

Full Length Research Paper

Participatory variety selection of okra (*Abelmoschus esculentus* L.) genotypes for adaptation to the semi-arid agro-ecology of Northern Ghana

Sugri I.^{1*}, Abdulai M. S.¹, Larbi A.², Hoeschle-Zeledon I.³, Kusi F.¹ and Agyare R. Y.¹

¹CSIR-Savanna Agricultural Research Institute, P.O. Box 52, Tamale, Ghana.

²International Institute of Tropical Agriculture, Africa RISING Project, P. O. Box TL6, Tamale, Ghana.

³International Institute of Tropical Agriculture, Oyo Road, Ibadan, Oyo State, Nigeria.

Received 8 August, 2015; Accepted 6 October, 2015

In a two-year study, participatory variety selection (PVS) was employed to evaluate the performance of 19 okra (*Abelmoschus esculentus* L.) c. v. Moench genotypes in a semi-arid agro-ecology in northern Ghana. The PVS sessions were organized at 65, 80 and 95 days after planting for 272 farmers to select the most preferred genotypes base on plant growth, maturity period and yield components. Results of this study indicate high significant differences among the genotypes ($P < 0.0001$) for most essential agronomic yield traits evaluated. Five most recurring preference traits were high fruit yield, early maturing, multiple harvest frequency, drying quality and long tender-life. Glabrous leaf, stem and fruit were important to farmers because most of the production operations are still being manually done. Genotypes with high potential included: NOKH 1004 (9.55 ton\ha), FV-Unn-manna (5.85 ton\ha), NOHK 1003 (5.17 ton\ha), NOKH 1002 (2.83 ton\ha), FV-Kpazeya (2.83 ton\ha), TZ-SMN-86 (2.30 ton\ha), AAK (2.11 ton\ha), NB-55-Srivan (1.98 ton\ha), Sasilon (1.70 ton\ha), FV-Unn (2.20 ton\ha) and Ex-Makutopora (1.27 ton\ha). Genotypes Sasilon, NOKH-1004, NB-55-Srivan and NOKH-1003 recorded the highest ranking among farmers during the PVS. High yielding and early maturing genotypes which are amendable to drying may show wide adoption rate due to the premium on dehydrated okra. These genotypes can be suggested as candidates for inspection by the National Variety Release and Technical Committee for release to farmers to increase access to improved okra varieties.

Key words: Okra genotypes, Sudan savanna, drying quality, participatory variety selection, preference traits.

INTRODUCTION

Okro (*Abelmoschus esculentus* L.) c.v. Moench is a traditional vegetable in many tropical, subtropical and

Mediterranean countries (Düzyaman, 2005; Arapitsas, 2008; Saifullah and Rabbani, 2009). Every part of the

*Corresponding author. E-mail: isugri22@gmail.com. Tel: +233243850292.

plant (leaf, flower and fruit) is consumed either in the fresh or dehydrated form. The young immature pods are consumed in various forms: boiled, fried, cooked or dehydrated for future utilization. Seven-day old fresh pods have the highest concentration of nutrients (Ndunguru and Rajabu 2004; Agbo et al., 2008). The fresh pods are low in calories (20/100 g), practically no fat, high in fiber, and have several valuable nutrients such as 30% of the recommended levels of vitamin C (16-29 mg), 10-20% of foliate (46-88 mg) and about 5% of vitamin A (14-20 RAE). Both mesocarp and seeds are excellent sources of zinc (80 mg/g) as well as phenolic compounds with important biological properties like quaternary derivatives, catechins, oligomers and hydroxycinnamic derivatives (Glew et al., 1997; Arapitsas, 2008). In Ghana, okra is the fourth most popular vegetable after tomato, pepper and garden egg (Oppong-Sekyere et al., 2012). It is often the vegetable of choice among rural and urban consumers, and even at food joints. National production hovers around 120,000 Mt produced on 19,500 ha of arable land with yield potential of 5.5 Mt/ha. Okra production serves an important source of cash to farmers particularly in the dry season where commercial production is carried out using smallholder irrigation schemes such as dug-outs, small dams and along river banks. On arable lands, they may appear as a sole, inter or boarder crop. In northern Ghana, okra production has a strong commercial value particularly to rural women farmers, where both fresh and dehydrated products are sold to supplement household income (Oppong-Sekyere et al., 2012).

A review of okra seed systems suggests that breeding programmes' has only been carried out in a limited scale by the commercial sector (Kumar et al., 2010; Benchasri, 2012; Oppong-Sekyere et al., 2012). In particular, seed programmes to enhance access to improved genotypes are not well developed in most developing countries. Most crop improvements efforts over the years have been oriented towards intensive cultivation using high yielding, short duration, pests and disease resistance as well as wide adaptation to photoperiod insensitivity (Benchasri, 2012). Genotypes characterization have been typically to identify high yielding genotypes with resistance to yellow mosaic virus, fruit borers, jassid and higher vitamins C content in species that can be utilized for the improvement of *A. esculentus* (Bisht and Bhat, 2006; Nwangburuka et al., 2011). However, some traits of aesthetic and sensory qualities of essence to end-users still require some research. Considerable effort is currently being made in breeding programmes to improve yield attributes such as seed yield, number of pods per plant, pod length, width and shape (Alam and Hossain, 2008). Although some attractive American and Indian cultivars have found their way to commercial growers in some parts of Africa, there is still enormous scope for cultivar improvement. Crossing between promising

parents combined with pedigree selection or backcrossing remains the most common breeding procedure (Benchasri, 2012). However, the quest for high pod yield per plant is limited due to low genotypic variability (Ariyo, 1990; Nwangburuka et al., 2011). Up to now, molecular markers analyses have shown rather low level of genetic diversity in cultivated okra in spite of large phenotypic variability. Quiet scanty information exist on improvement using biotechnology apart from *in vitro* DNA extraction and plant regeneration from various explants and callus tissue. Thus, opening up the need to prioritize research strategies to amplify the potential of okra for food, nutrition and income security to both commercial and smallholder farmers is essential.

In most parts of Ghana, the existing okra cultivars are land races which have been recycled for many decades. Some of these landraces are late maturing and photoperiod-sensitive with low marketing and export potential; due to fruit color, shape and pubescence. However, some of the landraces have multi-purpose traits such as high yielding, good drying properties and resistance to drought, diseases and pests. Most of the improved cultivars and hybrid seed introduced to many parts of Ghana are not widely adapted by farmers due to their relative susceptibility to some biotic and abiotic stresses, and some are not also amendable to drying. Thus, requiring interventions to increase access to improved seed, and scale-up improved production to postharvest technologies to increase production, availability and utilization as well as economic returns to farmers. Selection for genotypes with good drying properties in particular could reduce current postharvest losses in okra. Accordingly, the Savanna Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR) in collaboration with the World Vegetable Centre (AVRDC) have been providing training and information on good vegetable production practices; collecting, characterizing and establishing database of various traditional African vegetables; and developing extra-early high yielding vegetable varieties and hybrids to growers. Most of the previous okra selection studies have been conducted on-station with little involvement of the growers and end-users. This study involved the use of participatory variety selection to evaluate the agronomic performance of 19 genotypes in a semi-arid Sudan-savanna agro-ecology in northern Ghana. This approach enabled the identification of some essential traits to growers and end-users that can be incorporated into future okra improvement programmes.

MATERIALS AND METHODS

Study site

The study was carried out during the 2012 and 2013 cropping seasons at the Manga Agriculture Station (Latitude 11° - 01' N,

Table 1. Some physical and chemical properties of the surface (0-15 cm) soil at the experimental site at the Manga Agricultural Station and; weather characteristics in the years, 2012 and 2013.

Soil physical and chemical properties		Month	Average Year : 2012			Average Year: 2013		
			Rainfall (mm)	Temperature (°C)	Relative humidity (%)	Rainfall (mm)	Temperature (°C)	Relative humidity (%)
Sand (%)	80.4	June	150	27.7	79.0	128.4	29.0	75.0
Silt (%)	14	July	256.1	27.2	83.0	184.4	27.2	84.0
Clay (%)	5.6	August	214.8	26.5	73.0	161.4	26.8	84.0
Soil texture	Loamy sand	September	222.8	27.7	68.0	192.5	25.3	75.0
Soil pH (H ₂ O)	4.22	October	22.0	26.8	52.0	42.7	27.6	73.0
Organic carbon (%)	0.47							
Total nitrogen (%)	0.06							
Available P (mg/ kg)	20.25							
Ca	0.08							
Mg	0.04							
K	27.30							
CEC [cmol (+)/ kg]	4.55							

Longitude 00° - 16° W, and elevation of 249 m above sea level) of the CSIR-SARI near Bawku in the Upper East region of Ghana. The study area is in the Sudan savanna agro-ecological zone with annual rainfall of approximately 950 mm. The rainfall distribution, which is mono-modal, peaks between August and September, and ends in October. The soils, which are of Plinthic lixisol classification and developed from granite and stones, are light, varying in texture from coarse sands to loams. Table 1 describes some physical and chemical properties of the surface (0-15 cm) soil at the experimental site at the Manga Agricultural Station and; some weather characteristics in the years of 2012 and 2013.

Morphological and agronomic data collection

Nineteen okra genotypes, consisting of 13 improved genotypes (Sasilon, P1496946, TZ-SMN-86, ML-OK-37, ML-OK-16, ML-OK-35, ML-OK-10, AAK, NOKH 1002, NOKH 1003, NOKH 1004, NB-55-SRIVAN and Ex-Makutopora) and 6 landraces, were evaluated. Planting

was done on July 17, 2012 and June 30, 2013 at a spacing of 75 cm between ridges and 30 cm apart on a ridge. In both years, planting was done under rain-fed conditions, and seedlings were thinned to 1-3 plants per stand at 2 weeks after germination. Plots were not sprayed with insecticides. Agronomic data collected included: plant establishment, plant height, days to flower bud nodulation, days to 50% flowering and fruiting stages, stem diameter, branching habit and fruit yield components. Basic morphological characteristics of the genotypes were described using qualitative descriptors such as: color, shape and texture of main stem, leaf and fruits. Leaf and fruit shape characteristics were described using reference descriptors for okra (IBPGR, 1991) as shown in Figure 1.

Farmers field schools and participatory variety selection

Three sessions of farmer field schools (FFS) and participatory variety selection (PVS) were organized at 65, 80 and 95 days after planting (DAP) for a total of 272

farmers from 9 major vegetable producing communities (Table 2). During FFS, participants were taken through good vegetable production practices from nursery and field management to post-harvest and marketing operations.

During PVS, farmers were asked to select their preferred genotype using traits such as plant vigor, architecture, yield, harvesting frequency, viscosity, taste, color, drying quality and marketing potential. The PVS processes enable farmers to identify genotypes they preferred as well as traits that are critical to end-users.

Data analysis

The agronomic data were analyzed as a randomized complete block design with genotypes over years using GenStat (9th Edition) statistical package. Differences between treatment means were separated by least significant difference at 5% level of probability. Pearson's correlation analyses between pairs of agronomic parameters were performed using Statistix (Edition 9.1). Data sets from the FFS and PVS sessions were analyzed

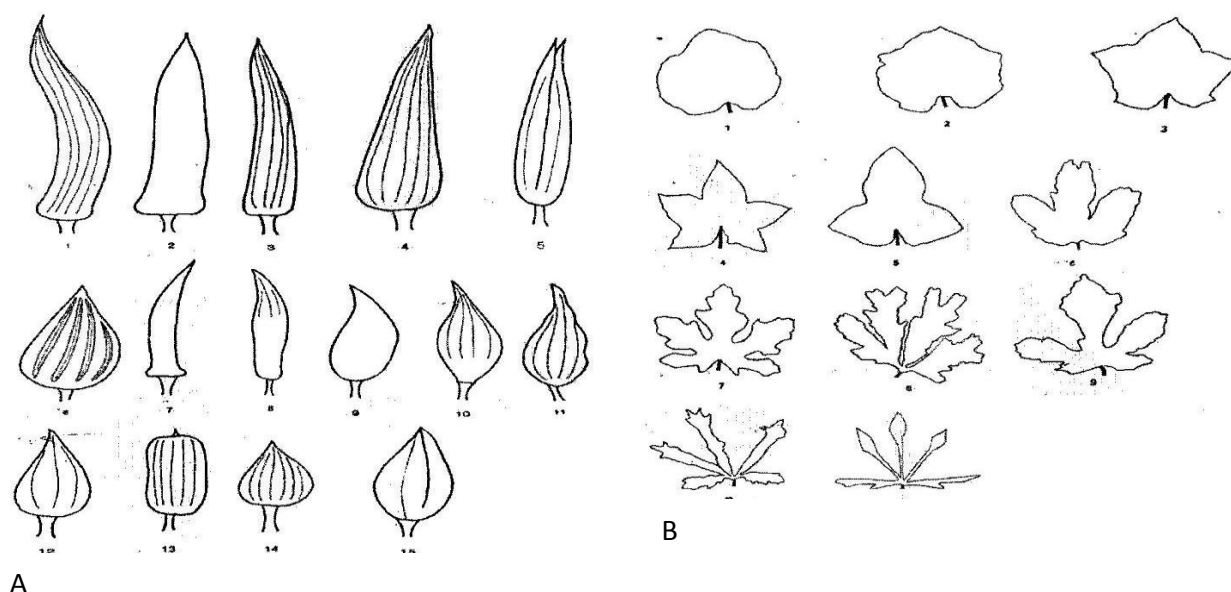


Figure 1. Reference descriptors for fruit and leaf shapes of okra genotypes. A: variability in fruit shape (IBPGR, 1991); B: variability in leaf shape (IBPGR, 1991).

Table 2. Number of farmers attending the farmer field schools and participatory variety selection sessions.

District	Community	Number of farmers in attendance		
		Male	Female	Total
Binduri	Nayorko 1	5	20	25
Binduri	Boku	5	20	25
Binduri	Azum-Sapielga	5	20	25
Bawku municipal	Nyorigu	5	20	25
Bawku municipal	Mognori	10	20	30
Bawku municipal	Tampezuwa	10	20	30
Kassena-Nankana East	Bado	6	16	22
Kassena-Nankana East	Tekuru	15	30	45
Kassena-Nankana East	Bonia	10	25	35
Total = 3	9	81	191	272

using descriptive statistics involving frequencies and percentages.

RESULTS

Morphological and agronomic yield components

Table 3 shows some morphological characteristics of the genotypes. Most genotypes had erect growth and sparse branching habits with green stem, leaf and fruit color. Leaf and fruit shape varied widely among the genotypes. Two morphological features of interest to farmers were stem, leaf and fruit pubescence; and plant height (Figure 2). For instance, height at flowering and fruiting were of significance because tall plants with thin stems are often susceptible to lodging, which has influence on dry matter,

disease incidence, fruit yield and quality. Glabrous leaf, stem and fruit pubescence were also critical to farmers as weeding and harvesting operations are still manually being done.

Plant establishment, height at harvest, days to 50% flowering and fruiting stages, and fresh fruit yield varied significantly ($P < 0.0001$) among the genotypes (Table 4). Using the number of days to 50% flowering and fruiting stages as criteria for earliness, the genotypes can be grouped into three maturity classes, namely: extra-early-maturing genotypes attaining 50% flowering by 40-50 days after planting (DAP) and 50% fruiting at 55-65 DAP, e.g., genotypes NOKH 1002, NOKH 1003, NOKH 1004 and NB-55-Srivan; early-maturing genotypes attaining 50% flowering at 51-65 DAP and 50% fruiting at

Table 3. Description of some morphological characteristics of the genotypes.

Variety	Growth habit	Branching habit	Stem color	Stem pubescence	Leaf color	Leaf pubescence	Leaf shape	Fruit color	Fruit pubescence	Fruit shape
Sasilon	Erect	Sparse	Red	Intermediate	Green, PV	Intermediate	3	Red, GV	Intermediate	1
TZ-SMN-86	Erect	Sparse	Red	Intermediate	Green, PV	Intermediate	7	Red, GV	Intermediate	1
P1496946	Erect	Sparse	Green	Intermediate	Green, PV	Intermediate	3	Green	Hairy	6
AAK	Erect	Sparse	Green	Hairy	Green	Hairy	9	Green	Intermediate	1
Ex-Makutopora	Erect	Sparse	Green, PV	Intermediate	Green, PV	Intermediate	9	Green, PV	Intermediate	3
NB-55-Srivan	Erect	Sparse	Green	Hairy	Green	Hairy	9	Green	Intermediate	1
ML-OK-10	Erect	Sparse	Green	Hairy	Green, PV	Intermediate	4	Green, PV	Intermediate	3
ML-OK-16	Erect	Sparse	Green, PV	Intermediate	Green	Glabrous	5	Green, PV	Intermediate	3
ML-OK-35	Erect	Sparse	Green	Hairy	Green	Intermediate	4	Green,	Intermediate	7
ML-OK-37	Erect	Sparse	Green	Intermediate	Green	Hairy	9	Ash-green	Intermediate	2
NOKH 1002	Erect	Sparse	Green	Intermediate	Green	Glabrous	9	Green	Intermediate	1
NOKH1003	Erect	Sparse	Green	Hairy	Green	Intermediate	10	Green	Intermediate	1
NOKH 1004	Erect	Sparse	Green	Hairy	Green	Intermediate	9	Green	Intermediate	1
FV-Unn	Erect	Sparse	Green	Hairy	Green	Hairy	9	Green	Hairy	4
FV-Unn manna	Erect	Sparse	Green	Hairy	Green	Hairy	3	Green	Hairy	4
FV-Kpazeya	Erect	Sparse	Green	Hairy	Green	Intermediate	3	Green	Hairy	4
FV-Kpora napong	Erect	Sparse	Green	Hairy	Green	Hairy	7	Green	Intermediate	8
FV-Kpora nasong	Erect	Sparse	Green	Hairy	Green	Hairy	5	Green	Intermediate	3
FV-Shie manna	Erect	Sparse	Green	Hairy	Green	Hairy	5	Ash-green	Intermediate	8

Description of leaf and fruit shape variability was done using reference descriptors for okra (IBPGR, 1991) as shown in Figure 1; PV: with purple veneration; GV: with green veneration.

60-70 days, e.g., genotypes Sasilon, TZ-SMN-86, AAK, ML-OK-37 and Ex-Makutopora; and the late-maturing group which attained 50% flowering 66 DAP. Genotypes with high potential included: NOKH 1004 (9.55 ton\ha), FV-Unn-manna (5.85 ton\ha), NOHK 1003 (5.17 ton\ha), NOKH 1002 (2.83 ton\ha), FV-Kpazeya (2.83 ton\ha), TZ-SMN-86 (2.30 ton\ha), AAK (2.11 ton\ha), NB-55-Srivan (1.98 ton\ha), Sasilon (1.70 ton\ha), FV-Unn (2.20 ton\ha) and Ex-Makutopora (1.27 ton\ha). Correlation analysis of some agronomic yield components of the genotypes is provided in Table 5. The correlation analyses showed

significant, high ($r > 0.78$), positive correlations between fresh fruit yield and fruit counts at 60, 90 and 120 days. Thus, days to flower bud nodulation, flowering and fruiting which translate into early harvesting from 60 DAP had significant association with yield.

Consumer preference traits

Genotypes Sasilon, NOKH-1004, NB-55-Srivan and NOKH-1003 recorded the highest ranking from the different PVS sessions (Table 6). Traits

influencing farmers' ranking were high yield, early maturing, harvesting frequency, drying quality and long tender-life. Other frequently discussed traits were fruit size, taste, fruit viscosity, price, late senescing and market potential. Fruit color, such as purple in Sasilon, did not influence farmers' criteria of selection. Fruit viscosity was a much subjective trait as some prefer much viscous as compared to less viscous types and vice versa. Tender-life referring to the number days the fruits maintain tender quality before becoming fibrous was stated. Most growers harvest at every 3 to 7 days; depending on mainly the market days interval

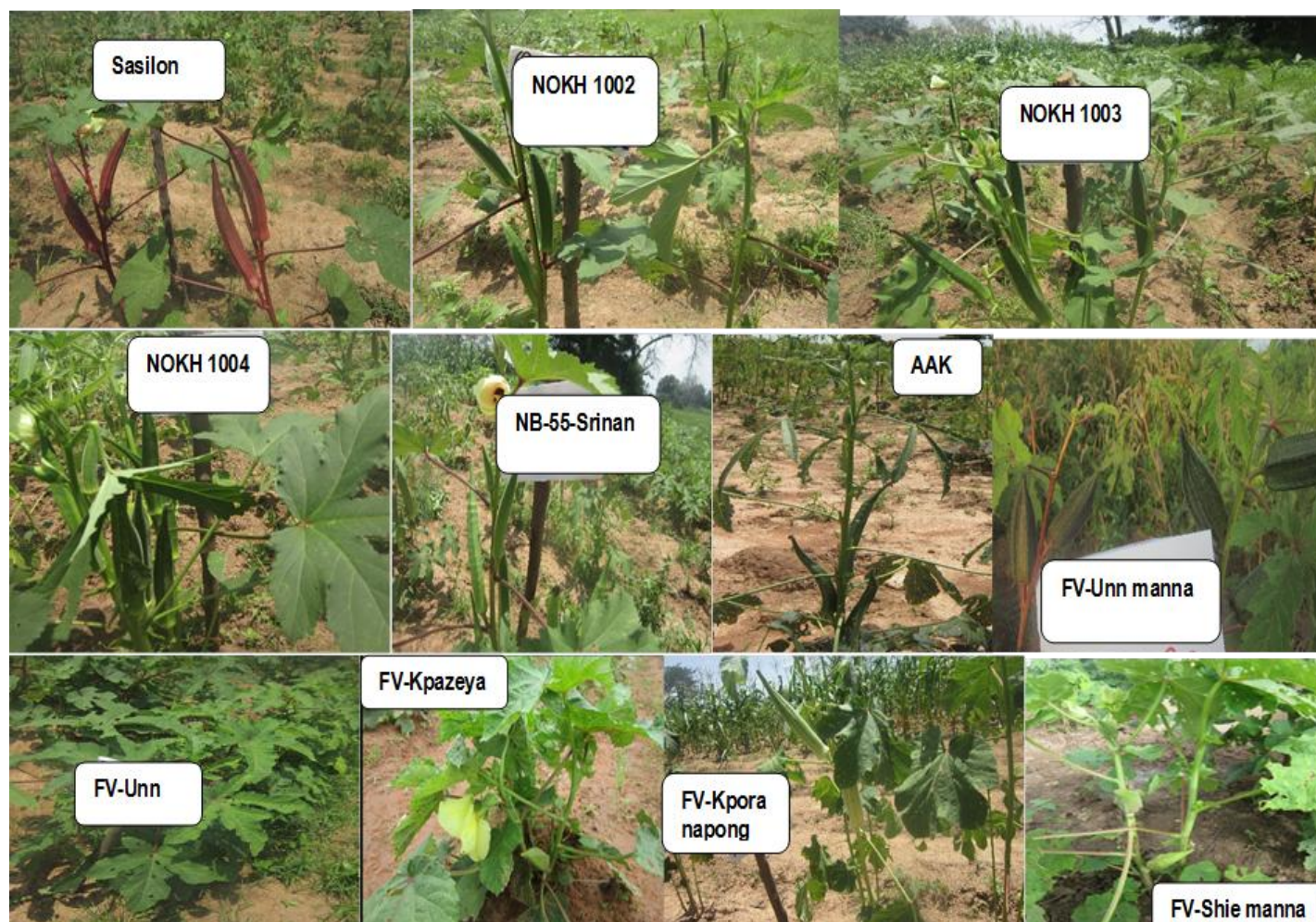


Figure 2. Features of some of the most preferred genotypes.

of the area.

DISCUSSION

In Ghana, okra production has remained an essential component of household income across gender to urban, peri-urban and rural farm families. Farmers often grow okra as a pre-season cash crop or a second crop to take advantage of residual water after harvesting an earlier crop. In most parts of sub-Saharan Africa generally, okra is traditionally cultivated as a rainy season crop typically by women on marginalized lands which are easily accessible to them (Kumar et al., 2010). Due to rapid urbanization and population growth, the demand for vegetables such as fresh and dehydrated okra has increased over the years. Thus, requiring appropriate production strategies to meet the supply gap. This study demonstrates the superiority of 4 genotypes as compared

to 6 widely grown landraces in the area. Five traits which were most critical to farmers include high yield (HY), early maturing (EM), multiple harvest frequency (MHF), drying quality (DQ) and long tender-life. For production under irrigation, dry season gardens and pre-season production, EM, HY and MHF were essential traits identified at the group discussions. Late maturing genotypes with poor DQ were less preferred. The farmer varieties in this study were usually selected due to their high yield under rain-fed conditions and good drying properties. Drying quality was particularly critical due to seasonal gluts occurring at the peak of harvesting. The high ranking for Sasilon was of particular significance since The World Vegetable Center (AVRDC) has promoted some of these promising lines (Sasilon, Batoumambe and Safi) in Mali and The Gambia over the last 5 years (Kumar et al., 2010). In our view, any genotype with yield potential of above 1 ton/ha may perform well at other locations due to the peculiar low soil fertility

Table 4. Summary of agronomic yield components of the genotypes.

Genotype	Plant establishment (%)	Plant height at harvest (cm)	Days to			Fruit count			Average fruit		Yield (t/ha)
			50% flower bud nodulation	50% flowering stage	50% fruiting stage	60 days	90 days	120 days	Length (cm)	Diameter (cm)	
Sasilon	75.0	43.5	48.2	60.3	69.3	17.0	32.0	50.3	18.7	7.2	1.70
TZ-SMN-86	87.2	53.2	56.8	64.2	71.2	1.2	20.0	94.5	18.7	7.4	2.30
P1496946	65.4	28.7	70.0	82.3	93.2	0.0	5.0	36.0	8.7	7.3	0.43
AAK	67.0	39.8	44.2	50.7	57.3	62.7	66.7	108.0	18.7	7.6	2.11
Ex-Makutopora	56.8	57.0	45.5	59.8	68.5	25.0	50.5	66.8	14.5	7.7	1.27
NB-55-Srivan	52.8	58.2	44.2	47.3	50.3	42.0	56.3	104.5	15.0	8.1	1.98
ML-OK-10	35.1	23.0	64.0	75.3	87.7	0.0	4.3	14.5	12.7	7.5	0.37
ML-OK-16	46.5	48.0	57.5	72.0	80.5	0.0	12.3	19.0	13.0	6.9	0.36
ML-OK-35	37.8	19.3	61.8	71.3	84.3	0.0	5.8	10.5	10.0	7.3	0.35
ML-OK-37	62.9	38.7	53.0	65.0	79.3	11.0	24.2	44.0	13.0	6.1	0.68
NOKH 1002	51.2	48.8	43.2	46.8	51.0	41.2	54.7	126.0	14.0	8.3	2.83
NOKH 1003	86.7	45.2	42.2	47.2	51.7	93.7	150.2	295.5	17.0	8.6	5.17
NOKH 1004	85.4	51.0	42.2	47.9	53.0	115.8	156.2	296.8	14.0	8.8	9.55
FV-Unn	84.4	83.8	56.3	69.5	78.2	0.0	5.7	213.5	10.3	9.5	2.20
FV-Unn manna	80.2	79.5	44.5	56	64	11.7	92.8	213.5	8.9	9.6	5.85
FV-Kpazeya	83.5	28.2	64.5	72.2	80.8	0.0	36.8	195.2	10.7	8.6	2.83
FV-Kpora napong	63.0	41.0	55.8	65.5	75.3	2.8	8.0	24.3	12.3	7.0	0.26
FV-Kpora nasong	68.2	44.3	55.8	66.2	78.2	1.6	11.7	15.2	11.1	7.3	0.45
FV-Shie manna	74.3	33.7	59.5	72.8	83.0	2	8.8	10.3	11.3	7.1	0.27
Genotype	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Year	0.064	0.047	0.020	0.071	0.343	0.004	0.204	0.001	0.955	0.917	0.295
Genotype x Year	0.894	0.232	0.578	0.607	0.001	0.010	0.097	0.001	0.895	0.970	0.345
LSD _(0.05)	16.14	15.31	9.51	4.57	5.91	9.71	25.44	20.03	3.371	1.21	0.75
CV (%)	7.7	10.2	2.3	1.2	1.2	1.8	6.9	1.7	8.1	1.8	4.5

status of the study area and late planting in both years; which was due to pre-season drought. Although, the genotype AAK was high yielding, it was probably not selected due to stem, leaf and fruit pubescence. Due to pre-season drought which led to late planting of experiments, the yield potential of the late maturing genotypes, which

were mostly also photoperiod sensitive, was not fully expressed.

Most important agro-yield traits in okra generally include number of total fruits per plant, fruit size characteristics, maximum plant height, days to flower bud nodulation, stem diameter and number of fruiting internodes and branches. Many studies

demonstrate that number of fruits per plant, fruit weight and total fruit production often show high variability as compared to other quantitative traits (Adeniji and Aremu, 2007; Bennet-Lartey and Oteng-Yeboah, 2008; Ahiakpa et al., 2013). It has been suggested that component breeding would be very effective when there is positive association

Table 5. Correlation analyses of agronomic yield components of the genotypes.

	DFBN	DFF	DFFR	FC120	FC60	FC90	FD	FL	PPE	PLHT	YD
DFBN	1										
DFF	0.8132**	1									
DFFR	0.7797**	0.9531**	1								
FC120	-0.4152*	-0.5265*	-0.5700**	1							
FC60	-0.6207**	-0.7486**	-0.7577**	0.7164**	1						
FC90	-0.6141**	-0.7084**	-0.7200**	0.8234**	0.8584**	1					
FD	-0.1393	-0.2465*	-0.2983*	0.6303**	0.2969*	0.3976**	1				
FL	-0.4648**	-0.4912**	-0.5141**	0.1236	0.3699*	0.3159*	-0.1797*	1			
PPE	-0.0689	-0.1021	-0.1558	0.5525**	0.2468*	0.3695*	0.3633*	0.0498	1		
PLHT	-0.2096*	-0.2367*	-0.3167*	0.2426*	0.2023*	0.1273	0.3359*	0.1396	0.2473*	1	
YD	-0.4769**	-0.5602**	-0.5893**	0.8858**	0.7757**	0.8301**	0.5525**	0.1396**	0.4997**	0.2282*	1

Where: (*), (**) Significant at 5 and 1% levels of probability, respectively; DFBN: days to 50% flower bud nodulation stage, DFF: days to 50% flowering stage, DFFR: days to 50% fruiting stage, FC120: fruit count at 120 days, FC60: fruit count at 60 days, FC90: fruit count at 90 days, FD: fruit diameter, FL: fruit length, PPE: percent plant establishment, PLHT: plant height, YD: fresh fruit yield.

Table 6. Overall ranking and traits influencing farmers' selection of the genotypes.

Most preferred genotype	Overall preference		Traits influencing their selection	Reasons for dislike
	Frequency	%		
Sasilon	41	15.1	HY, EM, Long-bold fruits, long tender-life, viscous, good taste	Poor DQ
NOKH 1004	40	14.7	HY, EM, MHF, long fruits, good taste	Poor DQ, short tender-life
NB-55-Srivan	35	12.9	HY, EM, MHF, long fruits, viscous	Poor DQ, short tender-life
NOKH1003	24	8.8	HY, EM, MHF, Long fruits, less hairy	Poor DQ, short tender-life
FV-Kpazeya	21	7.7	HY, MHF, good DQ, high price of dried okra, viscous	Late maturing, hairy
FV-Unn manna	20	7.4	HY, MHF, good DQ, high price of dried okra, viscous	Late maturing, hairy
FV-Kpora napong	20	7.4	HY, MHF, high price, long tender-life, less viscous	Late maturing
FV-Kpora nasong	20	7.4	HY, MHF, high price, long tender-life, less viscous	Late maturing
FV-Unn	19	7.0	HY, MHF, good DQ, high price of dried okra, drought resistant, good taste	Late maturing, hairy
FV-Unn manna	20	7.4	HY, MHF, good DQ, high price of dried okra	Late maturing, hairy
AAK	16	5.9	HY, EM, Long fruits, long tender-life, viscous, good taste	Poor DQ, hairy
NOKH 1002	5	1.8	HY, EM, long fruits, less hairy	Poor DQ, short tender-life
ML-OK-16	4	1.5	HY, EM, long fruit, viscous	Poor DQ
Ex-Makutopora	4	1.5	HY, EM, less hairy, long fruits	Poor DQ, short tender-life
TZ-SMN-86	3	1.1	HY, EM, less hairy, good taste	Poor DQ, late maturing
Total	272	100		

Poor drying quality: The cultivar respond slowly to drying or become fibrous or easily grow mouldy when dried, HY= high yielding, EM=early maturity, MHF= multiple harvesting frequency, DQ= drying quality.

of major yield characters (Hazra and Basu, 2000). The correlation analyses in this study showed high ($r > 0.78$) correlation between fruit yield and fruit counts at 60, 90 and 120 days. Thus, days to flower bud nodulation, flowering and fruiting which translate into early harvesting from 60 DAP influenced fruit production. A related study showed strong positive correlation between fruit yield and first fruit producing node ($r = 0.76$); first fruit producing node and first flowering node ($r = 0.79$); and number of fruits per plant and stem diameter at base ($r = 0.88$) (Ahiakpa et al., 2013). They also found highly significant correlation ($P < 0.01$) between fruit length at maturity and total fruits per plant and suggest the possibility of selecting highly prolific fruit types with longer fruits. Adeniji and Aremu (2007) reported negative correlations among these traits. Opong-Sekyere et al. (2012) also noticed strong correlation between the first flowering node and first fruiting node ($r = 0.74$) in evaluating fruit yield. They recommend that total fruit production, first fruit-producing node, first flowering node, number of fruits per plant and stem diameter at the base should be given more attention when selecting for higher yield and high dry matter in okra. However, the view of this study is in contrast with earlier view that early flowering is detrimental to overall productivity of okra as the source to sink ratio will be potentially limited for effective photosynthesis (Aboagye et al., 1994). Another opinion is that wide range of flowering periods among the accessions implies varying maturity periods even on the same plant making it difficult for uniform or mechanical harvesting (Ahiakpa et al., 2013). Generally, early flowering and fruiting is particularly essential in irrigation and pre-season cropping systems where time, water and labor resources are limiting factors. Respondents in this study preferred genotypes that can produce at least one fruit a week for a prolonged period; apparently due to the high price variability at harvest and other socio-economic considerations.

Conclusion

This study was part of broad strategies to unlock the potential of okra for food, nutrition and income security to urban, peri-urban and rural farm families through evaluating, introducing and promoting promising high yielding genotypes which can be utilized in both rain-fed and irrigation production ecologies. The study showed that it is possible to upgrade the current okra germplasm in Ghana using the 4 most ranked genotypes (Sasilon, NOKH-1004, NB-55-Srivan and NOKH-1003). Sasilon was ranked first due to its long tender-life and bold fruits. Four other genotypes: NOKH 1002, TZ-SMN-86, Ex-Makutopora and AAK, which showed good yield potential could be added in future okra improvement programmes. These 8 genotypes have been advanced to participatory multi-location on-farm evaluations to further validate their

potential. The major weaknesses of these genotypes are their poor drying quality and short tender-life. These genotypes can be suggested as candidates for inspection to the National Variety Release and Technical Committee for release to farmers in order to increase access to improved okra varieties. The PVS suggest that high yielding and early maturing genotypes which are amendable to drying may have wide adoption among farmers; due to the premium on dehydrated okra. Most of the farmer varieties in this study were selected due to fruit yield, multiple harvesting frequencies, ability to dry, long tender-life and late senescing.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the USAID-Feed the Future /IITA-Africa RISING Research for Development Programme for supporting the primary data collection of this study. They acknowledge the role of The World Vegetable Center (AVRDC-Mali) in providing accessions for the study. Views expressed in this study are the opinion of the authors.

REFERENCES

- Aboagye LM, Isodas A, Nyima H, Takasaki Y, Yoshimura T, Ishikawa T (1994). "Plant type and dry matter production in peanut (*Arachis hypogea* L.) cultivars; varietal differences in dry matter production", Japan J. Crop. Sci. 63(2):289-297.
- Adeniji OT, Aremu CO (2007). "Interrelationships among characters and path analysis for pod yield components in West African okra (*Abelmoschus caillei* A. Chev) Stevels)", J. Agro. 6(1):162-166.
- Agbo AE, Gnagri D, Beugre GM, Fondio L, Kouame C (2008). Maturity degree of four okra fruit varieties and their nutrients composition. Elect. J. Food Plant Chem. 5:1-4.
- Ahiakpa JK, Kaledzi PD, Adi EB, Peparah S, Dapaah HK (2013). "Genetic diversity, correlation and path analyses of okra (*Abelmoschus* spp. (L.) Moench) germplasm collected in Ghana", Int. J. Dev. Sustain. 2(2):1396-1415.
- Alam AKMA, Hossain MM (2008). Variability of different growth contributing parameters of some okra (*Abelmoschus esculentus* L.) accessions and their interrelation effects on yield. J. Agric. Rural Dev. 6(1,2):25-35.
- Arapitsas P (2008). Identification and quantification of polyphenolic compounds from okra seeds and skins. Food Chem. 110:1041-1045.
- Ariyo OJ (1990). Variation and heritability of fifteen characters on okra (*Abelmoschus esculentus* (L.) Moench). Trop. Agric. 67:213-216.
- Benchasri (2012). Okra (*Abelmoschus esculentus* (L.) Moench) as a valuable vegetable of the world. Ratar. Povrt. 49:105-112.
- Bennet-Lartey SO, Oteng-Yeboah AA (2008). "Ghana Country Report on the State of Plant Genetic Resources for Food and Agriculture", CSIR, Plant Genetic Resources Research Institute, (PGRRI), Bunso, Ghana, pp. 15-33.
- Bisht IS, KV Bhat (2006). Genetic resources, chromosome engineering and crop improvement series. Edited by Ram J. Singh. 3:148-162.
- Düzyaman E (2005). Phenotypic diversity within a collection of distinct okra (*Abelmoschus esculentus*) cultivars derived from Turkish land

- ances. *Genet. Resour. Crop Evol.* 52:1019-1030.
- Glew RH, VanderJagt DJ, Lockett C, Grivetti LE, Smith GC, Pastuszyn A, Millson M (1997). Amino acid, fatty acid, and mineral composition of 24 indigenous plants of Burkina-Faso. *J. Food Comp. Anal.* 10:205-217.
- Hazra P, Basu D (2000). Genetic variability, correlation and path analysis in okra. *Ann. Agric. Res.* 21(3):452-453.
- International Board for Plant Genetic Resources, IBPGR (1991). Report on International Workshop on Okra Genetic Resources, National Bureau for Plant Genetic Resources, New Delhi, India.
- Kumar S, Dagnoko S, Haougui A, Ratnadass A, Pasternak D, Kouame C (2010). Okra (*Abelmoschus* spp.) in West and Central Africa: potential and progress on its improvement. *Afr. J. Agric. Res.* 5(25):3590-3598.
- Ndunguru J, Rajabu AC (2004). Effect of okra mosaic virus disease on the above-ground morphological yield components of okra in Tanzania. *Sci. Hortic.* 99:225-235.
- Nwangburuka CC, Kehinde OB, Ojo DK, Popoola AR, Oduwaye O, Denton OA, Adekoya M (2011). Molecular characterization of twenty-nine okra accessions using the Random Amplified Polymorphic DNA (RAPD) Molecular Marker. *Acta SATECH* 4(1):1-14.
- Oppong-Sekyere D, Akromah R, Nyamah EY, Brenya E, Yeboah S (2012). Evaluation of some okra (*Abelmoschus* spp L.) germplasm in Ghana. *Afr. J. Plant Sci.* 6(5):166-178.
- Saifullah M, Rabbani MG (2009). Evaluation and characterization of okra (*Abelmoschus esculentus* L. Moench.) genotypes. *SAARC J. Agric.* 7:92-99.