

# Integrating Conventional and Participatory Breeding Approaches in Assessment of Common Bean Varieties for Farmer Preferred Traits

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## Abstract

It is estimated that over 75% of rural households in Tanzania depend on common bean (*Phaseolus vulgaris* L.) for daily subsistence. Recently, farmers have been increasingly looking for improved bean varieties which meet specific market demands characterized with yellow seed colour, early maturing and/or adapted to local agro-ecologies. Study focused on assessing the performance of bean varieties for agronomic traits through variety and environmental interactions by identifying high yielding, early maturing and market demand seed classes among the tested materials. For testing adaptability and stability, experiments were conducted in low to high altitudes for two consecutive years using randomized complete block design (RCBD) with three replicates. Eight common bean varieties KG98, Navy line 1, KATB9, SABRYT, KATB1, Lyamungu 85, JESCA and Calima Uyole were used. Absolute, matrix and pairwise ranking were used integratively for farmers' and researcher's assessment and selection. Participatory variety selection approach gave farmers an opportunity to assess and select varieties from a range of near finished materials in the breeding process. As part of the Farmers' participatory variety selection process, seventeen participants as among the consumers 46% being women were selected to participate in a focused group discussion. Results revealed that, days to flowering, days to maturity and yield across the tested environments showed significant differences ( $p \leq 0.05$ ) as well as yield and diseases interactions for genotype, environment and season. Field data and farmers' assessment data showed two varieties of KATB1 (yellow round) and KATB9 (red round) for better performance (high yield) and grain preference respectively. It showed that, early maturing; seed type and marketability varieties are highly demanded by bean farmers in Tanzania.

**Keywords:** marketability, participatory, variety, early maturing, seed type

## 1. Introduction

Common bean (*Phaseolus vulgaris*) plays a principal role in the livelihoods of smallholder farmers in Tanzania as food security crop and source of income. It is the leading leguminous crop, accounting for 78% of land under legume cultivation (FAO, 2013). It is estimated that over 75% of rural households in Tanzania depend on common beans for daily subsistence (Kalyebara et al., 2008). Common bean production and national demand have been increasing while the average annual production of 790,818 MT for 2010 to 2014 is still low but the production appears relatively high compared to other sub-Saharan Africa but the actual yield per unit area is still low equated to the potential yield of 2 t ha<sup>-1</sup> (FAOSTAT, 2014; Binagwa, 2016). In East African region, disease is the second biggest constraint to common bean production after low soil fertility (CIAT, 2003; PABRA, 2009). Fungal foliar diseases such as angular leaf spot (ALS) (*Phaeoisariopsis griseola*), anthracnose (*Colletotrichum lindemuthianum*); viral diseases bean common mosaic and necrotic virus (BCMNV); and bacterial diseases particularly common bacterial blight (CBB) (*Xanthomonas axonopodis* pv. *phaseoli*) and halo blight causes severe yield losses in common beans where they are prevalent and environmental conditions are favorable (Buruchara et al., 2010) and abiotic constraints but not limited to low soil fertility and drought (Wortmann &

Allen, 1994; Katungi et al., 2009). Economic diseases for Tanzania are ALS and CBB basing on occurrence and distributions.

Recently, farmers have been increasingly looking for improved bean varieties characterized with early maturing, round seed type, diseases tolerant/resistant, market seed classes and/or varieties which are adapted to local agro-ecologies (Nile Basin, 2012). To ensure preferences and acceptance of developed common bean varieties, farmers are involved in variety selection procedures through participatory research approach. This involvement of farmers confirms awareness, acceptance, adoption and spatial diffusion of the developed common bean varieties (Letaa et al., 2015). The participatory variety selection refers to the approach that involve the examination of farmers' crops around harvest time, and the pre-selection of varieties by farmers from trials of many entries grown on a research station or on a farm (Witcombe et al., n.d.). This approach gives farmers an opportunity to assess and select varieties from a range of near finished materials in the breeding process and gives researchers the chance to understand the criteria farmers used in the selection process and identify farmer and market preferences (Witcombe et al., 1996). The participatory common bean breeding program is diverse in scope and have been further classified as contractual, consultative, collaborative, and collegiate with increasing degree of farmers involvement in the decision-making process (Bishaw & Turner, 2008). Farmers are involved after various on-farm evaluations that assist in trait assessment for variety selection, assessment of genetic variability to identify desirable traits or eliminate undesirable traits during materials evaluation and confident incorporation of genetic tools such as marker-assisted breeding and bioinformatics (Sankaran et al., 2015). This happened because it is stated that the rigid release requirements and unrepresentative testing conditions can lead to mismatches between what is offered by crop researchers and what is desired by farmers (Witcombe & Virk, 1997). This means there should be clear traits, gaps or challenges that are faced by farmers which should be addressed by plant breeders. The most preferred specific grain traits by farmers, traders and consumers at large include round medium sized seeds for better market class, early maturing, drought tolerant, diseases tolerant/resistant and high. It has showed that the improved bean varieties in East Africa is the best-known example of the successful application of PVS which has fueled common bean crop improvement in several countries including Rwanda, Tanzania, and Malawi (Weltzien et al., 2003).

Smallholder farmers have limited access to pesticides and fertilizer and are suffering most from this production loss, this study focused on evaluating bean varieties in different agro-ecologies in Tanzania and involved farmers during selection. This is the breeding approaches which is most ecological and economical mean to control diseases in low input agriculture, and particularly important to maintain stable yields of smallholder farming systems. The objective was to assess the effects of integrate conventional and participatory breeding approaches in assessment of common bean varieties for farmer preferred traits by i) identifying early maturing, diseases tolerant/resistant and high yielding varieties ii) identify market seed classes that preferred by local farmers, consumers and traders.

## 2. Materials and Methods

Total of eight bean varieties including checks (KG98, Navy line 1, KATB9, SABRYT, KATB1 sourced from CIAT and KARLO Kenya) and Lyamungu 85, JESCA and calima Uyole were evaluated on-farm across different agro-ecologies that representing common bean growing areas in the country for adaptability and stability studies. Varieties were tested at Selian-Arusha (1,414 m. a.s.l.), Uyole Mbeya (2,014 m. a.s.l.), Maruku-Kagera (1,352 m. a.s.l.) and Lambo-Kilimanjaro (995 m. a.s.l.) locations in 2014 to 2016 long rain growing season(s) while the Participatory Variety Selection conducted at Karatu, Babati and Bukoba districts. In all locations the trials were laid out for different years in Randomized Complete Block Design (RCBD) with 3 replications. The experimental plot size was 4 rows, 5 m long and 50 cm apart and 20 cm within a row. The net plot size was 4.2 m<sup>2</sup> across testing sites. Observations and data collection were made on days to 50% flowering, diseases severity 1-9 scale, 1 = non-pathogenic, 9 = pathogenic (CIAT, 1987) and days to maturity. The grain yield was measured from the centered two rows using precised balanced scale (0.01 g) when grains were at 14% moisture content. The collected and organized data were analyzed using GenStat 16th Edition with the following linear model  $Y_{ijk} = \mu + G_i + \gamma_j + G_i \cdot \gamma_j + \alpha_k + G_i \cdot \gamma_j \cdot \alpha_k + e_{ijk}$ , where;  $Y_{ijk}$  = Response variable (Yield) with variety  $i$ , environment  $j$  and season  $k$ ;  $\mu$  = Overall mean for all the observed response;  $G_i$  = Fixed effect of variety;  $\gamma_j$  = random environmental effect of the observed response;  $G_i \cdot \gamma_j$  = Interaction effects between variety and environment;  $\alpha_k$  = Random effect of replication within a season;  $G_i \cdot \gamma_j \cdot \alpha_k$  = Interaction effect of variety, environment and season;  $e_{ijk}$  = Random term error which is assumed to be normally distributed with 0 mean and variance  $\delta^2$  which were summarized in a given results.

Farmers' assessments were conducted during physiological maturity of common bean varieties so that farmers could observe clearly early maturing, diseases tolerant/resistant and yield parameters (pods per plant and seeds per

pod). In the on-station testing, farmers were engaged to set the selection as; early maturity, drought tolerance, high yielding and market preference. The most common criteria used for assessing drought was observing around margins of leaves with the dead leaf tissue between veins toward the midrib, folding of leaves and signs of early maturing (Texas A&M Agrilife Extension Book (n.d.)). To assess seed market class preferences and grain quality, seeds from previous season were placed along each plot for observation and assessment. Other farmer assessment methodology for different traits were adopted with amendments of the one used by Kund et al. (2015a, 2015b) on pigeon pea (*Cajanus cajan* L.). Total of 17 participants 46 % being women as representative of farmers and consumers were selected according to the standard number of participants required for Focus Group Discussion (FGD) (Stewart et al., 2007; Gibbs, 1997) in crop assessment. The farmers who participated had either tested by themselves the varieties or had direct exposure to them through the on-farm trials, and with long time experience in bean farming this was done through volunteering sampling. The varieties were evaluated using absolute, pair wise and matrix ranking assessment tool as the researchers mentioned criteria required and farmers ranked them according to their prioritization. The gender disintegration was highlighted as different groups of men and women were assembled and segregated in groups for the assessment of their preferences. In common bean systems, market traits refer to consumer preferences for bean characteristics along the bean value chains. For example, in different countries consumers prefer different market classes; red mottled for Uganda, Tanzania, Ethiopia, Malawi and Zambia; large red kidneys for USA and Belgium, round yellow for Kenya, Tanzania and Burundi. All these preferences are accompanied with other characteristics of canning quality, color, shape, size and other cooking properties such as cooking time and digestibility (Mishili et al., 2009).

### 3. Results and Discussion

The targeted traits for measuring the varieties preferences and productivity were early maturing, diseases tolerant/resistant, seed yield stability and market demand. There was significant difference ( $p \leq 0.05$ ) on days to flowering (Table 1), days to maturity (Table 2) and yield across four different environments and seasons with exception to Lambo Kilimanjaro where yield ( $\text{kg ha}^{-1}$ ) resulted not significant in 2014/15 season (Table 5a). This insignificant may be because of the high incidence of variety being tested in different environment which complicates the testing picture in cropping systems cultivated in marginal environments (Ceccarelli et al., 1996). Based on the results, proposed bean candidates KATB1 and KATB9 showed less number for days to flowering (Table 1) and full maturity (Table 2) compared to standard released bean varieties JESCA and Lyamungu 85 as well as market grain quality for KATB 1 (Tables 6, 7, 8 and 9). Other studies states that the production environment is not only marginal but also heterogeneous, this statement was revealed by barley breeders do the bulk of their selection in farmers' fields in spatially disperse locations (Ceccarelli et al., 2004). Severity of ALS and CBB was high in 2014/15 season than the rest season and results shows that KG98 was highly susceptible with a score of  $> 6.00$  across the tested environments (Tables 3 and 4).

Despite to this merit, the yield of these proposed bean varieties was above  $1 \text{ t ha}^{-1}$  across 87.5% of testing locations with exception to Lambo in 2014/15 which shows less yield even in other varieties, probably was because of erratic drought. In neighbouring countries (Kenya and Burundi) where these varieties released the yield ranged from  $1,123\text{-}1,197 \text{ kg ha}^{-1}$  while for Tanzania the seed yield ranged  $1,050\text{-}2,658 \text{ kg ha}^{-1}$  (Table 5a). This difference was due to erratic rainfall (drought) in the testing locations. Generally, both on farm and on station trials showed better adaptability and stability at both high and mid altitudes like what happened to advanced yield trials conducted in other neighbouring countries. The KATB1 flowered (31-32 days after planting) and matured (75-79 days after planting) below the mean value of the location while the check variety Lyamungu 85 and Calima Uyole had higher number of days to flowering and maturity compared to the mean yield of the location (Tables 1 and 2). This explains the need to release these varieties due to their advantage in early maturity compared to the released varieties which means they have characteristics of escaping drought condition.

Table 1. Days to flowering of common bean varieties across seasons and environments

| Varieties    | Experimental locations |         |         |         |         |         |         |         |
|--------------|------------------------|---------|---------|---------|---------|---------|---------|---------|
|              | Selian                 |         | Uyole   |         | Lambo   |         | Maruku  |         |
|              | 2014/15                | 2015/16 | 2014/15 | 2015/16 | 2014/15 | 2015/16 | 2014/15 | 2015/16 |
| KATB1        | 32.00                  | 32.00   | 31.00   | 31.00   | 32.00   | 32.00   | 32.00   | 31.00   |
| KATB9        | 32.00                  | 32.00   | 32.00   | 33.00   | 32.00   | 32.00   | 32.00   | 33.00   |
| JESCA        | 33.00                  | 33.00   | 32.00   | 34.00   | 32.00   | 35.00   | 35.00   | 36.00   |
| Calima Uyole | 34.00                  | 34.00   | 36.33   | 36.33   | 36.33   | 34.00   | 36.00   | 36.00   |
| Navy line 1  | 36.00                  | 36.00   | 35.65   | 35.65   | 35.65   | 36.00   | 36.00   | 36.00   |
| SARBYT       | 36.00                  | 36.00   | 37.00   | 37.00   | 37.10   | 36.00   | 35.33   | 35.33   |
| Lyamungu 85  | 36.00                  | 36.00   | 37.67   | 36.67   | 37.67   | 36.00   | 36.00   | 36.00   |
| KG98         | 42.00                  | 42.00   | 42.33   | 42.33   | 42.33   | 42.00   | 41.33   | 41.33   |
| Mean         | 35.00                  | 35.12   | 35.42   | 35.42   | 35.42   | 35.13   | 35.58   | 35.58   |
| CV%          | 0.90                   | 0.90    | 2.10    | 2.10    | 2.10    | 0.90    | 4.30    | 4.30    |
| LSD          | 0.54                   | 0.50    | 1.30    | 1.30    | 1.30    | 0.54    | 2.65    | 2.65    |
| P = 0.05     | *                      | *       | *       | *       | *       | *       | *       | *       |

Note. \* = significant.

Table 2. Days to full maturity of varieties across seasons and environment

| Varieties    | Experimental locations |         |         |         |         |         |         |         |
|--------------|------------------------|---------|---------|---------|---------|---------|---------|---------|
|              | Selian                 |         | Uyole   |         | Lambo   |         | Maruku  |         |
|              | 2014/15                | 2015/16 | 2014/15 | 2015/16 | 2014/15 | 2015/16 | 2014/15 | 2015/16 |
| KATB1        | 75.00                  | 75.00   | 76.00   | 76.00   | 78.00   | 76.00   | 76.00   | 79.00   |
| KATB9        | 77.00                  | 77.00   | 78.00   | 79.00   | 79.00   | 80.00   | 76.00   | 80.00   |
| JESCA        | 79.00                  | 79.00   | 80.00   | 80.00   | 81.00   | 82.00   | 79.00   | 81.00   |
| Calima Uyole | 86.00                  | 86.00   | 86.00   | 86.00   | 86.00   | 86.00   | 86.00   | 86.00   |
| Navy line 1  | 88.00                  | 88.00   | 88.00   | 88.00   | 88.00   | 88.00   | 88.99   | 88.99   |
| SARBYT       | 89.00                  | 89.00   | 89.00   | 89.00   | 89.00   | 89.00   | 89.00   | 89.00   |
| Lyamungu 85  | 87.00                  | 87.00   | 87.00   | 87.00   | 87.00   | 87.00   | 87.00   | 87.00   |
| KG98         | 89.00                  | 89.00   | 89.00   | 89.00   | 89.00   | 89.00   | 89.00   | 89.00   |
| Mean         | 87.25                  | 87.25   | 87.21   | 87.21   | 89.00   | 89.00   | 87.21   | 87.20   |
| CV%          | 1.20                   | 1.20    | 1.20    | 1.20    | 1.20    | 1.20    | 1.20    | 1.20    |
| LSD          | 1.81                   | 1.81    | 1.88    | 1.88    | 1.81    | 1.81    | 1.88    | 1.88    |
| P = 0.05     | *                      | *       | *       | *       | *       | *       | *       | *       |

Note. \* = significant.

Table 3. Diseases severity scores (1-9) across environment 2014/15

| Varieties    | Experimental locations |          |        |      |        |      |        |       |
|--------------|------------------------|----------|--------|------|--------|------|--------|-------|
|              | Selian                 |          | Uyole  |      | Lambo  |      | Maruku |       |
|              | ALS                    | CBB      | ALS    | CBB  | ALS    | CBB  | ALS    | CBB   |
| KATB1        | 3.00                   | 4.00     | 5.00   | 4.00 | 3.00   | 2.00 | 4.00   | 3.00  |
| KATB9        | 3.00                   | 4.00     | 3.00   | 4.00 | 3.00   | 1.00 | 5.00   | 1.00  |
| JESCA        | 4.00                   | 4.00     | 4.00   | 3.00 | 3.00   | 2.00 | 4.00   | 2.00  |
| Calima Uyole | 4.00                   | 2.00     | 4.00   | 4.00 | 3.00   | 2.00 | 4.00   | 3.00  |
| Navy line 1  | 2.00                   | 2.00     | 3.00   | 2.00 | 4.00   | 1.00 | 5.00   | 1.00  |
| SARBYT       | 3.00                   | 2.00     | 2.00   | 3.00 | 2.00   | 3.00 | 2.00   | 4.00  |
| Lyamungu 85  | 2.00                   | 1.00     | 3.00   | 2.00 | 3.00   | 1.00 | 2.00   | 1.00  |
| KG98         | 7.00                   | 2.00     | 6.00   | 2.00 | 6.00   | 2.00 | 6.00   | 1.00  |
| Mean         | 3.00                   | 2.62     | 3.79   | 2.96 | 3.38   | 2.04 | 4.00   | 1.92  |
| CV%          | 13.7                   | 23.5     | 23.6   | 28.0 | 26.6   | 39.5 | 29.4   | 63.90 |
| LSD          | 0.81                   | 1.08     | 1.57   | 1.45 | 1.57   | 1.41 | 2.06   | 2.15  |
| p = 0.05     | < 0.001*               | < 0.001* | 0.007* | ns   | 0.004* | ns   | 0.010* | ns    |

Note. ALS = Angular Leaf Spot, CBB = Common Bacterial Blight, ns = not significant, \* = significant.

Table 4. Diseases severity scores (1-9) across environment 2015/16

| Varieties    | Experimental locations |      |          |      |        |      |        |      |
|--------------|------------------------|------|----------|------|--------|------|--------|------|
|              | Selian                 |      | Uyole    |      | Lambo  |      | Maruku |      |
|              | ALS                    | CBB  | ALS      | CBB  | ALS    | CBB  | ALS    | CBB  |
| KATB1        | 1.00                   | 2.00 | 6.00     | 1.00 | 2.00   | 3.00 | 3.00   | 1.00 |
| KATB9        | 4.00                   | 3.00 | 5.00     | 2.00 | 2.00   | 3.00 | 3.00   | 1.00 |
| JESCA        | 4.00                   | 2.00 | 6.00     | 1.00 | 2.00   | 5.00 | 3.00   | 2.00 |
| Calima Uyole | 3.00                   | 2.00 | 4.00     | 1.00 | 4.00   | 4.00 | 4.00   | 1.00 |
| Navy line 1  | 4.00                   | 2.00 | 5.00     | 2.00 | 3.00   | 4.00 | 3.00   | 1.00 |
| SARBYT       | 3.00                   | 3.00 | 26.00    | 3.00 | 4.00   | 4.00 | 2.00   | 1.00 |
| Lyamungu 85  | 3.00                   | 3.00 | 4.00     | 2.00 | 3.00   | 5.00 | 2.00   | 1.00 |
| KG98         | 4.00                   | 3.00 | 4.00     | 1.00 | 5.00   | 5.00 | 5.00   | 1.00 |
| Mean         | 3.17                   | 2.50 | 4.83     | 1.54 | 3.21   | 4.17 | 3.08   | 1.08 |
| CV%          | 56.6                   | 30.9 | 10.5     | 59.0 | 30.9   | 25.9 | 32.5   | 37.7 |
| LSD          | 3.14                   | 1.35 | 0.89     | 1.56 | 1.75   | 1.89 | 1.76   | 0.71 |
| p = 0.05     | ns                     | ns   | < 0.001* | ns   | 0.028* | ns   | ns     | ns   |

Note. ALS = Angular Leaf Spot, CBB = Common Bacterial Blight, ns = not significant, \* = significant.

Table 5a. Grain yield (kg ha<sup>-1</sup>) observed in varieties cultivated in several locations in Tanzania

| Varieties    | Experimental locations |          |         |          |         |         |          |          |
|--------------|------------------------|----------|---------|----------|---------|---------|----------|----------|
|              | Selian                 |          | Uyole   |          | Lambo   |         | Maruku   |          |
|              | 2014/15                | 2015/16  | 2014/15 | 2015/16  | 2014/15 | 2015/16 | 2014/15  | 2015/16  |
| KATB1        | 1341.20                | 1222.00  | 1195.00 | 1920.00  | 1134.30 | 1345.00 | 1307.40  | 1087.40  |
| KATB9        | 1359.84                | 1889.00  | 1879.00 | 2658.00  | 942.78  | 1881.00 | 1294.60  | 1050.50  |
| JESCA        | 1455.16                | 1897.00  | 1717.00 | 1863.00  | 965.24  | 1344.00 | 797.00   | 800.00   |
| Calima Uyole | 1306.03                | 1152.00  | 1879.00 | 1333.00  | 1075.40 | 1423.00 | 599.50   | 629.80   |
| Navy line 1  | 1058.25                | 1968.00  | 1059.00 | 2083.00  | 746.75  | 1172.00 | 484.20   | 697.60   |
| SARBYT       | 1367.94                | 2405.00  | 1023.00 | 2162.00  | 1395.87 | 916.00  | 1858.50  | 545.30   |
| Lyamungu 85  | 1156.83                | 1040.00  | 1512.00 | 1400.00  | 676.51  | 1301.00 | 774.00   | 1024.20  |
| KG98         | 1215.95                | 950.00   | 2526.00 | 896.00   | 1150.63 | 882.00  | 748.00   | 401.30   |
| Mean         | 1282.70                | 1502.00  | 1591.60 | 1789.30  | 1010.90 | 1283.00 | 983.00   | 779.50   |
| CV%          | 16.40                  | 3.10     | 29.30   | 19.10    | 37.20   | 20.60   | 20.80    | 19.00    |
| LSD          | 369.21                 | 82.58    | 816.52  | 597.61   | 658.12  | 462.53  | 357.52   | 258.73   |
| p = 0.05     | ns                     | < 0.001* | 0.021*  | < 0.001* | ns      | 0.010*  | < 0.001* | < 0.001* |

Note. ns = not significant, \* = significant.

Genotype, environment and season interactions was significantly different (< .001) Table 5b in terms of yield. The average highest yield was at Uyole (1690.46 kg ha<sup>-1</sup>) followed with Selian (1892 kg ha<sup>-1</sup>) then Lambo (1446.98 kg ha<sup>-1</sup>) and last Maruku (881.26 kg ha<sup>-1</sup>). Talking about these two seasons, the 2015/16 had an average yield of 1338.69 kg ha<sup>-1</sup> while that of 2014/15 showed an average of 1217.05 kg ha<sup>-1</sup>. Like wise, the interactions effects observed at foliar diseases for each environment tested.

Table 5b. Combined genotype, environment and season interactions

| Varieties    | Environment | 2014/15 (kg ha <sup>-1</sup> ) | 2015/16 (kg ha <sup>-1</sup> ) |
|--------------|-------------|--------------------------------|--------------------------------|
| Calima uyole | Lambo       | 1075.40                        | 1422.67                        |
|              | Maruku      | 599.51                         | 1050.50                        |
|              | Selian      | 1306.03                        | 1152.00                        |
|              | Uyole       | 1878.73                        | 1333.33                        |
| SABYT        | Lambo       | 746.75                         | 1172.00                        |
|              | Maruku      | 484.16                         | 697.62                         |
|              | Selian      | 1058.25                        | 1968.25                        |
|              | Uyole       | 1059.29                        | 2082.54                        |
| Navy line    | Lambo       | 1395.87                        | 916.07                         |
|              | Maruku      | 1858.45                        | 545.28                         |
|              | Selian      | 1367.94                        | 2404.76                        |
|              | Uyole       | 1022.7                         | 2161.51                        |
| Jesca        | Lambo       | 965.24                         | 1344.00                        |
|              | Maruku      | 797.03                         | 800.00                         |
|              | Selian      | 1455.16                        | 1396.83                        |
|              | Uyole       | 1717.22                        | 1863.02                        |
| KATB1        | Lambo       | 1134.29                        | 1344.67                        |
|              | Maruku      | 1307.44                        | 629.76                         |
|              | Selian      | 1341.19                        | 1222.22                        |
|              | Uyole       | 1195.16                        | 1920.48                        |
| KATB9        | Lambo       | 942.78                         | 1881.33                        |
|              | Maruku      | 1294.60                        | 1024.21                        |
|              | Selian      | 1359.84                        | 1888.89                        |
|              | Uyole       | 1821.59                        | 2657.62                        |
| KG98         | Lambo       | 1150.63                        | 882.13                         |
|              | Maruku      | 748.20                         | 401.27                         |
|              | Selian      | 1215.95                        | 950.40                         |
|              | Uyole       | 2526.27                        | 896.00                         |
| Lyamungu 85  | Lambo       | 676.51                         | 1301.33                        |
|              | Maruku      | 774.71                         | 1087.37                        |
|              | Selian      | 1156.83                        | 1040.00                        |
|              | Uyole       | 1511.98                        | 1400.00                        |

Note. G·S = genotype Season interactions, G·E·S = Genotype, Environment and Season interactions.

P < 0.001; CV% = 26.60; LSD of G·S = 254.36 and G·E·S = 508.72.

Market criteria was the most preferred followed by better yield and early maturity and the varieties that scored best in early maturity and market aspects were KATB1 and KATB9 compared to other varieties used (Tables 6 and 9). Similar study on early-maturing pearl millet variety Okashana 1 was another PVS success story in Sub-Saharan Africa (Bidinger, 1998) whereby ICRISAT-India generated variety then selected by farmers in Namibia in 1987 and released in 1989 as official variety and ready to be used by farmers in the country. In Absolute ranking KATB1 had the highest score followed by KATB9 and Lyamungu and Navy line 1 then SARBYT (Table 11) then more preferred by farmers; In Matrix ranking KATB1 had the highest scores whereas in pairwise ranking KATB1 scored higher than KATB9, Lyamungu 85 and JESCA. This shows that variety KATB1 was the most preferred since it was accepted in all tested sites with scoring of 5 points followed by KATB9, Lyamungu and JESCA (Tables 6, 7, 8, 9 and 10). It is not necessary that all tested materials should be preferred or released by the authority and that's why in eight varieties only two were accepted by farmers and released by seed authorities in the nation. Studies conducted by Tripp in 1997 for rice varieties, several varieties were tested in India but was not released because of perceived fatal flaw of susceptibility to lodging. Since the acceptance or rejection of any variety/technology is based on farmers' criteria which is assessed at the end of the season particularly during maturity stage. Therefore, farmer's data revealed that common bean varieties, KATB1

and KATB9 were the most preferred in Tanzania. Similar conventional-farmer engagement integrative research approach was applied in Peru in the final evaluation and six of the most promising clones from six years of on-station selection and three years of testing in farmers' testing farmers selected seedling no. 380389.1. This selection was released nationally as Canchan-INIAA in 1990 (Gastelo et al., 1991). The most preferred criteria by farmers in the variety selection were good market quality and; high yield respectively. The varieties that scored excellent were KATB1, KATB 9, Navy line and checks for good market, high yielding and tolerance in pests/disease respectively. Also, the preferences were gendered whereby Lyamungu 85 and SABRYT were preferred cultivars/varieties by men than women (Table 4). The pair wise ranking results were similar to those found through absolute and matrix rankings for all tested varieties (Tables 6 and 7).

Table 7. Matrix ranking common bean varieties farmers' selection at Maruku-Kagera

| Criteria                  | Common Bean varieties Releasing Candidates |           |             |           |           |             |           | Total | Rank |
|---------------------------|--------------------------------------------|-----------|-------------|-----------|-----------|-------------|-----------|-------|------|
|                           | KG98                                       | KATB1     | Navy line 1 | SABRYT    | KATB9     | Lyamungu 85 | JESCA     |       |      |
| Good market               | 3                                          | 5         | 4           | 4         | 4         | 5           | 3         | 28    | 1    |
| High yield                | 4                                          | 4         | 4           | 4         | 3         | 4           | 4         | 27    | 2    |
| Drought tolerance         | 3                                          | 3         | 4           | 4         | 3         | 4           | 4         | 25    | 4    |
| Early maturity            | 3                                          | 5         | 3           | 3         | 4         | 3           | 5         | 26    | 3    |
| Tolerance to disease/pest | 3                                          | 3         | 3           | 3         | 3         | 3           | 4         | 22    | 5    |
| <b>Total</b>              | <b>16</b>                                  | <b>20</b> | <b>18</b>   | <b>18</b> | <b>17</b> | <b>17</b>   | <b>18</b> |       |      |
| <b>Rank</b>               | <b>4</b>                                   | <b>1</b>  | <b>2</b>    | <b>2</b>  | <b>3</b>  | <b>3</b>    | <b>2</b>  |       |      |

Note. 1 = Poor; 2 = Satisfactory; 3 = Average; 4 = Good; and 5 = Excellent.

Table 8. Pair wise ranking of bean varieties at Maruku-Kagera

|                    | JESCA | Lyamungu 85 | KATB9 | SARBYT      | Navy line 1 | KATB1 | KG98        | Total | Rank |
|--------------------|-------|-------------|-------|-------------|-------------|-------|-------------|-------|------|
| <b>JESCA</b>       |       | Lyamungu 85 | JESCA | SARBYT      | JESCA       | JESCA | JESCA       | 4     | 2    |
| <b>Lyamungu 85</b> |       |             | KATB9 | Lyamungu 85 | Lyamungu 85 | KATB1 | Lyamungu 85 | 4     | 2    |
| <b>KATB9</b>       |       |             |       | KATB9       | Navy line 1 | KATB1 | KATB9       | 3     | 3    |
| <b>SARBYT</b>      |       |             |       |             | Navy line 1 | KATB1 | SARBYT      | 2     | 4    |
| <b>Navy line 1</b> |       |             |       |             |             | KATB1 | Navy line 1 | 3     | 3    |
| <b>KATB1</b>       |       |             |       |             |             |       | KATB1       | 5     | 1    |
| <b>KG98</b>        |       |             |       |             |             |       |             | 0     | 5    |

Table 9. Matrix ranking bush bean varieties Selian– Arusha

| Criteria                  | Bean candidates |           |             |           |           |             |           | Total | Rank |
|---------------------------|-----------------|-----------|-------------|-----------|-----------|-------------|-----------|-------|------|
|                           | KG98            | KATB1     | Navy line 1 | SABRYT    | KATB9     | Lyamungu 85 | JESCA     |       |      |
| Grain market quality      | 2               | 6         | 4           | 4         | 4         | 5           | 3         | 28    | 1    |
| High yield                | 4               | 4         | 4           | 4         | 4         | 3           | 4         | 27    | 2    |
| Drought tolerance         | 3               | 3         | 4           | 4         | 3         | 4           | 4         | 25    | 4    |
| Early maturity            | 3               | 5         | 3           | 3         | 5         | 2           | 5         | 26    | 3    |
| Tolerance to disease/pest | 3               | 3         | 3           | 3         | 3         | 3           | 4         | 22    | 5    |
| <b>Total</b>              | <b>15</b>       | <b>21</b> | <b>18</b>   | <b>18</b> | <b>17</b> | <b>17</b>   | <b>19</b> |       |      |
| <b>Rank</b>               | <b>4</b>        | <b>1</b>  | <b>2</b>    | <b>2</b>  | <b>3</b>  | <b>3</b>    | <b>2</b>  |       |      |

Note. 1 = Poor; 2 = Satisfactory; 3 = Average; 4 = Good; and 5 = Excellent.

Table 10. Pair wise ranking of bean varieties Uyole – Mbeya

|                    | JESCA | Lyamungu 85 | KATB9 | SARBYT      | Navy line 1 | KATB1 | KG98        | Total | Rank |
|--------------------|-------|-------------|-------|-------------|-------------|-------|-------------|-------|------|
| <b>JESCA</b>       |       | Lyamungu 85 | KATB9 | SARBYT      | JESCA       | JESCA | JESCA       | 4     | 2    |
| <b>Lyamungu 85</b> |       |             | KATB9 | Lyamungu 85 | Lyamungu 85 | KATB1 | Lyamungu 85 | 4     | 2    |
| <b>KATB9</b>       |       |             |       | KATB9       | Navy line 1 | KATB1 | KATB9       | 4     | 2    |
| <b>SARBYT</b>      |       |             |       |             | SARBYT      | KATB1 | SARBYT      | 3     | 3    |
| <b>Navy line 1</b> |       |             |       |             |             | KATB1 | Navy line 1 | 3     | 3    |
| <b>KATB1</b>       |       |             |       |             |             |       | KATB1       | 5     | 1    |
| <b>KG98</b>        |       |             |       |             |             |       |             | 0     | 5    |

Table 11. Absolute Ranking of tested bean varieties

| No | Bush bean varieties | Participants | Rank |
|----|---------------------|--------------|------|
| 1  | KATB 1              | 6            | 1    |
| 2  | JESCA               | 1            | 5    |
| 3  | Lyamungu 85         | 1            | 6    |
| 4  | KG 98               | 0            | 7    |
| 5  | KATB 9              | 4            | 2    |
| 6  | SARBYT              | 2            | 4    |
| 7  | Navy line 1         | 3            | 3    |

Some of basic descriptions of the selected bean varieties:

*KATB 9 = SELIAN 12*

Growth habit—Dwarf

Plant height—Medium (50 cm)

Seed shape/size—Round/medium

Seed colour—Red

*KATB 1 = SELIAN 13*

Growth habit—Dwarf

Plant height—Medium (40cm)

Seed shape/size—Round/medium

Yellow

Integrating conventional assessment for disease tolerant/resistance, drought tolerance, adaptation to low fertility soils, early maturity and high yield shorten time and increases efficiency in crop breeding program and quick adoption process by bringing the selection process much closer to the farmers in collaboration with researchers and extension officers. On the strength of the attributes and evidence from field and farmers assessments, the *Phaseolus* bean research programme together with Tanzania Official Seed Certification Institute (TOSCI) and National Variety Release Committee (NVRC) officiated the releases of these new bean varieties and named KATB 9 as SELIAN 12 and KATB1 as SELIAN 13 (Seed Act, 2003; Seed Regulation, 2017). The selected varieties will help in complementary of the existing bean seed availability gap and increased diversity of farmer demanded variety (ies) options. Consequently, improved flexibility on seed access to stakeholders', especially smallholder farmers and commercial growers for seed supply systems for enhanced food security and incomes to end users.

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