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Full Length Research Paper

Vol. 5 (4), pp.66 - 78, September, 2017

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Assessment of some okra germplasm

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Abstract

In the study, twenty-five accessions of okra collected from different parts of Ghana were evaluated for their horticultural and agronomic attributes in the major and minor cropping seasons of 2008 at the crop and soil sciences experimental field, Kwame Nkrumah University of Science and Technology (KNUST) Kumasi, Ghana, using a randomized complete block design (RCBD) with four replications. The objectives of the experiment were to investigate the horticultural characteristics and performance of all the okra entries. Data collected included fruit and leaf characteristics; Days to first flowering, first flowering node, first fruit-producing node, fresh fruit weight, fruit length at maturity, fruit width, maximum plant height, number of internode, number of seeds per fruit, number of total fruits per plant, seed yield, 100 seed weight. The accessions KNUST/SL1/07Nkrumahene, DA/08/02Dikaba and GH 5787Asontem, GH6102Fetri and 'Asontem' showed number of days from sowing to first-flowering at between 44.00 and 48.00 days, first flowering and fruiting nodes at between 5.00 and 6.00th nodes, days to 50% emergence at 8 days after sowing, the average number to total fruits per plant at 60.00 to 145.00 fruits and green immature fruit colour. The results showed that most of the okra displayed symptoms of okra mosaic virus (OMV) and okra leaf curl virus (OLCV). Fruit size varied among the entries. A correlation of the characters with the total fruit production showed that plant height, days to flowering and nodulation, fruit yield and seed yield recorded positive and significant associations, which generally mean that they influenced fruit production or yield. Specific accessions; KNUST/SL1/07Nkrumahene, DA/08/02Dikaba and GH 5787Asontem, GH6102Fetri and 'Asontem', identified in this study, could be passed on to breeders for utilization in the okra improvement programmes in Ghana.

Keywords: Accessions, assessment, okra mosaic virus (OMV), okra leaf curl virus (OLCV), susceptibility, vegetables.

INTRODUCTION

Vegetables are indispensable ingredient in the daily diets of humans as they offer numerous nutritional benefits. They are normally eaten fresh and in sauces and are used by the growing fast-food, hotel, and restaurant industry (Tyler et al., 1989; Lamont Jr., 1999). They are consumed almost daily and are traded by a broad range of market participants, particularly in Ghana.

Okra, (*Abelmoschus esculentus* L.), a member of the *Malvaceae* (mallow) family can be found in nearly every market in Africa. In Ghana, it is the fourth most popular vegetable after tomatoes, pepper, and garden eggs (Sinnadurai, 1973; Lamont Jr., 1999). The world okra production, as of 2007, was estimated at 4.8 million tons with India leading the production by 70% followed by

Nigeria (15%), Pakistan (2%), Ghana (2%), Egypt (1.7%) and Iraq (1.7%) (Gulsen et al., 2007). About 10 to 15 t/ha of yield can be obtained under good management (NARP, 1993). The okra provides an important source of vitamins and minerals (Lamont, 1999).

Okra is a vegetable which one finds in a fresh state in almost all markets in Ghana, during the rainy season and in a dehydrated form during the dry season. It is particularly found in Northern Ghana due to its strong commercial value for poor women farmers and its vital importance as food diet among the inhabitants of the cities and villages. Notwithstanding the importance of the crop, the country cannot boast of any improved varieties; varieties that are perennial in growth habit and at the same time combine higher yields and early maturity with longer harvest duration and more so resistant to diseases and pests. Improved varieties in terms of fruit size, shape and colour are also very much desired in the Ghanaian okra export market, as a quality standard in vegetable export.

This paper seeks to bring to light some horticultural as well as agronomic characteristics of some okra landraces grown in the various regions of Ghana; then to identify and assess accessions with superior agronomic performance suitable for adoption by okra farmers; more so, accessions with unique features useful for the okra breeding programme in Ghana.

MATERIALS AND METHODS

Twenty-five genotypes of okra, twelve from the Plant Genetic Resources Research Institute (PGRRI) of the Council for Scientific and Industrial Research (CSIR), Bunso, twelve from the University of Education, Winneba-Mampong; College of Agricultural Science and one from the Department of Horticulture, Kwame, KNUST-Kumasi.

The study was undertaken at the Department of Crop and Soil Sciences experimental field, KNUST, in the major and minor seasons of 2008. The land was slashed, ploughed and harrowed to a fine tilt for the experiment. The experimental design used was randomized complete block design (RCBD) with 4 replications. The total experimental area was 14 m x 83 m.

Sowing was by direct seeding on the field at the rate of 2 seeds per hill. Seedlings were thinned to one plant per stand two weeks after germination. There were a total of 100 plots with each plot measuring 2.4 by 1.8 m. Each plot had sixteen plants with a spacing of 60 by 45 cm. Data was taken from four plants within the middle rows of each plot.

Standard agronomic practices including thinning, weed control, watering. Compound fertilizer in the form of N.P.K. 15:15:15 at a rate of 250 kg/ha and urea at a rate of 125 kg/ha were applied to the plants at 30 days after sowing. Plants were also sprayed against insects, pests and diseases using Pyrical 480EC at a rate of 20 ml/15 L of water, then later with kombat 2.5EC (Lambda Cyhalothrin) at a rate of 36 ml/15 L of water. Weeding was done with a hoe at 2 and 4 weeks after emergence and at early flowering respectively and when necessary.

Data was taken on four hundred plants in total. Data was collected on germination percentage (number of days from sowing to 50% seedling emergence), first flowering (number of days from sowing to 50% full bloom flowering), number of epicalyx segments, fruit length at maturity, number of fruit ridge(s), total number of fruit(s) per plant, peduncle length, epicalyx number, epicalyx length, epicalyx width, 100 seed weight, number of segments from the stigma, plant height, number of internodes, leaf length, leaf width, first flowering node, node(s) producing fruits on main stem and position of fruit on the main stem. Averages, range, standard deviation and coefficient of variation were computed for the measurement data. Quantitative data was subjected to analysis of variance (ANOVA) using GenStat discovery edition 3.0 (GenStat 5 Committee, 2000). Means were separated by least significant difference at 5%. Pearson's correlation analyses between pairs of quantitative parameters were also performed using SPSS version 16.0, with reference to yield parameters.

RESULTS

Growth characteristics

Days to first flowering (DFF)

Generally, all the okra accessions recorded high germination percentages. Earliness in okra is determined by the number of days from sowing to 50% full-bloom. This character recorded a wide variation among the okra accessions studied. These variations are as shown in Figure 1.

Okra accession Atuogya-Asante recorded the longest number of days to flowering of up to 128 days. Shorter number of days to flowering was recorded in accessions KNUST/SL1/07Nkrumahene, DA/08/02Dikaba, GH5787Asontem, GH6102 Fetri and Asontem, recording as early as between 44 and 48 days (Table 1). This is a character that breeders are interested in and will exploit to improve yield. For instance, early maturing plant types could be selected for areas with short rainy seasons in the rain fed ecologies. Such genotypes will also be suitable in areas where farmers grow a second crop to take advantage of residual water after harvesting the early crop (Kumar et al., 2010).

Maximum plant height, MPH

The height of plants in this study varied significantly among the okra accessions studied (Table 1). The tallest plant with the height of 127.5 cm occurred among GH 5787Asontem followed by GH1169Fetri with 116.0 cm. On the other hand, accession DA/08/001Wun mana recorded the shortest plant height of 26.80 cm. Height at flowering and fruiting (final height) are of particular interest for breeding programmes because tall, thin stems increase lodging near harvesting time and this could result in loss of dry matter and a subsequent decrease in fruit yield.

Number of total fruits per plant, NTF/P

Number of matured green fruits per plant for the okra genotype varied significantly. Harvesting was done every

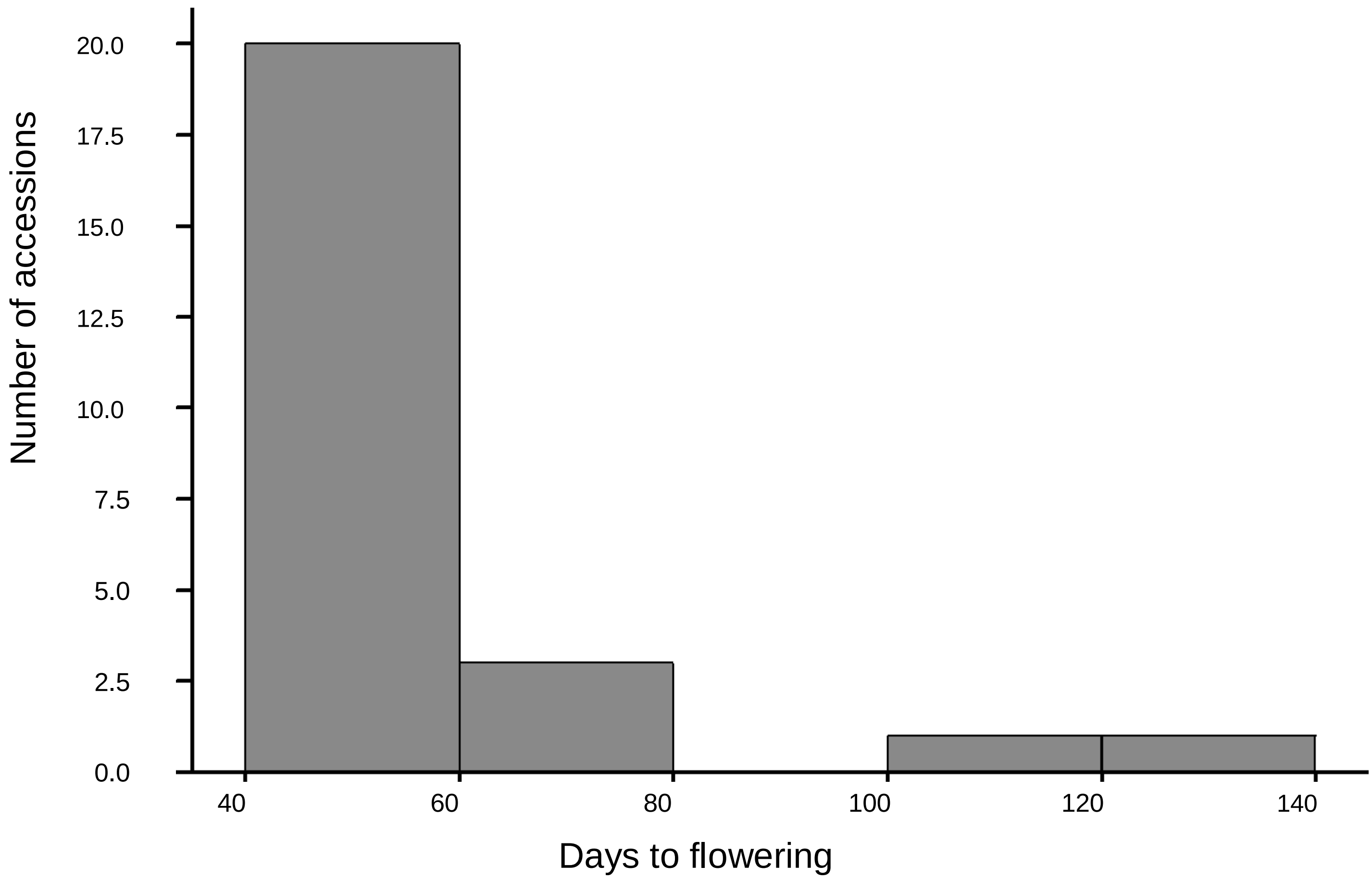

Figure 1. Variation in the number of days to flowering.

other day and fruit yield per treatment was determined by harvesting mature fruits into well-labeled polybags. The highest yield of 144 fruits was observed for Atuogya-tiatia followed by GH5787 Asontem with 142 fruits and accession GH5793 Gyeabatan producing 112 fruits. Accession number GH4499 Fetri had the least number of fruits of 16.8 (Table 1). Yield was significantly affected by environmental factors leading to flower drop and low yield.

Susceptibility to viral diseases- okra leaf curl disease, okra mosaic virus (OLCV, OMV)

Atuogya, Wun mana and Sheo mana types of okra exhibited high resistance to the mosaic and Leaf curl diseases of okra (Table 9).

Siemonsma (1991) had indicated that, okra mosaic virus (OMV), transmitted by flea beetles (*Podagrica*), is widespread in Africa but damage is much less important than that caused by okra leaf curl disease (OLCV), transmitted by whitefly (*Bemisia tabaci*). Differences in diseases/insects/pests susceptibility observed among the okra genotypes, particularly the Atuogya types, might be due to the inherent genetic potential of the different okra landraces (differences in cultivar types) to resist environmental stresses including diseases/pests/insect. Research findings of Lamont Jr (1999) are in support of this result. This resistance by the Atuogya accessions could be used as a genetic base to improve other susceptible varieties such as GH3801 Pora (Bish et al., 1995).

agronomic performance among okra accessions

Correlation analysis

A correlation of the characters with the total fruit production showed that the following characters (Table 3) showed positive correlation, which generally means that they influenced fruit production or yield. The highest significant ($p < 0.01$) correlation was recorded between first flowering node and first fruiting node (0.736).

The correlation results revealed a positive and a highly significant association between maximum plant height and number of internodes (0.467, $p < 0.01$) and fruit length at maturity (0.502). Maximum plant height again

Table 1. Ascension means for quantitative characters that showed variation in okra.

N0.	Accession	NS/F	MPH (cm)	DFF	FFN	NTF/P	FF-PN	FFrtWt(g)	SDYLD (Kg/plot)	SW100 (g)
1	GH4487 Muomi	95.50	68.00	58.50	7.00	59.80	7.75	5.45	8.94	3.86
2	GH4482 Muomi	71.20	57.00	52.25	6.50	51.00	6.00	6.60	8.13	3.51
3	GH4499 Fetri	8.00	39.60	49.00	7.50	16.80	8.00	5.64	7.75	3.35
4	GH1169 Fetri	63.00	116.00	55.75	6.75	79.20	5.25	5.92	7.76	3.35
5	GH4376 Atuogya	72.20	55.80	52.25	8.00	91.20	8.50	6.67	8.86	3.83
6	GH4490 Fetri	77.00	54.80	51.75	7.75	76.20	7.00	7.01	7.15	3.09
7	GH3801 Pora	68.50	65.20	45.25	6.50	58.00	7.00	3.53	7.37	3.19
8	GH6102 Fetri	63.00	60.50	47.25	5.75	56.50	5.50	6.42	8.30	3.59
9	GH4964 Muomi	84.00	54.20	43.25	8.00	69.00	8.25	6.86	6.66	2.88
10	GH5793 Gyeabatan	74.80	71.10	70.00	7.50	112.20	7.75	12.40	7.52	3.25
11	GH5787 Asontem	78.50	127.50	44.00	6.25	142.00	6.50	7.29	7.26	3.14
12	GH3736 Fetri	83.80	63.20	50.25	7.75	58.80	7.75	6.85	7.70	3.33
13	Atuogya-tiatia	72.50	43.20	54.25	3.75	144.00	4.50	7.27	6.66	2.88
14	DA/08/001 Wun mana	84.00	26.80	74.25	10.75	67.80	9.25	14.22	14.79	6.39
15	DA/08/02 Sheo mana	85.20	28.20	48.50	6.25	73.20	6.00	12.26	7.30	3.16
16	DA/08/02 Asontem	70.20	61.70	41.75	6.75	69.20	7.00	11.57	7.99	3.45
17	Atuogya-Asante	76.00	63.50	128.25	7.75	52.50	7.25	12.40	8.51	3.68
18	Asontem	73.00	71.00	51.25	6.25	62.00	5.50	8.58	7.07	3.06
19	DA/08/04 Wun mana	73.00	42.70	50.25	6.00	69.80	7.00	13.43	7.04	3.04
20	DA/08/004 Agbodro	84.20	49.50	68.25	7.75	29.00	7.25	6.76	7.95	3.44
21	GBODRO-wild	74.20	48.50	50.25	7.75	76.00	7.75	8.68	8.14	3.52
22	DA/08/02 Dikaba	72.50	64.90	48.00	6.25	68.00	6.00	12.01	7.83	3.38
23	DA/08/03 Sheo mana	82.80	71.20	53.25	8.00	54.30	8.25	13.08	7.35	3.18
24	Atuogya-tenten	73.00	40.20	50.00	7.00	58.00	6.50	9.21	7.87	3.40
25	KNUST/SL1/07Nkrumahene	105.50	69.20	46.75	6.50	70.20	6.25	9.42	4.71	2.04

NS/F: Number of seeds per fruit, MPH: Maximum plant height, DFF: Days to first flowering, FFN: First flowering node, NTF/P: Number of total fruits per plant, FF-PN: First fruit –producing node, FFrtWt (g): Fresh fruit weight, SDYLD: Seed yield, $SW_{100 (g)}$: 100 seed weight.

recorded significant positive correlation between first flowering node (0.246, $p < 0.05$) and first fruit-producing node (0.213).

Correlations between first flowering node and first fruit producing node, and fruit length at maturity were significantly high and positive (0.736, $p < 0.01$); (0.253, $p < 0.05$). Correlation results between days to first flowering and first flowering node (r = 0.252), fresh fruit weight (0.291), seed yield (0.282) and 100 seed weight (0.282) were also positive and significant ($p < 0.05$). Number of total fruits per plant revealed significantly high and positive correlation ($p < 0.01$) with first flowering node (0.258), first fruit-producing node (0.308), fruit length at maturity (0.557) and maximum plant height (0.435) but negative correlation with fruit width (-0.020).

Highly significant association was revealed between seed yield and days to first flowering as well as between 100 seed weight and days to first flowering (0.282, $p < 0.01$) but a negative yet non-significant association was recorded between either of the two and number of seeds per fruit (-0.013) (Table 3).

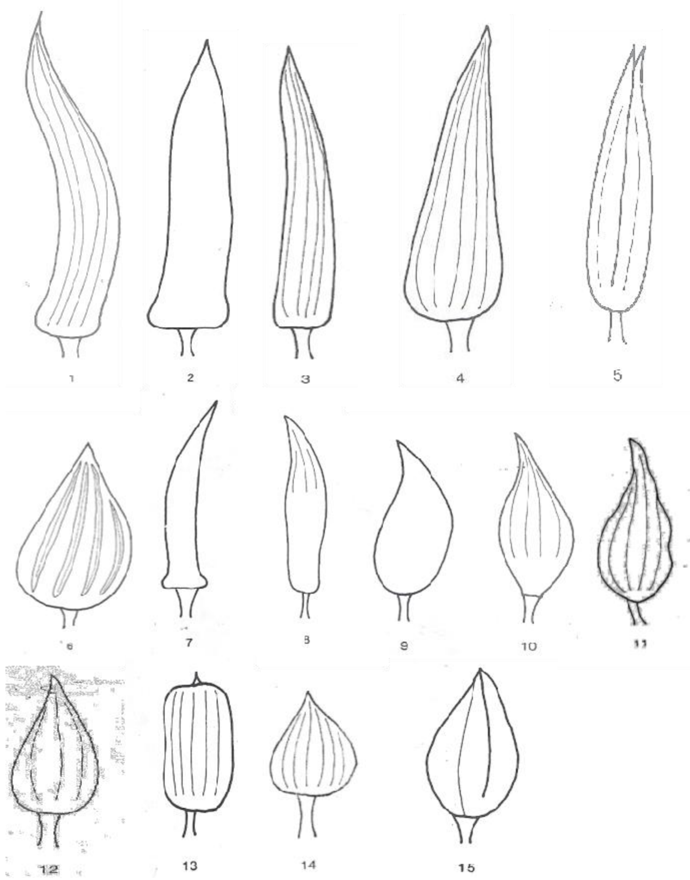

Plate 1. Variability in fruit shape (IBPGR, 1991).

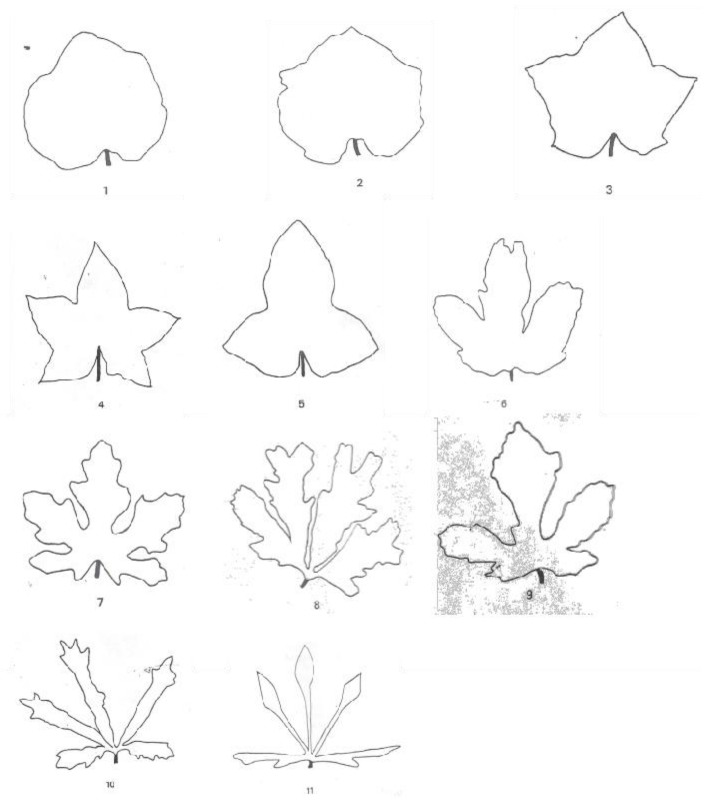

Plate 2. Variability in leaf shape (IBPGR, 1991).

DISCUSSION

Growth characteristics

Different genotypes have different growth habits. The commonest growth habit among all the landraces observed was indeterminate growth habit with erect general growth appearance (Unique orthotrop axis).

Erect plant type is advantageous to okra production since it would allow maximum and uniform exposure or distribution of all leaves (Plate 2) and other vegetative parts for better interception of sunlight. This would result in an increase in dry matter production and a subsequent increase in yield. This is in conformity with the findings of Hanson (2005). Moreover, there is less chance of fruits touching the ground or soil thereby causing fruit rot.

The indeterminate nature of the okra landraces is a character which might have been selected for over the years by researchers and farmers because it allows for longer and continuous fruit harvest. This is an advantage when prices of the vegetable fluctuate. Farmers do not want these plants to produce long branches and would rather opt for more plants per area unit. Previous studies in Tomatoes by Hanson (2005) suggested this to be advantageous because it allows the combination of large numbers of fruit with many plants per unit space, which is an indicator for high yield. Short branches and internode length with flowers are, however desirable.

Fruit characters and production

Fruits displayed great diversity in size-shape and length. They ranged from short and triangular to long straight or long curve (Plate 1). Earliness, expressed by the lower leaf axil in which flower buds appear, is partly due to varietal characteristic. Fruits with characteristics such as smooth, spineless, slender with green (light or dark) skin are very desirable in the Ghanaian local and export markets (Irimerin and Okiy, 1986; Sinnadurai, 1992; Duzyaman, 2005). Varieties such as KNUST/SL1/07 Nkrumahene, DA/08/004 Agbodro and Asontem were among the landraces that displayed such traits. 'Atuogya', 'Sheo mana' or 'Wun mana' were compa-ratively high yielding with longer harvest duration and also highly resistant to environmental stresses such as diseases and pests and drought but revealed undesirable fruit shape and colour.

Performance among agronomic characters

Number of seeds per fruit, maximum plant height

Table 2. Means, standard error, range, coefficient of variation (CV%), standard deviation (SD) and F. probability at l.s.d. 5% of 25 okra accessions.

Traits	N	Mean ± S.E	Range	C.V%	S.D	F. Pro.
NS/F	25	74.60 ±0.48	8.00-105.50	0.70	15.70	<0.001
MPH(cm)	25	59.60 ±1.35	6.80-127.50	3.10	35.40	0.031
DFF	25	55.38 ±1.85	41.75-128.25	2.70	18.48	<0.003
FFN	25	7.04 ± 0.23	3.75-10.75	3.40	1.60	0.003
NTF/P	25	70.60 ±2.65	16.80-144.00	6.00	26.90	<0.001
FF-PN	25	6.95 ± 0.25	4.50-9.25	4.40	1.53	0.024
FFrtWt (g)	25	8.78 ± 0.14	3.53-14.22	1.90	3.12	<0.001
SDYLD(Kg/plot)	25	7.86 ± 0.33	4.71-14.79	0.49	2.30	<0.001
$SW_{100\ (g)}$	25	3.40 ± 0.14	2.04-6.39	4.90	9.90	<0.001

NS/F: Number of seeds per fruit, MPH: Maximum plant height, DFF: Days to first flowering, FFN: First flowering node, NTF/P: Number of total fruits per plant, FF-PN: First fruit –producing node, FFrtWt (g): Fresh fruit weight, SDYLD: Seed yield, $SW_{100\ (g)}$: 100 seed weight.

Table 3. Correlation analysis of quantitative characters in okra accessions.

Character	DFF	FFN	FF-PN	FFrtWt(g)	FLM (cm)	FW (cm)	MPH (cm)	NI	NS/F	NTF/P	SD YLD (kg/plot)	SW_{100} (g)	Wt (kg)
DFF	1												
FFN	0.252*	1											
FF-PN	0.144	0.736**	1										
FFrtWt (g)	0.291**	0.026	-0.000	1									
FLM (cm)	0.172	0.253*	0.238*	0.073	1								
FW (cm)	-0.011	0.088	-0.028	-0.033	-0.125	1							
MPH (cm)	0.082	0.246*	0.213*	0.099	0.502**	0.019	1						
NI	-0.033	-0.097	-0.047	0.008	0.194	0.154	0.467**	1					
NS/F	0.069	0.044	0.056	0.022	0.142	-0.075	0.008	0.051	1				
NTF/P	0.023	0.258**	0.308**	0.049	0.557**	-0.020	0.435**	0.127	0.025	1			
SD YLD (kg/plot)	0.282**	0.232*	0.205*	0.210*	0.195	0.105	0.178	0.132	-0.013	0.081	1		
SW_{100} (g)	0.282**	0.232*	0.205*	0.210*	0.195	0.105	0.178	0.132	-0.013	0.081	1.00**	1	

(*), (**) Significant at 5 and 1% levels of probability, respectively; *DFF = Days to first flowering, *FFN = First flowerin g node, *FF-PN = First fruit-producing node, *FFrtWt (g) = Fresh fruit weight; *FLM (cm) = Fruit length at maturity, *FW (cm) = Fruit width, *MPH (cm) = Maximum plant height, *NI = Number of internode; *NS/F = Number of seeds per fruit, *NTF/P = Number of total fruits per plant, *SD YLD (kg/plot) =Seed yield, *SW_{100} (g) = 100 seed weight.

(cm), days to 50% flowering, fruiting and node formation, number of total fruits per plant, fresh fruit weight, seed yield, 100 seed weight and susceptibility to diseases insects and pests were among the agronomic characters that exhibited significant variation among the okra accessions studied (Table 2).

Progress in crop production depends, to a great extent, on the ability of breeders to select high yielding varieties to improve yield attributes such as seed yield, number of fruits per plant, fruit length and fruit width. The result of the present study indicated that**,** days to 50% flowering, first node of fruiting, weight of fresh fruits, seed yield, final plant height, fruit yield and number of seeds per fruit showed highly significant variation ($p < 0.05$, Table 2).

Generally, the significant differences ($p < 0.05$) revealed among the aforementioned attributes of yield may be due to environmental influences on the genotypes as well as differences in the genetic potential of the different okra landraces (cultivar types). This corroborate findings of (Sing et al. 1986; Ariyo, 1993; Adeniji, 2003) who mentioned the role of environmental factors as well as differences in the genetic make-up of different varieties in yield determination of okra.

Association among morphological traits (correlation analysis)

The association between pairs of quantitative yield traits (Table 3) in the okra landraces studied saw flowering and fruiting parameters (fruit size, fruit weight, average number of fruits per plant, first-flowering node, first fruiting node and days to first-flowering), maximum plant height and number of internodes recording significant ($P < 0.01$) positive associations. Findings of several researchers (Hazra and Basu, 2000) suggested that component breeding would be very effective when there is positive association of major yield characters, as found in this study.

Earlier findings of Kumar and Reddy (1982) had also revealed that number of total fruits per plant had the highest direct effect on seed yield followed by maximum plant height and days to first flowering. The highly significant correlation ($P < 0.01$) recorded between fruit length at maturity and average number of total fruits per plant in this study indicated the possibility of selecting highly prolific fruit types with longer fruits. This is supported by the research findings of Akinyele and Oseikita (2006).

The significant positive relationship of days to first flowering, first flowering node with first fruiting node and maximum plant height at flowering observed in the study shows that there is strong relationship between days to flowering and days to fruit or node production and maturity hence, indicative of a strong relationship between the stages of plant growth at which flowering is initiated and final height at which the entire crop life cycle is completed. These results corroborate findings of Akinyele and Oseikita (2006).

The number of total fruit per plant exhibited positive and significant correlation with maximum plant height, according to the result of the correlation analysis. This implies that plant height favoured the performance of the okra plants and should be selected for as a component of yield; the implication being that any improvement in height of okra accessions would indirectly select for or increase fruit yield. Similar results were found by Reddy et al. (1985) and Henry and Krishna (1990).

The positive correlation recorded between days to first flowering and first fruit-producing node indicates that days to flowering can be used as a criterion for selecting lines that have a few numbers of days to maturity, so that production can occur twice in a cropping season. This finding is similar with the report of (Oseikita and Akinyele, (2008).

The non-significant negative association between the fruit length and fruit width characters in the present study shows that the two characters could be selected for separately as they are components of seed yield. This is supported by Shukla (1990) in his earlier finding of correlation and path co-efficient analysis in okra.

Henry and Krishna (1990) noted that characters that exercise negative correlation with one another will be difficult to select for in characterization of desirable traits, and that those with negative association but non-significant correlation will be disregarded in selection for crop variety improvement.

It could therefore be deduced from the associations mentioned earlier, that, any improvement sort that is directed at maximum plant height (height at flowering), days to first flowering and number of internodes, among others, would indirectly result in improvement in (fresh) fruit weight, seed yield and a subsequent increase in total fruit yield, results that is a prerequisite in any breeding programme.

From the study, the following okra accessions; KNUST/SL1/07Nkrumahene, DA/08/02Dikaba, GH5787Asontem, GH6102 Fetri and 'Asontem' recorded the most promising results in terms of days to 50% flowering at between 44.00 and 48.00, first flowering and fruiting nodes at between 5.00 and 6.00th nodes, days to 50% seedling emergence at 8 days, average number of total fruits per plant at between 60 and 145 fruits and fruit colour (green). Moreover, their fruit sizes at maturity, leaf colour, branching position, as well as their susceptibility to diseases and insect and pests were satisfactory. These okra accessions are therefore recommended for further improvement in terms of quality and yield.

Some horticulture/agronomic characteristics among okra accessions studied

The finding in this work has brought to light some important and unique horticultural features as well as superior agronomic characters of some selected okra accessions (Tables 4 - 8). It is believed that this information, as thoroughly researched, would be of great value to Agronomists and Breeders alike in their improvement programmes in Ghana and beyond, which would go a long way to help the vegetable crop industry and subsequently improve the per capita income of Ghana.

Table 4. Growth characteristics of 25 okra accessions.

Variety	Plant growth habit /general appearance	Branching position at main stem	Immature leaf colour	Mature leaf colour	Leaf shape	Length of branches (cm)	Stem pubescence
GH 4487 Muomi	Erect	UOA	Green	Green	2	0	LP
GH 4482 Muomi	Erect	UOA	Green	Green+red veins	1	0	‘’
GH 4499 Fetri	Erect	UOA	Green	Green	2	0	‘’
GH 1169 Fetri	Erect	UOA	Green	Green+red veins	2	0	‘’
GH 4376 Atuogya	Erect	UOA	Green	Green+red veins	2	0	‘’
GH 4490 Fetri	Erect	UOA	Green	Green+red veins	1	0	‘’
GH 3801 Pora	Erect	UOA	Green	Green+red veins	7	0	‘’
GH 6102 Fetri	Erect	UOA	Green	Green	2	0	‘’
GH 4964 Muomi	Erect	UOA	Green	Green+red veins	1	0	‘’
GH 5793 Gyeabatan	Erect	UOA	Green	Green+red veins	1	0	‘’
GH 5787 Asontem	Erect	UOA	Green	Green+red veins	2	0	‘’
GH 3736 Fetri	Erect	UOA	Green	Green	2	0	‘’
Atuogya-tiatia	Erect	DBB	Green	Green	3	1	‘’
DA/08/001Wun mana	Erect	DBO	Green	Green	3	0	‘’
DA/08/02Sheo mana	Erect	DBB	Green	Green+red veins	3	0	‘’
DA/08/02 Ason-Wen	Erect	UOA	Green	Green+red veins	2	0	‘’
Atuogya-Asante	Erect	DBO	Green	Green+red veins	3	1	‘’
Asontem	Erect	UOA	Green	Green	4	0	‘’
DA/08/04Wun mana	Erect	DBO	Green	Green	2	1	‘’
DA/08/004 Agbodro	Erect	DBO	Green	Green	4	1	‘’
GBODRO-wild	Erect	DBO	Green	Green	2	0	‘’
DA/08/02Dikaba	Erect	DBB	Green	Green	2	0	‘’
DA/08/03Sheo mana	Erect	DBB	Green	Green	2	1	‘’
Atuogya-tenten	Erect	DBB	Green	Green	2	0	‘’
KNUST/SL1/07Nkrumahene	Erect	UOA	Green	Green	2	0	‘’

*UOA=unique orthotrop axis; DBO=densely branched all over; DBB= densely branched base; *LP: Little pubescence 0= no branches. 1= branches rarely > 10cm.

Table 5. Colouring of diverse plant parts in 25 okra accessions.

Variety	Leaf Rib colour	Petiole colour	Petal colour	Colour of darkest ridges	Stem colour	Red colour @ bottom petal (PB)
GH 4487 Muomi	Green	Green	Golden yellow	Light	Green	Inside the petal (Internal)
GH 4482 Muomi	Green+red veins	Green+red veins	‘’	Light	Green + red spots	‘’
GH 4499 Fetri	Green	Green+red veins	‘’	Light	Green	‘’
GH 1169 Fetri	Green+red veins	Green+red veins	‘’	Light	Green + red spots	‘’

Table 5. Contd.

GH 4376 Atuogya	Green+red veins	Green+red veins	Yellow	Light	Green	‘’
GH 4490 Fetri	Green+red veins	Green+red veins	Golden yellow	Light	Green	‘’
GH 3801 Pora	Green+red veins	purple	‘’	Light	Purple	‘’
GH 6102 Fetri	green	green	‘’	Light	green	‘’
GH 4964 Muomi	green	Green+red veins	‘’	Light	Green+ red spots	‘’
GH 5793 Gyeabatan	green	Green+red veins	Yellow	Light	Purple	‘’
GH 5787 Asontem	Green+red veins	Green	Golden yellow	Light	Green	‘’
GH 3736 Fetri	green	Green	‘’	Light	Purple	‘’
Atuogya-tiatia	Green+red veins	Green+red veins	Yellow	Light	green	‘’
DA/08/001Wun mana	Green+red veins	Green	Yellow	Dark	green+ red spots	‘’
DA/08/02Sheo mana	Green+red veins	Green+red veins	Golden yellow	Dark	green	‘’
DA/08/02 Ason-Wen	green	Green	‘’	Light	Green	‘’
Atuogya-Asante	Green	Green	Yellow	Light	Green + red spots	‘’
Asontem	green	Green	Golden yellow	Light	green	‘’
DA/08/04Wun mana	Green+red veins	Green	Yellow	Dark	Green +red spots	‘’
DA/08/004 Agbodro	Green+red veins	Green+red veins	Yellow	Light	Green + red spots	‘’
GBODRO-wild	Green+red veins	Green+red veins	Yellow	Light	Green + red spots	‘’
DA/08/02Dikaba	green	purple	‘’	Light	Green	‘’
DA/08/03Sheo mana	green	Green	Golden yellow	Light to dark	Green	‘’
Atuogya-tenten	green	Green	Yellow	Dark	Green + red spots	‘’
KNUST/SL1/07Nkrumahene	green	Green	Golden yellow	Light	Green	‘’

Table 6. Flowering characteristics okra accessions.

Variety	No. epicalyx segments	Epicalyx segment shape	Epicalyx segment persistence	Flowering span	No. of segments from stigma
GH 4487 Muomi	8 to 10	L	PP	S. flowering	9
GH 4482 Muomi	8 to 10	‘’	‘’	‘’	9
GH 4499 Fetri	8 to 10	‘’	‘’	‘’	12
GH 1169 Fetri	8 to 10	‘’	‘’	‘’	7
GH 4376 Atuogya	5 to 7	‘’	‘’	‘’	9
GH 4490 Fetri	>10	‘’	‘’	‘’	6
GH 3801 Pora	8 to 10	‘’	‘’	‘’	9
GH 6102 Fetri	8 to 10	‘’	‘’	‘’	6
GH 4964 Muomi	8 to 10	‘’	‘’	‘’	6
GH 5793 Gyeabatan	5 to 7	‘’	‘’	Grouped flowering	5
GH 5787 Asontem	8 to 10	‘’	‘’	S. flowering	9

Table 6. Contd.

GH 3736 Fetri	8 to 10	‘’	‘’	S. flowering	5
Atuogya-tiatia	5 to 7	‘’	‘’	Grouped flowering	6
DA/08/001Wun mana	8 to 10	‘’	‘’	Grouped flowering	9
DA/08/02Sheo mana	8 to 10	‘’	‘’	S. flowering	5
DA/08/02 Ason-Wen	8 to 10	‘’	‘’	S. flowering	7
Atuogya-Asante	5 to 7	‘’	‘’	Grouped flowering	10
Asontem	5 to 7	‘’	‘’	S. flowering	9
DA/08/04Wun mana	5 to 7	‘’	‘’	Grouped flowering	9
DA/08/004 Agbodro	8 to 10	‘’	‘’	Grouped flowering	5
GBODRO-wild	5 to 7	‘’	‘’	Grouped flowering	9
DA/08/02Dikaba	8 to 10	‘’	‘’	S. flowering	6
DA/08/03Sheo mana	8 to 10	‘’	‘’	S. flowering	10
Atuogya-tenten	8 to 10	‘’	‘’	Grouped flowering	5
KNUST/SL1/07Nkrumahene	8 to 10	‘’	‘’	S. flowering	9

* Partial persistence: PP Lanceolate: L (other shapes: linear, slanting and triangular).

Table 7. Fruit characteristics of 25 okra accessions.

Variety	Fruit colour	Fruit pubescence	Fruit shape
GH 4487 Muomi	Green	Smooth	2
GH 4482 Muomi	Green	‘’	2
GH 4499 Fetri	Green	‘’	8
GH 1169 Fetri	Green	‘’	8
GH 4376 Atuogya	Green	‘’	2
GH 4490 Fetri	Green	‘’	8
GH 3801 Pora	Purple	Little rough	3
GH 6102 Fetri	Green	Smooth	8
GH 4964 Muomi	Green	‘’	2
GH 5793 Gyeabatan	Green+red spots	Little rough	4
GH 5787 Asontem	Green	‘’	8
GH 3736 Fetri	Green	‘’	8
Atuogya-tiatia	Green+red spots	Little rough	4
DA/08/001Wun mana	Dark green to black	Downy+hairy	6
DA/08/02Sheo mana	Green	Little rough	14
DA/08/02 Ason-Wen	Green	Smooth	8
Atuogya-Asante	Green	Little rough	1
Asontem	Green	Smooth	8

Table 7. Contd.

DA/08/04Wun mana	Dark green to black	Downy+hairy	15
DA/08/004 Agbodro	Green	Smooth	7
GBODRO-wild	Green to yellow	Little rough	3
DA/08/02Dikaba	Green	Smooth	13
DA/08/03Sheo mana	Green to yellow	Downy+hairy	15
Atuogya-tenten	Green	Little rough	1
KNUST/SL1/07Nkrumahene	Green	smooth	2

Table 8. Fruit characteristics of 25 okra accessions continued.

Variety	No. of ridges/fruit	Position of fruit @ main stem	Length of fruit peduncle
GH 4487 Muomi	0	intermediate	1 to 3 cm
GH 4482 Muomi	0	‘’	1 to 3 cm
GH 4499 Fetri	b/n 5 and 12	‘’	1 to 3 cm
GH 1169 Fetri	b/n 5 and 12	‘’	1 to 3 cm
GH 4376 Atuogya	b/n 5 and 12	Slightly falling	1 to 3 cm
GH 4490 Fetri	b/n 5 and 12	Intermediate	1 to 3 cm
GH 3801 Pora	b/n 5 and 12	Horizontal	1 to 3 cm
GH 6102 Fetri	b/n 5 and 12	Intermediate	1 to 3 cm
GH 4964 Muomi	0	‘’	1 to 3 cm
GH 5793 Gyeabatan	b/n 5 and 12	‘’	>3 cm
GH 5787 Asontem	b/n 5 and 12	Erect	1 to 3 cm
GH 3736 Fetri	b/n 5 and 12	Intermediate	1 to 3 cm
Atuogya-tiatia	b/n 5 and 12	horizontal	>3 cm
DA/08/001Wun mana	b/n 5 and 12	Intermediate	>3 cm
DA/08/02Sheo mana	b/n 5 and 12	‘’	1 to 3 cm
DA/08/02 Ason-Wen	b/n 5 and 12	‘’	1 to 3 cm
Atuogya-Asante	b/n 5 and 12	‘’	>3 cm
Asontem	b/n 5 and 12	Erect	1 to 3 cm
DA/08/04Wun mana	b/n 5 and 12	Horizontal	> 3 cm
DA/08/004 Agbodro	0	Drooping	>3 cm
GBODRO-wild	5	Intermediate	>3 cm
DA/08/02Dikaba	b/n 5 and 12	Erect	1 to 3 cm
DA/08/03Sheo mana	b/n 5 and 12	‘’	>3 cm
Atuogya-tenten	5	Intermediate	>3 cm
KNUST/SL1/07Nkrumahene	b/n 5 and 12	Erect	1 to 3 cm

Table 9. Diseases, insects and pest characteristics of 25 okra accessions.

Variety	Susc. diseases/ insects; scale: 1 to 9	Susc. to diseases	Susc. to/pests
GH 4487 Muomi	2	OMV	PS/A/CS
GH 4482 Muomi	2	OMV	PS/A/CS
GH 4499 Fetri	2	OMV	PS/A/CS
GH 1169 Fetri	2	OMV	PS/A/CS
GH 4376 Atuogya	2	OMV	PS/A/CS
GH 4490 Fetri	2	OMV	PS/A/CS
GH 3801 Pora	9	OLCV	PS/A/CS
GH 6102 Fetri	2	OLCV	PS/A/CS
GH 4964 Muomi	2	OLCV	PS/A/CS
GH 5793 Gyeabatan	2	OLCV	PS/A/CS
GH 5787 Asontem	0	-	PS/A/CS
GH 3736 Fetri	5	OLC	PS/A/CS
Atuogya-tiatia	5	OLC	PS/A/CS
DA/08/001Wun mana	0	-	PS/A/CS
DA/08/02Sheo mana	0	-	PS/A/CS
DA/08/02 Ason-Wen	2	OMV	PS/A/CS
Atuogya-Asante	2	OMV	PS/A/CS
Asontem	2	OMV	PS/A/CS
DA/08/04Wun mana	2	OMV	PS/A/CS
DA/08/004 Agbodro	0	-	PS/A/CS
GBODRO-wild	2	OMVA	PS/A/CS
DA/08/02Dikaba	0	-	PS/A/CS
DA/08/03Sheo mana	0	-	PS/A/CS
Atuogya-tenten	5	OMV	PS/A/CS
KNUST/SL1/07Nkrumahene	0	-	PS/A/CS

*Scale for suscpt. to diseases and insects/pests; scale: 1 to 9; *Not susceptible; Scale 0-1, Weak susceptibility; Scale 1 to 3, Intermediate susceptibility; Scale 3 to 5, High susceptibility; Scale 6 to 9; *OMV= Okra Mosaic Virus, OLCV= Okra Leaf Curl Virus *PS=*Podagrica* spp *A= Aphids*CS= Cotton stainer.

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