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Research Article

On-Farm Evaluation of Beans Varieties for Adaptation and Adoption in Kigoma Region in Tanzania

Tulole Lugendo Bucheyeki[1,2] and Tuaeli Emil Mmbaga[3]

[1] *University of KwaZulu-Natal, Private Bag X01, Scottsville 3209, South Africa*
[2] *Tumbi Agricultural Research and Development Institute, P.O. Box 306, Tabora, Tanzania*
[3] *Selian Agricultural Research and Development Institute, P.O. Box 6024, Arusha, Tanzania*

Correspondence should be addressed to Tulole Lugendo Bucheyeki; tlbucheyeki@yahoo.co.uk

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On-farm beans research was carried out in Kigoma region, Tanzania. Objectives were to evaluate beans varieties for yield under farmers' management conditions and to assess farmers' preferences on beans varieties. Nine farmers from three villages with three farmers per village participated in beans trials. A randomized complete block design with five plots per replications was used to evaluate five bean varieties: Lyamungo 90, Jesca, Uyole 94, Kablanketi, and Kigoma yellow (control). Beans were planted on a 10 m × 2.5 m plot at a spacing of 50 cm × 20 cm. Data was subjected to analysis using ANOVA table in GenStat statistical computer software. Three villages × three seasons resulted in nine environments which were used for stability analysis. Farmers developed their criterion to assess the performance and acceptability of beans varieties. Lyamungo 90 and Jesca ranked high and outyielded other varieties with an average yield of 1430.00 and 1325.67 kg ha^{-1}, respectively. Genotypes sum of squares accounted for the most of the variability (89.12%). Introduction of high yielding bean varieties with the desired farmers' traits is expected to revamp beans production and contribute to the improved food security in Tanzania.

1. Introduction

Common bean (*Phaseolus vulgaris* L.) is an important herbaceous annual grain legume in the world chiefly grown as a cheap source of protein among majority of Sub-Saharan African people [1].

Farmers frequently use it as a vital component in crop rotation for its ability to fix nitrogen [2, 3]. According to FAOSTAT [4] estimate for the year 2006, world beans production was 1235 kg ha^{-1} while that of Africa was 799 kg ha^{-1}. The average beans yield per annum in many African countries is always lower than that of the world. Lack of improved varieties associated with edaphic and biotic factors has been cited as one of the primary sources of lower beans production [5]. In Tanzania, common bean is an important food and cash crop which is mostly grown by small-holder farmers [6]. However, common bean production in Tanzania is low and does not meet the increasing demand. The average yield is 741 kg ha^{-1} which is lower than that found in the developed countries [4]. The low beans yield is mostly contributed by the use of unimproved varieties. Farmers use the locally available varieties with low yield potential. The result is low yield per area and reduced beans production (Figure 1).

In addition to the lack of improved varieties and high seed demand during planting seasons, farmers use recycled seeds [7, 8]. This has stalled production of beans in the country and calls for more breeding efforts to curb the problem.

Development of new varieties requires full participation of stakeholders [9]. On-farm trials have been reported by researchers as vital tools for speeding up of breeding processes and enhanced cultivars adoption rates in farming communities [10, 11]. On-farm trial enables the incorporation of farmers' opinions and ensures testing of technologies under farmers' management conditions [12]. There are reports of increased rate of adoption and reduced variety abandonment when farmers' knowledge and experiences are acknowledged [13, 14]. To speed up variety evaluation, testing, and eventually

Table 1: Six testing sites description for three seasons (2003–2006) in Kasulu district, Kigoma region.

Farmer	District	Village	Longitude	Latitude	Altitude (masl)	Max. temp (°C)	Max. temp (°C)	Rainfall (mm)
John Bichila	Kasulu	Titye	030 17′281″E	04 40′756″S	1148	28.70	18.70	1014.80
Fabian Ntalumanga	Kasulu	Titye	030 17′596″E	04 40′185″S	1138	29.30	19.10	1026.60
Selina Dulubaye	Kasulu	Titye	030 17′584″E	04 40′163″S	1139	29.10	18.10	1180.90
Geralid Bilaro	Kasulu	Nyenge	030 15′786″E	04 37′080″S	1139	29.80	18.30	1025.90
Elias Kapisi	Kasulu	Nyenge	030 15′782″E	04 37′096″S	1140	29.70	18.00	1138.20
Margerth Mussa	Kasulu	Nyenge	030 15′783″E	04 37′046″S	1145	29.60	16.00	1039.90
Koladi Mussa	Kasulu	Kanazi	030 11′728″E	04 31′497″S	1236	29.30	15.70	1204.40
Mohamed Issa	Kasulu	Kanazi	030 13′371″E	04 33′981″S	1231	30.70	16.70	1126.40
Japhet Kipara	Kasulu	Kanazi	030 13′423″E	04 33′669″S	1257	31.30	18.90	1028.20

Table 2: Average yield of beans varieties for three seasons (2003–2006).

Variety	Seasons			
	2003/2004	2004/2005	2005/2006	Mean
Lyamungo 90	1394	1427	1469	1430.00
Jesca	1326	1334	1317	1325.67
Uyole 94	880	870	857	869.00
Kablanketi	924	924	878	908.67
Kigoma yellow	684	732	728	714.67
Grand mean	1041	1058	1050	1049.60
SED	48.2	49.2	50.3	
CV	9.8	9.9	10.2	

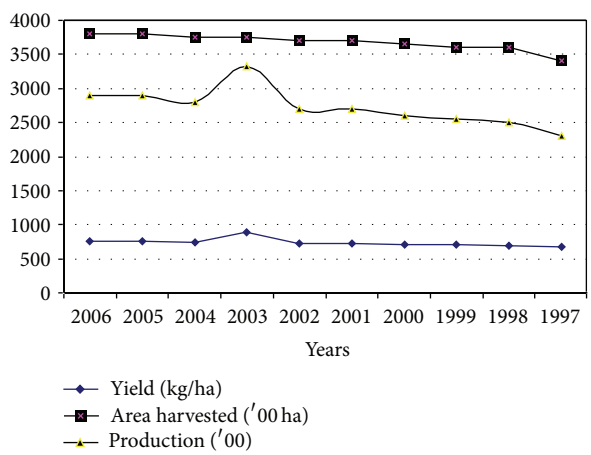

Figure 1: Yield of beans and proportion area in Tanzania (1997–2006). Source: (FAOSTAT, 2008).

introducing new bean varieties to farmers, on-farm bean trials were conducted in Kigoma region, Tanzania. Objectives were to evaluate bean varieties for yield under farmers' management conditions and to assess farmers' preferences on bean varieties.

2. Materials and Methods

Common beans on-station trials were conducted in Kigoma region, Tanzania, from 2003 to 2006 seasons. Researcher-managed trials (same managements) were planted in three villages with three farmers per village. Villages included Kanazi, Nyenge, and Titye (Table 1).

A randomized complete block design (RCBD) with five plots per replications was used to evaluate five beans varieties: Lyamungo 90, Jesca, Uyole 94, Kablanketi, and Kigoma yellow (Control). Beans were planted on a 10 m × 2.5 m plot at a spacing of 50 cm × 20 cm. Data was subjected to analysis using ANOVA table in GenStat statistical computer software. Stability analysis was employed to evaluate varieties sensitivity in different farmers' fields. Three villages × three seasons resulted in nine environments which were used for stability analysis. To assess farmers, preferences on beans cultivars, participating farmers gathered together and jointly select-ed ten criteria for ranking the cultivars: large seed size, good taste, short cooking time, early maturity, high market demand, high yielding, disease resistance, insect-pest resistance, cooking quality, and suitability to short rainfall farming system (njera season). A scale of 1–5 was used to assess these traits with the definition as follows: 1 = not preferred, 2 = less preferred, 3 = moderately preferred, 4 = highly preferred, and 5 = excellent. Farmers were given 5 grains and asked to place 1, 2, 3, 4, or 5 grains to score a given trait and cultivar. Seeds were counted, and the largest total count was ranked first.

3. Results

There were high significant yield differences among varieties across three seasons ($P < 0.001$) with Lyamungo 90 and Jesca outyielding other varieties (Table 2). Lyamungo 90 and Jesca recorded an average yield of 1430.00 and 1325.67 kg ha^{-1},

Table 3: AMMI analysis of variances of five bean varieties across nine environments.

SOV	DF	SS	MS	F	F pr	SS or GE × SS%
Blocks	18	776278	43127	4.48	<0.001	6.65
Genotypes	4	10409365	2602341	270.17	<0.001	89.12
Environment	8	89684	11211	0.26	0.97661	0.77
G × E	32	404514	12641	1.31	0.17020	3.46
AMMI model						
IPCA1	11	266533	24230	2.52	0.00969	65.89
IPCA2	9	80958	8995	0.93	0.50149	20.01
IPCA3	7	51734	7391	0.77	0.61648	12.79
Residual	5	5289	1058	0.11	0.98983	1.31
Total treat	44	10903563	247808	25.73	<0.001	
Error	72	693518	9632			
Total	134	2373359	92338			

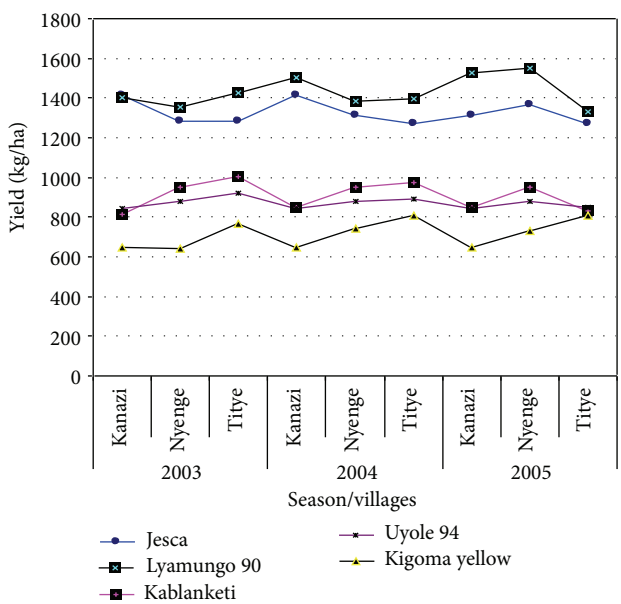

Figure 2: On-farm performance of five bean varieties across three villages for three seasons (2003–2006).

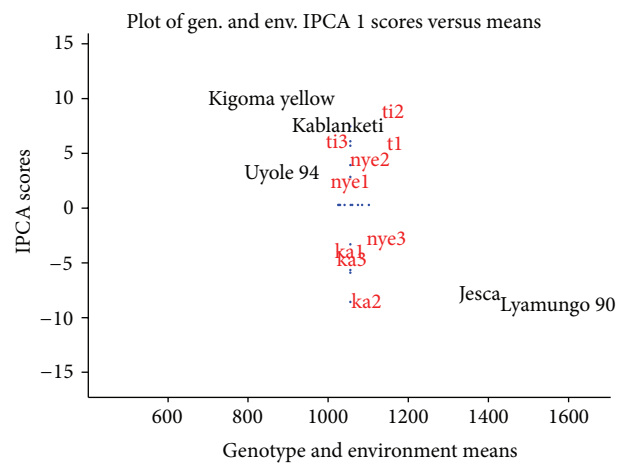

Figure 3: IPCA1 scores of five bean varieties, nine environments, and genotype × environment means. Key: t1, 2, and 3 = Titye for seasons 1, 2, and 3; ka1, 2, and 3 = kanazi for seasons 1, 2, and 3; nye1, 2, and 3 = Nyenge for season 1, 2, and 3.

respectively. The overall average yield for all varieties was 1049.60 kg ha^{-1}.

Results also revealed that the local check (Kigoma yellow) recorded the lowest average yield of 714.67 kg ha^{-1}.

Figure 2 elaborates the performance of five bean varieties grown in three villages for three seasons. Similar beans yield trends as that of Table 2 were observed.

When additive main effects and multiplicative interactions (AMMI) analysis of five bean varieties across nine environments was performed (Table 3), the IPCA1 was found to be significant. However, IPCA2 and IPCA3 were not significant.

The genotypes sum of squares (SS) accounted for the most of the variability (89.12%). In addition, results further showed that G × E interactions were superior to environment effects. However, G × E interactions were not significant to denote less importance of its joint effect. Figure 3 elaborates interaction principal component analysis (IPCA) scores against genotypes and environment means.

Figure 3 showed varieties being more dispersed than environments. From this figure, Lyamungo 90 and Jesca bean varieties were allocated on the high yield environments while Kigoma yellow (local check) was on the lower yield environments. Lyamungo 90 and Jesca bean varieties were placed far from zero which is the indication of variety instability. Uyole 94 showed fairly high G × E stability.

Tables 4 and 5 show farmers' assessment on five beans across three seasons.

By using 10 beans traits developed by them, farmers ranked fourth Kigoma yellow (local check) while Lyamungo 90 and Jesca were ranked first and second, respectively. The developed beans traits for assessment were included.

4. Discussions

On-farm research on beans revealed significant differences ($P < 0.001$) among varieties with Kigoma yellow recording

Table 4: Farmers on-farm evaluation of five bean varieties for three seasons (2003–2006).

Variety	Seasons			Ranks
	2003/2004	2004/2005	2005/2006	
Lyamungo 90	1	2	1	1
Jesca	2	3	2	2
Uyole 94	5	3	5	5
Kablanketi	3	1	3	3
Kigoma yellow	4	4	4	4

Key: ranks: 1 = highly preferred, 5 = least preferred.

Table 5: Farmers evaluation criteria of five bean varieties at the end of three years project, 2006.

Variety	Criteria										Total	Rank
	Se	Ta	Co	Ma	Mark	Yield	Disease	Pest	C	S		
Lyamu	4	4	5	4	3	4	4	3	2	3	36	1
Jesca	3	3	4	2	3	5	3	3	5	3	34	2
Uyole	1	1	2	3	2	2	2	2	2	2	19	5
Kablan	5	5	3	2	4	1	2	3	3	2	30	3
Kigo	3	2	3	1	2	1	3	3	3	4	25	4

Key: Se = large seed size, Ta = good taste, Co = short cooking time, Ma = early maturity, Mark = high market demand, yield = high yielding, disease = disease resistance, pest = insect-pest resistance, C = cooking quality, and S = suitability to short rainfall farming system. Varieties: Lyamu = Lyamungo 90, Jesca, Uyole = Uyole 94, Kablan = Kablanketi, and Kigo = Kigoma yellow.
Scores: 5 = highly preferred, 1 = least preferred.

the lowest yield. These results clearly indicate the superiority of the introduced varieties over the local variety in the area. The recorded yield was above the national beans yield of 741 kg ha^{-1} [4]. The observed yield was in accordance to Mekbib [15] who recorded the yield range of 1511–2216 kg ha^{-1}. The high yielding varieties which were accompanied by farmers' preferences on the new varieties observed in this study suggest the possibility of increased adoption rate in the area. Farmers tend to adopt new technologies that fit their selection criteria [12]. Additionally, high yielding varieties have an added advantage of improving food security and raising farmers' income through reduction of uncertainties and unexpected crop failures provided they are accepted by the community [16].

Farmers' assessment on varieties revealed farmers' power on varieties evaluation and selection. Farmers ranked high Lyamungo 90 and Jesca bean varieties. The reasons given by farmers were high yielding and short cooking time. To improve beans breeding program in Tanzania, these traits are expected to be incorporated in the breeding processes. Statistical analysis ranked the fifth locally adapted variety (Kigoma yellow).

Farmers differed with researchers by ranking it fourth according to their developed criteria. Kigoma yellow was ranked fourth instead of being last because it fits Kigoma farming systems of long and short cropping seasons. It can be planted in both seasons. This variety had adapted Kigoma conditions and thus became suitable for two production seasons. Farmers plant this variety for provision of an added food security to the families [17]. Varieties evaluation and selection which use farmers criteria to meet specific objectives have been reported by other researchers [18, 19].

Stability analysis revealed that yield variations were mostly contributed by genotypes (89.12%). These findings support observations by Jutsum et al. [20]. However, González et al. [21] recorded high environmental variation contribution than genotypes effects. The plot of the interaction principal components analysis against the genotypes and environment means enabled the visual comparison of environments, genotypes, and their interactions. This plot revealed Lyamungo 90 and Jesca as unstable varieties. In addition, these varieties recorded the highest yields across environments. Uyole 94 showed relatively high G × E interaction stability. The reason could be that Uyole 94 was developed at Uyole Agricultural Centre to suite highland environments as that of Kigoma region. Although this variety obtained the lowest rank from farmers' assessment, its stability and yielding relatively high than Kigoma yellow could be a better variety for risk avoidance against production uncertainties [22, 23].

5. Conclusion

To speed up variety introduction to farmers, on-farm beans experiments were conducted in Kigoma region, Tanzania. Lyamungo 90 and Jesca recorded the highest yield across the environments. Farmers ranked them high which was attributed to high yielding and short cooking time. Introduction of high yielding bean varieties with the desired farmers' traits could revamp beans production and could contribute to the improved food security in the region. Information gathered by this study can be utilized by plant breeders and farmers for incorporation of farmers preferred traits into beans breeding program and bean farming systems.

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