since farmers do not have access to source of the

seeds within their localities. Considering the two biofortified bean varieties in Table 4, NARO BEAN 2 62(29%) and NARO BEAN 4 C 8 (3.7%) it indicates low levels of uptake of the varieties.

Table 5: Reasons for motivating farmers to continue growing the biofortified bean varieties.

Reasons motivating farmers to continue growing biofortified bean varieties	Response	Frequency	Percent
Tolerance to drought	Most important	106	49.5
	Least important	00	00
	Not important	00	00
	Total	**106**	**100**
Early maturity period	Most important	106	49.5
	Least important	00	00
	Not important	00	00
	Total	**106**	**100**
seed size	Most important	106	49.5
	Least important	00	00
	Not important	00	00
	Total	**106**	**100**
Tolerant to poor soils	Most important	00	00
	Least important	106	49.5
	Not important	00	00
	Total	**106**	**100**
Market availability	Most important	106	49.5
	Least important	00	00
	Not important	00	00
	Total	106	100
Resistant to pest and diseases	Most important	106	49.5
	Least important	00	00
	Not important	00	00
	Total	**106**	**100**

Source: Primary Data, 2021

According to research findings the respondents 106 (49.5%) of the respondents mentioned tolerance to drought, early maturity periods and seed size as the most important reasons why they have grown beans including biofortified bean varieties.

Table 6: Source of biofortified bean varieties.

Source of biofortified bean varieties	**Frequency**	**Percent**	**Standard deviation**	**Variance**
Neighbour	25	11.7	.49367	.244
Extension workers	35	16.3		
Input dealers	12	5.6		
Total	**72**	**41.0**		

Source: Primary Data, 2021

The study findings from above indicates that majority of the respondents 35(16.3%) acquired biofortified bean verities from extension workers, 25 (11.7%) mentioned neighbour and 12 (5.6%) mentioned input dealers.

Further analysis from the ANOVA established that there is no significance between farmer belonging to farmer groupand the number of times bio fortified beans are cooked and consumed in homesteads in a week

A p-value of greater than 0.05 (P-value=0.0731) was obtained in relation to farmers belonging to farmer groups and how often (number of times) they cook biofortified beans in their homes in a week.

Table 6: ANOVA showing the relationship between farmer belonging to farmer groups and the number of times farmer cook biofortified bean in their home.

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.391	2	.391	3.243	.073[a]
	Residual	25.558	212	.121		
	Total	25.949	214			

a. Predictors: (Constant), do you belong to a farmer group
b. Dependent Variable: how often do cook biofortified beans in your home in a week

Table 7: Coefficient Results Showing the Relationship between farmers continuing growing biofortified bean varieties when some interventions are done.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.132E-15	.062		.000	1.000
	Construction of storage facilities	-.039	.034	-.077	-1.147	.253
	Provision of post-harvest inputs like tarpaulins	.032	.084	.028	.374	.709
	Creation of markets like promotion of school feeding programmes	.426	.083	.518	5.118	.000
	Strengthening farmer groups	.008	.091	.009	.086	.931

a. Dependent Variable: Farmers continuing growing biofortified bean varieties

A p-value of less than 0.05 (P-value=0.000) was obtained when markets of biofortified bean varieties are created by promoting school feeding programmes.

A p-value of great than 0.05 (P-value=0.253) was obtained when construction of storage infrastructures was compared to farmers continuity growing biofortified bean varieties.

This implies that farmers would even adopt biofortified bean varieties even when there are no storage facilities.

Table 8: Model Summary Showing the Relationship between farmers continuing growing biofortified bean varieties when some interventions are done.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.518[a]	.268	.254	.35555

a. Predictors: (Constant), strengthening farmer groups, construction of storage facilities, provision of post-harvest inputs like tarplines, creation of markets like promotion of school feeding programmes

An R-squared of 26.8% was obtained. This implied that the simple linear model with provision of different adoption strategies/interventions as the independent variable explained 2.5% of the variations in farmers continuing growing biofortified bean varieties. This meant that when interventions like provision of inputs, free distribution of seeds, and construction of storage facilities are provided the adoption and farmers continuing growing biofortified bean varieties changed by 26.8%.

Table 9: ANOVA for the relationship between farmers continuing growing biofortified bean varieties when some interventions are done.

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	9.691	0	2.423	19.166	.000[a]
	Residual	26.421	209	.126		
	Total	36.112	214			

a. Predictors: (Constant), strengthening farmer groups, construction of storage facilities, provision of post-harvest inputs like tarplines, creation of markets like promotion of school feeding programmes,
b. Dependent Variable: farmers continuing growing biofortified bean varieties

A p-value of less than 0.05 (P-value=0.000) was obtained. This implies that when some interventions like provision of inputs like fertilizers, free distribution of quality seeds, construction of storage facilities are provided and established, farmers will adopt and continue growing biofortified bean varieties.

5. Discussion

The social factors that influence adoption of biofortified bean varieties

Among the socio-economic characteristics of the farmers that were found to be influencing their adoption decision of biofortified bean varieties where the level of formal education, farmers income and access to extension. Age of the farmer, farm size, gender, household size, market access, farmer's perception and access to credit affected their adoption decision. of the several farm and farmer attributes included in the model, farmers' income and education were statistically significance in influencing the adoption of biofortified bean varieties. Farmers with an off-farm income invested part of it to purchase farm inputs. They were able to afford the costs involved in purchasing inputs for the adoption of biofortified bean varieties. For example, the establishment of biofortified bean gardens requires some fertilizers to enhance the fertility of the soils since most of the soils have lost fertility due to erosions. This implies that households with higher incomes may adopt biofortified bean varieties and their management practices quickly compared to those with lower incomes.

This can be compared with [15] who pointed household income plays a role of financing the uptake of new

innovation. High farm income improves the capacity to adopt agricultural innovations as they have the necessary capital to start the innovation. The influence of off-farm income in the adoption of new technologies is derived from the fact that income earned can be used to finance the uptake of new innovation. High income has a positive influence on the initial stages of trial of innovations as the wealth allows the farmer to invest a relatively small proportion if their income into an uncertain enterprise. Also, [16] pointed out that the contributions of income to household's adoption of recommended agricultural practices like use of improved seed varieties, fertilizers application, spacing, weeding, and pest management.

This is in line with [13] who pointed out that education of the household head has a positive influence on adoption of new technology. The reason behind is that more educated household heads are expected to be more efficient to understand and obtain new technologies in a shorter period of time than uneducated people.

Extension is a service or system which assists farm people, through educational procedures, in improving farming methods and techniques, increasing production efficiency and income, bettering their levels of living, and lifting social and educational standards. An extension service enables farmers to improve their agricultural practice through knowledge, innovations and skills. With the help of extension service the farmers can increase their productivity and income and, reduce environmental problems in their fields.

This can be compared with [17] who pointed out that extension is regarded as a process of integrating indigenous and derived knowledge, attitudes and skills determined assistance available to overcome particular obstacle. An extension agent's role is to provide smallholder farmer with the necessary agricultural and livestock production knowledge and skill that enable them to make rational production decision, for increasing production that ultimately improves their socio-economic status. The same source also claimed that the level of adoption of improved agricultural technologies and practices is clearly related to the quality of extension workers. Adoption of biofortified bean varieties was not in any way influenced by the farmers" age. Age of the farmers had no effect on adoption of biofortified bean varieties. Low adoption of biofortified bean varieties was found across farmers of different ages. This is contrary to [17] findings in West Africa that older farmers could have had preferential access to new technologies through increased contact with technology promoters and other development projects in the area thus promoting their probability of adopting new agricultural technologies and the ones from the interviews with local leaders;

Women do most of the farm work unlike their male counterparts who normally make more reliable farming decisions. In this region of study, women were found to be better and faster adopters of new agricultural technologies since farming form the main economic enterprise for most of them. Further, males may be more educated than females giving them a wider opportunity of off-farm employment and therefore farming may be a part time activity for them. Low levels of education among females generally tend to limit their chances of being absorbed in off-farm employment. They are mostly confined in the farms and are expected to be more likely to adopt new agricultural technologies that provide high yields, due to their obligations of meeting food demands for their families. This contradicts [18] who found no significant relationship between adoption of improved seed varieties and gender of the farmers.

Farmers' perception of the characteristics of biofortified bean varieties

Results indicated that farmers liked biofortified beans that are large seeded with cubiod shape, adaptability to soil fertility, tolerant to pests and diseases, high yielding, short cooking time and fetch high market value. This is in line with [19] who pointed out that in Africa adoption improves on beans with farmers preferred characteristic.

The extent to which the interventions have been put in place to motivate farmers in adoption of biofortified beans.

The study findings established that there were a number of activities going on to motivate farmers in adopting biofortied farmers for example free distribution of biofortified bean varieties, construction of storage structures/facilities this was discovered in Ntungamo under Agricultural Cluster development Project, creation of markets both local and international was key in adoption of biofortified beans as markets facilitates increase on household income and food security through buying from the market for those who don't grow especially town dwellers. This is in line with [20,21] that creation of markets, institutions, availability of storage facilities increase adoption of bean varieties.

6. Conclusion

The study findings conclude that to achieve high level of adoption of biofortified beans varieties all the social economic factors like the level of formal education, farmers' income and access to extension, age of the farmer, farm size, gender, household size, market access, farmer's perception and access to credit must be put into consideration in design of any related project or programme so that malnutrition is minimized using these beans.

The study findings established that farmers prefer biofortified beans with large seeded beans with cubiod shape, adaptability to soil fertility, tolerant to pests and diseases, high yielding, short cooking time and fetch high market value as discovered that among released biofortified beans seeds NARO BEAN 2 meeting farmers preference in Sheema and Ntungamo districts. This agrees with [22].

The study findings further established that for adoption to take its course some interventions like free distribution of biofortified bean varieties, construction of storage structures/facilities and promotion within the Government Agricultural projects as discovered in Ntungamo under Uganda multi- sectoral school nutrition project and Agricultural Cluster development project, creation of markets both local and international was key in adoption of biofortified beans. Research concludes that evaluation must continue to the released varieties as not all released varieties are adopted across districts within the farmers.

7. Recommendations

The study findings recommend that agricultural research institutions achieving substantial impact through a dynamic farmer participatory approach to technology development, dissemination and evaluation, there is need to involve national agricultural extension services and non-governmental organizations as well as the private

sector in making seeds available to larger numbers of farmers, access to other essential agricultural inputs to increase productivity as well as information on varieties and crop management practices.

Technical, institutional and market solutions to improve access and availability of households to basic inputs should be subsidized and supplied to farmers.

The sale of small seed packets of bean seed of preferred varieties involving farmers and village retailers gives an idea of the actual demand for seed as well as farmers' willingness to buy seed. Seed production relying entirely on rainfall is highly risky.

Training stakeholders along the value chain is critical for the sustainability of the interventions all levels especially at Parish and Sub county levels.

The study findings also recommends that for all planting materials developed to be given to farmers, special consideration should be taken whereby all categories in terms of **a**ge of the farmer, farm size, gender, household size, market access, farmer's perception and access to credit to carry out assessment before and in all regions for easy adoption into communities.

There is need to provide farmers with firsthand information on the characteristics of improved varieties and agronomic practices

There is a need also to empower farmers to select new varieties under their own management and criteria.

Seed production relying entirely on rainfall is highly risky. Efforts are needed to ensure that critical classes of seed such as breeder and foundation seeds are produced in secure environments with appropriate facilities including supplementary irrigation and this supplementation should also focus on demonstration farmers.

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References

[1]. Blair, M. W., and Izquierdo, P. (2012). Use of the advanced backcross-QTL method to transfer seed mineral accumulation nutrition traits from wild to Andean cultivated common beans. *Theor. Appl. Genet.* 125, 1015–1031. doi: 10.1007/s00122-012-1891-x

[2]. Petry, N., Boy, E., Wirth, J.P. and Hurrell, R.F., 2015. The potential of the common bean (Phaseolus vulgaris) as a vehicle for iron biofortification. *Nutrients*, *7*(2), pp.1144-1173.

[3]. Blair, M. W., Izquierdo, P., Astudillo, C., and Grusak, M. A. (2013). A legume biofortification quandary: variability and genetic control of seed coat micronutrient accumulation in common beans. *Front. Plant Sci.* 4:275. doi: 10.3389/fpls.2013.00275

[4]. Finkelstein, J. L., Haas, J. D., and Mehta, S. (2017). Iron-biofortified staple food crops for improving

iron status: a review of the current evidence. *Curr. Opin. Biotech.* 44, 138–145. doi: 10.1016/j.copbio.2017.01.003

[5]. Pandey, N., Hossain, F., Kumar, K., Vishwakarma, A.K., Muthusamy, V., Manjaiah, K.M., Agrawal, P.K., Guleria, S.K., Reddy, S.S., Thirunavukkarasu, N. and Gupta, H.S., 2015. Microsatellite marker-based genetic diversity among quality protein maize (QPM) inbreds differing for kernel iron and zinc. *Molecular Plant Breeding*, *6*.

[6]. Larochelle, C. and Alwang, J.R., 2014. *Impacts of improved bean varieties on food security in Rwanda* (No. 329-2016-12942).

[7]. Larochelle, C., Asare-Marfo, D., Birol, E., &Alwang, J. (2016). Assessing the Adoption of Improved Bean Varieties in Rwanda and the Role of Varietal Attributes in Adoption Decisions

[8]. Asare-Marfo, D., Birol, E., Katsvairo, L., Manirere, J.D., Maniriho, F. and Roy, D., 2011. Farmer choice of bean varieties in rwanda: lessons learnt for harvestplus delivery and marketing strategies. *Unpublished project report. Washington, DC: International Food Policy Research Institute, HarvestPlus*.

[9]. Stanley, N., (2016). Release of bio-fortified bean varieties in Uganda.

[10]. Daily monitor (Saturday, 12th, may, 2018). Release and distribution of bio-fortified bean varieties in Uganda

[11]. Rose. N. et al,. (2019). Yield perceptions, determinants and adoption impact of on farm varietal mixtures for common bean and banana in Uganda.

[12]. Awio, B., (2015). Agronomic performance and farmer preferances of selected bean varieties in Uganda, Hoima and Rakaidistricts.Thesis (Masters of science in plant Breeding and seed systems. Makerereuniversity, Kampala. UG.77P.

[13] Kafle, B., 2010. Determinants of adoption of improved maize varieties in developing countries: A review. *International Research Journal of Applied and Basic Sciences*, *1*(1), pp.1-7.

[14]. Silva, K. N. (2022). Access to and use of agricultural information and technology in a sample of paddy farmers in the Hambantota district of Sri Lanka: a survey. *Sri Lanka Journal of Social Sciences*, *45*(1), 33-44.

[15]. Njeru, E.K., 2016. *Factors influencing adoption of conservation agriculture by small holder farmers in Kenya a case of Laikipia East sub-county: Kenya* (Doctoral dissertation, University of Nairobi).

[16]. Danso-Abbeam, G., Bosiako, J. A., Ehiakpor, D. S., & Mabe, F. N. (2017). Adoption of improved maize variety among farm households in the northern region of Ghana. *Cogent Economics & Finance*, *5*(1), 1416896.

[17]. Lividini, K., & Fiedler, J. L. (2015). Assessing the promise of biofortification: A case study of high provitaminA maize in Zambia. Food Policy, 54, 65–77.

[18]. Murray-Kolb, L.E., Wenger, M.J., Scott, S.P., Rhoten, S.E., Lung'aho, M.G., Haas, J.D., 2017. Consumption of Iron-Biofortified Beans Positively Affects Cognitive Performance in 18-to 27-Year-Old Rwandan Female College Students in an 18-Week Randomized Controlled Efficacy Trial. Journal of Nutrition 147, 2109-2117.

[19]. Barnett, C., Chisvo, M., & Pinto, Y. (2011). Country case studies on the pass value chain strategy/approach and its impact/effect on smallholder farmer yields in Africa.People-Centre Performance.

[20]. Mabaya, E. (2016). Adoption of GM crops in Africa : why the seed sector matters. Analyses

[21]. Bazuin, S., Azadi, H., &Witlox, F. (2011). Application of GM crops in Sub-Saharan Africa: Lessons learned from Green Revolution. Biotechnology Advances, 29(6), 908–912

[22]. De Groote, H., Chege, C. K., Tomlins, K., &Gunaratna, N. S. (2014). Combining experimental auctions with a modified home-use test to assess rural consumers' acceptance of quality protein maize, a biofortified crop. Food Quality and Preference, 38, 1–13.