# EFFECTS OF PRUNING AND NITROGEN FERTILIZATION ON FLUSHING AND POD PRODUCTION IN CACAO †

# [EFECTOS DE LA PODA Y FERTILIZACION NITROGENADA SOBRE LA EMISION FOLIAR Y PRODUCCIÓN DE MAZORCAS EN CACAO]

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## SUMMARY

**Background**. Maintenance pruning is an essential activity in cacao in order to maintain height, avoid intersections of branches between trees, and generate new foliar shoots. Usually, fertilization is applied at the same time as pruning, but there are little information when it should be applied to synchronize with the metabolic events triggered when pruning. The application of N, its effectiveness and the effect of different doses is very important, but there is very little known. **Objective**. To evaluate the effect of the fertilization of two doses of N (50 and 110 g per tree) before, during and after pruning on flushing, number of cherelles (pods smaller than 5 cm in length) and pods, fresh weight and numbers of almonds in trees which are 8 years old. **Methodology**. a split-plot design was established. Main plot was assigned to pruning (pruning and without pruning) and sub plots the doses of nitrogen fertilization and the time of application factor. One week after fertilization, the number of flushing emissions, cherelles and number of pods in different stages were counted weekly in 4 trees per treatment until week 20. Mature pods also were harvested and the number of almonds and fresh weight were counted. **Results.** Pruning affected the flushing, shortening the periods between maximum emissions. The application of N in doses of 110 g/tree one week after pruning leads to a higher and significant number of flushing number of cherelles and number of pods. **Implications** Pruning does not influence the production parameters, but the greater availability of N given in the higher applied dose leads to a greater number of pods and fresh weight. The greater availability of N after pruning leads to a more efficient use for the formation of new pods. greater number of almonds and greater fresh weight. **Conclusion**. These results show that nitrogen fertilization carried out after pruning is a feasible strategy to achieve a number of flushing, pods and production.
**Key words:** pruning; nitrogen; cacao.

## RESUMEN

**Antecedentes**. La poda de mantenimiento es una actividad necesaria en cacao con la finalidad de mantener altura, evitar entrecruces de ramas entre los árboles y generar nuevos brotes foliares. La fertilización usualmente se aplica cuando se realiza la poda, pero no está evidenciado cuando debe aplicarse para sincronizar con los eventos metabólicos que se desencadenan al realizar la poda. En especial la aplicación de N juega un papel importante y su efectividad es poco conocida, como tampoco el efecto de diferentes dosis. **Objetivo**. Evaluar el efecto de la fertilización de dos dosis de N (50 y 110 g por árbol) antes, en la poda y después de la misma sobre la emisión de hojas, número de chereles (frutos menores a 5 cm de largo) y mazorcas, peso fresco y números de almendras en arboles de 8 años. **Metodología**. Se estableció un diseño de parcelas divididas. A la parcela principal se le asignó la poda (poda y sin podar) y a las subparcelas las dosis de fertilización nitrogenada y el momento de aplicación del N. Una semana después de la fertilización, se contó semanalmente en 4 árboles de cada tratamiento hasta la semana 20 el número de emisiones de hojas, chereles y el número de frutos en diferentes etapas. También se cosecharon las mazorcas maduras y el número de almendras y peso fresco. se contabilizo. **Resultados.** La poda afecto la dinámica de emisión de brotes foliares de hojas acortando el periodo entre máximos de emisiones. La aplicación de N en dosis de 110 g/árbol una semana

† *Submitted June 14, 2022 – Accepted November 31, 2022. http://doi.org/10.56369/tsaes.4421*

ISSN: 1870-0462.
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después de la poda conlleva a un mayor y significativo número de emisiones, número de chereles y número de frutos. **Implicaciones**. La poda no influye en los parámetros de producción, pero la mayor disponibilidad de N dado en la mayor dosis aplicada produce a un mayor número de almendras y peso fresco. La mayor disponibilidad de N después de la poda conduce a un uso más eficiente para la formación de nuevas mazorcas. mayor número de almendras y peso fresco. **Conclusión** Estos resultados muestran que la fertilización nitrogenada realizada posterior a la poda es una estrategia factible para lograr una mayor número de emisiones de hojas, número de mazorcas y producción.
**Palabras clave:** poda; nitrógeno; cacao.

## INTRODUCTION

Cacao (*Theobroma cacao* L.) is considered one of the most important perennial crops globally with an annual production of 4.9 million tons (ICCO, 2022). Traditionally cacao was handled like a tree and its pods were harvested using long scoops that knocked down the pods. Over time, the heights of the trees were reduced to help the harvest and today the plantations are managed with trees that do not exceed heights of 4 m. This leads to pruning being an essential activity in cacao management. In general, pruning is a horticultural and forestry activity which purpose is to regulate its vegetative capacity. In addition, it reduces the canopy, promotes the sprouting of terminal buds, and increases flowering and fruit production and quality (Jaimez *et al*., 2002; Casierra *et al*., 2012; Bedker *et al*., 2014; Bhagawati *et al*., 2015). In the case of cacao, this involves eliminating the excessive amount of shaded, intertwined, old and dry branches in order to increase the useful life of the tree. This practice also maintains adequate ventilation, the height of the tree and increases the production capacity (Reyes and Capriles, 2000). Likewise, pruning leads to reducing the shade at a certain time of the year which allows disease control through aeration of the stand (Armengot *et al*., 2016, Kongor *et al*., 2018) and the development of new buds. Moreover, it increases flowering and fruit production (Gutiérrez *et al*., 2019), with the perspective of balancing vegetative growth with reproductive growth and thus directing the increase in productivity and almonds quality (Sánchez *et al*. 2007). Therefore, pruning serves as a key tool to achieve micro-environmental conditions that favor cacao production, however, it must be considered the intensity and time in which it is carried out (Niether *et al*., 2017).

There are three types of pruning in cacao: formation maintenance and rejuvenation. Formation pruning consists in seeking three or four primary branches during the first two years of the plant to give it a better shape (Enríquez, 2004). Formation pruning is different in plants from seeds and those from rooted stakes or grafts. The plants from seeds develop orthotropic growth naturally with apical dominance typical of the main stem, later it stops and gives way to plagiotropic growth with the formation of 4 or 5 axillary buds that originate the same number of branches distributed in a fan shape. In plants from grafts, between three and four stems develop in a plagiotropic way. Maintenance pruning that is usually carried out, once the tree has been given its shape, it seeks aeration and the entry and distribution of light in the canopy to increase the production and quality of the pods (Casierra *et al*., 2012). Also it has been reported fresher and drier weights almonds from trees which had light pruning compared to those that had heavy pruning (Buitrago *et al*., 2019). Finally, rehabilitation or rejuvenation pruning is carried out with the aim of generating new trees by obtaining terminal buds in plantations over 20 years old (Córdova, 2013). However, this is not economically effective, since high productions are obtained after four or five years (Riedel *et al*., 2019).

The modification of the leaf area through pruning affects the source-demand relationship (Arévalo *et al*., 2012) and depending on the moment and intensity, it can lead to increases or decreases in production (Casierra *et al*., 2012; Buitrago *et al*., 2019). For example, very intense pruning above 75% results in decreases in the production of news pods, at least in the following eight months after having done it, while a pruning of 25% reduction in foliage leads to obtaining of a greater number of pods (Gutierrez-Brito *et al*., 2019). The higher production is related to faster foliage recovery, however between these two types of pruning, the contents of all nutrients and fat were similar (Gutierrez-Brito *et al*., 2019). Other experiments coincide with 30% pruning also resulting in a greater number of branches in relation to lower percentage pruning (10 and 20%), however the highest significant fat content in the almonds is obtained with 20% pruning (Uchoi *et al*., 2018). Moreover, with greater pruning intensity, the pod index (number of pods to achieve one kilogram of dry weight of almonds) and the grain weight are not affected (Leiva-Rojas *et al*, 2019). These results lead to consider that the intensity and moment of pruning should be carried out based on the growth period of the pods. For example, at a time when most of the pods are in the stage of greatest growth, pruning should not be carried out due to competition between new shoots and emerging leaves. However, in cacao pods of different sizes will usually be found and their quantities will also vary.

It has also been reported in cacao that pruning promotes an increase in the photosynthetic rate in relation to non-pruned plants (Susanti *et al*., 2017). It is also suggested that the increase in the amount of carbohydrates available after pruning, is mobilized in greater quantity towards the growth of leaves that begin to emerge (Leiva-Rojas *et al*., 2019). This change in the source-sink relationship can have adverse effects on production, since a greater amount of carbohydrates will be used for leaf replacement and growth. Despite the regularity of this practice, its effect on cacao yield is little known; therefore, it is necessary to quantify and relate the growth and production variables to the leaf area. On the other hand, the periods of maximum production change depending on the environmental conditions and the cultivar. This raises the possibility that pruning decreases the distribution of photoassimilates towards the formation of pods, which probably leads to their fall. However, although there is fruit drop due to pruning, the additional effect of fertilizer applications at the time of pruning and days before or after is unknown. This would seem important if the plantation also receives irrigation, which avoids water limitations and the effect of pruning will benefit more. It is usually practiced to apply fertilization at the time of pruning, but it is not clear whether the application of fertilizer is beneficial at the time the plant changes its distribution of assimilates due to pruning.

The hypothesis is raised that under irrigation conditions the effect of non-severe pruning (25 %) on flushing and pod production will be affected by changes in the amounts of nitrogen fertilization and the time of its application depending on when the pruning is carried out. This work aims to evaluate the effects of pruning and different doses of nitrogen applied before, at the time of pruning, or after on the dynamics of flushing, pods and on the fresh weight and number of almonds.

## MATERIALS AND METHODS

The research was carried out in a commercial plantation of clone CCN 51 aged 8 years located in the Las Chacras Adentro, Portoviejo, Ecuador, (0°58'19.5" S and 80°26'01.4" W). The area has a characteristic climate of dry tropical forest, with an annual average temperature of 26 °C. The soil had a silty-clay to clay texture, with a pH of 6.5%.

In the month of June 2021, a split-plot design was established. Main plot was assigned randomly to pruning (with "P" pruning and without "NP" pruning), to the sub plots the nitrogen fertilization factor (N1 = 55 and N2 = 110 g/tree) and sub-subplot the time of application factor (one week before the "AP" pruning, at the time of the "P" pruning and one week after of pruning “DP”). In total, 12 treatments, three replicates and 36 experimental units were evaluated. The experimental unit was made up of 8 plants. In addition, all the trees received a fertilization of 41 and 164 gr/tree of P and K, respectively, using commercial fertilizer. Before pruning, all the pods were removed from the tree

The pruning consisted in the elimination of 25% of branches in which the trees were kept at a height of 3 meters, measured from the ground to the apex. Unproductive, intersecting secondary and tertiary branches were eliminated from their ends towards the interior of the tree, avoiding intertwining between branches of one tree with another, and thus allowing a greater entry of radiation into the interior of the plantation. The trees that were not pruned had an average height between 3.5 to 4 meters, measured from the ground to the apex of the leaf canopy. They had unproductive branches, intertwined both inside the tree and between one plant and another, however, it showed no signs of pest and disease attacks.

One week after fertilization and pruning, the number of flushing emissions per tree was counted weekly in 4 trees per plot of each treatment until week 20. Similarly, cherelles (pods smaller than 5 cm in length) and number of pods in different stages (pods between 5-9 cm, between 10-15 cm, 16-19 cm months and greater than 20 cm) were also counted.

From each treatment, 24 mature pods were harvested and the number of almonds and fresh weight (mucilage with the almonds) were counted. Data were analyzed through analysis of variance and separation of means with Fisher's test ($p<0.05$). It was used the statistical package Minitab version 2018.

## RESULTS AND DISCUSSION

### Numbers of flushes

During the first ten weeks, the accumulated number of flushes was significantly affected ($p\leq0.05$) by the N content and pruning (appendant A). There was a significant effect of the triple interaction of pruning x moment of application of N x N dose. Between the 11th and 20th week there was a significant effect of the concentration of applied N, where the highest concentration of N produced 62.5 flushing in relation to the lowest concentration of N (41.4). Timing of application and pruning was also significant where the application after pruning was significantly higher (58.2 emissions) compared to the application at the time of pruning (44.6 emissions). The moment x N interaction was the only one significant ($p\leq0.05$). With respect the total sum of flushes, the significant effect ($p\leq0.05$) was also due to the concentration of N, at the moment of application and in the moment x N interaction (appendant A). The treatment with the application of N 110 g/plant after pruning was the highest number of flushes (table 1, table 2), which implies a greater leaf area. In most of the treatments where only 55 g of N was applied, the number of flushes were always the lowest (table 2 and table 3).

Since the pruning was completed, seven weeks passed without flushing. From this moment on, in the pruned plants, the number of flushes in all treatments increased progressively until the tenth week, when the maximum values were obtained. In the fourteenth week, another emission maximum was recorded in most of the treatments with the exception of the 110 g N treatment before pruning (APN2) in which the maximum value occurred in the seventeenth week (figure 1A). From the seventh to the seventeenth week, the treatments that received N fertilization after pruning maintained a higher number of flushes.

In non-pruned plants, flushing also began in the seventh week and reach the first maximum of flushes in the same week as in pruned plants (figure 1B). Subsequently, it began to decline and another maximum value with a lower number of flushes occurred in the eighteenth week. The treatments with the application of N of 110 g maintained the highest values during the 20 weeks of evaluation.

Although there is a tendency of 2 maximum moments in the number of leaf emissions in both pruning treatments the time between both maximums is shortened in pruned trees. In the pruned trees. it is a period of 4 weeks while in unpruned trees it is 8 weeks. This shows possible changes from a greater distribution of photoassimilates towards the formation of leaves in trees pruned in less time. It seem in the interflush the stock of carbohydrates is reestablished quickly. It also indicates changes in the flushing dynamics. in which after the tenth week in pruned trees. the number of emissions is higher in all N fertilization treatments. in relation to unpruned plants. Although it has been shown that pruning of 30% leads to a greater number of branches in relation to lower pruning percentages (Uchoi *et al*., 2018). The results in this study show that by using higher nitrogen dosages it is possible to obtain higher leaf emissions in less time. This effect is more significant if the application of N is made after pruning. After pruning greater availability of N may imply the use of N more efficiently towards leaf formation. This is related to the apical dominance which is regulated by nutrients in the leaves (Almeida and Valle. 2007). Similarly. the higher rate of $CO_2$ assimilation previously reported in pruned plants in relation to non-pruned plants (Susanti *et al*., 2017) could be increased with a greater availability of N after pruning. This hypothesis should be evaluated in subsequent works.

**Table 1. Effect of pruning (NP: trees not pruned. P: trees pruned) and N dose (N1:55 g N2: 110 g) applied 10 days before pruning (AP) at pruning (P) and 10 days after pruning (DP) on the number of flushing between 11 and 20 weeks and total numbers of flushes.**

| Moment *nitrogen | Number of Flushing (11 and 20 weeks) | Total number of flushing |
|---|---|---|
| DPN2 | 72.7a | 106.8a |
| APN2 | 66.9a | 96.3a |
| PN 2 | 48.1b | 74.3b |
| DPN1 | 43.8b | 69.0b |
| PN1 | 41.1b | 67.3b |
| APN1 | 39.3b | 60.6b |

Different letters in the same column indicate significant differences according to Fischer's test ($p<0.05$). Values are means ± standard error.

**Table 2. Effect of pruning (NP: unpruned trees. P: pruned trees) and the dose of N (N1:55 g N2: 110 g) applied 10 days before pruning (AP). at pruning (P) and 10 days after pruning (DP) on the average number of total of flushings in the first 10 weeks. between 10-20 weeks and the total of the entire period after pruning.**

| Treatment | Pruning type | first 10 | treatment | Pruning type | 11-20 weeks | treatment | Prunning type | total |
|---|---|---|---|---|---|---|---|---|
| APN2 | NP | 38.2±6.7 a | DPN2 | P | 85.3±10 a | DPN2 | P | 120.4±11.5 a |
| DPN2 | P | 35.2±5.8 ab | APN2 | P | 75.4±5.1ab | APN2 | NP | 96.5±8.7 b |
| DPN2 | NP | 33.2±5.6 abc | DPN2 | NP | 60.1±5.2 bc | APN2 | P | 96.2± 5.2 b |
| PN1 | NP | 31.4±5.4 abcd | APN2 | NP | 58.3±4.3 bcd | DPN2 | NP | 93.2± 7.3 bc |
| DPN1 | NP | 29.2±4.3 abcd | DPN1 | P | 53.8±7.1 cde | PN2 | P | 77.1± 8.4 bcd |
| PN2 | NP | 27.0±4.4 abcd | PN2 | P | 51.8±6.5cdef | DPN1 | P | 75.8± 8.0 bcd |
| PN2 | P | 25.3±3.0 abcd | PN1 | P | 46.4±6.2cdef | NPN2 | NP | 71.5± 12.1 c |
| APN1 | P | 23.1±5.1bcd | PN2 | NP | 44.5±8.7cdef | PN1 | P | 67.4± 7.2 d |
| DPN1 | P | 21.3± 2.0 cd | APN1 | P | 41.4±6.1 def | PN1 | NP | 67.3± 5.5 d |
| PN1 | P | 21.0±4.9 cd | APN1 | NP | 37.3±6.5 ef | APN1 | P | 64.5± 5.4 d |
| APN2 | P | 20.8±3.4 cd | PN1 | NP | 35.8±4.1 ef | DPN1 | NP | 62.9± 9.0 d |
| APN1 | NP | 19.4±3.1 d | DPN1 | NP | 33.8±6.1 f | APN1 | NP | 56.7± 6.9 d |

Different letters in the same column indicate significant differences according to Fischer's test ($p <0.05$). Values are means ± standard error.

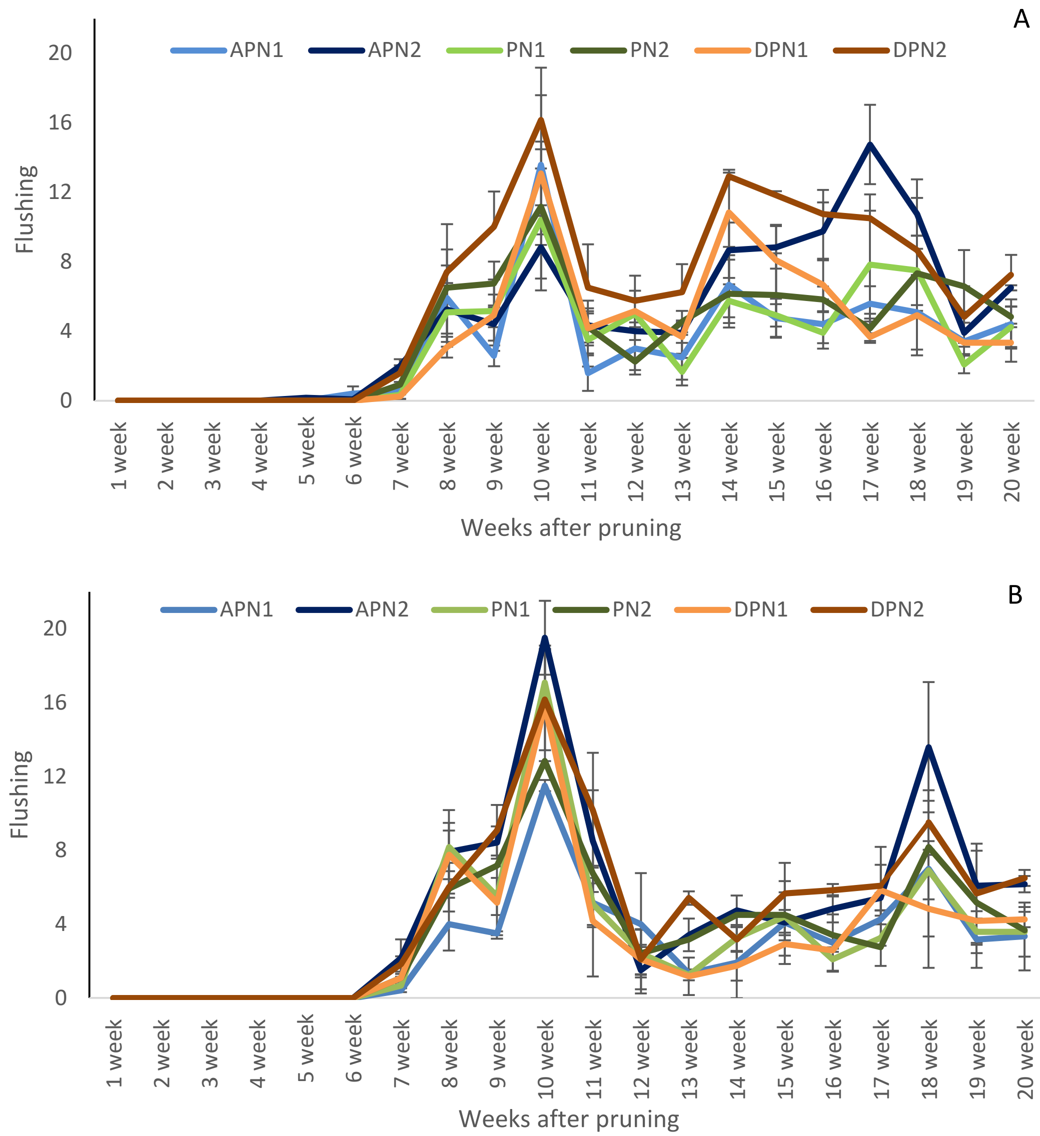


**Figure 1.** Dynamics of the average number of leaf emissions (Flushing) per plant in pruned (A) and unpruned (B) cacao trees with nitrogen applications of 20 g (N1) and 40 g per plant (N2) before pruning (APN), at the time of pruning (PN) and 10 days after pruning (DPN). Bars indicate standard error of the mean

The application of N did not influence the dynamics of flushing. However. the highest dose of N in pruned plants applied before pruning modified the numbers of flushes. It is the only treatment that a higher number of flushes is obtained in the second maximum. Few studies refer to the effect of pruning on the N content in the different parts of the plant. For example. Sanginga *et al*., (1994). in Glicicidia species. ($N_2$ fixing tree). *Senna siamea*. and *Senna*. *spectabilis* (non $N_2$ fixing trees) one year old. found that pruning at 50 cm height produced a mobilization of N towards the branches. These authors also reported that the distribution of P after pruning was particular to each species. presenting lower amounts of P in all the parts of plant in the three species studied after the pruning. These results show that after pruning most of the P and N stored in the stem and roots were mobilized towards the branches. More evidence shows that the decrease in the carbohydrate reserve of the remaining stems of tropical and temperate shrubs and trees. which occurs once pruning has been applied. plays an important role in the biomass production of the new branches and leaves in formation (Yasmashita. 1986. Erdmann *et al*., 1993).

**Number of cherelles**

There was no significant effect ($p \leq 0.05$) in pruning. but there was in the amount of N supplied and the time it was applied on the number of cherelles produced. No significant effects were found in the interactions (appendant A). The application of a dose of 110 g after pruning (DPN2) and also the same application of N for the same moment of pruning led to the highest production of cherelles (table 3).

In both the trees that were pruned and those that were not pruned the appearance of cherelles began from the second week after fertilization was carried out after pruning. In the pruned trees. the number of cherelles gradually increased to reach the maximum quantity between the thirteenth and sixteenth week (figure 2A). Subsequently. it begins to decrease and by the twentieth week the values ranged between 5 and 2

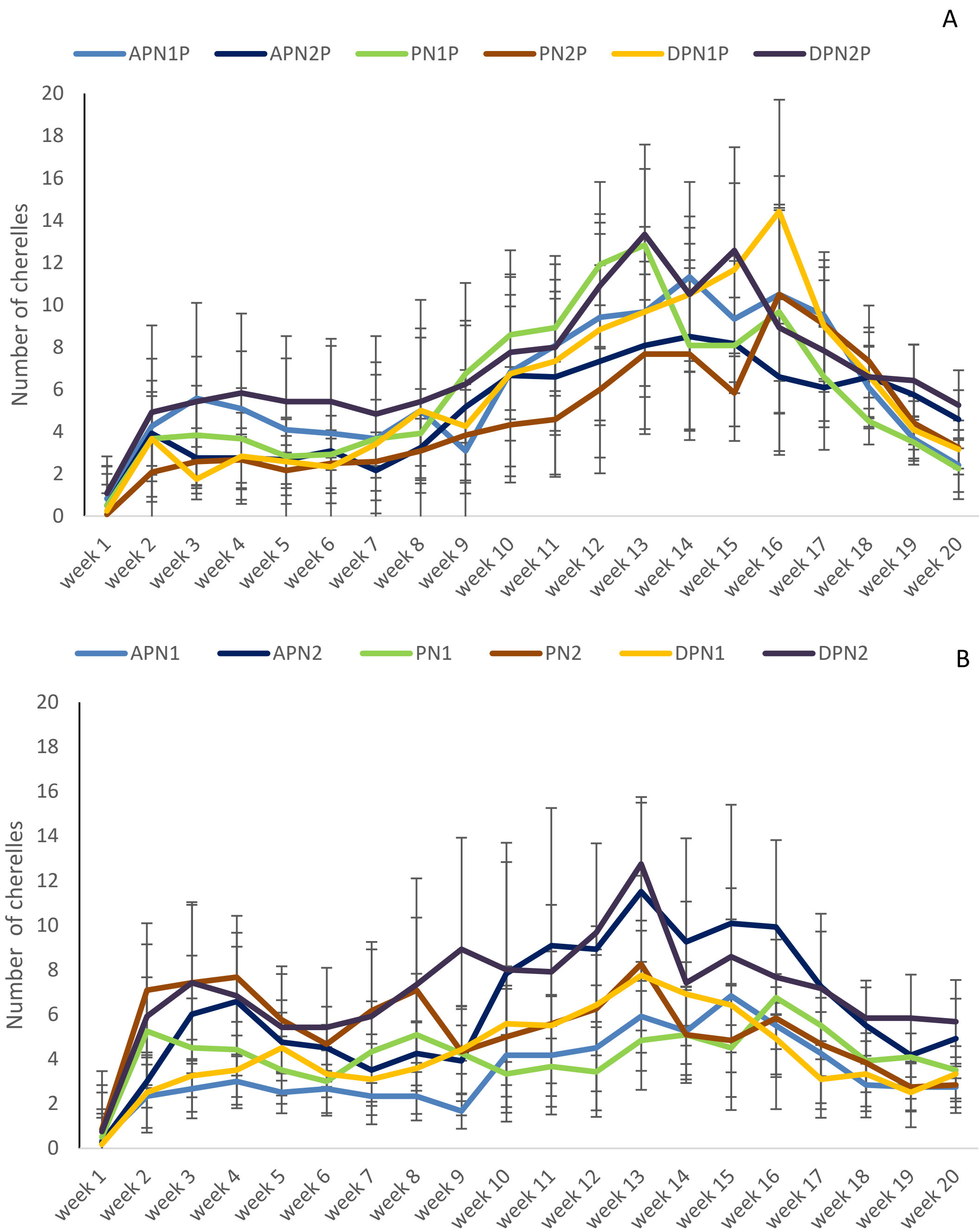


**Figure 2.** Dynamics of the average number of cherelles per plant in pruned (A) and unpruned (B) cacao trees with nitrogen applications of 55g (N1) and 110g per tree (N2) before pruning (APN), at the time of pruning (PN) and 10 days after pruning (DPN). Bars indicate standard error of the mean

**Table 3. Effect of pruning (NP: trees not pruned. P: trees pruned) and N dose (N1:55 g N2: 110 g) applied 10 days before pruning (AP) at pruning (P) and 10 days after pruning (DP) on the average number of cherelles produced.**

| Treatment | Pruning type | Number of cherelles |
|---|---|---|
| DPN2 | P | 141.6 ±14.1 a |
| DPN2 | NP | 139.7 ± 25.2 a |
| APN2 | NP | 124.9 ± 22.7 ab |
| APN1 | P | 121.5 ± 25.1ab |
| PN1 | P | 117.9 ±11.4 abc |
| PN1 | P | 116.2 ± 21.7abc |
| PN2 | NP | 105.1 ± 13.2 abc |
| APN2 | P | 100.7 ± 16.3 abc |
| PN2 | P | 92.2 ± 16.4 abc |
| DPN1 | NP | 83.9 ± 0.4bc |
| PN1 | NP | 82.9 ± 15.5 bc |
| APN1 | NP | 68.4 ± 11.3 c |

Different letters in the same column indicate significant differences according to Fisher's test (($p < 0.05$). Values are means ± standard error.

cherelles per tree. In most weeks the trees that received the highest amount of N after pruning showed the highest values of cherelles numbers. The maximum numbers of cherelles were reached in the treatments with N application after pruning (14.4 cherelles/tree with 55 g of N and 13.3 cherelles/tree with 110 g of N). In unpruned trees the increase was also progressive and the maximum values were obtained in most of the treatments at the thirteenth week (figure 2B). Later the number of cherelles decreased. The highest number was obtained with the highest application of N in the following order DPN2>APN2>PN2 with values of 12.7; 11.5 and 8.2 cherelles per tree. respectively.

The appearance of cherelles from the second week in all treatments is related to the flowering period of CCN51 plants which occurs precisely between the end of the rainy period (May) and the beginning of the dry period (June) (Jaimez *et al*., 2022). It seems that pruning did not influence the drastic decrease in flowering and the subsequent appearance of cherelles. The delay in the beginning of the emission of leaves that begins in the seventh week after pruning could also be a period when a greater number of photoassimilates is directed fundamentally towards the formation of flowers and fruits.

**Number of pods between 20-22 cm long**

There was a significant effect of the dose of N, the moment and the interaction moment *N in the number of pods between 20-22 cm long (appendant A). The average number of pods obtained was 3.06 and 1.48 with applications of 110 and 55g N, respectively (Table 4). The number of pods between 20-22 cm long (4-month-old pods) which is the approximate time when the pod stops growing and the maturation stage begins (Niemenak *et al*.. 2009) varied between treatments. The tendency is a greater number of pods with the greater doses of N both in pruned plants and in non-pruned plants from week 19 after pruning (figure 3). In pruned trees the maximum average number of pods was 3.7 pods/tree with N applications of 110 g/tree after pruning. However, in unpruned trees a maximum of 4.3 pods/tree was obtained with the same amount of N application after pruning.

**Table 4. Effect of pruning (NP: trees not pruned. P: trees pruned) and N dose (N1:55 g N2: 110 g) applied 10 days before pruning (AP) at pruning (P) and 10 days after pruning (DP) on the number of pods at 20 cm in length at 20 weeks after pruning**

| Tratamiento | Pruning type | Number of pods |
|---|---|---|
| NDPN2 | NP | 4.3 ± 0.5 a |
| NAPN2 | NP | 3.7 ± 0.6 a |
| DPN2 | P | 3.7 ± 0.6 a |
| APN2 | P | 3.4 ± 0.4 ab |
| PN2 | P | 1.9 ± 0.4 bc |
| NDPN1 | NP | 1.8 ± 0.5 c |
| DPN1 | P | 1.6 ± 0.4 c |
| APN1 | P | 1.6 ± 0.4 c |
| NPN2 | NP | 1.5 ± 0.2c |
| NPN1 | NP | 1.5 ± 0.4 c |
| PN1 | P | 1.3 ± 0.7 c |
| NAPN1 | NP | 1.3 ± 0.3 c |

Different letters in the same column indicate significant differences according to Fisher's test ($p < 0.05$). Values are means ± standard error

**Fresh weight and number of almonds**

There were not significant differences found with the pruning moment factor or any of the interactions for neither the number of pods or fresh weight. However. the N factor was significant for both variables (appendant B) ($p < 0.05$). The highest weights and number of almonds were found with the application of higher N content (110 g) after pruning. However. they were not significantly different with the treatment of 110 g of N application in unpruned plants applied one week before the pruning (table 5). There is a tendency in all the treatments where the least amount of N was applied the lowest amounts of almonds and fresh weight were found (table 5).

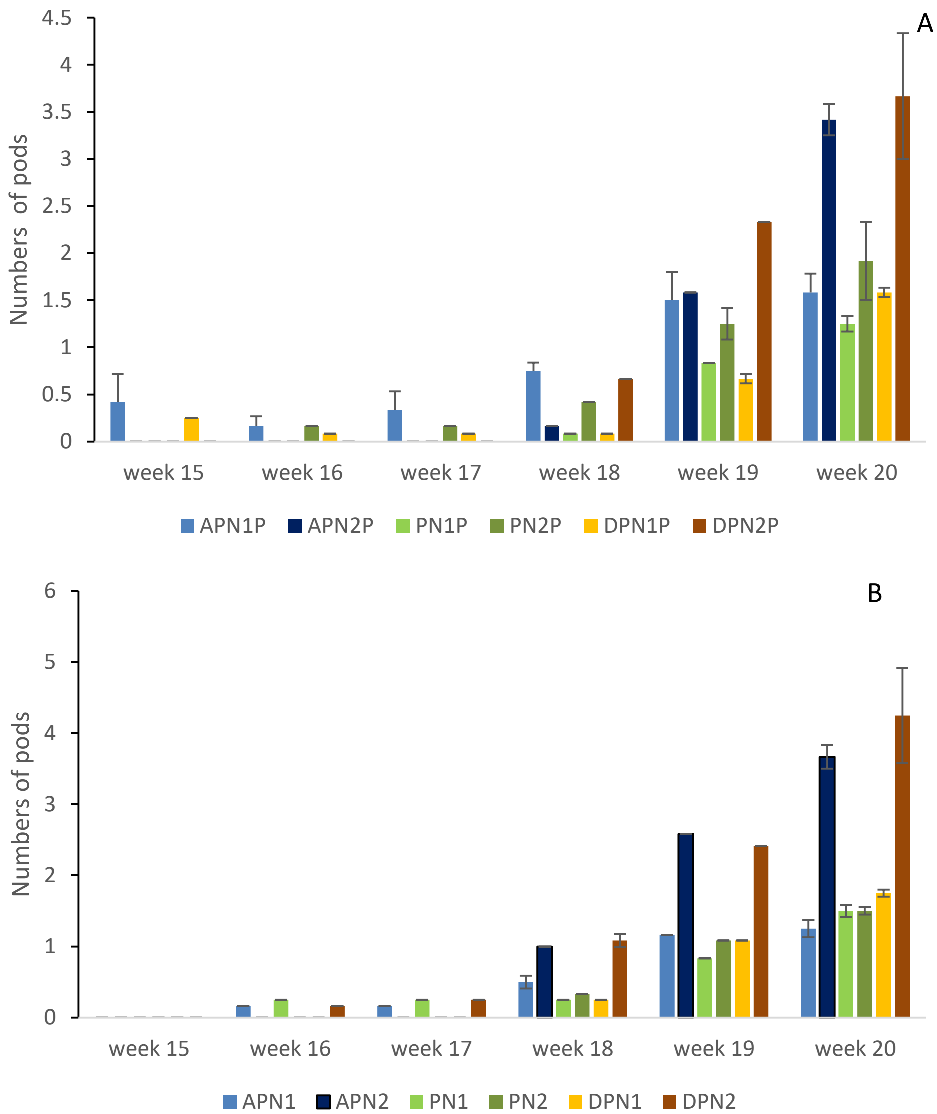


**Figure 3.** Dynamics of the average number of pods between 20-22 cm long in pruned (A) and non-pruned (B) cacao trees with applications of nitrogen of 55 gr/tree (N1) and 110 g/tree (N2) 10 days before pruning (APN) at the time of pruning (PN) and 10 days after pruning (DPN). Weeks refer to weeks after pruning. Lines indicate a standard error of the mean

The effect of applying N in the amount of 110 g/plant after pruning leads to a greater amount of almonds. Previous research coincides with the results of this study. For example. Vega *et al*. (2021) reports that pruning and applying N through organic fertilizers achieves a significant increase of 15% dry weight of almonds per plant in relation to exclusively pruned plants. Even in this last work. the effect of only the application of organic fertilization led weights similar to that obtained with the pruning and organic fertilization treatment. Silva *et al*. (2014) also found that N application increases the number of pods and almonds per pod. However, increases in the fertilization dose of macronutrients also lead to an increase in the number of cherelles. number of emissions and performance. For example, Sitohang *et al* (2021) found that applications of 1344 g/tree in the ratios of 12.9:11.4:16.8:10.6:4.8 of N P K Ca Mg. respectively. produced the highest values of number of flushing. cherelles and greater production. In maintenance pruning. it has been suggested that the relationship between N content and carbohydrate reserves will determine the number of pods that will reach maturity. This relationship is especially affected by the leaf area and the amount of carbohydrates located in the timber part (Wood and Lass. 1985). According to the results of this study it seems that increasing fertilization after pruning helps a greater distribution of this element towards the formation of branches and leaf area that support fruit growth.

**Table 5. Effect of pruning NP (unpruned trees. P: pruned trees) and the dose of N (N1:55 g N2: 110 g) applied 10 days before pruning (AP) at pruning (P) and 10 days after pruning (DP) on the fresh weight of the seeds (seeds + mucilage. g) and number of almonds.**

| Treatment | Pruning type | Fresh weight (g) | Treatment | Pruning type | Number of almonds |
|---|---|---|---|---|---|
| DPN2 | P | 263 ± 2.0 a | DPN2 | P | 56.8 ± 0.8a |
| APN2 | P | 261 ± 3.3a | APN2 | NP | 56.3 ± 1.0 ab |
| APN2 | NP | 254 ± 6.7ab | PN2 | P | 55.8 ± 0.9 ab |
| PN2 | NP | 254 ± 0.7ab | DPN2 | NP | 55.3 ± 0.4 ab |
| PN2 | P | 254 ± 7.2ab | PN2 | NP | 55.3 ± 1.7 ab |
| DPN2 | NP | 253 ± 10.1 abc | APN2 | P | 54.0 ± 0.8 ab |
| DPN1 | P | 248 ± 3.0.abcd | DPN1 | P | 53.8 ± 0.4 ab |
| DPN1 | NP | 246 ± 0.7 abcd | APN1 | P | 53.3 ± 0.6 ab |
| APN1 | NP | 240 ± 3.7 bcd | APN1 | NP | 52.8 ± 06b |
| PN1 | P | 237 ± 08 bcd | DPN1 | NP | 52.8 ± 0.5 b |
| APN1 | P | 236 ± 12.3 cd | PN1 | NP | 52.8 ± 0.8 b |
| PN1 | NP | 232 ± 3.7d | PN1 | P | 52.6 ± 0.6 b |

Different letters in the same column indicate significant differences according to Fischer's test ($p < 0.05$). Values are means ± standard error

## CONCLUSIONS

Pruning affects the dynamics of flushing in the period between the 10th and the 20th week. In this period the time between maximum values decreases in relation to unpruned plants. The application of N in doses of 110 g/tree one week after pruning leads to a significant higher number of flushing, numbers of cherelles and pods. The greater availability of N (110 g N/tree) after pruning allows to a more efficient use for the formation of new pods, greater number of almonds and fresh weight.

**Funding.** Research costs were funded by the authors.

**Interest conflict.** The authors do not have any kind of conflict of interests to declare

**Compliance with ethical standards.** Do not apply

**Data availability.** The data is available with the author for correspondence (**rjaimezarellano@gmail.com** )
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**Author contribution statement (CRediT). C. Cañarte:** Conceptualization. Writing-Review and Editing. Methodology. **R. Jaimez:** Supervision, Conceptualization, Investigation, Writing-Review and Editing. Methodology. **V. Marquez:** Formal Analysis. Methodology. Writing-Review and Editing

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***Appendix A***

**Analysis of variance on the effects of pruning, timing and amount of nitrogen applied on the number of flushes at 10, 11-20 weeks and total numbers of flushes. I**

| | GL | MC Ajust. | Valor F | *p* |
|---|---|---|---|---|
| **Numbers of flushes until 10 week** | | | | |
| Pruning | 1 | 997.51 | 3.93 | 0.049 |
| Moment | 2 | 56.44 | 1.00 | 0.371 |
| Nitrogen | 1 | 1161.67 | 4.45 | 0.037 |
| pruning*moment | 2 | 106.9 | 0.21 | 0.810 |
| pruning*nitrogen | 1 | 5.84 | 0.02 | 0.881 |
| moment* nitrogen | 2 | 296 | 1.17 | 0.315 |
| pruning*moment*nitrogen | 2 | 926 | 3.65 | 0.029 |
| **Numbers of flushes 11-20 weeks** | | | | |
| Pruning | 1 | 7112.1 | 13.94 | 0.000 |
| Moment | 2 | 2265.3 | 4.44 | 0.014 |
| Nitrogen | 1 | 16086.7 | 29.16 | 0.000 |
| pruning*moment | | 669.7 | 1.31 | 0.273 |
| pruning*nitrogen | 1 | 215.1 | 0.39 | 0.533 |
| moment*nitrogen | 2 | 1804.5 | 3.54 | 0.032 |
| pruning*moment*nitrogen | 2 | 198.1 | 0.39 | 0.679 |
| **Total numbers of flushes** | | | | |
| Pruning | 1 | 2782.6 | 3.09 | 0.081 |
| Moment | 2 | 3523.8 | 4.27 | 0.016 |
| Nitrogen | 1 | 25894.2 | 28.75 | 0.000 |
| pruning*moment | 2 | 1083.1 | 1.31 | 0.273 |
| pruning*nitrogen | 1 | 150.1 | 0.17 | 0.684 |
| moment*nitrogen | 2 | 3562.2 | 4.32 | 0.015 |
| pruning*moment*nitrogen | 2 | 406.5 | 0.49 | 0.612 |
| **Cherelle numbers** | | | | |
| Pruning | 1 | 4.3403 | 0.75 | 0.387 |
| Moment | 2 | 23.3819 | 4.05 | 0.020 |
| Nitrógen | 1 | 82.5069 | 14.30 | 0.000 |
| Pruning*moment | 2 | 0.0486 | 0.01 | 0.992 |
| Pruning *nitrogen | 1 | 2.0069 | 0.35 | 0.556 |
| Moment *nitrogen | 2 | 16.3403 | 2.83 | 0.062 |
| Pruning*moment*nitrogen | 2 | 3.2569 | 0.56 | 0.570 |
| **Pods numbers of de 20 cm longitud** | | | | |
| Pruning | 1 | 0.2500 | 0.07 | 0.792 |
| Moment | | 20.8403 | 5.83 | 0.004 |
| Nitrogen | 1 | 90.2500 | 25.24 | 0.000 |
| pruning*moment | | 0.7708 | 0.22 | 0.806 |
| pruning*nitrogen | 1 | 0.1111 | 0.03 | 0.860 |
| moment*nitrogen | | 14.1458 | 3.96 | 0.021 |
| pruning*moment*nitrogen | | 1.3819 | 0.39 | 0.680 |

***Appendix B***

**Analysis of variance of the effects of pruning, timing of application and amount of nitrogen applied on the number of almonds and fresh weight.**

| Number of almonds | GL | MC Ajust. | Valor F | Valor p |
|---|---|---|---|---|
| N | 1 | 80.0833 | 33.33 | 0.000 |
| Pruning | 1 | 0.3333 | 0.14 | 0.712 |
| Moment | 2 | 1.6875 | 0.70 | 0.502 |
| N*pruning | 1 | 0.7500 | 0.31 | 0.580 |
| N*moment | 2 | 0.6458 | 0.27 | 0.766 |
| pruning*moment | 2 | 4.5208 | 1.88 | 0.167 |
| N*pruning*moment | 2 | 3.8125 | 1.59 | 0.219 |
| Fresh weight | | | | |
| N | 1 | 0.003267 | 22.60 | 0.000 |
| Pruning | 1 | 0.000133 | 0.92 | 0.343 |
| Moment | 2 | 0.000270 | 1.86 | 0.170 |
| N*pruning | 1 | 0.000061 | 0.42 | 0.521 |
| N*moment | 2 | 0.000095 | 0.66 | 0.525 |
| pruning*moment | 2 | 0.000024 | 0.16 | 0.849 |
| N*pruning*moment | 2 | 0.000076 | 0.52 | 0.597 |