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Research Application Summary

Farmers' participatory breeding of Lablab (*Lablab purpureus* (L.) Sweet): A nutritional, food security and climate smart crop in northern Tanzania

Letting, F.K.,[1, 2]* Venkataramana, P.B.[1] & Ndakidemi, P.A.[1]

[1]Department of Sustainable Agriculture, Biodiversity and Ecosystems Management, School of Life Science and Bio-Engineering, The Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania
[2] Department of Seed, Crop and Horticultural Sciences University of Eldoret, School of Agriculture and Biotechnology, Eldoret, Kenya
***Corresponding Author:** lettingf@yahoo.com

Abstract

Farmer participatory breeding is considered an alternative technique to conventional breeding. Farmers play a major role in germplasm conservation, maintenance and selection of preferred traits especially in neglected and under-utilized crops such as Lablab (*Lablab purpureus* L. Sweet*)*. The current study focused on examining the farmers' practices and production constraints in Northern Tanzania. The study was done in an on-going agro-morphological study in Northern Tanzania. Thirty-one farmers from Babati, Karatu, Kondoa, Same and Arusha were involved in the study during the podding stage of lablab accessions. Semi-structured questionnaires and focused group discussions were conducted to understand the farmers' socio-demographic characteristics, practices, production constraints and trait preference. Most of the farmers utilize lablab for various purposes while also consuming a combination of the crop parts. Most farmers use farmer saved seeds for subsequent cropping seasons. Most appropriate period to sell their produce is October-December with majority of farmers selling through middle men. Pests and diseases are the major impediment in lablab production with aphids prevalent in the field and bruchids during storage. Trait development in lablab should focus on developing pest and disease resistant varieties to overcome the burden of pest attacks. Breeding of improved varieties should also be emphasized to avoid the use of farmer saved seeds. Lablab improvement will pave way for increased use, consumption and production by the farmers in Tanzania.

Keywords: *Lablab purpureus,* partcipatory breeding , production constraints, Tanzania

Résumé

La sélection végétale participative des agriculteurs est considéré comme étant une technique alternative à la sélection conventionnelle. Les agriculteurs jouent un rôle majeur dans la conservation du germplasme, l'entretien et la sélection des traits préférés, notamment pour les cultures négligées et sous-utilisées telles que le Dolique à œil noir (Lablab purpureus L. Sweet). La présente étude visait à examiner les pratiques des agriculteurs et les contraintes de production dans le nord de la Tanzanie. L'étude était réalisée dans le cadre d'une étude agro-morphologique en cours dans le nord de la Tanzanie. Trente et un agriculteurs de Babati, Karatu, Kondoa, Same et Arusha ont participé à l'étude pendant la phase de formation des gousses des accessions de Dolique à œil noir. Des questionnaires semi-structurés et des discussions par focus groupe étaient menées pour comprendre les caractéristiques socio-démographiques des agriculteurs, leurs pratiques, les contraintes de production et leurs préférences en termes de traits. Les résultats ont démontré que la plupart des agriculteurs utilisent le Dolique à œil noir à diverses fins tout en consommant une combinaison des parties de la plante. La plupart des agriculteurs utilisent des semences conservées pour les saisons de culture suivantes. La période la plus appropriée pour vendre leur production est d'octobre à décembre, la majorité des agriculteurs vendant à travers des intermédiaires. Les ravageurs et les maladies sont le principal obstacle à la production de Dolique à œil noir, avec des pucerons prévalents dans les champs et des bruches pendant le stockage. Le développement des caractères du Dolique à œil noir devrait se focaliser sur la création de variétés résistantes aux ravageurs et aux maladies afin de surmonter le fardeau des attaques de ravageurs. La sélection de variétés améliorées devrait également être privilégiée afin d'éviter l'utilisation de semences conservées par les agriculteurs. L'amélioration du Dolique à œil noir ouvrira la voie à une utilisation, une consommation et une production accrues par les agriculteurs en Tanzanie.

Mots-clés : Lablab purpureus, élevage participatif, contraintes de production, Tanzanie

Introduction

Lablab (*Lablab purpureu*s (L.) Sweet) is an under-utilized and under-exploited orphan crop indigenous to Africa (Maass *et al.,* 2010; Letting *et al.,* 2021). Lablab is a vital leguminous crops contributing to diets with the leaves, fresh pods, fresh seeds and dry beans forming important part of daily meals in most parts of the world (Minde *et al.,* 2020; Pongener and Deb, 2021). The species is nutrient dense and is considered as the “poor man’s meat” due to its high protein content (Kilonzi *et al.,* 2017) as well as contributing to the social economic welfare of the rural livelihoods in Africa. Lablab is also significant as animal feed (Ewansiha *et al.,* 2016), conservation strategies (Miller *et al.,* 2018), pharmacological importance (Rai *et al.,* 2021) and as intercrop (Nord *et al.,* 2020) and as climate smart crop (Grotelüschen, 2014). Incorporating lablab crop into research programs is important for food and nutritional security, climate resilience and sustainable farming systems.

Research on lablab has mainly focused on its use as forage crop (Wangila *et al.,* 2021), green manure (Jibat and Gerkabo, 2021) and intercrop (Nord *et al.,* 2020). Little research on its utilization as a food crop has been documented. Lablab grain yield in sub-Saharan Africa is reported to range from 0.4-0.6t/ha (Miller *et al*., 2018; Nord *et al*., 2020) which is lower than the potential 10ton/ha (Salim *et al.,* 2013). The yield gap is attributed to production constraints such as field and storage pests (Boit *et al.,* 2018; Naveena *et al*., 2011), storage pests (Naveena *et al.,* 2011), soil salinity (Devaraj and Dsouza, 2016), lack of improved varieties (Chawe *et al.,* 2019), and low yields (Kankwatsa, 2018). Additionally, lack of farmer preferred traits (Chawe *et al.,* 2019) and scanty information and knowledge pertaining the genetic diversity of the existing germplasm collections has hampered development of improved lablab varieties (Letting *et al.,* 2021).Yet such information would catalyse focused research for development of superior varieties with farmer-desired traits.

Breeders can create better varieties that are geared toward the goals of the end-users by integrating this local knowledge with their scientific expertise and cutting-edge technologies. Attempts to understand the farmers’ practices, production constraints and trait preferences is important as a bedrock for future lablab breeding ventures. Genetic diversity is key in any crop improvement initiatives. Access, utilization and information pertaining existing diversity of landraces and germplasm collections are the pillars towards lablab breeding (Letting *et al.,* 2021). Exploiting this existing genetic variability enables breeders to develop elite/superior genotypes and thus improve yield. To stimulate the development of improved varieties with farmer-preferred traits, researchers and plant breeders require a holistic view of the diversity inherent in present lablab germplasm. This study was conducted to examine farmers' production practices and constraints in order to generate valuable information towards lablab breeding.

Methodology

Lablab field experimental study was set up at the Nelson Mandela African Institution of Science and Technology (NM-AIST), Arusha (Northern part) Tanzania during the long rainy season (May-August 2020). NM-AIST lies at Latitude 03º02'17.0" S and Longitude 037º35'24.9"E at an elevation of 1106 m.a.s.l. The mean maximum temperature ranges from 22ºC to 28ºC while the mean minimum temperature ranges from 12ºC to 15ºC. Three hundred and twenty lablab accessions were planted in an augmented block design with three checks and replicated twice in each block. There were 10 blocks summing up the total experimental units to 390. This was done on a 40×30 m land size divided into 10 blocks of 39 rows, each representing one accession (treatment), and 10 seeds planted on each row (one seed per hole) with a plant intra-spacing of 45 cm and row inter-spacing of 70 cm between with a path of 1m between the blocks.

The farmer participatory study was done when the plants were at podding stage. Farmers were selected purposively from lablab growing regions of Tanzania. Thirty-one farmers, Babati (4), Karatu (5), Kondoa (5), Same (5), and Arusha (12) were selected to participate in the study at the NM-AIST field. The questionnaire delved on information regarding socio-demographic factors, production practices and constraints of lablab crop. Similarly, the information on traits of interest by the farmers for lablab improvement was generated from the discussions and the semi structured questionnaires. These traits were essential in selecting the most preferred accessions from the experimental field. Farmers were grouped into six (6) with 5 participants each and a trained assistant assigned to aid during the field visit. Gender and region was considered when grouping the participants to avoid biasness. The farmer were then allowed to identify the most important trait for lablab improvement for animal feed, disease tolerance, early maturity, food, yielding potential, pest resistance, intercrop, seed shape, seed color, market and soil conservation. The traits with the maximum number of frequencies were selected.

Data analysis. For the participatory plant breeding, quantitative and qualitative data collected from the questionnaire and focus-group discussions were coded, organized, summarised, and analysis done using the statistical package IBM SPSS 21. The analysis included cross-tabulations and descriptive statistics computed from the data obtained.

Results

Socio-demographic characteristics of farmers. Analysis of the socio-demographic profiles showed no significant differences. The majority of the farmers (71%) were male while (29%) were female with the trend cutting across each of the five study regions. More than 83% of the participants were more than 36 years of age. Most of the respondents were married (80%), whereas 12.9% were single and 6.5% were widowed. In terms of literacy levels, 74% of the respondents had completed their primary school, 19.4% had finished their secondary education, and 3.2% had completed their higher education. Seventy percent of the respondents had less than ten years of experience cultivating crops. Lablab was cultivated on less than 2 acres (0.9 ha) of land which was the case with 87.1% of the respondents (Table 1).

Lablab utilization, market information and seed source. In terms of utilization there was no significant differences except in animal feed. Most of the farmers utilize lablab for food (83.9%), commercial purposes (74.2%), animal feed (71%), and soil conservation (61.3%). In relation to parts consumed, significant differences was reported in green beans only ($P<0.05$). Parts of lablab consumed vary from green beans (48.4%), leaves (61.3) to dry beans (90.3%) (Table 2).

Significant differences were observed in the marketing channels used by farmers ($P<0.001$). Eighty four percent (84%) of the participants sold their produce in the local market, while the remaining 16% relied on middlemen. Farmers stated that peak period that they sell their produce to be October to December. Significant differences were observed in the seed sources mentioned by farmers with the farmers owned saved seed and neighbours being most common. Over 51% of the farmers grew lablab from their own saved seeds from the previous season, followed by purchasing seeds from local markets (25.8%), NGOs each constitute 19.4% and neighbours a paltry 12.9% of the total (Table 2).

Major constraints in lablab production. Inadequate rainfall, expensive agro-chemicals, and poor marketability were significant factors in production of lablab. Pests and diseases, poor seed quality, low yields, and poor storage did not show any discernible differences. However, pests and diseases (87.1%) and poor marketability (38.7%) were highlighted by farmers as their highest ranked challenges in every region. Low yields (19.4%) and poor storage (6.5%) reportedly had little impact on lablab production. The main challenge bedevilling farmers in the Same district was identified as insufficient rainfall. Although poor storage was the challenge that was least cited, 6.5% of the farmers in Karatu and Same acknowledged it as a bottleneck in lablab production.

There were significant differences in occurrence of the pests affecting lablab in the field ($P<0.001$). Pod borers, aphids, and mites were the main field pests that attack lablab in the field (48.4%, 41.9%, and 9.7%, respectively). All the farmers from the studied regions reported aphid pest as the most common in their farms. During cropping season, farmers from Babati and Kondoa reported mite infestation. The farmers in Babati and the Same area, however, had no problems with pod borers. Despite being a resilient crop, lablab is commonly attacked by diseases. The diseases identified by the farmers differed significantly ($P<0.001$)in importance in this study. The two main diseases that affect lablab production are bacterial wilt (38.7%) and late blight (25.8%). Bruchid (*Callosobruchus* spp.) (87.1%) was the most devastating storage pest accounting for up to 100% grain loss. Bean weevil attacks occurred during storage for the remaining farmers (12.9%). While 7.1% of farmers use botanicals to minimize the losses, over 92% of them apply pesticides prior to storage. To control storage pests, farmers from Kondoa and Babati apply botanicals (Table 3).

Trait preference for lablab development. The farmers identified six features they regarded as key for lablab crop. The majority of farmers (38.7%) cited increased pest and disease resistance as the most fundamental aspect to take into account. Early maturity variety (42,9%) ranked next, while forage quality (7.1%) had the lowest percentage. Farmers (6.5%) also indicated the necessity to improve a combination of all four attributes.

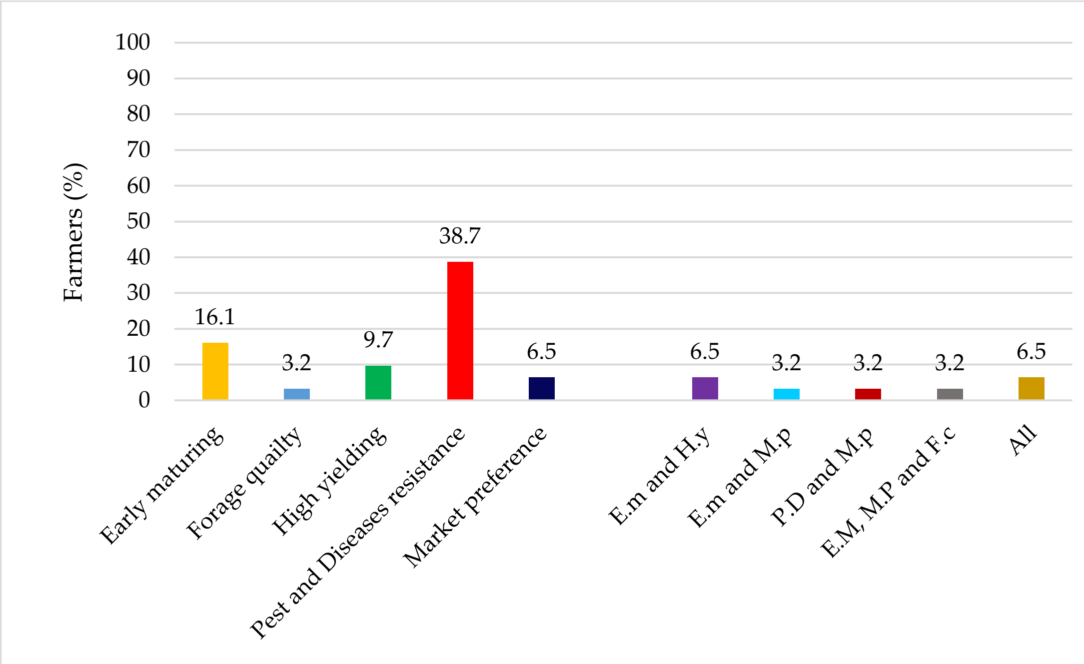

Figure 1. Most preferred trait by farmers

Discussions

Farmer participation is an approach that augments conventional breeding by integrating farmers, breeders, consumers, and other end-users in the entire breeding process. Farmers participate in decision-making from the inception of the breeding process until the variety is released (Sanghera *et al.,* 2013). Tanzania used to produce lablab, but this was abandoned as higher yielding, commercially oriented legumes were introduced (Ngailo *et al.,* 2003). This study explored the production practices and constraints limiting lablab utilization and consumption in Northern Tanzania.

Lablab is an economically important crop especially in Northern Tanzania which borders Kenya, where it has a high market value (Grotelüschen, 2014). Owing to financial benefits, men frequently engage in the production of crops that are regarded to have high economic value, which is one reason that is believed to have contributed to the high proportion of men in the study (Quisumbing *et al.,* 2015). Regarding farming activities, family ownership is essential as it provides cheap, readily available and affordable labor force. Basic formal education expedites the adoption of technologies, the understanding of common farming practices, and the application of such practices to spur productivity (Oduro-ofori *et al.,* 2015). Limited land has been reserved for the production of lablab due to low perception of the crop. Increasing production of this crop and maximizing profitability necessitate raising awareness.

Lablab is a versatile crop with multiple uses and most of its plant parts contributes towards alleviating nutritional insecurity (Kilonzi *et al.,* 2017; Minde *et al.,* 2020). The majority of farmers also use lablab as a multipurpose crop, which is essential for the resource-poor rural livelihoods that rely on small-scale production. Low profits result from farmers selling their crops to nearby

Table 1. Socio-demographic description of the farmers from the selected regions in Tanzania

		District									
Variable	Category	Arusha	Babati	Karatu	Kondoa	Same	Total		DF	Chi-square	P-value
Gender	Male	6	4	4	5	3	22	71	4	6.732	0.151
	Female	6	0	1	0	2	9	29			
Age (yrs)	21-35	2	1	1	1	0	5	16.1	8	4.854	0.773
	36-50	4	2	2	3	1	12	38.7			
	over 50	6	1	2	1	4	14	45.2			
Marital status	Single	2	0	1	0	1	4	12.9	8	5.146	0.742
	Married	9	3	4	5	4	25	80.6			
	Widow	1	1	0	0	0	2	6.5			
Education level	Primary	7	2	5	5	4	23	74.2	12	13.19	0.355
	Secondary	4	1	0	0	1	6	19.4			
	University	0	1	0	0	0	1	3.2			
	Others	1	0	0	0	0	1	3.2			
Experience of the farmer in farming (yrs)	0-5	8	1	5	0	1	15	48.4	24	43.174	0.01
	6--10	1	2	0	1	3	7	22.6			
	11--15	0	0	0	2	1	3	9.7			
	16-20	0	1	0	0	0	1	3.2			
	21-25	0	0	0	2	0	2	6.5			
	26-30	2	0	0	0	0	2	6.5			
	0ver 31	1	0	0	0	0	1	3.2			
Size of land under crop cultivation(acres)	0-2	6	1	2	2	1	12	38.7	12	11.083	0.522
	3--5	6	3	2	1	3	15	48.4			
	6--10	0	0	1	1	1	3	9.7			
	>10	0	0	0	1	0	1	3.2			
Land under lablab production (acres)	0-2	10	2	4	4	2	22	71	8	11.414	0.179
	3--5	2	2	0	1	3	8	25.8			
	6--10	0	0	1	0	0	1	3.2			

markets from October through December. Compared to other legume crops, neglected crops, such as lablab, lack a structured marketing channel (Mudau *et al.,* 2022). Dry beans are a main food source for the respondents because of the high protein content they contain (Kilonzi *et al.,* 2017). The majority of farmers also use them as a multipurpose crops, which is essential for the resource-poor rural livelihoods that rely on small-scale production. Low profits result from farmers selling their crops to nearby markets from October through December. Compared to other legume crops, neglected crops, such as lablab, lack a structured marketing channel (Mudau *et al.,* 2022). This element of the lablab production chain needs improvement through coordinated efforts. Farmers are compelled to use their own-saved seeds which have deteriorated in quality owing to continuous cultivation, culminating in genetic losses. It is imperative to breed high quality seeds by initiating lablab breeding programs.

Despite being a resilient crop, pests and diseases still limit lablab productivity. This encompasses bruchid (Letting *et al.,* 2021) during storage to aphids and pod borers (Boit *et al.,* 2018) in the field. Research focus on developed varieties with resistance to prevalent pests and diseases would increase farmers profitability and boosts lablab production. One of the common diseases that plague lablab, particularly in the early phases of seedling development, is bacterial wilt. This disease causes stunted growth and mortality, which affects the plant population and ultimate yields (Osdaghi *et al.,* 2020). Additionally, bruchids (*Callosobruchus* spp.) are a threat to stored lablab produce resulting in reduction of both quality and quantity as well as market value (Letting *et al.,* 2021).

Farmers underscored the importance of developing pest-resistant crop varieties which would result in higher yields and reduced production costs. Tanzania is a country with a diversity of plant species and an ecologically varied environment. Farmers who have used botanicals to control pests acknowledged its effectiveness. Mkenda and Ndakidemi (2014) asserted that some botanical plants are effective in preventing pests from damaging legume crops. The appropriate dosage and large quantities required for its use, however, is a barrier for the farmers. Thus, breeding resistant species may present an approach to enhance lablab improvement.

Conclusion

The prime focus of the current study was on understanding farmer practices and drawbacks that hinder lab production. Due to its versatility, lablab provides farmers the potential to use it in a variety of ways. To help farmers optimize their profits, a formal marketing channel for lablab produce has to be developed. The development of pest and disease resistant varieties should be the main goal of lablab improvement in order to increase adoption, consumption, and production by farmers. Similarly, more exploration into the genetic diversity of the available germplasm is necessary to allow the development of high-quality superior varieties.

Table 2. Use, marketing and seed source of lablab

		District									
Variable	Category	Arusha	Babati	Karatu	Kondoa	Same	Total	Percentage (%)	DF	Chi-square	P-value
Utilization of lablab	Food	10	2	5	4	5	26	83.9	4	5.373	0.251
	Animal feed	7	1	4	5	5	22	71	4	9.321	0.054
	Commercial purposes	10	3	2	3	5	23	74.2	4	5.843	0.211
	Soil conservation	6	1	3	4	5	19	61.3	4	6.764	0.149
Parts of lablab consumed	Leaves	5	2	3	4	5	19	61.3	4	6.062	0.195
	Dry beans	11	3	5	4	5	28	90.3	4	2.78	0.595
	Green beans	2	3	2	3	5	15	48.4	4	11.713	0.02
Marketing channels	Local markets	12	1	5	3	5	26	83.9	4	16.585	0.002
	Middlemen	0	3	0	2	0	5	16.1			
Source of market information	Media	3	1	4	2	0	10	32.3	8	12.359	0.136
	Neighbours	1	0	1	0	0	2	6.5			
	Middlemen	8	3	0	3	5	19	61.3			
Peak selling period	January-march	1	1	0	0	0	2	6.5	12	13.965	0.303
	April-June	1	0	0	0	0	1	3.2			
	July-September	4	3	1	0	1	9	29			
	Oct-December	6	0	4	5	4	19	61.3			
Seed source	Own saved seeds	6	3	1	1	5	16	51.6	4	8.573	0.073
	Neighbours	0	1	0	3	0	4	12.9	4	13.649	0.009
	Local markets	4	1	2	1	0	8	25.8	4	2.71	0.608
	Non-governmental organizations	2	0	1	0	3	6	19.4	4	2.78	0.595

Table 3. Constraints of lablab production

Constraints of lablab production											
		District									
Variable	Category	Arusha	Babati	Karatu	Kondoa	Same	Total	Percentage (%)	DF	Chi-square	P-value
Constraints of lablab production	Pests and diseases	12	3	3	4	5	27	87.1	4	6.53	0.163
	Poor quality seed	3	2	2	1	1	9	29	4	1.636	0.802
	Inadequate rainfall	2	1	0	1	5	9	29	4	15.388	0.004
	Low yields	1	2	0	1	2	6	19.4	4	5.907	0.206
	Poor storage	0	0	1	0	1	2	6.5	4	4.49	0.344
	Expensive agrochemicals	1	2	0	0	3	6	19.4	4	11.033	0.026
	Poor marketability	3	3	2	0	4	12	38.7	4	9.925	0.042
Field pests	Caterpillars	11	0	2	2	0	15	48.4	8	26.252	0.001
	Aphids	1	2	3	2	5	13	41.9			
	Mites	0	2	0	1	0	3	9.7			
Diseases in lablab	Bacterial wilt	5	2	0	5	0	12	38.7	12	46.952	0.00
	Late blight	5	0	3	0	0	8	25.8			
	Powdery mildew	2	2	2	0	0	6	19.4			
	Yellowing	0	0	0	0	5	5	16.1			
Storage pests	Bruchids	12	4	4	4	3	27	87.1	4	6.085	0.193
	Bean weevils	0	0	1	1	2	4	12.9			
Storage pest control	Pesticides	12	4	4	3	3	26	92.9	4	11.685	0.166
	Botanicals	0	1	0	1	0	2	7.1			

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