Influence of Planting Date and Harvesting Sequence on Growth and Fruit/Seed Yields in West African Okra (*Abelmoschus Caillei* (A.Chev [Stevels])

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Abstract
Flowering and fruiting in West African okra are day-sensitive, but the crop can be grown all year round provided there is adequate moisture. However, duration of growth before flowering, final plant architecture and yield are dependent on planting date. Therefore a research was conducted in 2014/2015 to determine appropriate planting date and harvesting sequence for optimum growth and fruit/seed production in West African okra in Obubra, South Eastern Nigeria. The experimental design was a randomized complete block with 3x4 factorial arrangements and replicated three times. The treatments were three planting dates at 60 days intervals (D_1=April 1, D_2=June 30and D_3=August29) and four harvesting sequences (H_0 =no harvesting of any fruit, H_1 = harvesting of every fruit, H_2 = harvesting of every 2nd fruit and H_3 = harvesting of every3rd fruit).The result showed progressive and significant decline in all growth, yield attributing characters and fruit/seed yields from April to August plantings. Fresh fruit yields of 1237.33, 6147.44 and1377.03 kg/ha were obtained at D_1, D_2 andD_3, respectively and these were significantly different. Similarly, average seed yields of 624.92, 255.29 and 63.31 kg/ha were obtained at D_1D_2 and D_3, respectively and these were also significant. .Fruit and seed yields also responded significantly to harvesting sequence. Fruit yields of 10770.03, 6528.48 and 2833.56 kg/ha were produced atH_1, H_2 and H_3, respectively. While seed yields of 393.54, 240.07 and 313.00 kg/ha were obtained at H_2, H_3 and H_4, respectively. The D x H interactions were significant for fruit and seed yields. The18660.80 kg/ha produced at D_1H_1 was highest compared to 10881.20 kg/ha and 2558.10 kg/ha produced at D_2H_1 and D_3H_1, respectively. However, the highest seed yield of 759.16 kg/ha was produced at D_1H_0 while the lowest was obtained at D_3H_3. Relative yields total of 1.34 obtained at $D_1H_2$was highest and this showed that planting in April with harvesting every 2nd fruit was the best combination for fruit/seed production. West African okra could be planted in April and every 2nd fruit harvested for optimum fruit and seed production.

Keyword: *West African okra, Abelmoschus caillei, sowing date, fruit yield, harvesting sequence, relative yield of fruit/seed.*

1.0 Introduction

West African okra *(A. caillei)* belongs to the Family Malvaceae. It is a cultigen of *A. esculentus* (lady's finger). It originated in West Africa and its cultivation is strictly restricted to the tropical and subtropical Africa (Siemonsma, 1981). It is cultivated for its young leaves and fruits, which are shredded and dried or used fresh in stews and soups. Like lady's finger, West African okra is an important source of minerals and vitamins in human nutrition. The dried products are of high economic value, providing a substantial source of revenue for the local farmers during off-season. Over 90% of West African okra produced in Nigeria is grown by peasant farmers as an intercrop with major crops such as yam, cassava and/or maize (Olasantan and Bello, 2004). Commercial production of West African okra in pure stands is still not a common practice in West Africa.

Okra (*A. caillei* and *A. esculentus*) is the most widely distributed vegetable crop in the world (Adeniji, 2003). There are, however no accurate statistics for *A. caillei* production. Data available tend to have merged production of *A. caillei* with *A. esculentus*. Estimated production figures for *A. caillei* in 2009 were put at 200,000-300,000 tons/year (FAOSTAT, 2012).

In Nigeria about 455-1000 hectares of land is under okra production. This constitutes about 4.6 per cent of the total staple food production in 1970-2003 (*CBN, 2004*). A larger part of this figure is most probably that of *A. caillei*. In traditional farming systems and home gardens, people prefer plants with long production season so that there is always something to harvest. West African okra adequately fits into these traditional farming systems, making it more popular for subsistence use.

A. caillei, unlike *A. esculentus*, is highly day-length sensitive, initiating flowers only when day length exceeds the critical limit (Martins *et al.*, 1981). Oyolu *(*1977) reported that this critical day-length is $12^1/_2$ hours for flower initiation. Its cultivation is therefore restricted to areas where day-length at one time or other exceeds this critical limit. However, when cultivated at any other time that moisture permits, vegetative growth continues until appropriate exposure to day-length is achieved. This has resulted in many types of plant architecture and levels of yield. Early season crops, planted between April and May in the Humid South, become highly vegetative and take between four to six months to initiate flowers and start fruiting in September (Martins *et al.*, 1981). Late season crops planted between June and July or under irrigation, and/or in *fadamas*, between September and October are less vegetative and initiate flowers within 30 to 90 days after planting (Martins *et al.*, 1981). However, both early and late season crops flower at about the same time. Both continue to fruit throughout November – December and even up to the next sowing season, under appropriate moisture management (Undie *et al.*, 2017). This makes West African okra more attractive to subsistence farmers, for regular vegetable supply, compared to lady's finger (Siemonsma, 1982).

It has been reported that complete or partial picking of fruits in okra increases fruit yield while failure to pick fruits for seed production results in early senesces and death of the plant (Velumani and Ramaswanny, 1980, Siemonsma, 1982, Nabi *et al.*, 2010, Chand *et al*., 2013, Kumari *et al*., 2013). Chand *et al.* (2013), for example, observed that plants whose fruits were all harvested but 6, 8, 10 or 12 retained were taller than the control whose fruits were not harvested at all. Sequential harvesting has not been investigated, though this also may prolong harvesting period for possible increased production of fruits and seeds.

Studies on appropriate planting dates for maximum resource use and productivity in West African okra are limited. Much of our knowledge of *A. callei* comes from speculations and mixed data that are reported for *A. esculentus*. The relatively recent discovery that West African okra is different from lady's finger has opened up new possibilities in the research, cultivation and management of the crop. This study was therefore undertaken to investigate the effects of planting date and harvesting sequence on, and to make appropriate recommendations for, the cultivation and management of West African okra.

2.0 Study site, materials and methods

2.1 Study site

The study was sited at the teaching and research farm of the Faculty of Agriculture and Forest Resources Management, Cross River University of Technology, Obubra campus, Nigeria. The area lies between latitude 6^o N and longitude 8^o 18'E in the rain forest agro-ecological zone.

The area typically has distinct wet and dry seasons. The general rainfall pattern within the area is bimodal with peaks occurring in July and September. Obubra is characterized by mean annual rainfall of 2250 mm – 2500 mm and with temperature ranging between 25°C and 27°C (Inyang, 1975).

2.2 Planting materials

West Africa okra seeds were obtained locally from Bebuatsuan Village in Obudu Local Government Area of Cross River State. Pre-planting treatment was carried out by soaking the seeds in water. The floated seeds where discarded while those that sunk where used for planting to ensure uniform germination.

2.3 Experimental treatment and design

The experimental treatments consisted of three sowing dates with four harvesting sequences. In each of the sowing dates, the harvesting sequences were assigned in a randomized complete block design with factorial combinations and replicated three times. Sowing dates were coded as D_1 for 1st April, D_2 for 30th June and D_3 for29th August, each 60 days apart. There were four harvesting sequences (H_0=harvesting no fruit, H_1= harvesting every fruit, H_2=harvest every 2nd fruit and H_3=harvesting every3rd fruit). There were therefore twelve factorial combinations (D_1H_0,D_1H_1,D_1H_2,D_1H_3,D_2H_0,D_2H_1,D_2H_2,D_2H_3,D_3H_0,D_3H_1,D_3H_2, andD_3H_3).Each plot measured 3 m x 3 m ($9m^3$). The net plot size for data collection was 1m x 1m ($1m^2$). Inter-plant spacing was 75 cm and inter-row spacing was 1m throughout.

2.4 Cultural practices

2.4.1 Land preparation

The experimental site was cleared manually using a weeding hoe and cutlass. Minimum tillage was adopted.

2.4.2 Sowing

Three seeds of West Africa okra were sown manually using a meter tape to achieve the desired distances. Three seeds were sown per stand. The seedlings were thinned to one plant per stand at two weeks after sowing. There were no missing stands. Weeds were controlled manually with hoe weeding every fortnight after planting.

2.4.3 Fertilizer application

There was no application of fertilizer.

2.4.4 Pest control

There was no serious incident of pest infestation throughout the duration of the experiment.

2.4.5 Harvesting

The crop was harvested between September 2014 and January 2015. Harvesting was done manually by hand-picking the fresh fruits every three days for H_1 (harvesting every fruit), every 6 days for H_2 (harvesting every second fruit) and every 9 days for H_3 (harvesting every third fruit).

2.5 Collection of crop data and measurements

Crop data were taken randomly from crops within the net plot measuring 1 m^2. Twelve plants of okra were randomly sampled per plot for crop data and for yield measurements and computations. The following parameters were taken for West African okra.

- **i.** Number of leaf nodes per plants: This was determined by visually counting all the leaf nodes from the base to the top of the sample plants, including nodes on branches.
- **ii.** Plant height: This was taken at senesces of the plant with a meter rule from the base of the plant to the end of the shoot.
- **iii.** Days to 50% flowering: This was done by counting the number of days when 50% of the plants within the sampled area flowered.
- **iv.** 100-seed weight: This was determined by counting seeds at random from each yield sample used for seed yield. Counting was done manually by hand. The weight of the counted seeds was taken with an electronic scale in g/100 seeds.
- **v.** Stem diameter: This was taken with an electronic vernier caliper.
- **vi.** Number of branches per plant: This was visually counted as all the branches at full maturity on sampled plants.
- **vii.** Fruit length: this was measured from the tip of the fruit to the base of the fruit with a digital Vernier caliper.
- **viii.** Fruit diameter: Fruits as harvested were measured with a digital vernier caliper half way between the tip and the base of the fruit.
- **ix.** Fruit yield: These was calculated and recorded in g/plant and computed in kg/ha.
- **x.** Seed yield: These were weighed and recorded in g/plant and computed in kg/ha.

2.6 Statistical analysis

Crop data collected or computed were analysed using Windows Statistical Package for Social Sciences (SPSS) Version 20. Analyses of variance (ANOVA) were constructed to examine the effects of sowing dates and harvesting sequences on the plant characters studied. Treatment means were separated and compared using Duncan's multiple ranges test (DMRT) as given in Gomez and Gomez (1984).

3.0 Results

3.1Plant height

The effect of sowing date and harvesting sequence on plant height is presented in Table 1. The result obtained showed significant differences in plant height at each planting date and harvesting sequence. The tallest plants for sowing date were obtained in April planting, while the shortest were obtained in August planting. Effect of harvesting sequence showed that at each planting date, plants that were completely harvested were the tallest, while plants that were not harvested were the shortest.

Table 1: Effects of sowing date and harvesting sequence on plant height of West African okra

Plant height (cm)					
Sowing date	Harvesting sequence				
	H_0	H_1	H_2	H_3	Average
D_1	211.77	306.60	278.00	242.33	259.68a
D_2	129.53	187.33	166.57	144.43	156.97b
D_3	41.56	106.30	89.23	68.41	76.38c
Average	127.62d	200.08a	177.93b	151.72c	

. D_1 = 17th April, D_2 = 15th June, D_3 = 14thAugust, H_0 = no harvest, H_1 = harvest every fruit, H_2 = harvest every second fruit, H_3 = harvest every third fruit. Means in a row or column followed by a common letter are not significantly different at 5% probability level (DMRT)

The interaction effects (Table 1) showed that the tallest plants (3.07 m) were obtained at the interaction between April planting and when all the fruits were harvested (D_1H_1); and the shortest (0.42 m) were obtained in August planting with no harvesting of fruits (D_3H_0).

3.2: Number of nodes/plant

The effects of sowing date and harvesting sequence on number of nodes per plant followed the same trend as in plant height and the differences were significant (Table 2).The highest number of nodes as influenced by sowing date and harvesting sequence were obtained at D_1 and H_1, respectively. The interaction effects were also significant. The highest number of nodes (representing number of leaves/plant) was also obtained at D_1H_1, and the lowest at D_3H_0.

3.3: Number of branches per plant at maturity

The effects of sowing date and harvesting sequence on number of branches at maturity of West African okra is presented in Table 3.The result showed that there were significant differences in number of branches at each sowing dates from D_1-D_3.The highest number of branches/plant was obtained at D_1 while the lowest was at D_3. However, there were no significant differences between harvesting sequences in the number of branches per plant. Similarly, the interaction effects between sowing date and harvesting sequence were not statistically different.

3.4: Stem diameter

The result for stem diameter (Table 3) showed that there were significant differences between all the sowing dates from D_1-D_3, while that for harvesting sequence was not significant. The interactions between planting date and harvesting sequence were also not significant.

3.5 Number of days to 50% flowering

Table 2: Effects of sowing date and harvesting sequence on number of nodes/plant of West African okra

	Number of nodes/plant				
Sowing date	Harvesting sequence				
	H_0	H_1	H_2	H_3	Average
D_1	133.33	228.33	191.00	162.67	141.33a
D_2	52.00	118.33	97.33	73.33	85.25b
D_3	13.30	56.67	34.00	22.67	31.66c
Average	66.21d	134.44a	107.44b	86,22c	

. D_1 = 17th April, D_2 = 15th June, D_3 = 14thAugust, H_0 = no harvest, H_1 = harvest every fruit, H_2 = harvest every second fruit, H_3 = harvest every third fruit. In a row or column, means followed by a common letter are not significantly different at 5% probability level (DMRT).

Table 3: Effects of sowing date and harvesting sequence on number of branches/plant, stem diameter, number of days to 50% flowering, fruit length, fruit diameter and 100-seed weight of West African okra

Sowing date (D)	Branches per plant	Stem diameter (cm)	Days to 50% flowering	Fruit length (cm)	Fruit diameter (cm)	100-seed weight (g)
D_1	5.03a	8.66a	150.76a	8.41a	4.97a	9.88a
D_2	3.91b	5.08b	90.52b	7.06b	3.90b	7.88b
D_3	1.19c	3.08c	43.61c	6.09c	2.87c	6.71c
Harvesting sequence (H)						
H_0	3.94a	5.64a	94.98a	-	-	6.81a
H_1	4.28a	5.57a	95.66a	8.22a	3.93a	-
H_2	4.11a	5.52a	94.86a	8.09a	3.86a	6.77a
H_3	4.03a	5.50a	94.33a	7.97a	3.77a	6.68a
D x H	Ns	Ns	Ns	Ns	Ns	Ns

D_1 = 17th April, D_2 = 15th June, D_3 = 14th August, H_0 = no harvest, H_1 = harvest every fruit, H_2 = harvest every second fruit, H_3 = harvest every third fruit, Ns = not significant.
In a row, means followed by a different letter are significantly different at 5% probability level (DMRT).

The number of days to 50% flowering significantly varied at each planting date (Table 3). While it took April planting about 151 days to flower, August crops flowered in only 44 days. However, between harvesting sequences, the number of days to 50% flowering was statistically the same. Similarly, there were no interaction effects between sowing date and harvesting sequence.

3.6 Fruit length

The results for harvested fruit length (Table 3) showed significant differences for only planting date but not harvesting sequence. The longest and the shortest fruits were produced at D_1 and D_3, respectively. The interaction effects were not significant.

3.7 Fruit diameter

The results for harvested fruit diameter as affected by planting date and harvesting sequence are also presented in Table 3. The results showed that variation in sowing dates significantly increased fruit diameter while harvesting sequence had no significant influence on fruit diameter. There were also no interactions between the two treatments.

3.8 100-seed weight

The effects of sowing date and harvesting sequence on 100-seed weight of West African okra are also presented in Table 3. The result showed that sowing date had a progressive and significant effect on seed weight from $D_3 – D_1$. Harvesting sequence and its interaction effect with planting date were not significant.

3.9 Number of fruits per plant

The effects of sowing date and harvesting sequence on number of fruits per plant is presented in Table 4. The results obtained were retrogressive but significant for sowing date from D_1 to D_3 and for harvesting sequence from H_1 to H_3. The interactions between D_1H_1 gave the highest (428.86) number of fruits per plant, while that at D_3H_3 gave the lowest (13.36).

3.9 Fruit yield

The effects of sowing date and harvesting sequence on fruit yield of West African okra are presented in Table 5. The results obtained showed significant differences at each sowing date from D_1 to D_3 and at each harvest sequence from H_1 to H_3.There were progressive decline in fruit yield at D_2 (49.03%) and D_3 (10.99%) , over that produced at D_1. Similarly, harvesting sequence caused a decline in fruit yield by 60.62% and 12% at H_2 and H_3, respectively, over that produced at H_1.The interaction between April sowing date with harvesting every fruit (D_1H_1) consistently and significantly gave the highest fruit yield, followed by D_1H_2.

3.10 Seed yield

The effects of sowing date and harvesting sequence on seed yield of West African okra is presented in Table 6. The result for sowing date showed that there was retrogressive and significant decline in seed yield from D_1 - D_3. However for harvesting sequence, the highest seed yield was obtained at H_0 followed by H_3 and the least was at H_2, and all were significantly different. There was significant interaction between planting date and harvesting sequence and this showed that the seed yield (759.16 kg/ha) obtained at April planting with no harvest (D_1H_0) was the highest and the lowest (47.63 kg/ha) was obtained at August planting with harvesting every second fruit (D_3H_2).

Table 4: Effects of sowing date and harvesting sequence on number of fruits per plant in West African okra

	Number of fruits/plant				
Sowing date	Harvesting sequence				
	H_0	H_1	H_2	H_3	Average
D_1	-	428.86	211.00	93.85	244.57a
D_2	-	283.01	98.27	54.51	143.26b
D_3	-	73.97	32.01	13.36	39.78c
Average		196.46a	113.76b	53.91c	

. D_1 = 17th April, D_2 = 15th June, D_3 = 14thAugust, H_0 = no harvest, H_1 = harvest every fruit, H_2 = harvest every second fruit, H_3 = harvest every third fruit. In a row or column, means followed by a common letter are not significantly different at 5% probability level (DMRT).

Table 5: Effects of sowing date and harvesting sequence on fruit yield of West African okra

	Fruit yield (kg/ha)				
Sowing date	Harvesting sequence				
	H_0	H_1	H_2	H_3	Average
D_1	-	18660.80	13075.67	5875.53	12537.33a
D_2	-	10881.20	5403.50	2157.63	6147.44b
D_3	-	2558.10	1106.27	467.53	1377.30c
Average		10770.03a	6528.48b	2833.56c	

D_1 = 17th April, D_2 = 15th June, D_3 = 14thAugust, H_0 = no harvest, H_1 = harvest every fruit, H_2 = harvest every second fruit, H_3 = harvest every third fruit. In a row or column, means followed by a common letter are not significantly different at 5% probability level (DMRT).

Table 6: Effects of sowing date and harvesting sequence on seed yield of West African okra

	Seed yield (kg/ha)				
Sowing date	Harvesting sequence				
	H_0	H_1	H_2	H_3	Average
D_1	759.16	-	484.06	631.53	624.92a
D_2	329.26	-	188.53	248.07	255.29b
D_3	92.20	-	47.63	62.10	67.31c
Average	393.54a		240.07c	313.90b	

. D_1 = 17th April, D_2 = 15th June, D_3 = 14thAugust, H_0 = no harvest, H_1 = harvest every fruit, H_2 = harvest every second fruit, H_3 = harvest every third fruit.
In a row or column, means followed by a common letter are not significantly different at 5% probability level (DMRT).

3.11 Relative yields and relative yields total of fruit and seeds.

Relative yields and RYT for fruit and seed are presented in Table 7. Harvesting every second fruit consistently produced the highest RY (fruit), irrespective of the planting date. Similarly, harvesting every third fruit consistently produced the highest RY (seed) at all planting dates. The highest RY fruit was obtained at April planting with harvesting every second fruit (D_1H_2), while that for seed was also obtained at April planting with harvesting every third fruit (D_1H_3).

The highest RYT (1.34) was obtained at D_1H_2, while the lowest (0.85) was obtained at D_3H_3. At April planting date, RYT showed that producing fruits and seeds together was more profitable than producing either of the two alone.

Table 7: Effects of sowing date and harvesting sequence on relative yields and relative yields total of West African okra.

Treatments	Fruit yield (kg/ha)	Seed yield (kg/ha)	RY (fruit)	RY (seed)	RYT
D_1H_0	-	759.16	-	-	-
D_1H_1	18660.80	-	-	-	-
D_1H_2	13075.67	484.06	.70	.64	1.34
D_1H_3	5875.53	631.53	.31	.83	1.14
D_2H_0	-	329.26	-	-	-
D_2H_1	10881.20	-	-	-	-
D_2H_2	5403.50	188.53	.50	.57	1.07
D_2H_3	2157.63	248.07	.19	.75	0.94
D_3H_0	-	92.20	-	-	-
D_3H_1	2558.10				
D_3H_2	1106.27	47.63	.43	.51	0.94
D_3H_3	467.53	62.10	.18	.67	0.85

D_1 = 17th April, D_2 = 15th June, D_3 = 14thAugust, H_0 = no harvest, H_1 = harvest every fruit, H_2 = harvest every second fruit, H_3 = harvest every third fruit, RY= relative yield, RYT= relative yield total.

4.0 Discussion

Both planting date and harvesting sequence had profound effect on vegetative growth and development of West African okra. Vegetative parameters such as plant height, number of nodes/plant and stem diameter responded significantly to early planting in April than later plantings. This was expected. Across three varieties of *A. esculentus*, Dash *et al.* (2013) observed significant differences in vegetative parameters with January planting, compared to three other later planting dates. They attributed these differences to availability of more sunlight and other environmental resources that enhanced growth. This is particularly true in the tropic where early sowing has been associated with effective utilization of nitrogen by plants from early-rains flush (Ekwu and Nwokwu, 2012).

Number of days to 50% flowering also responded significantly to planting date effect, unlike what has been reported for *A. esculentus* by Dash *et al*., 2013 and, Iremirin and Okiy, 1986). *A. caillei*, unlike *A. esculentus*, is highly day-length sensitive, initiating flowers only when day length exceeds the critical limit (Martins *et al.*, 1981). Oyolu *(*1977) reported that this critical day-length is $12^{1}/_{2}$ hours for flower initiation. *A. caillei*, if cultivated after the long days in March continues with vegetative growth until appropriate exposure to day-length is achieved. Therefore, early season *A. caillei* crop, planted between April and May in the Humid South, takes between four to six months to initiate flowers and start fruiting in September (Martins *et al.*, 1981). Late season crops, planted between June and July, are less vegetative and initiate flowers within 30 to 90 days after planting (Martins *et al.*, 1981). This is unlike what was reported for *A. esculentus* that is not day-sensitive and sets flowers whenever physiology maturity is attained. This might explain the differences between *A. caillei* and *A. esculentus* in response to number of days to 50% flowering as observed in this study.

Yield and yield attributing parameters were consistent in response to planting date effects. Early planting positively influenced fruit length, fruit diameter, number of pods per plant, 100-seed weight, and fruit and seed yields. Other studies showed similar effect of planting date on *A, esculentus* (Dash *et al.*, 2013, Ekwu and Nwokwu, 2012, Incalceterra *et al.*, 2000) and some of these results were, probably, for *A. callei*.

Harvesting sequence had no significant effects on number of branches per plant, stem diameter, number of days to 50% flowering, fruit length and diameter, and 100-seed weight. This non-response might be explained by the fact that full growth and development was already attained at the commencement of harvesting. However, harvesting was observed to stimulate some growth attributes and yield. Thus, plant height, number of nodes (leaves) per plant, number of fruits per plant, fruit and seed yields were positively and significantly influenced by harvesting sequence. The physiological basis for this continual growth as a result of harvesting has been reported by Velumani and Ramaswanny (1980), Kumari *et al.* (2013), Chand *et al.* (2013) and Nabi *et al.* (2010) for *A. esculentus*. They attributed this continual growth of the shoot to nutrient remobilization from the growing fruits that were harvested, which became major sink, to the growing shoot, which had become minor sink.

5.0 Conclusion

1. Planting dates affect growth, development, fruit and seed yields in West African okra. Early planting in April is important to take advantage of nitrogen flush with early rains.
2. Harvesting of every second fruit, irrespective of the planting date, is necessary for optimal production of fruit and seeds.
3. The efficiency of fruit/seed production compared to sole practices is evidenced by relative yield total of more than one in early planting of *A. caillei*.

6.0 Suggestion

Sustainable and commercial production of *A. caillei* need programmed and dedicated production of both fruits and seeds by the local farmers.

7.0 References

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