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Effects of Months of Coppicing on Cacao (*Theobroma cacao* L.) Chupons' Flowering and Yield in Edo State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Rehabilitation through coppicing and chupon regeneration has been reported to improve cocoa yield. However, appropriate month for this operation is grossly scarce in literature. Therefore, investigation was carried out between 2017 and 2019 to evaluate effect of coppicing at different months on cocoa (*Theobroma cacao L*) chupons' flowering and yield performance in Cocoa Research Institute of Nigeria, Uhonmora, Edo State. Months of coppicing considered as treatments were December 2017 to November 2018. The experiment was laid out in Randomized complete block design with three replications. Data were collected on number of flowers, number of cherelles, number of pods, fresh pod weight, fresh bean weight and dry bean weight of the chupons. Data were analyzed with ANOVA at $P = .05$. This study revealed that old cocoa trees

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coppiced in the month of April were the most vigorous and showed earlier and steadier yield attributes than other treatments, coming into full flowering, cherelles and pods formation at 4, 9 and 14 months after coppicing, respectively. The old cocoa coppiced in April produced 8, 18, 27, 30 and 45 pods per tree (8999, 20189, 29631, 33331 and 50363 pods per hectare of coppiced cacao) after 14, 15, 16, 17 and 18 months, respectively. Also, it was observed that old cacao coppiced in the months of April and January produced the highest fresh pod weight, fresh bean weight and dry bean weight. April is therefore recommended as the appropriate month to coppice old cocoa plantation for yield performance of cocoa trees in Uhonmora, Edo-State, Nigeria.

Keywords: Chupon flowering; coppiced cocoa; old cocoa plantation; yield performance.

1. INTRODUCTION

Cocoa is a tree crop which is among long list of commercially important species in tropical region of the world. It shares features of being perennial plant with long cycle and declining yields with age. It is also expensive to establish and has long waiting periods before starting to reap benefit of the harvest. Cocoa farmers are mostly driven into rehabilitation when there is fall in cocoa yield due to combined effects of plant ageing, reduction in cocoa population density linked to accumulated natural mortality and increased incidence of pest and disease (Aikpokpodion & Adeogun, 2011; Jagoret *et al*., 2011; Mahrizal *et al*., 2014; Akinnagbe, 2015; Wessel & Quist-Wessel, 2015; Adebiyi *et al*., 2018).

Coppicing is one of the perfected techniques of cocoa rehabilitation that CRIN (Cocoa Research Institute of Nigeria) has developed (Ofori et al., 2022). It involves cutting down of the old cocoa tree in a slant position at 30 cm above ground level with a view to allow chupons growth, out of which the most vigorous and basal one or two are retained to replace the old cocoa tree. Somarriba et al. (2021) showed that regenerated amelonado trees in their sixth year after coppicing gave a yield of 1, 680 kg dry cocoa bean per hectare which is about four times the national average production of 460 kg per hectare. Other researchers got similar results on F3 Amazon where coppicing in November performed best in a monthly coppicing trial. Low bean yield of 400 kg/ha as obtainable in most cocoa plantations in Nigeria has been due to old age of the plantations and poor management practices. Adeyemi (1999) also got yield improvement under rehabilitated plot with soil application of NPK fertilizer. However, economic yield could only be evaluated after six years. In spite of these reported achievements on coppicing or chupon regeneration as a method of rehabilitation in cocoa, many cocoa farmers in Nigeria are still reluctant in adopting the technology because it involves cutting down of their cocoa trees, accompanied with high cost implication and not wanting to miss a year of harvest on coppiced cocoa plantation (Osei-Bonsu et al., 2002). For these reasons in Nigeria, Cocoa Rehabilitation Project (CRP) through coppicing and other rehabilitation techniques should be Federal Government initiative and part of the Economic Recovery Programme (ERP) package under the supervision of the World Bank (WB) and the International Monetary Fund (IMF) in conjunction with other institutions like Cocoa Research Institute of Nigeria (CRIN) and Agricultural Development Bank, as it is being done in Ghana and some other cocoa producing nations of the world (Kwaw-Nimesson & Tran, 2019). Although rehabilitation through coppicing and chupon regeneration has been reported to improve yield (Chibinga *et al*., 2016; Adebiyi *et al*., 2018; Somarriba *et al*., 2020; Adebayo et al., 2022), but information on the appropriate month in a year to carry out this productive operation is grossly scarce in the literatures. Therefore, the objective of the study was to study the effect of month of coppicing on cocoa flowering and yield performance in Edo State, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

Field experiment was carried out at the experimental farm of Cocoa Research Institute of Nigeria (CRIN), Uhonmora Station in Edo State between 2017 and 2019, covering two consecutive rainy seasons and two dry seasons. The location lies on latitude 6º 5' N and longitude 5º 50' E, a derived savanna zone of Nigeria. The rain fall is between 1000 – 1500 mm per annum. The maximum temperature ranges between 26 to 35 ºC with an average of about 30 ºC, while minimum temperature ranges from 15 to 25 ºC with an average of 20 ºC. Relative humidity is high during the rainy season, ranges from 50 to 85% with an average of 75%. There are seasonal variations in the values of relative humidity, which varies from 65 to 89% during the rainy season and 46 – 70% during the dry season. The rainy season which runs from April to October is characterized by heavy rain, low ambient temperature and high humidity; while the dry season runs from November to March and is characterized by little or no rain, high ambient temperature and very low humidity.

2.2 Acquisition and Preparation of Experimental Materials

About 50 x 30 m land area of old cacao plantation of about fifty years was selected for the experiment. Plantain suckers used as shade crop for regenerated chupons were collected from experimental plots in the Station. Other materials used for the experiment were: Chain saw for cutting down of the cacao trunks, Long ruler for measurement of cacao height to be coppiced, Vernier Caliper for measuring the stem girth, Red paint for covering the cut surfaces against pest infestation and disease infection. The experimental plot measuring 50 by 30 m were mapped out and the experiment was laid out with an average of 144 stands of cocoa trees.

2.3 Treatments and Experimental Design

The field experiment comprised four trees randomly selected for each treatment, making forty- eight (48) and one hundred and forty-four (144) cacao stands per block and experimental site, respectively. Two stands were eventually tagged per treatment for data collection. The experiment was laid in Randomized Complete Block Design (RCBD) with three replications. The months of coppicing considered as treatments were: December, 2017 to November, 2018 to make up to twelve treatments based on the number of months in a calendar year. One hundred and forty-four (144) plantain suckers were planted at 3 x 3 m spacing as shade crop. The experiment was monitored for 22 months after coppicing. Measurement, pegging and holing for plantain suckers were carried out before coppicing. The coppicing was carried out on treatment monthly basis by complete removal of the main stems of cocoa trees to encourage the regeneration of the canopy by chupon growth. The 30 cm from the soil surface of cocoa trees to be coppiced was marked out with red paint. Chain saw was placed on the marked portion of the trunk ready for coppicing in a slant position. Old cacao trunk was cut down in a slant position 30 cm above the soil surface. The cut surfaces were painted with red paint (Red paint contains red oxide) to prevent infestation and infection of pest and disease. A month after coppicing, there was chupon growth which was left for three (3) months before thinning. Three month after coppicing, the chupons on cocoa stump were pruned to two strong basal shoots. The two shoots were retained and allowed to develop mature canopies.

2.4 Data Collection

Data were collected on the yield parameters of cacao chupons. Number of flowers, number of cherelles and number of pods per chupon were determined by visual count; fresh pod weight, fresh bean weight and dry bean weight per chupon, were measured using weighing balance. These yield parameters were taken monthly for 22 months commencing from 4 months after coppicing (MAC).

Data collected were analysed using analysis of variance (ANOVA), and significant means separated by Duncan Multiple Range Test (DMRT) ($P = .05$).

3. RESULTS AND DISCUSSION

Effects of months of coppicing on yield performance of cocoa are presented in Tables 1 - 6. Only old cocoa coppiced in the month of April produced flowers at 4 and 5 months after coppicing. Month of April gave significant ($P = .05$) higher number of flowers at 4, 5, 6, 7 and 8 MAC (months after coppicing) compared to other months of coppicing. The significant higher number of flowers recorded in the month of April was distant followed by old cocoa coppiced in the months of June, July, March, May and September at 8 MAC (Table 1).

The results of Tables 2 and 3 also showed that coppicing in the month of April enhanced the number of cherelles and pods when compared to other treatments. It was the most vigorous, and showed early and steady yield attributes than other treatments, coming into full flowering, cherelles and pods formation as early as 4, 9 and 14 months after coppicing (Tables 1, 2 & 3). Therefore, the old cocoa coppiced in April was able to produce 8, 18, 27, 30 and 45 pods per tree after 14, 15, 16, 17 and 18 MAC, respectively.

Table 1. Effects of months of coppicing on number of flowers per hectare at 4, 5, 6, 7 & 8 MAC

Treatments	Months after coppicing				
Months	**4**	**5**	**6**	**7**	**8**
January	0.00b	0.00b	0.00b	0.00c	0.00c
February	0.00b	0.00b	0.00b	0.00c	0.00c
March	0.00b	0.00b	23,320a	10,360b	10,360b
April	10,350a	26,290a	23,330a	49,99a	102,570a
May	0.00b	0.00b	0.00b	4,077b	7,770b
June	0.00b	0.00b	0.00b	0.00c	18,880b
July	0.00b	0.00b	0.00b	0.00c	11,111b
August	0.00b	0.00b	0.00b	0.00c	0.00b
September	0.00b	0.00b	0.00b	0.00b	6,290b
October	0.00b	0.00b	0.00b	0.00b	0.00c
November	0.00b	0.00b	0.00b	0.00b	0.00c
December	0.00b	0.00b	0.00b	0.00b	0.00c

Means followed by the same letters in each column are not significantly different by Duncan Multiple Range Test (DMRT) (P = .05)

Table 2. Effects of months of coppicing on number of cherelles per hectare at 9, 10, 11, 12 & 13 MAC

Treatments	Months after coppicing				
Months	**9**	**10**	**11**	**12**	**13**
January	10.00c	16,630a	18,221a	22,554a	22,554a
February	4.00c	8,855b	11,077b	14,410bc	13,521b
March	4,077cd	8,477b	9,588b	11,077c	12,555b
April	21,109a	16,254a	20,332a	21,409a	23,142a
May	1,111d	14,399a	18,110a	20,332ab	23,398a
June	6,666bc	9,222b	11,444b	12,555c	15,521b
July	3,699cd	9,222b	11,810b	12,555c	14,410b
August	10.00c	8,477b	11,444b	10,333c	12,555b
September	7.00c	8,477b	11,077b	10,333c	11,810b
October	8.00c	8,477b	11,810b	11,810c	11,188b
November	2.00c	8,477b	11,444b	11,810c	12,188b
December	11.00c	8,855b	12,555b	11,077c	12,921b

Means followed by the same letters in each column are not significantly different by Duncan Multiple Range Test (DMRT) (P = .05)

Table 3. Effects of months of coppicing on number of pods per hectare at 14, 15, 16, 17 & 18 MAC

Treatments	Months after coppicing				
Months	**14**	**15**	**16**	**17**	**18**
January	4,810b	9,254b	12,587b	15,554b	34,998b
February	4,477b	2,222c	3,333d	4,444cd	19,810d
March	3,333b	5,921bc	7,777c	7,410c	25,743c
April	8,999a	20,187a	29,631a	33,331a	50,363a
May	1,477b	2,588c	2,588d	2,588d	19,444d
June	2,222b	2,966c	3,699d	3,333cd	19,444d
July	4,077b	2,588c	4,077d	3,333cd	19,444d
August	2,222b	2,966c	3,333d	4,444cd	19,810d
September	2,222b	2,588c	3,333d	5,188cd	19,188d
October	2,222b	3,333c	2,966d	5,188cd	19,188d
November	1,855b	2,966c	3,699d	3,333cd	19,555d
December	2,588b	2,966c	3,333d	4,077cd	21,299cd

Means followed by the same letters in each column are not significantly different by Duncan Multiple Range Test (DMRT) (P = .05)

These pod yields translated to 8,999, 20,189, 29,631, 33,331 and 50,363 pods per hectare of coppiced cocoa plantation, respectively (Table 4). Also, it was clearly observed that old cocoa coppiced in the months of April and January produced the highest fresh pod weight, fresh bean weight and dry bean weight (Tables 4, 5 & 6). It is worthy of note that at 18 MAC, month of July gave the lowest dry bean weight of 484 kg/ha while the highest dry bean weight of 4,654 kg/ha was obtained from the month of April (Table 6). This implies that the low bean yield of 400 kg/ha as obtainable in most cocoa plantation in Nigeria has been attributed to old age of the plantation and poor management practices by the farmers. Several researchers reported that the highest cocoa yield are achieved between 15 and 25 years, while Krung and Quartey- Papafio (1964) after conducting cocoa survey throughout the growing regions of the world recommended 30 – 40 years as the average economic life span of cocoa trees. The highest dry bean weight of 4,654 kg/ha obtained at 18 MAC for the month of April was far beyond 1,800 kg/ha dry bean of cocoa recorded after 18 month of coppicing. Also, Somarriba et al. (2021) noted that regenerated Amelonado trees in their sixth year after coppicing gave a yield of 1,680 kg/ha which was about four times the national average of 460 kg/ha at that time. The relative low yields recorded by the two authors could be as a result of the fact that appropriate techniques and period of application were not taken into consideration to get the required results. Adebiyi *et al*. (2018)

Table 4. Effects of months of coppicing on fresh pod weight (kg/ha) at 14, 15, 16, 17 & 18 MAC

Treatments	**Months after coppicing**				
Months	**14**	**15**	**16**	**17**	**18**
January	8,069a	10,703a	17,654a	29,000a	45,987a
February	1,938b	1,776c	2,664c	2,840d	11,549c
March	1,265ab	1,570bc	3,040bc	3,841bcd	15,751abc
April	7,925a	9,595a	16,501a	29,610a	60,407a
May	169.0b	266.0c	722.0bc	1,280bc	10,317bc
June	1,029ab	1,894bc	2,380bc	9,468ab	10,356abc
July	932.0b	840bc	1,324bc	1,099cd	9,444bc
August	788ab	882.0bc	762c	1,380cd	7,707bc
September	992.0ab	805.0bc	2,400bc	2,130cd	10,002c
October	666.0ab	2,571bc	2,571bc	4,968cd	10,862bc
November	659.0ab	882.0bc	4,886bc	4,126cd	13,286abc
December	2,385ab	1,334bc	1,487bc	1,334cd	13,205abc

Means followed by the same letters in each column are not significantly different by Duncan Multiple Range Test (DMRT) (P < 0.05)

Table 5. Effects of months of coppicing on fresh bean weight (kg/ha) at 14, 15, 16, 17 & 18 MAC

Treatments	**Months after coppicing**				
Months	**14**	**15**	**16**	**17**	**18**
January	2,688a	3,576a	5,876a	9,908a	13,246a
February	532b	592bc	788b	845b	1,058b
March	429ab	523bc	1,013b	1,280ab	1,917ab
April	2,641a	3,198a	5,500ab	9,987a	13,654a
May	70,0b	90.0c	280,0b	475.0ab	456,0ab
June	364.0b	654.0bc	795b	3,167ab	1,452ab
July	320b	290bc	445b	369b	484.0b
August	262.0b	294.0bc	257.0b	469b	572.0b
September	334ab	271bc	850b	723b	669b
October	223b	859abc	859b	1,656ab	954.0b
November	220b	294bc	1,630ab	1,375ab	478.0ab
December	798ab	447.0bc	495.0b	447ab	3,401ab

Means followed by the same letters in each column are not significantly different by Duncan Multiple Range Test (DMRT) (P < 0.05)

Table 6. Effects of months of coppicing on dry bean weight (kg/ha) at 14, 15, 16, 17 & 18 MAC

Treatments	Months after coppicing				
Months	**14**	**15**	**16**	**17**	**18**
January	899.0a	1,190a	1,959a	3,577a	4,400a
February	148c	222d	333d	355c	481c
March	147b	176c	3340c	429	639.0b
April	889a	1,266a	1,834a	3,629a	4,654a
May	30c	35d	95d	158c	152c
June	123b	98c	270c	1,056b	543.0bc
July	108b	97.0cd	150c	124.0bc	162.0bc
August	88.0bc	98.0cd	87.0cd	157.0b	195.0bc
September	122.9b	91.0cd	289.0c	245.0b	223.0bc
October	75.0bc	287.0bc	289.0c	557.0b	318.0bc
November	73.0bc	99.0cd	547.0bc	459.0b	1,667bc
December	267.0b	149.0c	165.0c	150.0b	1,133b

Means followed by the same letters in each column are not significantly different by Duncan Multiple Range Test (DMRT) (P < 0.05)

also reported that the appreciable increase in the yield of coppiced trees is an indication that the vibrant young trees from the coppiced old trees is increasing in size and height and is capable of carrying more cocoa pods. He equally observed 78.4 mean pod production at fifth year after coppicing. This work has rightly confirmed that rehabilitation through coppicing and chupon regeneration significantly enhanced the yield performance of cocoa as earlier reported (Chibinga *et al*., 2016; Adebiyi *et al*., 2018; Somarriba *et al*., 2020), but information on the appropriate month in a year to carry out this productive operation is grossly scarce in the literature and that is the essence of this study.

4. CONCLUSION AND RECOMMENDATION

This work has confirmed that rehabilitation through coppicing and chupon regeneration significantly enhanced the yield performance of cocoa. The appropriate techniques and period of application should be taken into consideration to get the required results. To obtain results close to the ones recorded in this work in farmers' farms, more training of farmers through farmers' field school to enable them rehabilitate their farms by themselves should be embarked upon by research scientists. Therefore, month of April is recommended for coppicing in Edo State for optimum yield. However, the recommendation is location specific. This calls for this research to be carried out in all cocoa ecologies in Nigeria.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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