Intraspecific Variations in Fruiting Phenology of African Pear (Dacryodes Edulis (G.DON) HJ LAM) under Mangrove and Rainforest Zone, Nigeria

Njoku, T. C.

Department of Crop Science and Biotechnology Imo State University, Owerri, Imo State, Nigeria.
*Corresponding author's email: tcnjoku2010@gmail.com Tel: +2348038832192

Received 2 May 2026, Accepted 28 July 2026, Published 21 August 2026

Direct Research Journal of Agriculture and Food Science

Vol. 14(3), Pp. 34-45, August 2026

https://journals.directresearchpublisher.org/index.php/drjafs; https://www.ajol.info/index.php/drjafs

Research Article
ISSN: 2354-4147

ABSTRACT

A three year survey was carried out in five states of mangrove and rainforest zone of Nigeria to evaluate the intraspecific variation in African pear fruiting phenology. In each of the state, three locations were selected and ten African pear trees fruiting for the past 10 years were marked and tagged given a total of 150 trees. Each tree was divided into four compartments for data collection. Randomized complete block design was used. Parameters collected include: time of anthesis to fruit formation, number of fruits per inflorescence, fruit weight and fruiting habits from 2013 - 2015. Additionally, temperature and rainfall data were also collected. The collected data were analyzed using analysis of variance, regression and correlation, standard errors and percentages were calculated where appropriate. Results showed that there were significantly ($p < 0.05$) differences in all the parameters measured within and between the locations. Mean duration of anthesis to fruit formation ranged from 26-40 days with a tree mean of 1.00 - 5.00 depending on year and location. The highest mean number of fruits per inflorescence at maturity ranged from 1.78 - 2.23, while the mean fruit weight ranged from 23.78g - 28.89g. African pear fruiting habit can be seen as annual since 57% -77% of the trees are annuals, while 23% - 43% were biennials and triennials. Peak fruiting of African pear was mostly February ending to march at the temperature range of 280C - 300C with little or no rainfall. Species variations that of genetic and horticultural interest exists in African pear. Therefore a planned selection and improvement program should be carried out for African pear.

Keywords: *African pear, Anthesis, Variation, Phenology*

Citation: Njoku, T. C. (2026). Intraspecific Variations in Fruiting Phenology of African Pear (Dacryodes Edulis (G.DON) HJ LAM) under Mangrove and Rainforest Zone, Nigeria. *Direct Research Journal of Agriculture and Food Science*. Vol. 14(3), Pp. 34-45. https://dx.doi.org/10.4314/drjafs.v14i3.4

INTRODUCTION

African pear (*Dacryodes edulis (G.Don) HJ Lam*) also referred to as bush butter is one of the most important indigenous African tropical fruit trees species (TFTS). It is a typical agroforestry species that is widely found in home gardens (Okorie *et al.*, 2000 cited by Njoku, 2021). It produces fruits that are softened in hot water or hot ash and eaten together with roasted or boiled maize; mainly during famine season when most of the staple foods have been exhausted. The potential of African pear in human nutrition, formulation of animal feeds or other industrial and environmental uses are enormous.

In recent years, TFTS has received little attention, particularly with regards to its fruiting phenology (Njoku, 2021). Knowledge of fruiting phenology is of central importance for conservation management generally, but is of special value in tropical forests which support a diversity of fruit dependent species. Phenology is the study of developmental timing in relation to the calender. It is essential in whole crop simulation model, which can be applied to specific developmental processes to maximize yield (Gallinat *et al.*, 2021). Njoku, (2023) has compiled a summary of flowering phenology of African pear in mangrove zone of Nigeria which indicated that flowering peak generally occur during the dry season, with January being the month of peak flowering at Rivers and Delta states. Sandor *et al.*, (2021) stated that current knowledge of fruiting phenology is still embarrassingly poor, if compared for example, with that of flowering phenology. Furthermore, datasets of plants' fruiting time are yet unavailable for any region of the world, leaving people ignorant about the effect of climate change on fruiting phenology. Also about the impacts of fruiting phenology on the future of vegetation (Heleno *et al.,* 2020). These information is critical for some important reasons; time of seed/fruit production will largely affect multiple biotic and abiotic factors of a plant's life cycle. There is increasing evidence that fruiting synchrony between native and introduced plants is critical to determine the seed/ fruit dispersal services available to facilitate the spread of invasive plants (Heleno *et al.,* 2020). Apart from their ecological value, the crucial role played by this TFTS in alleviating hunger are very important reasons for the research on fruiting phenology (Okorie, 2001 cited by Njoku, 2021). Knowledge of African pear fruiting phenology especially as it relates to fruiting in the crop plant is particularly important for the development and improvement of the species. The phenology of fruiting is governed by its own set of constraints. Mendes *et al.,* (2023) stated that there is an urgent need for comprehensive fruiting phenology research. The highly seasonal occurrence of favourable temperature and irradiance in the middle latitudes confines the necessary resources build-up for fruit production and ripening to a restricted period (Mendes *et al.,* 2023). La Spada *et al.,* (2024) suggests that fruit production is largely controlled by the environmental and agronomic factors, which can only occur towards the end of the growing season. In individual cases, flowering may restrict the fruiting calendar slot. Physical limitations on fruiting time are probably less acute in the tropics though seasonal rainfall is probably the single most important abiotic factor controlling resource availability (Mendez-Alenzo *et al.,* 2013). Time of fruiting may also be under some selective pressure which may affect its fruit ripening period, quality and commercial value (Zhang *et al.,* 2025). However, some tropical rain forests fruiting have virtually no seasonal pattern when viewed from the community level and plant phenological studies have suffered from a northern-temperate bias neglecting tropical ecosystems (Mendes *et al.,* 2023). Individual plant fruits production is often irregular in many species, fruit crops appear only once every few years in an unpredictable pattern, with several barren seasons in between.

Understanding fruiting phenology patterns (i.e. timing of fruit production) seems critical to predict the future of forest and consequently our own future (Mendes *et al.*, 2023). The phenology of fruiting has very important consequences for a constant supply of food. Knowledge of African pear fruiting phenology is particularly important for the development and improvement of the species. Such information is lacking in African pear. United Nations Environmental Programme, (2022) stated that species phenologies are the result of strong selective pressures as the timing of most of these events directly affects the way that organisms interact with their environment. Example, will an early flowering plant find suitable pollinator? Based on this, the time of fruit production will largely affect multiple biotic and abiotic factors of a plant life cycle. Such research work is lacking in African pear (AP). Therefore the objective of this work was to evaluate the intraspecific variation in the fruiting phenology of AP in the mangrove and rainforest zones of Nigeria.

MATERIALS AND METHODS

Fruiting Phenology Evaluation

Field survey trips were conducted in five (5) different states, three different location in each state of mangrove and rainforest zones of Nigeria namely: Abia (latitude 05^{o} 42′ N; longitude 07^{o} 52′ E, altitude: 120 m), Delta (latitude 05^{o} 70′ N; longitude 06^{o} 20′ E, altitude: 50 m) , Imo (latitude 05^{o} 57′ N; longitude 07^{o} 05′ E, altitude 150 m) , Rivers (latitude 04^{o} 75′ N; longitude 06^{o} 83′ E, altitude 20 m) and Enugu (latitude 06^{o} 45′ N; longitude 07^{o} 50′ E, altitude 220 m) where the species naturally occurs to find out the fruiting time of African pear in these various locations. This part of the humid tropics is characterized by a warm wet season and a hot dry season. Most of the annual precipitation of 1,810 - 2,260mm fall during the raining season, which is broken by a short period of drought of 10 to 14days during the raining season,the relative humidity is near saturation point (NIMET, 2013-2015; Njoku, 2022). The field survey on intraspecific variation on fruiting phenology were carried out for three (3) consecutive years (2013-2015) in the following states and communities: Imo State - Awogwu Logara, IMSU farm (Uratta) and Umuduru Egbeaguru. Abia State:– Umuariaga (Oboro), Isiala Ngwa and Alayi. Delta State: - Mile 5 Ugbolu, Anwai and Ogwashiukwu. Rivers State: – Etche, Elele and Obiebe. Enugu State: - Nsukka, Oba Owerre Nzoba and Oboko Amachala.These areas were selected based on the locations where African pear trees were found in large quantity (Njoku, 2022).

Materials employed during the survey include: A telescope (used to observe fruits very high on the tree), a camera, different types (cultigens) of African pear (AP) growing in the forests, homesteads, distant and nearby farms were used for the field study. In each location, ten trees were selected and marked with each tree divided into four compartments for data collection. Some individuals were assigned to observe the marked sampled trees for the period of the survey study and to collect phenological data as required. Sampled trees (fruiting for about ten years) were selected based on evidence of reproductive maturity (Njoku, 2022). A plan visit was also made to the various locations during fruiting time to examine the type of fruiting (fruiting habit), time of fruit formation, number of days from Anthesis to fruit formation, Number of days to 50% fruit formation. Also observed were the influence of biotic factors in fruiting phenology. Temperature and rainfall data for the five states were collected from Nigerian metrological center (NIMET), Lagos Nigeria for the period of study.

In addition to descriptive statistics and charts, the collected data were analyzed using randomized complete block design (RCBD) and correlation in Statgraphic centurion XVI (16) software package. Significant means were separated using Duncan's new multiple range test (DNMRT). Correlation coefficients and coefficients of variation (CV) were also used (Gupta, 2011).

RESULTS AND DISCUSSION

The results on the intraspecfic variations in fruiting phenology of African pear (*Dacryodes edulis*) under mangrove and rainforest zone with regard to mean number of fruit per inflorescence (NFI) and mean fruit weight (FW) are shown in (Tables 1a - 5b). Variations and some similarities were observed in AP fruiting phenology with regards to number of days from anthesis to fruit formation (Figures 1- 5) and fruiting habit (Figures 12 - 16). Furthermore, mean monthly rainfall and temperature for the five rainforest and mangrove zone visited are presented in (Figures 6 to 11).

Time of fruiting is an important phenomenon in the life history of any tree crop hence it could limit or enhance yield. The result obtained from the field survey of African pear (AP) in the mangrove and rainforest zones of Nigeria showed a lot of variations for the parameters observed and measured both within and between the locations (Tables 1a - 5b). There were some variations and similarities observed between and within the fruiting trees for three years of study (early fruit formation, maturity and ripening). These implied that AP has great potential for improvement and majority of the activities of African pear fruiting are mainly controlled genetically and a few others by environmental factors such as temperature and rainfall. Phenology points to timing. In AP, it points to time of activities such as period of anthesis to fruit formation and fruiting habit. It also influences number of fruits per inflorescence and fruit weight. Knowledge of fruiting phenology is of central concern because of its impact on the future of vegetation in harmony with Heleno *et al.,* (2020).

The field survey for time of fruiting clearly revealed great diversity of variations in fruiting time within and between the species African pear (*Dacryodes edulis)*. Generally, significant ($P < 0.05$) variations occurred not only between the one hundred and fifty (150) fruting trees but also within the thirty (30) fruiting trees per state and ten trees per location. This was in agreement with UNEP Report , 2021 which suggested that individual plants fruits production is often irregular in many species, fruit appeared only once every few years in an unpredictable pattern with several barren seasons in between (Figures 12-16). Furthermore, United Nations environmental Programme, (2022) stated that species phenologies are the result of strong selective pressures (temperature and rainfall) as timing of most of these events directly affects the way organisms interact with their environment (Figures 6 - 11).

Differences in time of fruiting were observed within and between the various locations surveyed (Figures1-5). These might be as a result of genetic and environmental factors prevalent at that point in time. Also, climate change played its own role. These findings are in conformity with the results obtained by Rosbakh *et al.,* (2021), who reported that time of fruiting of temperate and subtropical trees were genetically controlled. Furthermore, since the different fruit trees were found growing side by side, this suggests little environmental and higher genetic influence on the occurrence of these variations. Also climatic change might have influenced AP phenology. This is in conformity with Sandor *et al.* (2021), González-Varo *et al.,* (2021) and Legave *et al.,* (2008). They suggested that data of temperate perennial fruit trees have indicated that recent climatic changes influences plant physiology and phenology. This is an advantage, hence the higher the variability within the species the greater the potential for further improvement through the development of cultivars using horticultural techniques (Okorie *et al*., 2000).

Table 1a: Effect of location on mean number of fruit per inflorescence (NFI) of *Dacryodes edulis* in Imo State in 2013 – 2015.

	IMSU		Logara		Umuduru		Grand Mean
Years	X **(NFI)**	CV (%)	X **(NFI)**	CV (%)	X **(NFI)**	CV (%)	X **(NFI)**
2013	2.73[a]	0.35	0.74[b]	15.52	1.73[ab]	7.84	1.73
2014	2.84[a]	0.98	1.67[b]	5.49	3.08[a]	1.04	2.53
2015	1.74[a]	2.80	2.40[a]	1.47	2.08[a]	4.67	2.07
Total	7.31	4.13	4.81	22.48	6.89	13.55	6.33
Mean	2.44	1.38	1.60	7.49	2.30	4.52	2.11

Means on the same row followed by the same letters are not significantly different at ($p < 0.05$). X= Mean value, CV = Coefficient of variation, % = Percentage.

Table 1b: Effect of location on mean fruit weight (FW) of *Dacryodes edulis* in Imo State in 2013 – 2015.

Year	**IMSU**		**Logara**		**Umuduru**		**Grand Mean**
	X(g) FW	**CV (%)**	**X(g) FW**	**CV (%)**	**X(g) FW**	**CV (%)**	**X(g) FW**
2013	24.30[a]	2.89	19.19[a]	2.89	25.31[a]	9.06	22.93
2014	27.91[a]	3.75	23.73[a]	6.78	33.59[a]	2.90	28.41
2015	25.84[a]	3.55	32.83[a]	3.55	32.30[a]	5.43	30.32
Total	78.05	10.19	75.75	13.24	91.20	17.38	81.67
Mean	26.02	3.40	25.25	4.41	30.40	5.79	27.22

Means on the same row followed by the same letters are not significantly different at ($P < 0.05$). X= Mean value, CV = Coefficient of variation, % = Percentage.

Table 2a: Effect of location on mean number of fruit per inflorescence (NFI) of *Dacryodes edulis* in Abia State in 2013 - 2015.

Year	**Oboro**		**Alayi**		**Ngwa**		**Grand Mean**
	X (NFI)	**CV (%)**	**X (NFI)**	**CV (%)**	**X (NFI)**	**CV (%)**	**X (NFI)**
2013	1.18[ab]	10.66	0.62[b]	16.23	1.72[a]	7.44	1.17
2014	1.72[b]	6.93	1.99[b]	5.72	2.98[a]	1.07	2.23
2015	2.70[a]	0.48	1.40[a]	10.96	1.68[a]	7.95	1.93
Total	5.60	18.07	4.01	32.91	6.38	16.46	5.33
Mean	1.87	6.02	1.34	10.97	2.13	5.49	1.78

Means on the same row followed by the same letters are not significantly different at ($p < 0.05$). X= Mean value, CV = Coefficient of variation, % = Percentage

Table 2b: Effect of location on mean fruit weight (FW) of *Dacryodes edulis* in Delta State in 2013 - 2015.

	Anwai		**Ugbolu**		**Ogwashiukwu**		**Grand Mean**
Years	**X(g) (FW)**	**CV%**	**X(g) (FW)**	**CV%**	**X(g) (FW)**	**CV%**	**X(g) (FW)**
2013	34.78[a]	0.43	25.92[a]	2.34	24.77[a]	0.60	28.49
2014	32.20[a]	0.39	27.94[a]	3.28	24.40[a]	0.50	28.18
2015	38.38[a]	0.40	22.96[a]	0.85	28.64[a]	0.63	30.00
Total	105.36	1.22	76.82	1.41	77.81	1.73	86.67
Mean	35.12	0.41	25.61	0.47	25.94	0.58	28.89

Means on the same row followed by the same letters are not significantly different at ($p < 0.05$). X= Mean value, CV = Coefficient of variation, % = Percentage

Table 3a: Effect of location on mean number of fruit per inflorescence (NFI) of *Dacryodes edulis* in Delta State in 2013 - 2015.

	Anwai		Ugbolu		Ogwashiukwu		Grand Mean
Year	X **(NFI)**	CV (%)	X **(NFI)**	CV (%)	X **(NFI)**	CV (%)	X **(NFI)**
2013	2.37[ab]	1.49	2.55[a]	1.16	1.59[b]	5.73	2.17
2014	2.74[ab]	1.08	3.36[a]	0.92	2.51[b]	4.12	2.88
2015	2.89[a]	1.09	2.07[a]	6.86	1.86[a]	4.53	2.27
Total	8.00	3.66	7.98	8.94	5.96	14.38	7.32
Mean	2.67	1.22	2.66	2.98	1.99	4.79	2.44

Means on the same row followed by the same letters are not significantly different at ($p < 0.05$). X= Mean value, CV = Coefficient of variation, % = Percentage.

Table 3b: Effect of location on mean fruit weight (FW) of *Dacryodes edulis* in Enugu State in 2013 - 2015.

	Nsukka		Oba		Amachala		Grand Mean
Year	**X(g) (FW)**	**CV (%)**	**X(g) (FW)**	**CV (%)**	**X(g) (FW)**	**CV (%)**	**X(g) (FW)**
2013	25.25[a]	2.47	10.24[a]	12.75	24.35[a]	7.81	19.94
2014	28.46[a]	3.20	27.35[a]	4.38	22.52[a]	6.87	26.11
2015	38.99[a]	5.45	25.03[a]	5.19	20.33[a]	7.69	28.12
Total	92.70	11.13	62.62	22.31	67.20	22.36	74.17
Mean	30.90	3.71	20.87	7.44	22.40	7.45	24.72

Means on the same row followed by the same letters are not significantly different at ($p < 0.05$). X= Mean value, CV = Coefficient of variation, % = Percentage

Table 4a: Effect of location on mean number of fruits per inflorescence (NF/I) of *Dacryodes edulis* in Enugu State in 2013 - 2015.

	Nsukka		Oba		Amachalla		Grand Mean
Year	X (NFI)	CV (%)	X (NFI)	CV (%)	X (NFI)	CV (%)	X (NFI)
2013	2.56[a]	1.51	1.09[b]	13.93	1.75[ab]	7.62	1.8
2014	2.72[a]	1.76	2.74[a]	4.69	1.91[a]	6.26	2.46
2015	2.79[a]	1.61	1.49[b]	9.99	2.54[ab]	2.51	2.27
Total	8.07	4.88	5.32	28.62	6.20	16.38	6.53
Mean	2.69	1.63	1.77	9.54	2.07	5.46	2.18

Means on the same row followed by the same letters are not significantly different at ($p <0.05$). X= Mean value, CV = Coefficient of variation, % = Percentage.

Table 4b: Effect of location on mean fruit weight (FW) of *Dacryodes edulis* in Rivers State in 2013 - 2015.

	Etche		Elele		Obiebe		Grand Mean
Year	**X(g) (FW)**	**CV (%)**	**X(g) (FW)**	**CV (%)**	**X(g) (FW)**	**CV (%)**	**X(g) (FW)**
2013	39.04[a]	5.11	25.44[a]	9.69	17.66[b]	10.79	27.38
2014	39.16[a]	5.12	34.62[a]	5.61	29.44[a]	8.23	34.41
2015	38.99[a]	5.45	17.23[b]	13.84	17.43[b]	9.69	24.55
Total	117.19	15.68	77.29	29.14	64.53	28.71	86.34
Mean	39.06	5.23	25.76	9.71	21.51	9.57	28.78

Means on the same row followed by the same letters are not significantly different at ($p < 0.05$). X= Mean value, CV = Coefficient of variation, % = Percentage.

Table 5a: Effect of location on mean number of fruits per inflorescence (NFI) of *Dacryodes edulis* in Rivers State in 2013 - 2015

	Etche		Elele		Obiebe		Grand Mean
Years	X (NFI)	CV (%)	X (NFI)	CV (%)	X (NFI)	CV (%)	X (NFI)
2013	2.57[a]	1.80	1.75[a]	8.54	1.48[a]	10.80	1.93
2014	2.78[a]	2.11	2.78[a]	4.15	2.38[a]	6.29	2.65
2015	3.18[a]	1.22	1.41[b]	12.50	1.50[b]	9.60	2.03
Total	8.53	5.13	5.94	25.19	5.36	26.68	6.61
Mean	2.84	1.71	1.98	8.40	1.79	8.89	2.20

Means on the same row followed by the same letters are not significantly different at ($p <0.05$). X= Mean value, CV = Coefficient of variation, % = Percentage.

Table 5b: Effect of location on mean fruit weight (FW) of *Dacryodes edulis* in Abia State in 2013 - 2015.

Year	Oboro		Alayi		Ngwa		Grand Mean
	X(g) **(FW)**	CV (%)	X(g) **(FW)**	CV (%)	X(g) **(FW)**	CV (%)	X(g) **(FW)**
2013	25.73[a]	1.92	19.78[a]	9.39	14.62[a]	9.33	20.04
2014	28.45[a]	3.94	23.50[a]	7.38	34.94[a]	4.26	28.96
2015	28.22[a]	4.24	15.77[a]	12.42	23.00[a]	9.44	22.33
Total	82.40	10.10	59.05	29.19	72.56	23.02	71.33
Mean	27.47	3.37	19.68	9.73	24.19	7.67	23.78

Means on the same row followed by the same letters are not significantly different at ($p <0.05$). X= Mean value, CV = Coefficient of variation, % = percentage

The exceptionally long period of time from anthesis to fruit formation in all the five states surveyed confirmed the above statement. The mean number of days taken from anthesis to fruit formation were highest within 36-40 days with maximum mean trees of 5.0 from Delta State in 2014 (Figure.4). These variations may be both genetic

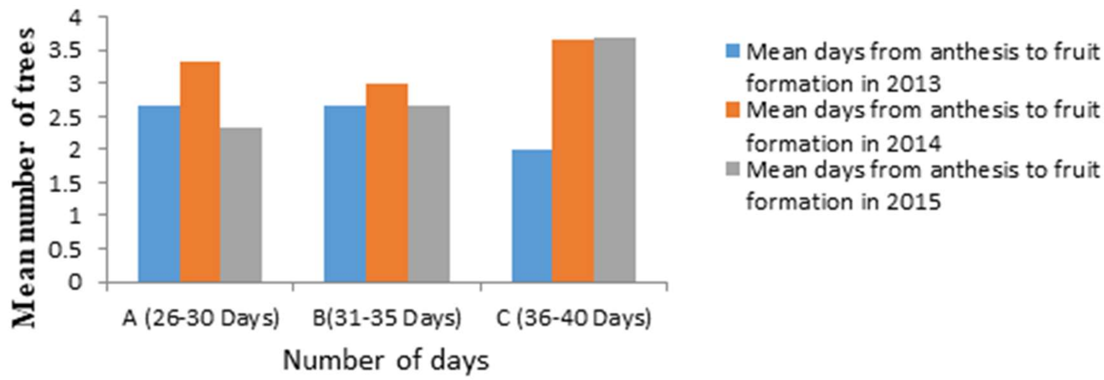

Figure 1: Mean days from anthesis to fruit formation in Imo State from 2013-2015

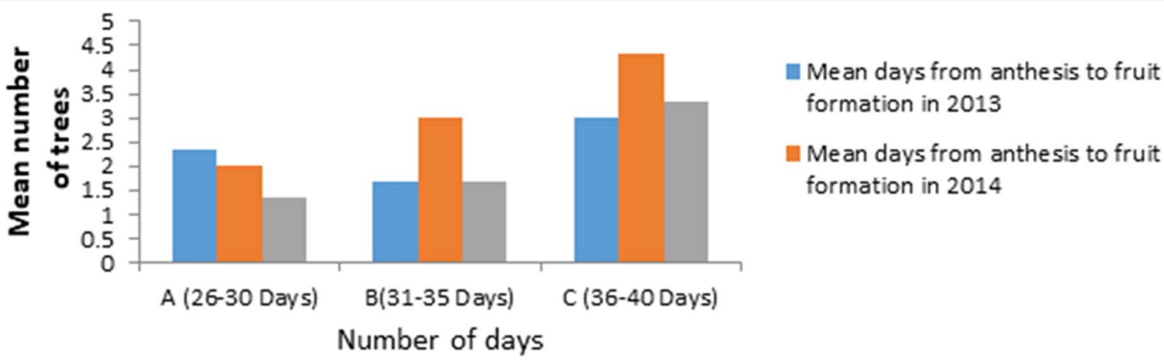

Figure 2: Mean days from anthesis to fruit formation in Rivers State from 2013-2015

and environmental factors. Therefore AP takes 26-40 mean days from anthesis to fruit formation in mangrove and rainforest zones of Nigeria. Anthesis to fruit formation mean days differed between the years and locations. In all the years and locations, 2014 had the highest mean days from anthesis to fruit formation (36 to 40 days) with a mean tree range of 3.5 - 5.0 for the 30 trees surveyed in each state (Figures 1-5). Also 2015 followed the same pattern with Imo, Delta and Enugu states having approximately four mean trees and above reaching 36 to 40 days (Figures1-5) from anthesis to fruit formation. This probably may be due to changes in climatic factors during the transformation stage. Also, acropetal blooming in AP may have contributed to the variations observed (Figures 1 -5).

The time of fruit formation in AP is often highly variable which suggest that this pattern is not entirely mediated by flower production, but rather by some factors that directly influences fruit production. Mendes *et al.,* (2023) found that minimum dry season temperature was related to fruiting. It may be that minimum temperature is simply acting as a cue to synchronize a segment. This could also mean that the beginning of dry season is a time when energy becomes readily available to the trees, permitting the buildup of the assimilates needed for fruiting. This indicates that fruiting peaks occur during periods of low photosynthetic activity or after periods of high rates of reserve accumulation. This is in harmony with this research finding that fruiting started from January to March, some times to April, during the dry season (Figures 6-11).

There were significant ($p < 0.05$) differences in mean number of fruits per inflorescence (NF/I) in some of the locations and years (Tables 1a-5a). In 2014 and 2015, significant ($p < 0.05$) difference existed at Logara with mean values of 1.67 and 2.40 with coefficient of variation (CV) values of 5.49 and 1.47, respectively. However, there were no significant ($p < 0.05$) difference observed at IMSU and Umuduru locations in Imo State. At Abia state, significant ($p < 0.05$) difference were observed at

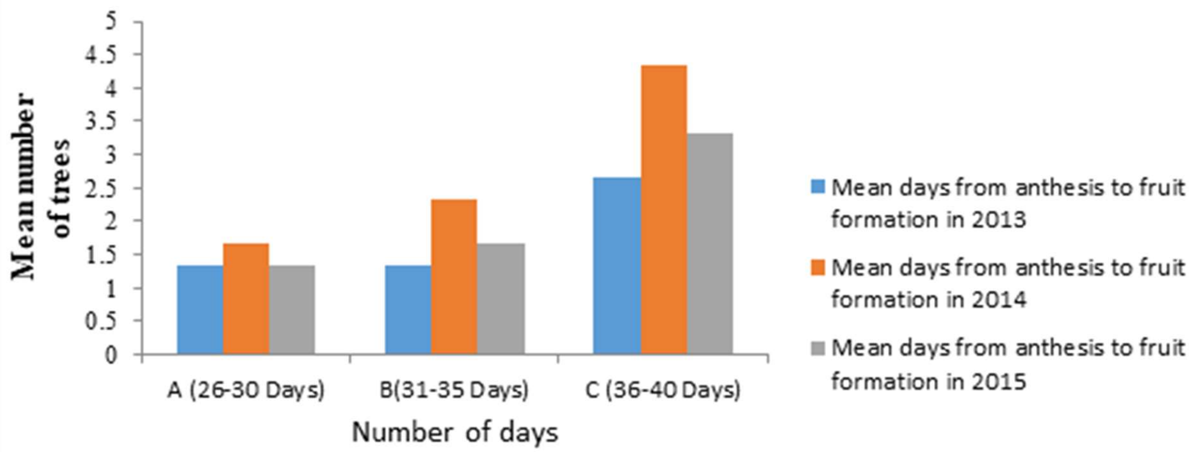

Figure 3 : Mean days from anthesis to fruit formation in Abia State from 2013-2015

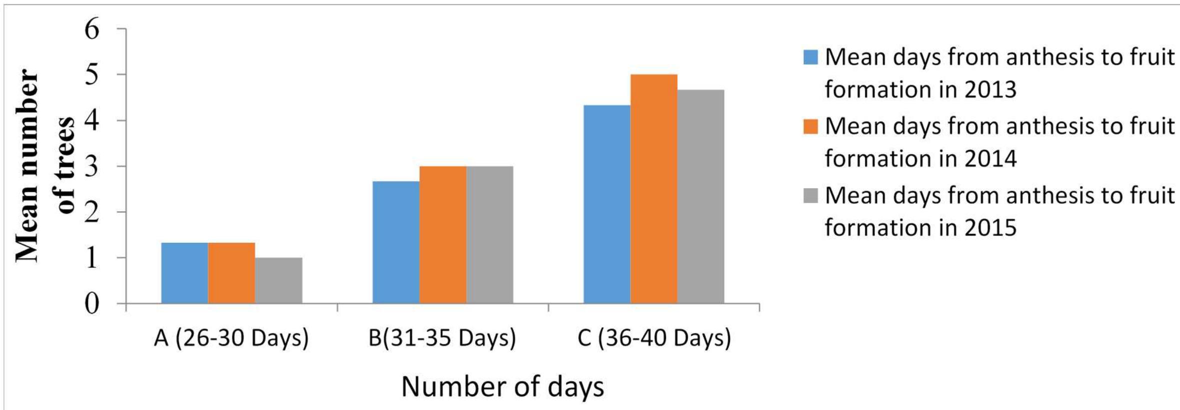

Figure 4: Mean days from anthesis to fruit formation in Delta State from 2013-2015

Oboro and Alayi with mean values of 1.72 and 2.70 and 1.99 and 1.40, respectively. At Delta in 2014 and 2015 only Ogwashiukwu recorded significant ($p < 0.05$) difference with mean NF/I of 2.51 and 1.86 with CV values of 4.12 and 4.53, respectively. Enugu and Rivers state followed the same pattern with significant ($p < 0.05$) differences recorded in Oba with means of 2.74 and1.49 in 2014 and 2015, respectively. While Elele had means of 2.78, and 1.41 in 2014 and 2015, respectively (Tables 1a-5a). In 2013 - 2015 at Etche Rivers state, the mean number of fruit per inflorescence was not significantly ($p < 0.05$) different. Similar result was obtained at Nsukka Enugu state and Ogbolu at Delta state (Tables 1a-5a). These variations and similarities observed in the various locations showed more of genetics than environmental factors (Rosbakh *et al.,* 2021). The intraspecific variation on fruit weight (FW) of African pear is shown on (Tables 1b-5b). Results for FW showed no variation for the three years and locations at Imo state with grand mean of 22.93g, 28.41g and 30.32g with low and high CV values of 2.89 % and 9.06 %. These CV values were not significantly ($p < 0.05$) different. FW showed slight variation at Rivers state in 2013 - 2015 at Elele and Obiebe location with the following CV values of 9.69 %, 5.61 % and 13.84 % and 10.79 %, 8.23 % and 9.69 %, respectively. Also FW at Delta, Abia and Enugu states were not significantly ($p < 0.05$) different within and between locations (Tables 1b - 5b). The studied African pear fruits displayed considerable variations and similarities in fruit weight. Most of the observed variations

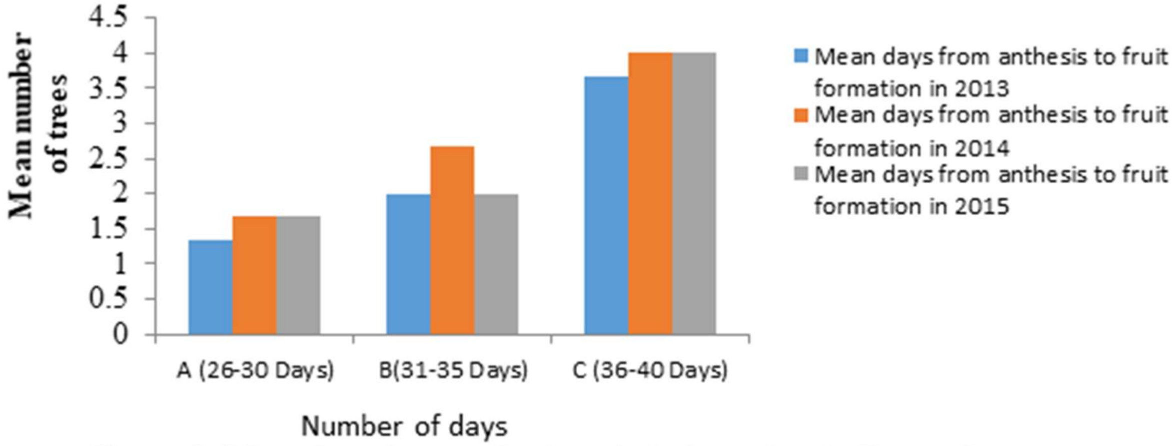

Figure 5: Mean days from anthesis to fruit formation in Enugu State from 2013-2015

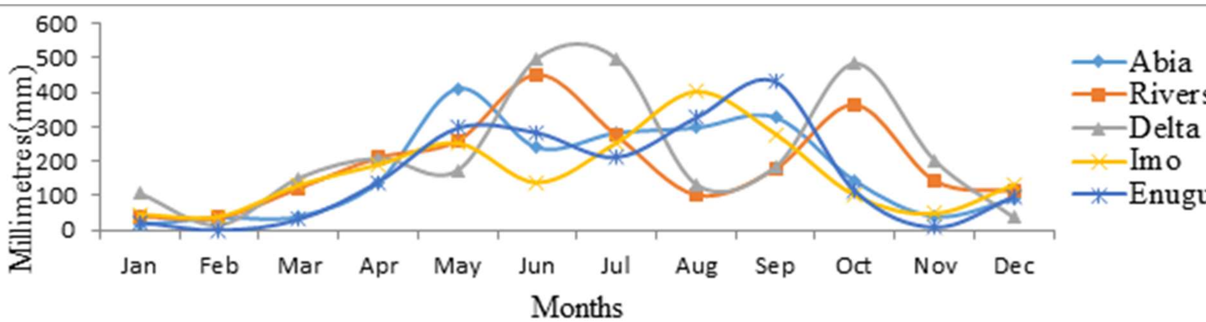

Figure 6: Mean monthly rainfall for the five study locations in 2013

Source: NIMET, 2013-2015

were held within locations, nevertheless, the between location variation were very high at Rivers state. The variations may be as a result of genetic factor inherent in them, hence the trees were growing in same place under the same environmental condition. No location showed the same time or periodicity for fruiting of all the trees. Furthermore, fruiting does not necessarily follow flowering if pollination fails, or if young fruits are aborted or destroyed or eaten by primates leading to few flowers maturing to fruiting (United Nations Environmental Programme, 2022). Also Mendes *et al.,* (2023) supported the above information by stating that population in warmer latitudes requires greater heat accumulation for the development of floral buds. The above statement agreed with the findings of the present research work (Tables 1a - 5a).

Also noteworthy is the differences observed in fruiting habit in all the location for the period of three years. The observations made during the survey revealed a great deal of variations in fruiting habits (fh) of African pear trees. In Imo State, majority of AP exhibit annual fruiting habit (74%), likewise all others with the following figures: 67%, 57%, 77%, and 77%, respectively for Rivers, Abia, Delta and Enugu States (Figs. 12 - 16). In all the locations with regard to fruiting, majorities of African pear trees (APT) were annuals (70%), very few were biennial (27%) while an insignificant number were triennial (3%) (Figs. 12 - 16). In Delta and Enugu states locations, only annual and biennial dominates. Therefore, three fruiting habits were identified. All these trees in the various states were found growing at the same place or location but some fruited yearly, others fruited once in two or three

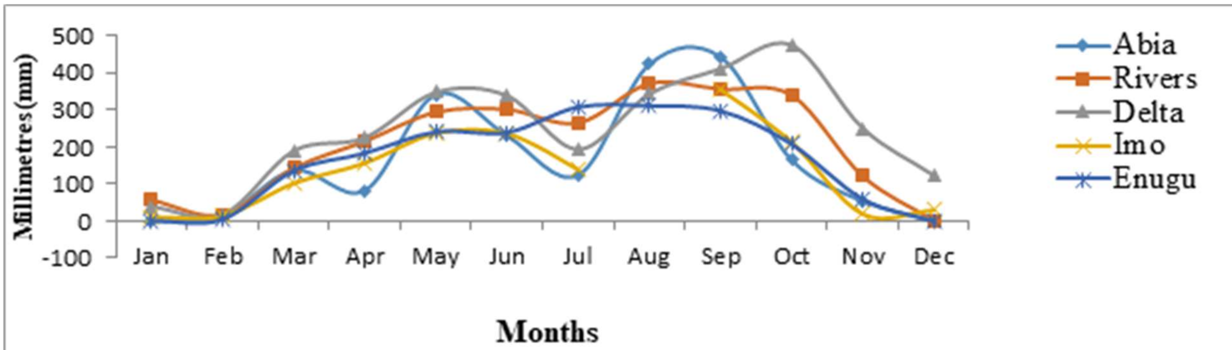

Figure 7: Mean monthly rainfall for the five study locations in 2014

Source: NIMET, 2013-2015

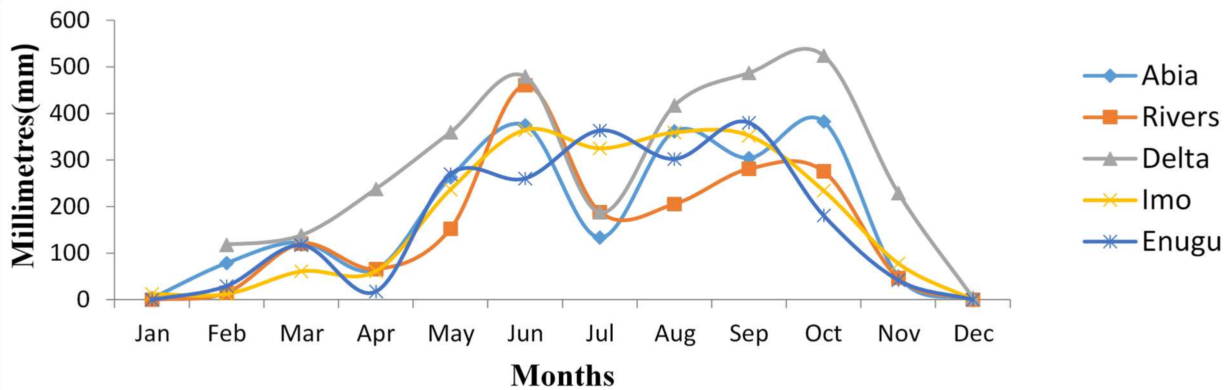

Figure 8: Mean monthly rainfall for the five study locations in 2015

Source: NIMET, 2013-2015

years. These equally showed that fruiting of AP trees might either be annual, biennial and triennial and were genetically controlled, hence the trees are exposed under the same environmental factors. There were low rainfalls in all the locations in January and February in 2013. The highest mean rainfall in January was at Delta with mean rainfall of 107 mm. Imo and Rivers State followed with a mean rainfall of 46 mm and 41 mm, respectively. Abia state recorded the least monthly mean rainfall of 15 mm (Figures 6). By the month of March, Imo, Delta and Rivers States had relatively high mean rainfall of 131 mm, 152 mm and 122 mm, respectively. In the other months of the year, differences exist in the amount of rainfall as shown in the monthly mean rainfall (Fig. 6). There was a change in rainfall pattern in 2014. By March, Delta State recorded the highest mean rainfall of 190 mm, this was followed by Rivers state, Abia, Enugu, and Imo States with mean values of 143 mm, 137 mm, 136 mm and 102 mm, respectively. There was no rainfall in Abia by January; others had a little rainfall of mean 1 mm, 12 mm etc (Figure 7). From April, some rise in the amount of rainfall were observed. There were a lot of variations in the monthly mean rainfall between the years and locations. In 2015 January, Enugu and Rivers State had no rainfall unlike the previous years. Also, Enugu, Imo, Rivers and Abia had no rainfall during the month of December 2015 (Figure 8). The mean monthly temperature for the five states during three years of study period are shown on Figs. 9-11. There were variations in temperature between the locations and years. In all the locations and years, temperature was always high from January to April. By May it started decreasing till

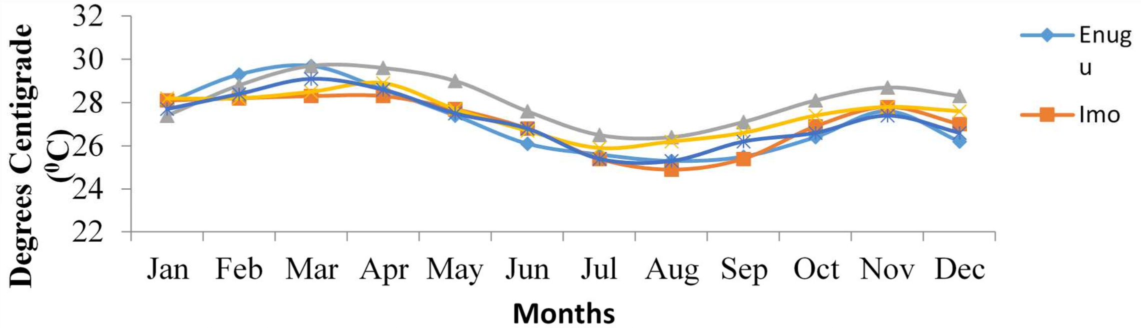

Figure 9: Mean monthly temperature for the five study locations in 2013

Source: NIMET, 2013-2015

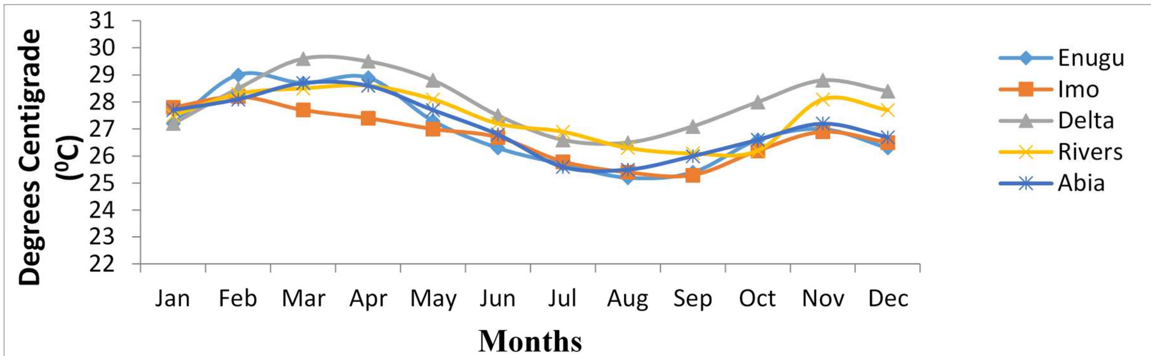

Figure 10: Mean monthly temperature for the five study locations in 2014

Source: NIMET, 2013-2015

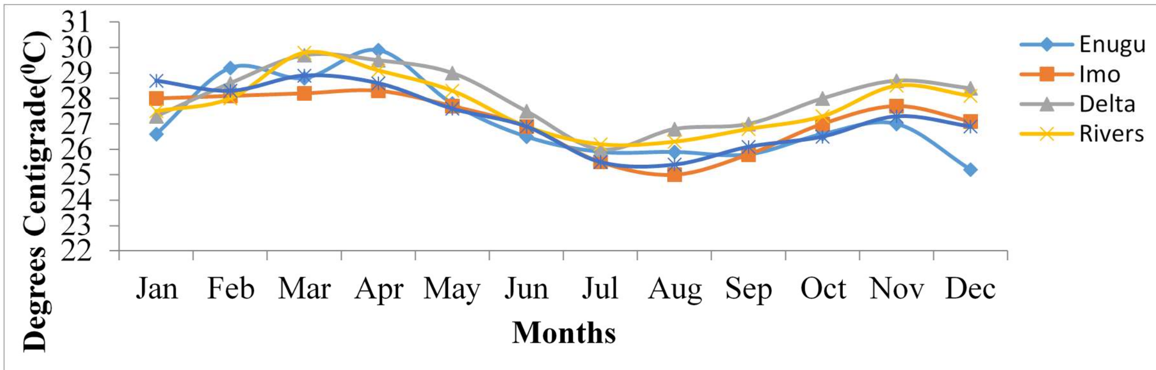

Figure 11 : Mean monthly temperature for the five study locations in 2015

Source: NIMET, 2013-2015

September (Figures 9-11). By January 2013, Imo and Enugu States had mean temperature of 28^o C and 28^o C, respectively while Delta and Abia States had 27^o C and 27^o C, respectively. Also by August of the same year, the mean temperature of Enugu and Abia state were the same 25^oC while Imo State had the least mean temperature a little bit below 25^oC. Within a particular month, differences in temperature existed in the various

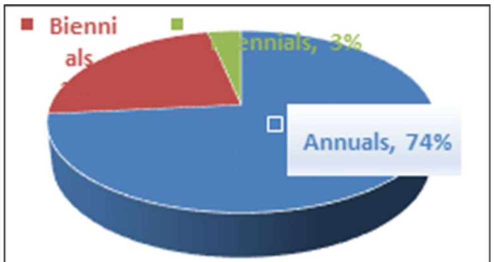

Figure 12: Fruiting Habit of *D. edulis* in Imo State locations

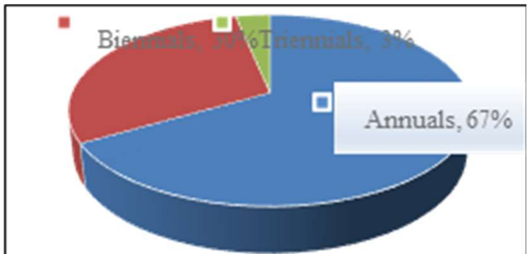

Figure 13: Fruiting Habit of *D. edulis* in Rivers State locations

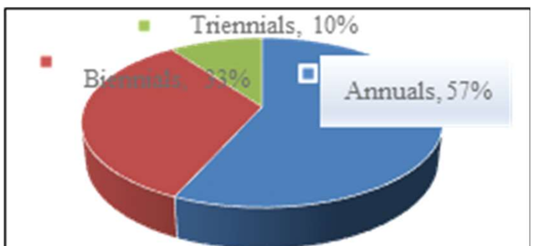

Figure 14: Fruiting Habit of *D. edulis* in Abia State locations

locations (Figures 9-11). Variation in temperature and rainfall between the states may be responsible for the variation in time of fruiting in AP in five states of the mangrove and rainforest zones of Nigeria. Njoku, (2022) opined that time of flowering in AP ranged from December to March with its peak flowering between January and February. The present study discovered that anthesis to fruit formation takes a period of 26- 40 days. Peak fruiting in AP was February to March at the temperature range of 26^{0}C to 29^{0}C with a rainfall of 0 - 200mm in the mangrove and rainforest zone of Nigeria.

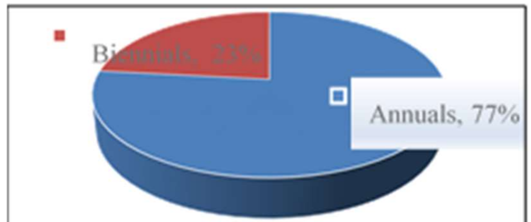

Figure 15: Fruiting Habit of *D. edulis* in Delta State locations

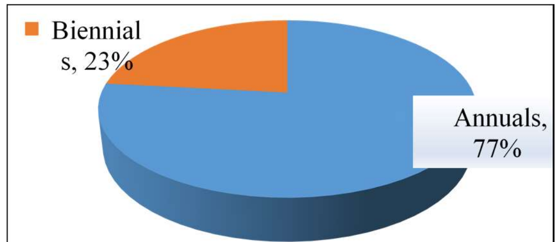

Figure 16: Fruiting Habit of *D. edulis* in Enugu State locations

Conclusion

The field survey on the intraspecific variation in fruiting phenology of African pear in the mangrove and rainforest zone of Nigeria showed that variations exist in time of fruiting of AP. This may be as a result of genetics, changes in rainfall and temperature. Fruiting habit of AP trees might be annual, biennial or triennial. The studied 150 trees of AP from 15 location of the five states displayed considerable variations in number of fruits per inflorescence and fruit weight within and between the locations. These results showed that variation existed in time of fruiting of AP. The period of anthesis to fruit formation in mangrove and rainforest zones of Nigeria ranged from 26 - 40 days, but majority fall within 36 - 40 day. Therefore, planting of African pear that reach anthesis to fruit formation within a short period of time should be encouraged hence they have the potential to ripe during the hunger period. The studied trees on phenological survey showed high variability in time of fruiting within and between the various locations. Time of anthesis to fruit formation varied within and between locations. Phenology of African pear fruiting is the study of time and season during which the developmental processes involved in fruit formation , development to maturity and ripening takes place. These processes do not take place at the same time.

The time of fruiting in African pear takes place from January to March or April during the period of this study while ripening started ending of April to July down to September. All these activities are controlled by climatic factors such as temperature and rainfall and genetics. Majority of the African pear form fruit at the temperature of 26^0C - 29^0C. In 2014, it took 3.67 trees about 36 to 40days from anthesis to reach fruit formation. The fruit mature for harvesting at the onset of the rain till the peak of the rainfall. This normally fall between May to September. Further research should be carried out on other factors that may affect fruiting of AP such as lack of pollination, failure of fertilization, ovule abortion, embryo degeneration, inadequate soil moisture and low photosynthesis level.

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