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Assessment of Farmers' Indigenous Knowledge and Preferences: A Tool for Sustainable Lablab Bean (*Lablab purpureus*. L. Sweet) Improvement and Utilization in Northern Tanzania

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Authors' contributions

This work was carried out in collaboration among all authors. Author KGC designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors PBV and PAN managed the analyses of the study. Author PAN managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Participatory farmers' selection of preferred lablab bean *(Lablab purpureus* L. Sweet) was conducted in Moshi Rural, Kilimanjaro in northern Tanzania to identify farmers preferred traits and accessions. An experimental plot was laid down in augmented block design where a total of 41 accessions including the local check (Katumani) and improved variety (HA4) were sown in three blocks at the spacing of 75 cm x 40 cm. Semi-structured questionnaire and checklists were prepared to gather the farmers' preferences and knowledge as well as factors for lablab crop abandonment. The factors for crop abandonment identified were unavailability of quality and improved varieties, low yield, the high cost of agro-chemicals, the presence of diseases and insect pests. In this study, farmers' selection criteria of the accessions were resistance to diseases and insect pest, the number of pods per plant, early maturity, high yielding capacity, seed colourand size. The results showed that accessions D163 scored higher votes followed by D137, D88, D27,

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D85, D155, D7, D159, and D151 while the least preferred accession was D140 with Garrets' mean score of 50.11, 50.06, 50.05, 50.02, 50.00, 49.88, 49.77, 49.59, 49.56 and 49.52, respectively. Farmers' ranked traits to be incorporated for future bean breeding in order of importance as; high yielding, better taste, earliness and short cooking time. Therefore, successful selection of germplasm through participatory research can raise awareness, adoption, and utilization of the lablab crop which change the portfolio of varieties available in the area and open the new door for plant breeders.

***Keywords**: Lablab bean; preferred traits; accessions; Garrett mean score.*

1. INTRODUCTION

Lablab bean *(Lablab purpureus* L.) is a reputable source of protein (20-38%), balanced amino acids with high lysine content (6-7%), vitamins and mineral contents compared with cereals for the majority of rural dwelling communities [1].Pulses particularly lablab beans contain large amounts of iron (155 mg/100 g dry weight) among other legumes [2]. Lablab beans complement heavy staple diets and fight against malnutrition in situations with nutrients deficit [3].

Furthermore, it is environmental friendly due to their symbiotic association with rhizobium in fixing nitrogen into soil rhizosphere thereby improving soil fertility and conserve nature in mixed cropping system. Thus sustaining agricultural productivity of lablab crop and its component crops in intercropping systems [4]. Pulses production in African subsistence farming community is a panacea against food and nutritional balances. However, the average production of lablab beans in the farming community is unknown due to the negative influence of environmental constraints such as unavailability of high quality, productive and improved cultivars; lack of awareness on the importance of this crop on food security and its impact on climate change resilient; lack of research and farmers involvement in breeding of this crop which results to poor adoption rate and crop abandonment.

Generally, farmers' participation in crop breeding is essential in the selection and testing of new varieties in their local production environment. Farmers need high yielding and early maturity varieties, diseases and insect pests resistance, drought and heat tolerant, bulk leaves, large grain size, good taste, less cooking time, and better cooking quality that meet their preferences [5,6]. Furthermore, farmers need plants that can adapt well to their growing conditions and which are compatible with their traditional cultivation practices [7]. However, farmers' preferences and perception are subjective depending on the varieties and location; thus, the involvement of farmers in breeding activities is a key determinant of adoption decisions [8]. However, not all improved varieties released are equally accepted by farmers because the process of developing the variety relying on conventional and modern plant breeding programme which does not consider farmers' criteria. Moreover, the involvement of farmers' preferred criteria in breeding has positively resulted in early adoption and accessibility of newly improved varieties [9]. In the heterogeneity rain-fed agriculture, farmers' participation has gained popularity in crop breeding for instance, rice breeding in Nepal [10], pearl millet in North Sudan [11], and maize in Burkina Faso [12]. Identification of preferred varieties of common beans in Tanzania provides an indication of rapid acceptability and adoption by farmer upon selection [13]. However, there is no available publication regarding the involvement of both researchers and farmers on orphan crops like the lablab beans. This limits crop diversity and exploitation of germplasm and as it causes genetic erosion and narrowing the genetic base for crop improvement.

Therefore, this study focuses on spinning up the existing breeding gap of neglected crops such as lablab beans and the importance of integrating farmers' knowledge in breeding activities. The main objectives were: (i) identification of farmers' selection criteria for lablab bean accessions; (ii) Farmers' choice of the best 10 lablab bean accessions (iii) evaluation of the major factors for lablab beans abandonment in the production environments of the northern Tanzania; (iv) identification of the most important criteria preferred by farmers for future lablab bean improvement and development.

2. MATERIALS AND METHODS

2.1 Descriptions of the Study Area

The study was conducted in Mosh Rural, Kilimanjaro region in the northern part of

Tanzania, where there is wide diversity of pulses and with cropping history of lablab beans. The experimental site was located at latitude 3°13′59.59″S and longitude 37°20′35″E with the elevation of 888 meters above sea level. The soil was originated from volcanic ash and characterized by low levels of total nitrogen and available phosphorus. The average annual rainfall is above 1200 mm with the temperature range of 23.4°C annually.

2.2 Sampling Procedure

Moshi Rural was purposively selected as representative because it is agriculturally potential area and traditionally it was one among the area where lablab beans were cultivated previously in Tanzania. A stratified random sampling procedure was used to randomly select six villages. Five farmers were selected from each village to capture the inherent variability within the district. A total of thirty (30) farmers were randomly selected based on their farming experiences of lablab beans production and assessed through the semi-structured survey. The composition of 30 respondents was such that 16 female and 14 male were involved in this survey to evaluate these trial objectively and effectively.

2.3 Field Layout and Experimental Design

The participatory variety selection was done at an experimental site. The experiment was laid down in augmented block design where thirty-nine (39) lablab bean accessions and two controls (HA4 and Katumani) were assigned at randomly in three blocks at a spacing of 75 cm x 40 cm. A total of 10 seeds of the single accession were planted in each row. To evaluate farmers' preferences on lablab bean cultivars, thirty (30) farmers were invited four times at different stage of crop growth and operations. This included at planting time, vegetative phase, flowering/podding phase and maturity phase. A group of five participants identified ten attributes for ranking the accessions. 300 paper ballots of different colours were prepared for the evaluation process. Ten (10) ballots of different colours were given to male and female farmer-participants where red colour represent (female) and green colour represent (male). Farmers were allowed to rank the accessions based on their preferred traits and uses. A scale of 1–10 was used to choose preferred accessions based on their traits of interest as follows: 1= extremely preferred and 10= not preferred. The participants were allowed to freely vote for the best accessions throughout the field trials by depositing paper ballots in front of the plots. The votes were counted and the highest total number was first classified. The participants were requested to observe and explain the reasons for their selected accessions.

2.4 Data Collection

Primary data was collected by using a semi-structured questionnaire and checklist through both formal and informal surveys. Local agricultural extension staff and contact personnel facilitated the survey by creating a good relationship with local people, mobilizing farmers for discussion and providing a list of farmers to be sampled for the formal surveys. A questionnaire designed had two sections including demographic and general cropping and production information. This approach enables the self-explanatory of individual farmer regarding the crop. While the group interview, the checklist was structured to collect farmer's preferences for lablab bean and factors for its abandonment. Throughout the process, a facilitator guided the activity, while enumerators focused on taking notes.

2.5 Statistical Analysis

The collected qualitative and quantitative data from the semi-structured questionnaires and checklists were classified, coded and analyzed using Microsoft Excel and IBM SPSS statistics version 20 software. The Pearson correlation coefficient was used to assess the future association of key determinants for the adoption and use of lablab beans. The data were subjected to simple tabular analysis and the results were compared, contrasted and interpreted according to the study's objectives.

The Garrett Ranking Technique was used to analyze the farmers' selection criteria and preferred traits for different lablab bean cultivars adoption and utilization in the study area. Also to identify the farmers, most preferred traits to be incorporated in the future lablab bean breeding. The technique ranks the set of parameters as perceived by the representative respondents based on certain criteria. According to Garrett [14] the order of merit assigned by the respondents was converted into percentage position by using the formula as follows;

$$Percent\ position = \frac{100(Rij - 0.5)}{Nj}$$

Whereby;

Rij = Rank given for i[th] traits by j[th] individual;
Nj = Number of traits ranked by the j[th] individual.

By referring the Garrett's ranking conversion table, the percent position of each rank calculated was converted into the Garrett score. Then, for each factor, the scores of various respondents were added and the Garrett mean score was determined. The factor with the highest mean score was considered the most important factor.

3. RESULTS

3.1 Demographic Nature of Rural Farming Community

The results from Table 1.showed that 53.3% female and 46.7% male were participated in the preference study. Of which majority (33.3%) of farmers were in the age of 46-51 and few (16.6%) were in between19-34. From six villages, the results showed that 76.7% of the participants had reasonable farming experience of lablab beans for more than 5 years. Most of the respondents (73.4%) had attained primary education level, and few had a tertiary level of education indicating that literacy level was low in the study area. Most farmers (83.3%) interviewed in all villages were both crop cultivators and livestock keepers with small land sizes ranging from 0.5 to 2 acres. Of the participants interviewed, 13.3% were employed in other sectors and agriculture was reported as their part-time activity and only 3.3% engaged themselves in entrepreneurship apart from agricultural activities.

3.2 Leguminous Crops Grown in the Study Area

The results indicated that the means of common beans and cowpeas were not significantly different from all village at 95% confidence interval (Fig. 1). It was also found that 28.20% of the farmers grow common bean as a major legume grain in their fields followed by cowpea (24.30%), pigeon pea (20.40%), green gram (16.50%) and bambara groundnuts (10.70%). However, the cultivation preferences of bambara groundnuts by participating farmers were significantly different from common beans, cowpeas, pigeon pea and green gram in all village. However, there was no single farmer who currently cultivates lablab bean legume according to this survey.

3.3 The Determinants for Lablab Beans Crop Adoption and Utilization in the Study Area

The majority of smallholder farmers in the study area in northern Tanzania are willing to cultivate lablab bean crop in the future. Correlation results from Table 2 showed that adoption rate and utilization of lablab crop can be strongly positively influenced by the ability of the person to make decisions (r=0.400*), purpose of cultivation like feeds for livestock (r=0.386*), and the availability of improved variety with determinate type (r=0.361*) at p-value 0.05. However, the purpose of use as food had a negative correlation (r= -0.426) with the adoption of this crop because farmers were willing to reuse the beans only if there is an improved variety with a good sensory attribute. In addition, lablab beans for food, an area of residence, marital status of the farmers are significant key determinants of adoption with the p-value of 0.019, 0.020, and 0.022, respectively. Correlation results depicted that education level (r=-0.711**) with the p-value less than 0.01 has a direct association with crop utilization and adoption.

3.4 Factors Hindering the Production, Consumption and Adoption of Lablab bean in Northern Tanzania

Farmers who previously cultivated lablab beans mentioned eight major constraints in the production and commercialization of this grain legume (Fig. 2). The overall results of this survey indicated that poor storage facilities (26.67%) are the most important factor limiting the production and utilization of lablab bean in Kibosho Kirima, followed by low rains during cropping season (23.08%), and unavailability of improved seeds (20.00%). However, in Kindi Kati, the major production constraint was the unavailability of improved seeds (20.00%) which lead to low yields (14.29%). Other factors were diseases and insect pests' infestations (15.79%) and low rains (15.38%) per cropping season. On the other hand, poor storage facilities, poor market demand, poor cooking quality and the high cost of agrochemicals such as insecticides, pesticides, and herbicides had little contribution to crop abandonment. In Boro village, low rainfall per growing season (7.69%) was said to be less contributor while the most important factors mentioned by farmers were poor cooking quality (23.53%), followed by expensive agrochemicals (21.05) and poor storage facilities (20.00%). In Shirimatunda village, the high cost of agricultural inputs (21.05%) was a major constraint to lablab bean production. Some farmers also mentioned low grain yield per harvest and poor cooking quality as drivers to poor adoption rate. Poor marketability of lablab beans in the local market and high diseases and field insect pests' infestation were the major reasons for neglecting this crop in Karanga village. In Sambarai village, the participants rated more or less similar to all production constraints of lablab crop. Also, farmers mentioned the insect pests which invade this crop in the field such as aphids, grasshopper, stink bugs, leaf miner, stem borer, pod boring noctuid caterpillars, and the spotted pod borer to be some of the major constraints. The field diseases such as bacterial leaf spot and leaf curly virus were also listed. During this survey, bruchids were mentioned by farmers and considered as the most dangerous storage pest of lablab grains. Other constraints considered as minor but were listed by the farmers are poor soil fertility and poor extension services.

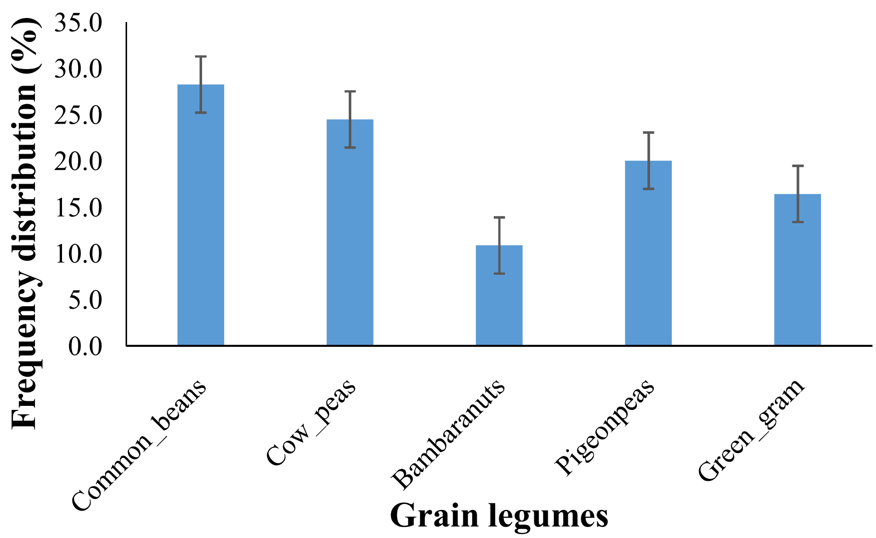

Fig. 1. Distribution of grain legumes grown in the study area

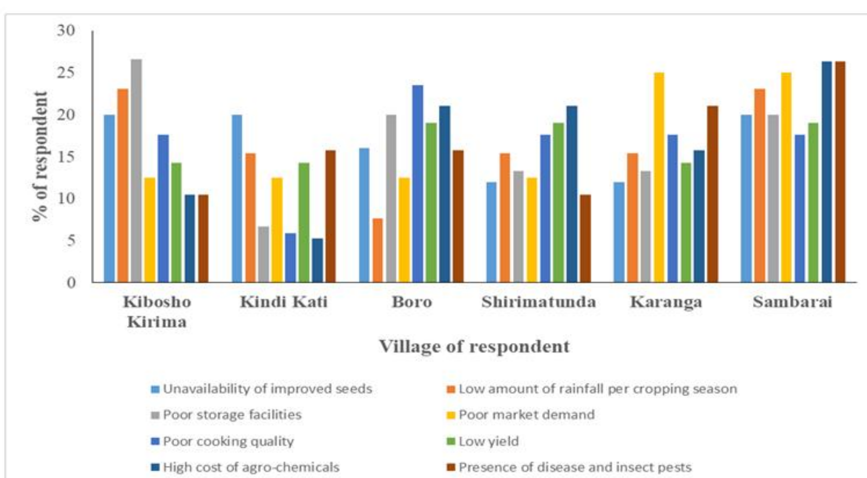

Fig. 2. Factors for the lablab bean abandonment in the study area

Table 1. Demographic characteristics, farming experiences and farm size of the respondent

Demographic category		**Village**						
		Kirima	**Kindi Kati**	**Boro**	**Shirimatunda**	**Karanga**	**Sambarai**	**Total**
		(%)	(%)	(%)	(%)	(%)	(%)	(%)
Gender	Female	6.7	6.7	10.0	6.7	13.3	10.0	53.4
	Male	10.0	10.0	6.7	10.0	3.3	6.7	46.6
Age (years)	19-34	0.0	3.3	3.3	3.3	0.0	6.7	16.6
	35-45	6.7	0.0	0.0	6.7	6.7	3.3	23.4
	46-51	3.3	6.7	10.0	3.3	6.7	3.3	33.3
	>51	10.0	10	0.0	0.0	0.0	6.7	26.7
Education level	Primary	16.7	10	10.0	16.7	13.3	6.7	73.4
	Secondary	0.0	3.3	3.3	0.0	3.3	6.7	16.6
	University	0.0	3.3	0.0	0.0	0.0	3.3	6.6
	Vocational	0.0	0.0	3.3	0.0	0.0	0.0	3.3
Occupation	Farmer + L/Keeper	13.3	13.3	13.3	16.7	16.7	10.0	83.3
	Employee	3.3	3.3	3.3	0.0	0.0	3.3	13.2
	Entrepreneur	0.0	0.0	0.0	0.0	0.0	3.3	3.3
Farming experience (years)	<5	3.3	3.3	3.3	3.3	0.0	10.0	23.2
	10	3.3	0.0	3.3	0.0	3.3	3.3	13.2
	20	3.3	0.0	0.0	6.7	6.7	0.0	16.7
	>20	6.7	13.3	10.0	6.7	6.7	3.3	46.7
Farm size cultivated (acre)	0.5 - 2	10.0	13.3	13.3	10.0	16.7	13.3	76.6
	2.1- 3	3.3	3.3	3.3	3.3	0.0	0.0	13.2
	>3	3.3	0.0	0.0	3.3	0.0	3.3	9.9

Table 2. The correlation between willingness to cultivate lablab bean crop and key determinants for cultivation

S/N	Determinants	Correlation coefficient	*P-value*
1	Location	-0.423*	0.020
2	Gender	0.029	0.878
3	Age	0.345	0.620
4	Education	-0.711**	0.000
5	Occupation	-0.137	0.470
6	Marital status	-0.416*	0.022
7	Decision maker	0.400*	0.028
8	Farm size	0.112	0.556
9	Determinate type	0.361*	0.050
10	Food	-0.426*	0.019
11	Feed	0.386*	0.035
12	Sale	-0.155	0.414

*** Correlation coefficient is significant at 0.01 level*
** Correlation coefficient is significant at 0.05 level*

3.5 Farmers' Selection Criteria of the Best Exotic Lablab Bean Accessions

Farmers assessed the performance of lablab bean under their indigenous growing soil. They identified and used similar criteria in selecting the lablab bean accessions grown in the experimental unit. Results showed the 10 most significant agronomic traits preferred by farmers for selecting newly introduced lablab bean accessions are presented in Fig. 3. The results revealed that the varietal attributes perceived by farmers to choose the accessions that satisfy their needs were drought/heat tolerant, number of pods per plant, disease and field insect pest resistance, high yielding capacity, maturity rate, leaf density, seed colour, plant height, seed size and growth type. The results showed no significant difference between the mean of 10 identified traits used by farmers to choose the accessions at a 95% confidence interval. Thus, all traits perceived by participating farmers had an equal chance to be included in the selection process.

3.6 Farmer's Choice of Lablab Bean Accessions

The best 10 accessions out of 41 lablab bean which score a large number of ballot during farmers' field evaluation are presented in Fig. 4. The results showed that accessions D163 scored higher votes followed by D137, D88, D27, D85, D155, D7, D159, D151 while the least preferred accession were D140 with the Garrets' mean scores of 50.11, 50.06, 50.05, 50.02, 50.00, 49.88, 49.77,49.59, 49.56, and 49.52, respectively (Table 3). However, the selection of these accessions was attributed by the contributions of each trait perceived by farmers. The major important varietal criteria perceived by farmers to choose the best accessions were those with low diseases and insect pests infestation, the maximum number of pods per plant, earliness, bulk leaves, high yielding capacity, seed colour, seed size, and drought or heat resistance. Results from Garrett mean score revealed that ability to resist diseases and insect pest infestation as well as large seed size (D7), number of pods per plant (D85, D163, D27, D159, D88), earliness to mature (D163, D151, D85, D140), high yielding capacity (D27, D88, D163, D151, D140, D85), cream seed colour (D159, D140), and drought and heat tolerant (D137, D155, D88) were the most important agronomic traits used by farmers to select these accessions.

3.7 Farmers' Preferred Criteria and Perceptions on the Lablab Crop Improvement

The various traits to be taken into consideration by the researcher during the breeding of lablab bean crop in the future are presented in Table 4. Results showed that majority of the respondents ranked high yielding (71.83), better taste (60.57), early maturity (54.40) and less cooking time (54.20) traits as the major traits to be incorporated for future beans breeding. Other traits perceived by representative's farmer were diseases and pest's resistance (49.50), long storage period (48.90), drought and heat tolerant (45.83), and brown seed colour (40.70). The least preferred characters were medium grain size (36.80) and determinate growth type

(34.80). These findings on grain yields are consistent with results reported by Sperling et al.,[15].

4. DISCUSSION

4.1 Demographic and Socio-economic Characteristics of the Farmers

Despite the farming experience of the majority of farmers who had an age of above 46 years of growing lablab, its production, and the consistent use has been decreasing gradually year after year. This could be due to the low proportion of able-bodied farmers who shift to cities and mining areas for better life resulting in a shortage of labour in the resources poor farming communities [16]. Also, old farmers were largely employed as cheap labour in the coffee plantation. Most of the respondent had attained primary education level, and few had a tertiary level of education indicating that literacy level among participant was low which corroborates with findings of Manyevere et al., Manyevere,et al. [17] who also found that literacy levels in the rural households in South Africa were very low. This showed great diversification in the education level where the majority of the respondent can write and read but are limited to indigenous language "Kiswahili". In the research point of views, it is a great opportunity to building capacity through training sessions, on-farm experimentation, and demonstrations. Most farmers interviewed were both crop cultivators and livestock keepers (83.3%) with small land sizes ranging from 0.5 to 2 acres. Farming activities could provide a good source of employment and entrepreneurship opportunities for the youths in Kirima, Kindikati, Boro, Shirimatunda and Karanga villages, where a large portion of the population is unemployed. Hebinck and Monde [18] stated that the rate of unemployment is highly attributed by shortage of land or lack of interest among youth due to dependency on the guardians. Generally, participated farmers were very receptive and it seems that participatory research with these farmers requires more awareness programme on the importance of lablab crop in food security, nutritional needs, and poverty alleviation through market value. These are likely to influence re-use and adoption of the lablab crop in the farming system.

4.2 Leguminous Crops Grown in the Study Area

Farmers prefer to grow indigenous and improved varieties of common beans, cowpeas, bambara groundnuts, pigeon peas, and green gram for food, feed to livestock and as well as cover crops to improve soil fertility in farming systems. The area under production for most farmers ranged from 0.5 to 2 acre in which both mixed and mono-cropping systems are practiced depending on the growing season. During the long rainy season, farmers usually cultivate common beans and cereals like maize, sorghum and oily crops such as sunflower and groundnut. However, from the survey, it was found that farmers' reuse

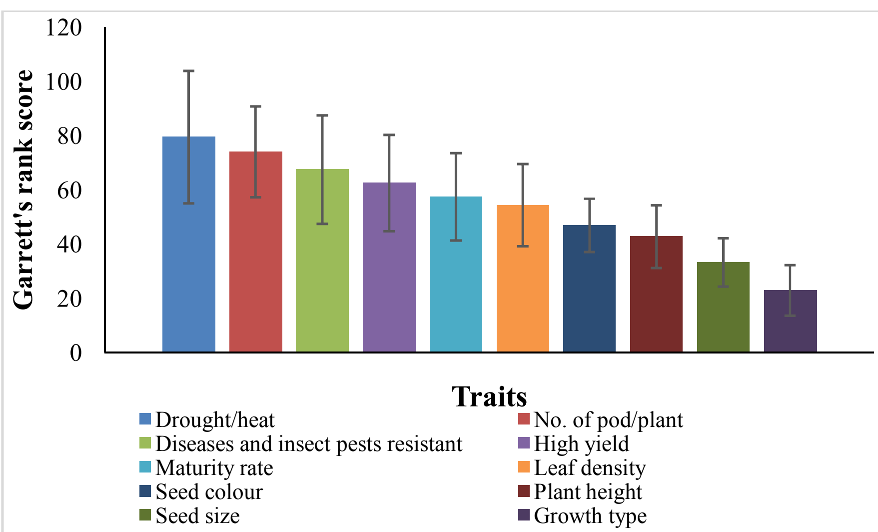

Fig. 3. Identified selection criteria of lablab bean accessions

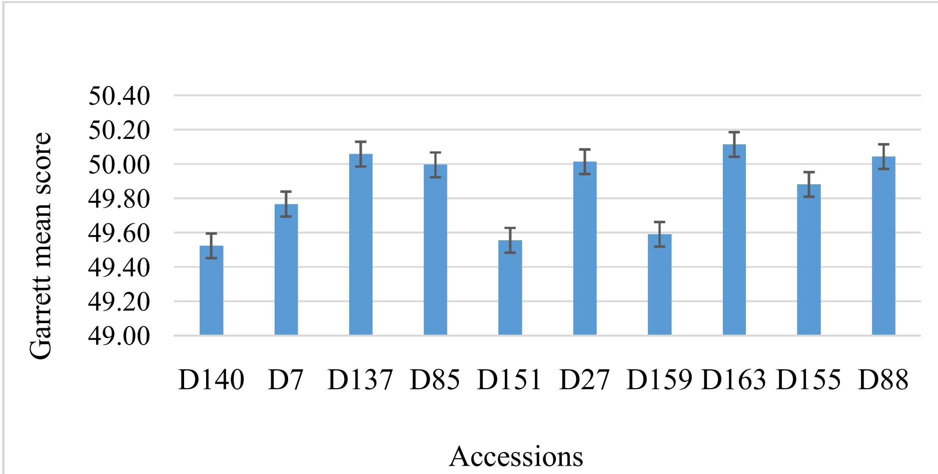

Fig. 4. 10 Best accessions selected during agronomic farmers' assessment

their local cultivars through farmers' exchange and farmers' saved seeds as the source of seed indicated that indigenous cultivars are dominant over improved varieties in the study area. Inaccessibility and unavailability of improved seeds are the major constraints that compel farmers to settle for local cultivars. Therefore, the results suggest that common bean and cowpeas were the major grain legume preferred by farmers which used to complement the main meal.

4.3 Factors Hindering Production, Utilization and Adoption of the Lablab Bean Crop

Crop production, utilization and adoption are influenced by many factors such as environmental and socioeconomic influences, beneficiaries' type, and the approaches used by extension personnel and breeders [19]. In this survey, the availability of new or improved varieties is an important factor determining lablab bean production, consumption, and early adoption. This is due to the fact that majority of the farmers highlighted unavailability of improved varieties as the major constraint which compels them to settle for local cultivars or farmers saved seeds that are susceptible to both abiotic and biotic stresses with low yield potential. In addition, abiotic and biotic stresses are the key determinants of yield losses in different agro-ecosystems. The biotic factors mentioned by the farmers are increasing in aphids (*Aphis craccivora*), stink bugs (*Coptasoma eribraria*), leaf miner, stem borer, pod boring noctuid caterpillars (*Adisura atkinsoni*), and the spotted pod borer (*Maruca testulalis*) infestation in the field. Bruchid beetles are the major storage pests mentioned by farmers, which damage the lablab grains. Lablab bean plants are vulnerable to viral diseases such as white clover mosaic, yellow mosaic virus and root rot nematodes, particularly in late maturing indeterminate type. Duke [20], indicated the biotic factors which are responsible for increasing costs of production in legumes. However, lack of research and development of neglected crops like lablab beans result in a lack of improved varieties which are resistant to both abiotic and biotic stresses. However, improved, early or tolerant varieties cannot address production constraints such as poor market demand and poor storage facilities. These two factors could be aggravated by the lack of awareness, clear approaches of seeds dissemination used by researchers, poor extension services and incubation center. David [21] described the dissemination approaches used by researchers for new varieties to the farming communities which encourage seed diffusion, adoption, and market demand. In addition, farmers also are highly concerned with the cost of purchasing the insecticides, herbicides, fungicides, and pesticides as among of the factors limiting the production of the lablab beans. These findings indicate that the rate of crop abandonment increases as most farmers cannot afford the high cost associated with agro-chemicals. Low yield is one of the constraint mentioned which can be attributed by a combination of other factors such as timely availability of high quality and improved varieties, sufficient rainfall per growing season, soil fertility and other agronomic practices due to its complexity.

Table 3. Agronomic selection criteria of the Lablab bean accessions in the study areas (N=30)

Traits	D140		D7		D137		D85		D151		D27		D159		D163		D155		D88	
	GS	**R**	**GS**	**R**	**GS**	**R**	**GS**	**R**	**GS**	**R**	**GS**	**R**	**GS**	**R**	**GS**	**R**	**GS**	**R**	**GS**	**R**
Disease/ pests resistance	66.17	3	71.40	1	65.17	3	60.73	3	24.37	10	62.50	3	31.27	10	25.37	10	63.17	3	48.30	6
Pod/plant	46.83	5	35.80	8	42.47	7	64.17	2	60.65	3	62.90	2	66.90	2	71.47	1	33.83	9	66.80	1
Maturity	66.87	2	30.70	10	29.53	10	70.83	1	73.00	1	50.90	5	34.53	8	58.83	3	44.90	6	51.00	5
Denser leaf	45.40	6	49.30	5	71.80	1	47.03	5	51.83	4	34.50	8	45.27	6	44.33	6	73.23	1	61.60	4
High yielding	68.50	1	32.20	9	39.07	8	56.20	4	69.07	2	69.20	1	32.47	9	69.60	2	28.73	10	65.70	2
Seed colour	49.93	4	49.10	6	45.67	5	39.73	8	41.00	9	31.20	10	73.23	1	37.07	8	50.80	5	41.40	7
Seed size	37.87	8	70.20	2	36.20	9	39.10	9	42.50	6	56.80	4	54.77	4	58.30	4	41.33	8	36.30	8
Plant height	39.47	7	51.70	4	45.20	6	41.27	7	42.43	7	49.40	7	49.07	5	36.97	7	44.67	7	33.10	10
Growth type	36.77	10	47.00	7	52.77	4	36.93	10	41.33	8	33.00	9	63.80	3	41.30	9	50.83	4	31.10	9
Drought tolerant	37.43	9	60.30	3	72.70	2	43.97	6	49.50	5	49.80	6	44.60	7	57.90	5	67.33	2	65.20	3
Total GMS	49.52		49.77		50.06		50.00		49.56		50.02		49.59		50.11		49.88		50.05	
Total Rank	10		7		2		5		9		4		8		1		6		3	

Traits with highest Garrett mean score is the most important; GS= Garrett Score; R= Rank, GMS= Garrett Mean Score

Table 4. Farmers and consumers satisfactory traits on lablab crop improvement (N=30)

S/N	Factors/ traits	Total score	Garrett mean score	Ranks
1	High yielding	2155	71.83	I
2	Better taste	1817	60.57	II
3	High storability	1467	48.90	VI
4	Less cooking time	1626	54.20	IV
5	Early maturity	1632	54.40	III
6	Disease and pest resistance	1485	49.50	V
7	Drought or heat tolerant	1375	45.83	VII
8	Determinate or intermediate type	1044	34.80	X
9	Brown grain colour	1221	40.70	VIII
10	Medium grain size	1104	36.80	IX

The trait of highest Garrett mean score is significant

4.4 Farmers' Selection Criteria

The selection criteria for the lablab bean accessions identified by farmers are large seed size, the number of pods per plant, high yielding, plant height, disease and insect-pest resistance, early maturity, grain colour, leaf density, growth type, drought and heat tolerant. Sperling et al., [15] found that the important criteria identified in the selection of common bean variety were high yield, earliness, resilience to abiotic stress, taste, cooking time and price. However, the results from this survey indicated that drought and heat tolerance, number of pods per plant, diseases and field insect pests resistance are the most important attributes used by farmers to choose the accessions that satisfy their needs. In a similar study, Gurmu [22] indicated that the selection criteria of common bean ranked by the farmers were seed colour, earliness, drought tolerance, disease resistance, marketability, pods load, insect pest resistance, seed size, shattering tolerance, vigorousity, growth habit (erect), pod length, first pod height from the ground, taste and cooking time. The findings from the survey are such that the first five attributes identified by the farmers have an agronomic advantage in the breeding program. Beebe [23] reported that yield, maturity time and drought tolerance are traits of agronomic importance in common bean breeding. Farmers ranked high yielding as the fourth criterion used because they understood the complexity of this trait. Therefore, they used other attributes in combination which are important in varietal selection and are key determinants of the crop yield. For instance, farmers considered the number of pods per plant as the second attribute in the selection of lablab beans as it can be used to predict the yielding potential of the crop [24]. Furthermore, farmers preferred earliness accessions with short growing cycles which enable bean varieties to utilize minimum rains, food insecure households to access food quickly. Also, it was found that farmers prefer late maturity accessions and resistance to drought or heat in drought-stressed environments because the accessions of this character have prolonged growth with denser leaves which can be used as food and feed in the time where these commodities are scarce resources.

4.5 Accessions Selected by Farmers

Farmers may opt more than one accessions because of their different qualitative and quantitative traits. However, the number of accessions chosen depends on the perceived criteria such as yielding capacity and stability, diseases and insect pests resistance, early maturity, drought or heat tolerant, and other superior traits [25]. Nevertheless, the variability of farmers' resources, growing environments, crop reproductive cycle and social variability among the farming communities are key factors which limit the number of the varieties chosen in farmers' crop stock [26]. Moreover, the purpose of use, high marketability, compatibility to their local production environment, and preference were the key determinant of variety selection and utilization [27]. In addition, the selection of appropriate accessions was based on forage and grain availability for both animal and human consumption by 80% of the farmers and livestock keepers. In this study, farmers chose accessions D137, D88, and D155 due to its denser leaves for livestock feed in the time of drought or during the dry season when the fodders are scarce commodity due to prolonged maturity. A similar purpose was identified by Abdullahi [28], when evaluated adoption of cowpea in Nigeria where farmers preferred long growth cycle variety for animal feeds. In addition, farmers chose the accessions D163, D27, D140, and D85 due to their earliness, fewer diseases and field insects' infestation, the higher number of pods per plant and high yielding. However, cream seed colour made farmers to choose accessions D137, D155, and D159 over other accessions, which were black in colour. Grain seed colour and size has great implication in the market and consumer demands because farmers consider these traits for planting [29].

Additionally, high yielding varieties, earliness maturity, seed colour, abiotic and biotic stresses resistance have an added advantage of improving food and nutritional security and sustainable livelihood through the lessening of uncertainties and unpredicted crop failure. Moreover, high yielding was considered an acceptable trait in the presence of other preferences related traits. Therefore, it is important for plant breeders or scientists to understand how and why farmers choose varieties of their interest. Farmers' choice of the accessions within plant population is essential in determining the adoption rate, utilization of new or improved variety, and diversity available in the locality for hybridization and subsequent selection of the plant. Therefore, it is clear that there is a link between selection criteria and the choice of accessions. Thus, the diversification of the traits of choice has a great impact on the breeding of new or improved lablab bean varieties for human consumption and climate change resilient.

4.6 Implications for Lablab Crop Improvement

This study found out farmers preferred lablab varieties which are high yielding, early maturing with better taste and short cooking time. These findings on grain yields are consistent with results reported by Sperling et al*.,* [15]. Moreover, this study indicated that breeding of the varieties with high yielding potentials accompanied by farmers' preferences has a great possibility of increasing the adoption rate. In addition, high yielding varieties have great value in maintaining food needs and nutritional security while increasing income per capital farmer by reducing the risks of production and unpredictable crop failures. Farmers prefer varieties that will give them a marketing advantage. This implies that different resources poor farmers chosen varieties for cultivation would actually be quite different from those anticipated by breeders [25]. Understanding farmers' selection, choice, knowledge, and skills can provide valuable insights for plant breeders. Ceccarelli and Grando [30] indicated that crop improvement programme needs to precisely target farmers' needs and fit their growing environment. These results have important breeding implications, such as high yielding varieties, which mature early with a better taste and a short cooking time. More consideration should be given to these characteristics in the breeding of lablab beans in all agro-ecological zones to ensure food security. Therefore, more effort is needed on improving this crop based on farmers' and consumers' preferences to satisfy their customers while increasing the demand for the released varieties.

5. CONCLUSION

Integration of farmers' knowledge and criteria using their overall preference scores with the breeder's criteria during cultivars selection have a great impact in plant breeding program development. Farmers' germplasm evaluations revealed their power on varieties choice and selection. However, farmers' involvement should be considered from the initial stage of developing appropriate technologies. Participatory variety selection is an efficient and effective approach of quantifying both farmers' and breeders' preferences. This approach can help researchers to understand and appreciate farmers' perception, skills, cultural crop management practices, and complexities of local agriculture in the heterogeneous environment. In addition, farmers' participation has great implication in breeding development as it helps to understand which varieties perform better and preferred by farmers. This study reveals that every farmer desires to adopt a variety which yields more, tastes better and maturing early, and short cooking time for food and nutritional security. Most respondents are willing to consume and adopt the lablab crop if the traits mentioned are incorporated during breeding so as to satisfy their needs. However, sample size, financial resource and access to literatures were the major limiting factors of this study. A small number of participants involved in the study, lack of enough capital to facilitate multi-locations at different growing seasons as well as lack of scientific literatures regarding lablab beans limits research development. It is important to have large number of participants, multi-location trials at different cropping seasons to increases accuracy of the results which reflect the actual population and breeding strategies. Therefore, breeders should take farmers' preferences as a protocol in bean breeding programme to facilitate easy variety dissemination, early market fusion, crop consumption and adoption in the heterogeneity environment where poor resource farmers are the key stakeholders.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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