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Full Length Research Paper

On-farm evaluation of promising groundnut varieties for adaptation and adoption in Tanzania

Tulole Lugendo Bucheyeki[1,2], Erasto.M. Shenkalwa[2], Theofora X. Mapunda[2] and Leah W. Matata[2]

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

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On-station and on-farm groundnut research was carried out in Sikonge district, Tanzania, to evaluate groundnut varieties for yield under researcher and farmer managed conditions and assess farmer preferences. On-station trial was laid in a randomized complete block design with three replications. Five varieties Johari, Pendo, Nyota, Sawia and Mamboleo were planted on 25 m^2 plots at spacing of 0.9 x 0.15 m. Twelve farmers were involved in conducting on-farm trials with each farmer as a replicate. Participatory farmers evaluation and stability analysis were done. Both on-station and on-farm trials revealed high yield among varieties with Pendo (1444 kgha^{-1}) and Johari (1163 kgha$^{-1)}$ out yielding other varieties which were also ranked by farmers and researchers as the most preferred genotypes. The genotypes and environments sum of squares accounted for the most of the variability by contributing 38.10 and 32.99% for genotypes and environments respectively. Mamboleo and Sawia varieties showed high G X E stability. Farmers and researchers ranked Pendo and Johari as the best varieties.

Key words: *Arachis hypogaea*, participatory farmers' evaluation, groundnuts, stability analysis.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important monoecious annual legume in the world mainly grown for oilseed, food and animal feed (Pande et al., 2003; Upadhyaya et al., 2006). It is the chief crop rotation component in many sub Saharan countries in the world (Gbèhounou and Adango, 2003). Based on production, the world average groundnut production was 1690 kg ha^{-1} in the 2006 (FAOSTAT, 2008). FAOSTAT (2008) further revealed that, groundnut yields in Africa was much lower (980 kg ha^{-1}) than the average world groundnut yields. Researchers associate these lower yields to abiotic, biotic and socio-economic factors (Caliskan et al., 2008; Pande et al., 2003; Upadhyaya et al., 2006).

In Tanzania, groundnut is important food and cash crop (Ramadhani et al., 2002). Despite the groundnut importance in the country, yield is still low. For the past 10 years groundnut production has experienced two production plateaus with relatively high yield of about 600 and 500 kg ha^{-1} respectively (Figure 1) compared to a potential yield of 1000 kg ha^{-1}. FAOSTAT (2008) estimates that, average groundnut yield with shells was only about 500 kg ha^{-1}. Reasons for low yields in the country include the use of unimproved varieties, unreliable rainfall, pests diseases and lack of institutional support (BACAS, 2000). Due to lack of improved varieties and seed availability, farmers recycle seeds which further complicates the situation (Doss et al., 2003). This has raised concerns to breeders, farmers and policy makers on the breeding for better groundnut varieties and their subsequent introduction in the country. Introduction of new varieties needs full participation of farmers. On-farm trials have been found to be effective in the evaluation and selection of new varieties and other technologies (Adjei-Nsiah et al., 2007; Assefa et al., 2005; Kaizzi et al., 2006). This is partly due to the big yield gap between on-station and on-farm trials (Sall et al., 1998), hence the need to compare on-farm and on-station results. Objectives were to evaluate groundnut varieties for yield

*Corresponding author. E–mail: 207522482@ukzn.ac.za

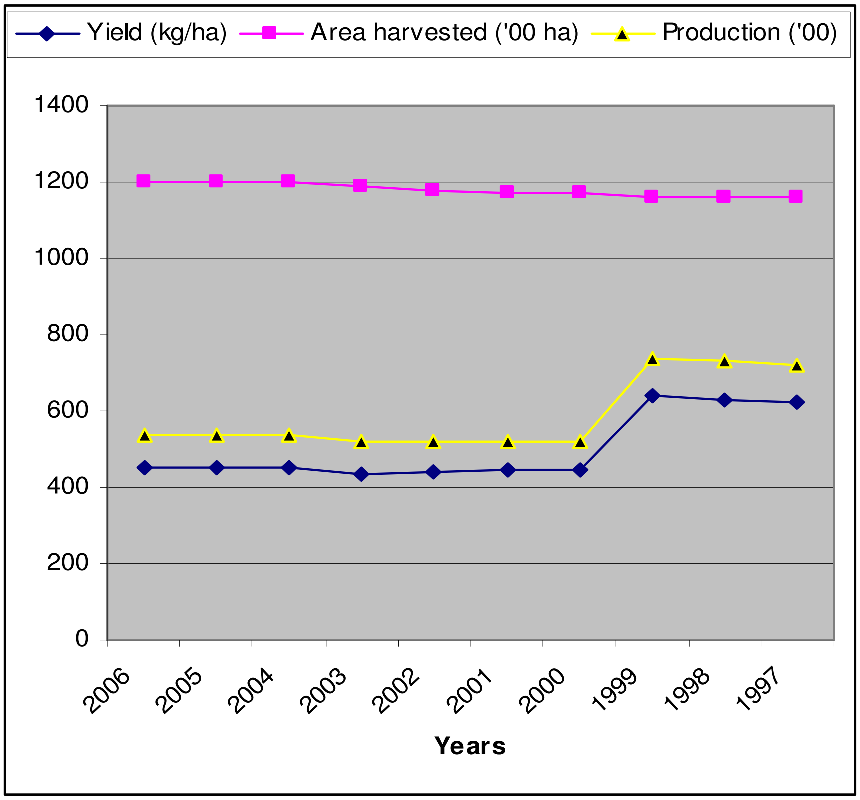

Figure 1. Yield of groundnut yield and proportion area in Tanzania (1997-2006). Source: (FAOSTAT, 2008).

under research and farmers management conditions and assess farmers' preferences on the groundnut varieties.

MATERIALS AND METHODS

On-station and on-farm field trials were conducted in Sikonge district, Tanzania from 2003 to 2006. A researcher managed trial was planted at Tutuo primary school, laid in randomized complete block design (RCBD) with five plots per replications. Five groundnut varieties; Johari, Pendo, Nyota, Sawia and Mamboleo (control) were planted on a plot size of 25 m^2 at spacing of 0.9 x 0.15 m. The net harvested area was three central rows (15 m^2). On-farm trials were spread out in four villages with three farmers per village. Data was analysed using ANOVA Matrix ranking was used to assess farmers' opinions and perceptions on the varieties. Stability analysis was performed on the varieties to assess their sensitivity to varying environment conditions and management practices.

RESULTS

On-station trials revealed high significant yield difference among varieties ($P<0.001$) with Pendo and Johari outyielding other varieties (Table 1). The overall average yield was 924.67 kg ha^{-1} which was higher than the national average yield of 500 kg ha^{-1}. On-farm trials showed similar trends (Table 2). Pendo outyielded all varieties across seasons with a mean of 937 $kgha^{-1}$. The local (Mamboleo) elect gave lower yield 556 $kgha^{-1}$. Overall yields were relatively lower on-farm as compared to on-station. Based on research managed and farmers managed trials, a yield advantage of 57.39% was recorded (Table 1 and 2). AMMI analysis of five groundnuts varieties across twelve environments showed that, genotypes and environments sum of squares (SS) accounted for the most of the variability. Genotype and environment contributed 38.10 and 32.99% respectively of the variability. Results further revealed that, environments were superior to G X E interactions.

Figure 2 shows on-farm performance of five groundnut varieties across four villages for three seasons. The result revealed that, Pendo and Johari constantly out yielded other varieties while Nyota and Mamboleo varieties yielded the lowest. Figure 3 presents IPCA scores against genotypes and environment means which showed varieties be more dispersed than their corresponding environments where they were grown. Pendo and Johari varieties were placed on the high yield environments while Mamboleo, Sawia and Nyota varieties were placed on the lower yield environments. Results further revealed that, Pendo variety was placed far from zero which is the indication of instability to environment change while Mamboleo and Sawia varieties showed high

Table 1. Yield (Kgha^{-1}) of five groundnuts varieties planted on-station (2003-2006).

Variety	Seasons			
	2003/2004	2004/2005	2005/2006	Mean
Johari	1188.00	1187.00	1115.00	1163.33
Mamboleo	599.00	530.00	592.00	573.67
Nyota	703.00	649.00	708.00	686.67
Pendo	1455.00	1426.00	1452.00	1444.33
Sawia	777.00	690.00	806.00	757.67
Grand mean	944.00	896.00	934.00	924.67
SED	69.90	39.70	202.8.0	
CV	14.80	5.40	26.60	

Table 2. Average yield of on-farm evaluation of groundnut varieties for three seasons (2003-2006).

Variety	Seasons			
	2003/2004	2004/2005	2005/2006	Mean
Johari	760.00	804.00	746.00	770.00
Mamboleo	588.00	538.00	542.00	556.00
Nyota	610.00	566.00	556.00	577.33
Pendo	970.00	913.00	928.00	937.00
Sawia	580.00	573.00	622.00	591.67
Grand mean	702.00	679.00	679.00	686.67
SED	55.40	58.00	74.30	
CV	19.30	21.00	26.80	

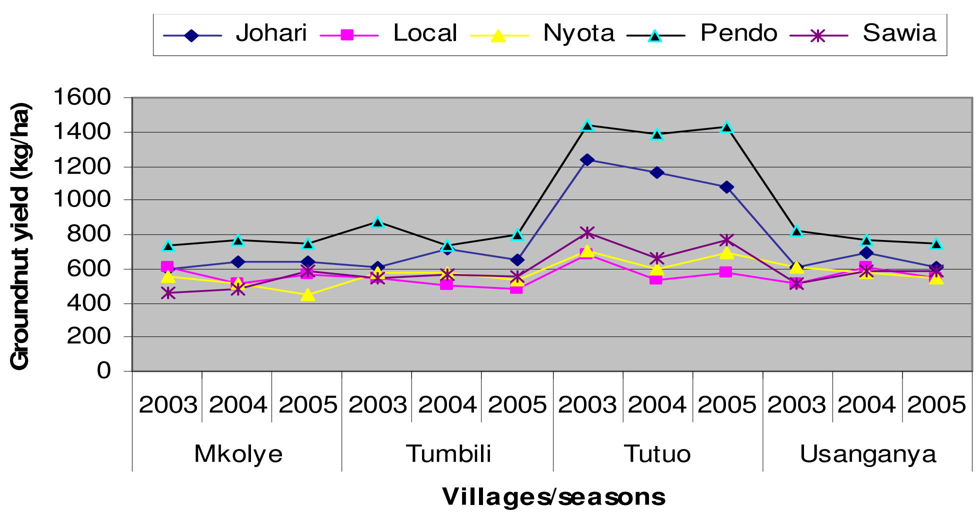

Figure 2. On-farm performance of five groundnut varieties across four villages for three seasons (2003-2006).

high G X E stability.

Famers identified 10 traits for evaluation of groundnut varieties (Table 3 and 4). These traits were good taste, short cooking time, large seed size, early maturity, high market demand, high yielding, insect-pest resistance, high oil content good peanut butter and disease resistance. Overall farmers' evaluation ranked Pendo and Johari as first and second respectively. Mamboleo variety which constantly gave low yields for consecutively three seasons was ranked fourth instead of the expected fifth

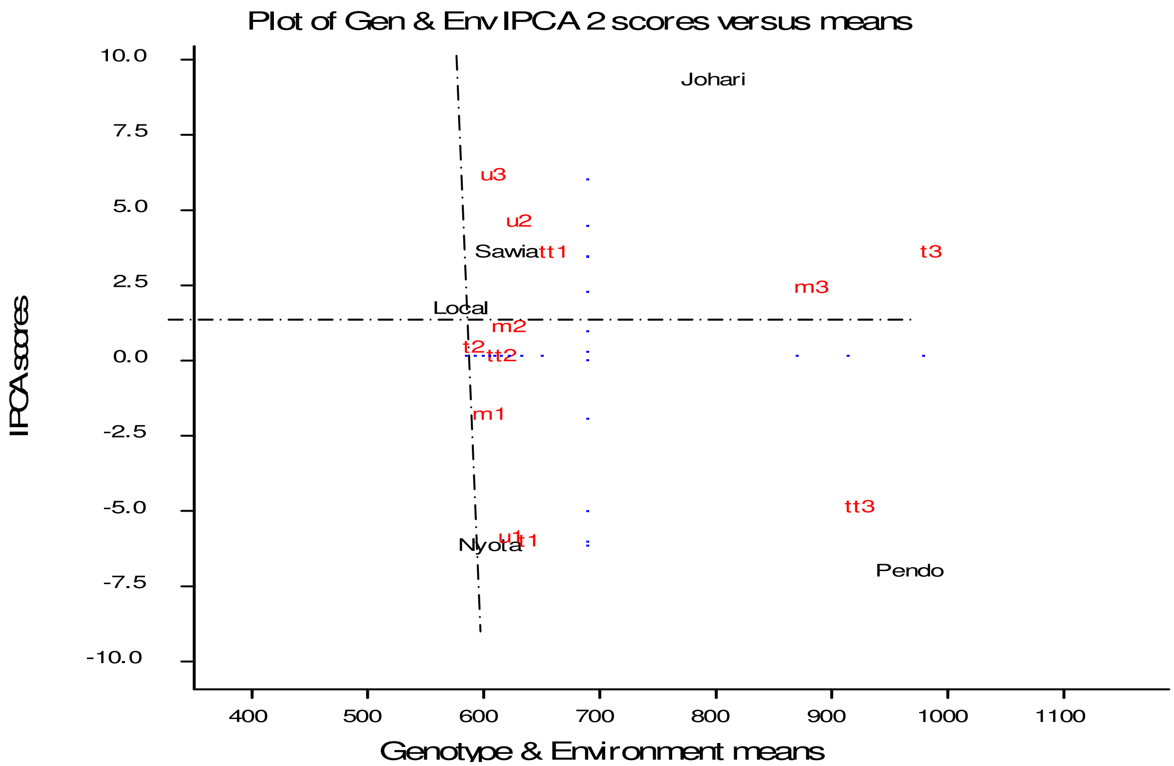

Figure 3. IPCA1 scores of five varieties, twelve environments and genotype x environment means. **Key:** u1, 2 and 3 = Usanganya for seasons 1, 2 and 3; m1, 2 and 3 = Mkolye for seasons 1, 2 and 3; t1, 2 and 3 = Tumbili for season 1, 2 and 3; tt1, 2 and 3 = Tutuo for seasons 1, 2 and 3. Local = Mamboleo.

Table 3. Farmers on-farm evaluation of five groundnut varieties for three seasons (2003-2006) in Sikonge district.

Variety	Seasons			Ranks
	2003/2004	2004/2005	2005/2006	
Johari	2	3	2	2
Pendo	1	2	1	1
Sawia	3	1	3	2
Mamboleo	4	3	4	4
Nyota	5	4	5	5

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

Table 4. Farmers on-farm evaluation criteria of five groundnut varieties at the end of three years project, 2006 in Sikonge district.

Variety	Criteria										Total	Rank
	Ta	Co	Se	Ma	Mark	Yield	Disease	Pest	Oil	Butter		
Johari	3	3	4	2	3	4	3	3	5	3	33	2
Pendo	4	4	5	4	4	5	4	3	2	3	38	1
Sawia	5	5	3	2	4	1	2	3	3	3	31	3
Local	3	3	3	2	2	2	3	3	3	4	28	4
Nyota	3	3	2	2	2	1	2	2	2	3	22	5

Key: Ta = good taste, Co = short cooking time, Se = large seed size, Ma = early maturity, Mark = high market demand, Yield = high yielding, Disease = disease resistance, Pest = insect-pest resistance, Oil = high oil content and Butter = good peanut butter. Scores: 5 = highly preferred, 1 = least preferred. Local = Mamboleo

Appendix 1. AMMI analysis of variance for five varieties across twelve environments.

SOV	DF	SS	MS	F	F pr	SS or GE X SS%
Blocks	24	876710	36530	2.99	<0.001	8.62
Genotypes	4	3873522	968381	79.16	<0.001	38.10
Environment	11	3354009	304910	8.35	<0.001	32.99
G x E	44	2062438	46874	3.83	<0.001	20.29
IPCA1	14	1853653	132404	10.82	<0.001	7.77
IPCA2	12	107368	8947	0.73	0.71756	0.45
IPCA3	10	55677	5568	0.46	0.91451	0.23
Residual	8	45740	5717	0.47	0.87629	0.19
Total treat	59	9289969	157457	12.87	<0.001	38.92
Error	96	1174356	12233			4.92
Total	179	11341035	63358			47.52

position. Nyota was ranked the least (Table 3 and 4).

DISCUSSIONS

Results from researcher's management and on-farm revealed significant differences (P<0.001) among varieties. The high yielding and farmers preferred introduced varieties shows the possibility of replacing the traditional Mamboleo variety in the area. Farmers normally adapt varieties that yield more than their locally adapted cultivars; and meet the preferred traits which differ from one community to another (Gowda et al., 2000).

High yield and acceptable varieties characteristics have shown significant adoption which resulted to subsequent crop improvements elsewhere: maize and wheat (Gowda et al., 2000; Matuschke et al., 2007; Mugo et al., 2005); beans (Assefa et al., 2005) and rice (Dorward et al., 2007; Gyawali et al., 2007). The yield advantage of 57.39% between on-station and on-farm environments clearly indicates the differential yields obtained by most farmers in sub-Saharan Africa. These results were in accordance with Barron and Okwach (2005) findings in semi-arid Kenya. The results indicate the need for site specific evaluation of new varieties for adaptation and adoption.

Farmers have specific criteria for selection of new varieties (Soleri et al., 2000). The selection criteria largely depend on the importance of the crop in the farming system and their uses (Abebe et al., 2005). In Tabora, farmers prefer groundnut varieties with high yielding, large seed size and resistant to diseases. These are important attributes by which breeders are required to use when developing varieties for this area. This will save the resources that could have gone to waste if a variety is developed and subsequently rejected by the end users. Variety Pendo and Johari were ranked high by farmers due to their large seed size and high yields potentials. Therefore, future breeding should continue to incorporate these traits identified by farmers.

Stability analysis of on-farm trials revealed high variability of genotypes and environments. The analysis clearly distinguished the stability of groundnut varieties and their environments interactions. Placement of the introduced varieties far from zero while putting Mamboleo varieties around zero is the indication of environment adaptation of local varieties. This means that farmers plant well environmentally adapted varieties which fits their farming systems from which they operate (Bänziger et al., 2006; Dorward et al., 2007). Genotype by environment interactions is a good indication of biotic and abiotic factors affecting crops production in the respective areas (Bänziger et al., 2006). Farmers normally associate stability of the introduced innovations to food security and risk avoidance of high failure under harsh environment conditions (Adjei-Nsiah et al., 2007; Bänziger et al., 2006).

Conclusion

Farmers are receptive to new technologies that have an added advantage over their current existing technologies. Pendo and Johari were identified by researchers and farmers as high yielding and farmer preferred characteristics. These two varieties were also recommended by researchers, extension agents and farmers as suitable varieties in the area. Further breeding for more varieties with farmer selection criteria in mind, will further increase groundnut production and hence income for the resource-poor farmers in Tabora.

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