Comparative Seeds Germinability and Proximate Chemical Composition of Interspecific F_1 Hybrids of *Abelmoschus* (*Esculentus* and *Caillei*) For Edible Pod Yield

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Abstract **-Seed viability and hybrid fertility has been a major challenge in the crossability studies between *Abelmoschus* species including the wild. A preliminary evaluation of interspecific hybrids of West African okra (*Abelmoschuscaillei* (A. Chev.) Stevels) and the conventional *A. esculentus* (L.) Moench was undertaken at the University of Ibadan, between September 2014 and May 2015 to determine their comparative performance in terms of seed viability, proximate chemical composition of the parents and the F_1 hybrids in order to examine the possibility of utilizing *A. caillei* in the improvement of *A. esculentus*. Crosses were carried out, including reciprocals, between the parent materials i.e. two *A. esculentus* cultivars (UI 4-30 and UI 53-139) on one hand and *A. caillei* on the other. The F_1 hybrids produced the lowest percentage germination of both scarified and unscarified seeds. However, that the interspecific hybrids produced seeds with 10 to 80% germination and fertile F_1 plants was an indication of the possibility of improving okra seeds (*A. esculentus*) through interspecific hybridization with *A. caillei*. The comparison of proximate compositions of the parent materials and the F_1 hybrids indicated no significant difference at 5% for the contents of moisture, crude protein, ether extract, crude fibre, nitrogen free extract and ash in every chemical constituent.**

Keywords: *A. esculentus, A. caillei.,* chemical composition, okra, seed viability

I. INTRODUCTION

Okra is one of the important warm season vegetables grown in the tropical and sub tropical parts of the world. Okra is a multipurpose and multifarious crop; however, it is extensively grown for its tender pods, which are used as a very popular, tasty and gelatinous vegetable (7). Okra is used daily in households in different forms (fresh fruits, grains, powder) due to their organoleptic qualities and wealth (9). Although it is widely consumed in Nigeria, okra has not received much consideration in the country in terms of genetic improvement and improved edible pod yield with attention given to consumer preferences such as smooth, plump edible pods with high mucilage content (3). The stabilization of okra in order to reduce post-harvest losses and its availability throughout the year is an important issue for the development of the crop.

Okra is mainly propagated by seed. Several researchers have reported differently on varietal difference noticed in the compatibility of *A. esculentus* with the donor parents, *A. caillei* and *A. tetraphyllus* as it affects seed viability. Reciprocal crosses registered higher compatibility than the direct crosses. Natural crossing of *A. tetraphyllus* with *A. esculentus* and *A. caillei* also was observed.

Bisht and Bhat (4) reported that interspecific crosses including reciprocals between *A. esculentus* on one hand and *A. tuberculatus*, *A. manihot*, *A. ficulneus*, *A. moschatus* and *A. caillei* on the other, resulted in pod production. However, it is noteworthy that the seeds obtained from the crosses either did not germinate or did not produce fertile plants. The sterility is attributable to various reasons such as chromosomal/genomic differences leading to irregular gamete formation. However, in other studies, the interspecific crosses between *A. esculentus* and *A. caillei* produced viable hybrids but with strongly reduced fertility (5). The various studies revealed that it is relatively easy to obtain F_1 plantlets irrespective of direction of crossing. However, in some cases F_1 plants were highly sterile and it was difficult to produce subsequent generations or even to obtain backcrosses (9).

The nutritional value of vegetables is in their content of micronutrients such as vitamins and minerals and poorly digestible complex carbohydrate dietary fibre, which has very little nutritional value but is important for bowel function (2).

Saifullah and Rabbani (9) highlighted Oyenuga's study on the chemical composition as well as the nutritional value of some vegetables and the beneficial contributions of okra to human nutrient requirements. The edible portion of the okra pod contains about 86.1% water, 2.2% protein, 0.2% fat, 9.7% carbohydrate, 1.0% fibre and 0.8% ash. The dry mature seed is made up of 20% edible oil (5). The fresh pod contains about 203mg ascorbic acid per 100 g fruit (8).

There have been reports on the need to improve okra yields in West African okra owing to relatively poor yields of traditional varieties as compared to yields reported in Asia. One approach to improvement is the transfer of desirable traits from *A. caillei* to *A. esculentus* which has resulted in significant improvement of conventional okra yield in Asia (5). Interspecific hybrids and seed germinability study have not been a major focus. The present study was undertaken to examine comparatively seed germinability and relative proximate chemical composition of the interspecific hybrids and the two parental materials i.e. a local accession of *A. caillei* and two local cultivars of *A. esculentus*. The results would help determine the possibility of utilizing the interspecific hybrids to develop improved okra varieties with optimum seed viability.

II. MATERIALS AND METHODS

The study was conducted on a field with a loamy sand soil and pH of 6.6 behind the main building of the Department of Agronomy University of Ibadan, Ibadan which lies in the humid forest zone of south-west Nigeria. The parental materials included an unselected volunteer plant of *Abelmoschus caillei* and two cultivars of *A. esculentus* viz. UI 4-30 and UI 53-139 obtained from the Department of Agronomy. The study was carried out from September 2014 to May 2015. Land preparation was carried out manually using cutlass and hoe for land clearing and tillage, respectively.

At the onset of flowering in early November 2014, crosses were carried out including reciprocals between the two *A. esculentus* cultivars and *A. caillei* by employing manual emasculation and pollination as describe by Joel (7). Seed generated were planted out on the same experimental site to evaluate the edible pod yields of *A. caillei*, the two cultivars of *A. esculentus* and their interspecific F_1 hybrids. Thus, there were seven genotype in all made up of the three parents and the four hybrids. On January 9, 2015, each genotype was sown in a single row plot arranged in a Randomize Complete Block Design with two replications. Each row was 6 m long and rows were 1m apart. Three seeds were sown per hole manually every 30 cm in each row and percentage germination of the seeds generated between the crosses were 100%. Three weeks later, plants were thinned to one plant per stand. NPK 15:15:15 fertilizer was applied at the rate of 80 kgN/ha in two equal doses, first at three weeks after planting and then at flowering.

Five plants per row each for fresh and dry pods were randomly selected and utilised for data collection. Of the five randomly selected plants of the F_1 hybrids as well as five plants of each *A. esculentus* parent i.e. UI 4-30 and UI 53-139fruits were harvested for fresh pod yield. Pods were harvested every five or six days, which is just before the tip of the pod becomes too firm to break when pushed with the thumb (7).The dry pods were harvested for hundred seed weight as well as percentage seed germination. Data collected included plant height at flowering, number of days to 50% flowering, number of pods per plant, fresh pod yield per plant, and number of seeds per pod. Dry matter yield was estimated as fresh yield x % dry matter. Harvested pods were weighed fresh and then oven-dried at 70℃ to constant weight for dry matter content determination. The dried pods were milled for proximate analysis. Thus, crude protein (CP), ether extracts (EE), crude fibre (CF) and ash content were determined according to procedures outlined by the Association of Official Agricultural Chemists, AOAC (1).

At the end of data collection in May 2015, the *A. caillei* parent had not flowered. Thus, the results in respect of edible pod yield apply only to the two *A. esculentus* cultivars and the interspecific F_1 hybrids with reciprocals so that there was a total of six genotypes. The data collected were processed using analysis of variance test (ANOVA 1) followed by linear correlation coefficients which were determined among chemical constituents and between each of them and agronomic traits, using the method outlined by Little and Hills (9). The significance level was set at 5%.

Seed viability test of the F_1 hybrids was also conducted in order to determine the seeds for germinability and dormancy if any, about one hundred, 25-day old, fully mature and dried F_1 hybrid seeds collected out of the both-way crosses attempted as well as seeds from the three parental lines i.e. *A.caillei* and *A. esculentus* parent with two cultivars, UI 4-30 and UI 53-139 were kept in petri dishes in the laboratory with scarified and unscarified seeds to determine comparatively, the percentage germination which was calculated using the standard formula i.e. (number of seeds germinated ÷ number of seeds ultilised) ×100, mainly to determine the viability of the hybrid seeds as compared to those of the parents.

III. RESULTS AND DISCUSSION

A. Seed viability in interspecific F_1 hybrid of *A. esculentus* × *A. caillei*

Some agronomic characteristics of the okra genotypes are shown in Table 1 The number of days to 50% flowering ranged from 44 days for UI 4-30 to 60 days for *A. caillei* x UI 4-30. Flowering period ranged from 20 days for UI 4-30 to 40 days for UI 4-30 x *A. caillei*. The UI 4-30 x *A. caillei* F_1 hybrid and its reciprocal had the tallest plants at initial flowering, averaging 69.2 and 58.8 cm, respectively while UI 53-139 had the lowest average plant height of 31.4cm at flowering. Average total number of edible pods harvested per plant ranged from 3.0 for UI 4-30 and UI 53-139 to 8.0 for UI 4-30 x *A. caillei*. The average number of seeds/pod which was higher among the cultivars ranged from 3.33 in UI 53-139 x *A. caillei* to 40.65 in UI 53-139.

Seed viability test revealed 100% germination of the seeds produced by the two *A. esculentus* cultivars, unscarified or scarified. *A. caillei* had 90% germination when scarified and 40% germination without scarification.With seeds produced by the hybrids, germination ranged from 0% for the unscarified *A. caillei* x UI 4-30 to 80% for unscarified UI 4-30 x *A. caillei*. In hybrids having the *A. esculentus* cultivars as female parents, unscarified seeds recorded higher germination rates than the scarified seeds. Hybrids with *A. caillei* as female parent recorded 0 to 10% germination whether scarified or unscarified.

The much lower number of seeds/pod as well as seed germination of the hybrids may be a reflection of some degree of incompatibility between the two species. The values for some of the agronomic traits of the cultivars such as number of days to 50% flowering, number of pods/plant and number of dry seeds/pod in this study differ from values reported by Yamuna *et.al* (3) which were averaged over a number of planting dates. This difference in values is indicative of the effects of different planting dates and environment on the expression of various traits. 100% seed weight of the cultivars ranged from 3.40 g for *A. caillei* x UI 53-139 to 5.48 g for UI 4-30 x *A. caillei*.

B. Chemical constituents

Table 2 shows the content of some chemical constituents of edible pods of the genotypes. Moisture content ranged from 87.5% for *A. caillei* x UI 53-139 to 89.1% for UI 53-139 which was close to the value of FAO (2004) recommendation of 90%. The crude protein (CP) content ranged from 32.56% for UI 4-30 x *A. caillei* to 40.18% for *A. caillei* x UI 53-139. These were higher than the FAO (6) minimum recommendation of 20%. The genotypes recorded ether extract (EE) content ranging from 7.49% in UI 53-139 to 8.14% in UI 4-30. The values were higher than the recommended minimum content of 3.08% (6). Crude fibre (CF) content ranged from 3.54% in UI 53-139 x *A. caillei* to 4.24% in UI 53-139. These were above the FAO (2004) recommendation of 0.9% thereby rendering the levels undesirable. Nitrogen free extract (NFE) ranged from 40.38% to 47.79% in UI 4-30 and *A. caillei* x UI 4-30, respectively. Ash content ranged from 4.63% in UI 53-139 to 7.49% in UI 53-139 x *A. caillei.* The coefficients of variation among genotypes ranged from 3.03% for ether extract to 18.48% for ash content. Thus, the ash content exhibited more variation than all other chemical constituents with their lower coefficient of variation values.

C. Correlation between agronomic traits and chemical constituents

Table 3 shows the linear correlation coefficients among the various agronomic traits and the chemical constituents of the genotypes. Moisture content was significantly correlated with fresh pod yield (r = 0.97). Also crude protein content was significantly correlated with fresh pod yield (r = 0.90) but negatively correlated with dry pod yield (r = -0.90). Nitrogen free extract was significantly correlated (r = 0.94) with number of days to 50% flowering. That there were no significant correlations between chemical constituents and some traits e.g. moisture content and days to 50% flowering (r = -0.37) and plant height at flowering (r = -0.20) indicate that selection for such traits should be carried out separately independent of the chemical constituents.

IV. CONCLUSION

The F_1 hybrids produced the lowest percentage germination of both scarified and unscarified seeds. However, that the interspecific hybrids produced seeds (10 to 80% germination) with fertile plants was an indication of the possibility of improving okra seeds (*A. esculentus*) through interspecific hybridization with *A. caillei*. This study allowed highlighting that all the interspecific hybrids indicated potential for use in genetic seed improvement. The coefficients of variation in respect of chemical constituents among genotypes ranged from 3.03% for ether extract to 18.48% for ash content i.e. the ash content exhibited more variation than all other chemical constituents. Although, no one genotype exhibited superiority over other genotypes in the comparison of proximate compositions of the parent materials and the F_1 hybrids i.e. no significant difference at 5% for the contents of moisture, crude protein, ether extract, crude fibre, nitrogen free extract and ash in every chemical constituent.

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Table I: Some agronomic characters and seed germination rates of *A. esculentus* cultivars and their F_1 hybrids with *A. caillei*

Entry	Days to 50% flowering	Edible pods/plant	Seeds/pod	Edible pod weight/plant		Height at initial flowering	Seed germination	
				fresh	dry		Scarified	Unscarified
	- - - - - - - - - - - - - no	- - - - - - - - - - - - -		- - - - - - - -g - -	- - -	- cm -	- - - - - - - %	- - - - - - - -
A. esculentus								
UI 4-30	44	3.0	32.25	27.36	2.97	44.80	100	100
UI 53-139	49	3.0	40.65	31.48	3.77	31.40	100	100
A. caillei[+]							90	40
UI 4-30 x *A. caillei*	51	8.0	7.22	63.64	7.65	69.20	50	80
A. caillei x UI 4-30	60	7.0	8.25	47.17	5.30	58.80	10	0
UI 53-139 x *A. caillei*	57	5.8	3.33	48.56	5.92	51.00	10	40
A. caillei x UI 53-139	57	5.8	6.25	24.91	3.10	53.60	10	10
[1]$LSD_{(0.05)}$		2.99	9.78	[2]ns	ns	13.33		

[1]LSD = least significant difference, [2]ns = non-significant difference

[+] No flowering at the termination of data collection

TABLE II: CHEMICAL CONSTITUENTS OF EDIBLE PODS OF OKRA GENOTYPES

Genotypes	Chemical constituents[1]					
	MC	CP	EE	CF	NFE	Ash
	. . . . %					
UI4-30	89.1	38.53	8.14	3.55	40.38	7.13
UI 53-139	88.0	40.08	7.49	4.24	42.23	4.63
UI 4-30 x *A. caillei*	88.0	32.56	8.07	4.10	41.21	7.01
A. caillei x UI 4-30	88.8	35.56	8.03	4.14	47.79	5.16
UI 53-139 x *A. caillei*	88.0	35.43	8.11	3.54	45.00	7.49
A. caillei x UI 53-139	87.5	40.18	7.95	4.12	46.42	6.89
cv(%)[+]	11.64	8.20	3.03	8.05	6.84	18.48

[1]MC = moisture content CP = crude protein, EE = ether extract, CF = crude fibre and NFE = nitrogen free extract

[+]cv = coefficient of variation among genotypes

TABLE III: LINEAR CORRELATION COEFFICIENTS BETWEEN CHEMICAL CONSTITUENTS AND SOME AGRONOMIC TRAITS OF THE OKRA GENOTYPES

Chemical Constituents	Agronomic traits			
	DF (50%)	PHF	FPY	DPY
MC	-0.37	-0.20	0.97**	-0.35
CP	-0.39	-0.74	0.90**	-0.90*
EE	0.15	0.62	0.34	0.31
CF	0.26	0.16	0.06	0.07
Ash	0.09	0.38	0.15	0.36
NFE	0.94**	0.29	-0.27	-0.02

*, ** significant at 0.05 and 0.01 levels of probability, respectively. Other values non-significant

MC – Moisture content
CP – Crude protein
EE – Ether extract
CF – Crude fibre
Ash – Ash content
NFE – Nitrogen free extract
DF (50%) – Number of days to 50% flowering
PHF – Plant height at flowering
FPY – Fresh pod yield per plant
DPY– Dry pod yield per plant