Response of cashew (*Anacardium occidentale* L.) to pruning systems for yield attributes and nut quality in Tchamba district, Togo

ABSTRACT

The effect of different pruning systems combined with the application or not of chemical fertilizers was studied in Tchamba (Togo) during the 2020-2021 agricultural season. A randomized complete block design with five replications was adopted. There were five treatments in the experiment, F0T0 ($N_0P_0K_0$ + no pruning), F0T1 ($N_0P_0K_0$ + central opening pruning), F0T2 ($N_0P_0K_0$ + modified leader pruning), F1T0 ($N_{15}P_{15}K_{25}$ + no pruning), F1T1 ($N_{15}P_{15}K_{25}$ + central opening pruning), F1T2 ($N_{15}P_{15}K_{25}$ +modified leader pruning). The results revealed that the pruning systems associated or not with fertilization had a positive effect on cashew nut productivity and their quality. Modified leader pruning system associated to $N_{15}P_{15}K_{25}$ gave significantly higher value of growth, and cashew nut yield attributes as compared to other treatments except for the value of kernel output ratio which is statistically identical to the control. Economic analysis showed thatmodified leaderpruning system without fertilizer had a highest acceptabilityindiceas compared to other treatments and can be recommended to producers under the conditions of our study.

***Keywords*:** Cashew nuts, different pruning systems, fertilization, productivity, quality, Togo.

INTRODUCTION

Due to its high potential for export and its inclination to provide growers with a profit, cashew is one of the crops in Togo with the highest economic potential (BM, 2019). On a countrywide area of 18527 acres, cashew nut production employs 18262 producers (DSID, 2015). The national policy for agricultural investment, food security, and nutrition for the decade of 2017–2026 includes cashew cultivation as a sector to be supported because it is a rising industry and one of the country's objectives (MAEH, 2017). The outcomes from the application of current governmental policies in the cashew growing industry are positive. From 2015 to 2018, more land was sown, going from 18527 hectares to 65000 hectares (DSID, 2015; Ricau, 2019).

The most crucial challenge of cashew production in Togo remains the problem of low yields. Indeed, yields in Togo are estimated at 390 kg.ha^{-1}(DSID, 2015)as compared to other countries like India, where the average yield is 800 kg.ha^{-1}(Nayak*et al*., 2020). Numerous factors contribute to this, including dwindling soil fertility and a poor rate of fruit set. By managing the canopy and ensuring enough soil fertility, these issues could be partially resolved. In an orchard, cultural methods, high-quality plant material, and the growing environment all contribute to good productivity and fruit quality (Olubode*et al*., 2018). Flowers appear on the shoots from the current year in cashew (Adiga*et al*., 2019).Thus, pruning by promoting the emission of new buds (Roy*et al*., 2021) multiplies the number of floral buds. Pruning also helps control the tree's size,decrease the incidence of diseases and facilitate the penetration of sprays (Persello, 2018). Reducing aerial biomass by pruning (Marini, 2003) makes carbohydrates more available for the fruit, which positively impacts yield (Uchoi*et al*., 2018).

Cashew pruning is completely new technology in Togo andit's not well understood. For many producers, this technology would rather reduce cahewnut productivity. What can be the real impact of pruning on cashew productivity and quality? This is the question that this study attempts to answer andaims to evaluate the effect of two pruning systems and fertilization on the yield and quality.In Togo, very few studies have been conducted on cashew production, and no study has been conducted on the effect of pruning on cashew production. The current study will act as a foundation for implementing new technology to improve the quality and productivity of cashew nuts. It could be a starting point for future work on cashew nut yield improvein Togo.

MATERIALS AND METHODS

Study site: The study was carried out at a farmer's field in Kouloumi (N: 8.94658, E: 1.55063) in Tchambadistrict (Togo). The area belongs to ecological zone III of Togo and has a Sudanian-type climate with two seasons, dry and rainy. Since the 1970s, there has been a shift in the potentially valuable rainy season in the area, which begins between May 13 and 28 and ends between October 7 and 24(Adewi*et al*., 2010). There is a marked dry season, which runs from November to April. The soil silty-sandy having pH6.01, EC 16.4 µs, C/N 32.1, 3.09% organic matter, .056 % available nitrogen, 1.79% carbon, 34.62 ppm available potassium and 13.78 ppm phosphorus.

Plant material: Cashew (*Anacardiumoccidentale* L.) plants used in this study were ten years old and from a local variety. They are spaced at 8m x 8m. They have stabilized production, and their yield for the 2019-2020 season was 265 kg/ha.

Experimental detail: The trial was set up during the vegetative recovery period (mid-June), which is the best time to prune cashew trees for fruiting under our conditions (Asogwa*et al*., 2008). Randomized complete block design was used. There were five treatments in the experiment, F0T0 ($N_0P_0K_0$ + no pruning), F0T1 ($N_0P_0K_0$ + central opening pruning), F0T2 ($N_0P_0K_0$ + modified leader pruning), F1T0 ($N_{15}P_{15}K_{25}$ + no pruning), F1T1 ($N_{15}P_{15}K_{25}$ + central opening pruning), F1T2 ($N_{15}P_{15}K_{25}$ +modified leader pruning). The fertilizer was applied to the outer third of the canopy in a circular furrow 10 cm deep and then immediately closed. In order to limit the external effects, two lines of plants on the four sides of the field were used as a border. The chemical insecticide imidacloprid (25% EC) was used to treat the trees just after pruning at the rate of one liter per hectare to limit the attacks of insects and phytopathogenic fungi. Two weedings were done during the trial (June and October).

Data collection: Data collected included growth (number of new shoots), number of fertiles inflorescences per square meter, number of fruits per square meter, nut productivity, and nut quality (seediness and kernel output ratio).

20 branches were identified and tagged after trimming, and the new buds on those 20 branches were manually counted to determine the growth rate (Yeshitela*et al*., 2005). After pruning, this count was conducted 60 days later (DAP). The number of viable inflorescences per square meter was counted just before the fruits were fully ripe. Using systematic nut weighing for each treatment,

productivity was evaluated at harvest. According to (Rongead, 2010) approach, the nut quality was assessed for seediness and kernel output ratio (Rongead, 2010).

An economic analysis based on the acceptability index (AI) was calculated. It consists of comparing new treatments' profitability to the reference or control treatment well known by the farmers.

$$\text{Acceptability Index (AI)} = \frac{Treatment\ Benefit}{Control\ benefit}$$

Thus, technology can only be easily adopted if the AI value equals or greater than 2. Adoption is reluctant if this value is between 1.5 and 2; below 1.5, there is rejection (Kaho*et al*., 2011). For the evaluation of benefits, the following expenses were considered: purchase of chemical fertilizers, labor costs for weeding, pruning, fertilizer application, insecticide spraying, harvesting and transportation. The fertilizers' price was 12500 FCFA per 50 kg for NPK 15-15-15 and 18000 FCFA per50 kg for K_2SO_4. The cost of other activities was evaluated in man-days, and was related to the charge of one man-day applied in the study area, i.e., 1500 FCFA. The selling price of one kilogram of nuts retained in this study was 325 FCFA, which matched the average selling price of one kilogramof nuts during the 2020-2021 season.

Statistical analysis: The collected data were entered into an Excel spreadsheet. Before the analysis of variance, the data were subjected to normality and homoscedasticity tests using R software. Whenever these tests were conclusive, an analysis of variance was performed. The Student-Newman-Keuls test was used to discriminate between means when the analysis of variance was significant. For the Pearson correlations between the different variables evaluated, the XLSTAT version 14 software was used, and the level of significance retained is 5%.

RESULTS AND DISCUSSION

Effects of the pruning system and fertilization on the number of new shoots, fertile inflorescences per square meter, the number of fruits per square meter, and productivity.

Pruning positively affectedgrowth and yield attributes whether or not combined with fertilization (table1).

Table 1: Effects of treatments on the number of new shoots, the number of fertiles inflorescences per square meter, the number of fruits per square meter and productivity

Treatments	New shoots on 20 branches	Number of fertilesinflorescences per square meter	Number of fruits per square meter	Productivity (kg per tree).
F0T0	17.2 ± .8 e	5.5 ± .4 d	4.0 ± .7 d	1.28 ± .1 c
F0T1	63.2 ± .8 c	8.9 ± .8 c	8.6 ± 1.9 c	1.4 ± .2 c
F0T2	94.8 ± 1.5 b	11.6 ± 1.1 b	16.7 ± .8 b	4.3 ± .6 b
F1T0	27.8 ± 1.3 d	9.3 ± .8 c	15.7 ± .8 b	3.7 ± .6 b
F1T1	68.4 ± 3.6 c	12.2 ± .8 b	21.9 ± 2.0 a	4.96 ± .7 a
F1T2	134.4 ± 10.1 a	17.4 ± .9 a	23.6 ± 1.3 a	5.38 ± .4 a
Mean	67.6 ± 40.3	10.8 ± 3.8	15.1 ± 7.1	3.5 ± 1.7
Significance codes	***	**	***	***

T0 = no pruning, T1 = open centre, T2 = modified leader, F0: $N_0P_0K_0$ and F1: $N_{15}P_{15}K_{25}$. Codes ** and *** represent significance levels of 1% and .1% respectively according to the Student-Newman-Keuls test.

Analysis of variance revealed a significant difference for the number of new shoots 60 DAP (p= .001). T2F1 (134.4) treatment resulted in an 681.4% increase in new shoots compared to the F0T0 (17.2) control. However, the modified leader system (T2) was more efficient than the open centersystem (T1), as shown by the results: F1T2 (134.4) > F1T1 (68.4) and F0T2 (94.8) > F0T1 (63.2). Theseresults can be explained by the fact that pruning suppresses apical dominance. The suppression of apical dominance acts on the cytokinin: auxin ratio (Dun*et al*., 2006), which by increasing promotes the release of new buds (Rufato*et al*., 2019).The fertilization is also kwon to limits apical dominance (Amissah*et al*., 2022).

The number of fertile inflorescences per square meter is statically higher for pruned plants than unpruned ones. The high significant (p =.01)number of fertile inflorescences per square meter was recorded by T2F1 (17.4) which was 216.4% higher than control T0F0 (5.5). This difference can be explained by the fact that pruning increases the number of new shoots of the current seasonon which appear cashew flowers (Adiga*et al*., 2019). These results corroborate those of Murali*et al*. (2015) who demonstrated that pruning cashew trees combined with foliar fertilizer sprayingsignificantly increases inflorescences per square meter. Pruning also affected positively others yield attributes such as number of fruits per square meter, number of fruits per square meter and productivity.Treatments F1T2 and F1T1 recorded high values for the number of fruitsper square meter and cashew nut productivity. The F1T2 increased 490% of number of fruits per square meter and 320.3% productivity compared to the control F0T0. Reducing aboveground biomass during pruning increases plant productivity and light absorption (Adigaet *al*., 2020). Furthermore, trimming greatly raises the proportion of bisexual flowers, according to Muraliet *al*. (2015). In fact, it has long been known that the proportion of bisexual flowers increases cashew nut output (Kumar and Udupa, 1996). The increased exposure to light from the canopy is what is causing the hermaphroditic flower rate to rise (Waghmare and Joshi, 2008).

Effects of the pruning system and fertilization on cashew nut quality: The analysis of variance of the number of nuts per kilogram and Kernel Output Ratio revealed a significant difference at the .1% level (Table 2). The nuts per kilogram ranged from 159 (F1T2) to 204 (F1T0) with an overall mean of 179.6 ± 20.3. F1T1 (159), while remaining statistically identical to the F0T0 (177), F0T1 (172), F1T1 (180), and F0T2 (186), had a smaller number of nuts per kg (large nuts).F1T2 (51.2) and F0T2 (49.1) recorded the highest value of Kernel Output Ratio. Pruning combined with fertilizer application tended to improve nut weight and kernel output ratio. These results are similar to those of Uddinet *al*. (2014), who found that pruned mango trees produce larger fruit than unpruned mango trees due to the maintenance of the excellent balance between growth and fruiting.

Table 2: Effects of treatment on cashew nut quality

Treatement	Number of nuts per kg	Kernel Output Ratio (lbs per 80 kg)
F0T0	177 ± 14.9 bc	54.8 ± 1.8 a
F0T1	172 ± 10.0 bc	46.1 ± 1.8 d
F0T2	186 ± 17.7 b	49.1 ± .5 c
F1T0	204 ± 26.4 a	44.2 ± 1.6 d
F1T1	180 ± 15.8 bc	45.2 ± .6 d
F1T2	159 ± 4.6 c	51.2 ± 1.1 b
Mean	180 ± 20.3	48.5 ± 3.9
Significance codes	***	***

T0 = no pruning, T1 = open centre, T2 = modified leader, F0: $N_0P_0K_0$ and F1: $N_{15}P_{15}K_{25}$. Code *** represents significance levels of .1%, respectively, according to the Student-Newman-Keuls test.

The global average of number nuts per kg was 180±20.3and kernel output ratiowas 48.5 ±3.9. These values correspond according to the scale ofRicau (2013)to the class of large nuts and acceptable quality.

Correlations between cashew nut yield attributes and quality parameters: The results indicated that productivity was positively and significantly correlated to the number of fertile inflorescences per square meter, which was also significantly positively correlated to the number of current season shoots (table 3). The productivity was positively correlated but not significantly to thenumber of nuts per kg (p=.7256). These results corroborate those of Kumar*et al.* (2014) who found a favourable correlation between productivity and the amount of fruits produced per square meter. When a tree produces more fruits, there is a higher need for water and photoassimilates, which is why there is no statistically significant correlation between kernel production ratio and productivity. The likelihood of having fewer full nuts is therefore greater than that of a tree with lesser output. Nut content per kilo revealed a weakly negative, but not statistically significant, connection with kernel output ratio. Smaller nuts have fewer high-quality kernels inside their shells, which can be the cause of this outcome.

Table 3: Pearson correlation coefficients between different production variables in cashew

Variables	**Currentseason shoots**	**Number of fertile inflorescences**	**Number of fruits per square meter**	**Productivity**	**Kernel Output Ratio**	**Number of nuts per kg**
Currentseason shoots	**1**					
Number of fertile inflorescences	**.906**	**1**				
Number of fruits per square meter	**.704**	**.873**	**1**			
Productivity	**.653**	**.817**	**.954**	**1**		
Kernel Output Ratio	.0575	-.0982	-.334	-.234	**1**	
Number of nuts per kg	**-.417**	-.256	-.057	.067	-.314	**1**

Values in bold are different from zero with a significance level at the 5% level.

Economic evaluation: The economic assessment of the different treatments revealed that 4 out of 5 treatments have an acceptability index higher than 2 (table 4). Treatment T2F0 (modified leader and$N_0P_0K_0$) gave the highest acceptability index (5.4). It was followed by treatments T2F1 (modified leader and $N_{15}P_{15}K_{25}$), T1F1(open centerand $N_{15}P_{15}K_{25}$) and T0F1 (no pruning and$N_{15}P_{15}K_{25}$), which had acceptability indices of 4.3, 3.9 and 2.9 respectively. These results imply that pruning technology combined with fertilization can be proposed to farmers with more chance of adoption (Kaho*et al*., 2011; Miningou*et al*., 2020). However, the T2F0 treatment with the highest acceptability index is more recommendable under the conditions of our study.

Table 4: Economic analysis of different treatments

Traitements	Costs of weeding and imidacloprid spraying (FCFA)	Cost of harvest(FCFA)	Costs related to technology (FCFA)	Total variablecosts (FCFA)	Yield (kg.ha^{-1})	Brut income (FCFA)	Net income (FCFA)	Acceptability Index
T0F0	32000	8100	0	40100	200	65000	24900	-
T0F1	32000	23400	75500	130900	577	187525	56625	2.3
T1F0	32000	8850	16500	57350	218	70850	13500	.5
T1F1	32000	31400	92000	155400	774	251550	96150	3.9
T2F0	32000	27200	24000	83200	671	218075	134875	5.4
T2F1	32000	34000	99500	165500	839	272675	107175	4.3

In conclusion, the study results show a good response of cashew plants to the two pruning systems (open center, and modified leader) associated with the addition of chemical fertilizer ($N_{15}P_{15}K_{25}$) through an improvement in cashew nut productivity and quality. Given the acceptability indices of the economic analysis of the different treatments, we can say that these technologies are viable and applicable in our study conditions.

REFERENCES

Adewi, E., K.M.S Badameli and V. Dubreuil, 2010. Evolution of rainy seasons potentially useful for Togo on the 1950-2000 period. *Climatologie*, 7: 89-107.

Adiga, J.D., B.M Muralidhara, P. Preethi and S. Savadi, 2019. Phenological growth stages of the cashew tree (Anacardium occidentale L .) according to the extended BBCH scale. *Ann. Appl. Biol.*, 175: 246-252.

Adiga, J.D., G.L. Veena, V. Thondaiman and M. Babli, 2020. An overview of canopy management in cashew (Anacardium occidentale L.). *J. Hortic. Sci.*, 15, 127-135.

Amissah, J.N., F.E. Alorvor, B. A. Okorley, C.M. Asare, D. Osei-safo, R. Appiah-opong and I. Addae-mensah, 2022. Mineral fertilization influences the growth, cryptolepine yield, and bioefficacy of cryptolepis sanguinolenta (Lindl.) Schlt. *Plants*, 11: 11-16.

Asogwa, E.U., L.A. Hammed and T.C.N. Ndubuaku, 2008. Integrated production and protection practices of cashew (*Anacardium occidentale*) in Nigeria. *African J. Biotechnol.,* 7: 4868-4873.

BM, 2019. *Etude sur l'inclusion économique des jeunes dans des chaînes de valeur à fort potentiel de marché et d'emploi*. Lomé, Togo.

DSID, 2015. *Rapport final Recensement des planteurs et plantations d'anacarde au Togo*.

Dun, E.A., B.J. Ferguson and C.A. Beveridge, 2006. Apical dominance and shoot branching. Divergent opinions or divergent mechanisms? *Plant Physiol.*, 142: 812-819.

Kaho, F., M. Yemefack, P. Feujio-Teguefouet and J. Tchantchaouang, 2011. Effet combiné des feuilles de Tithonia diversifolia et des engrais inorganiques sur les rendements du maïs et les propriétés d'un sol ferralitique au Centre Cameroun. *Tropicultura*, 29: 39-45.

Kumar, D.P. and K.S.Udupa, 1996. The association between nut yield attributing characters in cashew

(Anacardium occidentale L.). *Cashew*, 10(1): 11-17.

Kumar, B.P., K.H. Babu and D. Srihari, 2014. Effect of time and level of pruning on flowering, fruit and yield of cashew (Anacardium occidentale L.). *Acta Hortic.*, 42: 133-138.

Maeh, 2017. *Programme national d'investissement agricole, de sécurité alimentaire et nutritionnelle* (PNIASAN). MAEP, Togo.

Marini, R.P., 2003. Physiology of pruning fruit trees. Virginia Cooperative Extension Publication no. 422-025, Blacksburg, Virginia, USA.

Miningou, A., V. Golane, A.S. Traore and H. Kambire, 2020. Determination of the optimal dose and date of application of mineral manure on sesame (sesamum indicum L.) in Burkina Faso. *Int. J. Biol. Chem. Sci.,* 14: 2992-3000.

Murali, K., P.P. Kumar and M.S.A. Rani, 2015. Effect of Tertiary Shoot Pruning and Foliar Spray of Nutrients on Flowering and Yield of Cashew (Anacardium Occidentale L .) Under High Density Planting System. *The Biescan*, 10: 411-415.

Nayak, M.G., B.M. Muralidhara, P. Janani and S. Siddanna and S. Savadi, 2020. Performance of cashew (Anacardium occidentale) varieties under different planting density for growth and yield traits. *Indian J. Agric. Sci.,* 90: 1453-1459.

Olubode, O.O., T.T Joseph-Adekunle, L.A. Hammed and A.O.Olaiya, 2018. Evaluation of production practices and yield enhancing techniques on productivity of cashew (Anacardium occidentale L.). *Fruits,* 73: 75-100.

Persello, S., 2018. Réponse du manguier (Mangifera indica L.) à la taille: caractérisation et intégration dans un modèle structure-fonction des effets de la taille sur la croissance végétative et la reproduction. Thèse Dr. en Sci. Agron. Université de Montpellier, France.

Ricau, P., 2013. Connaître et Comprendre le marché international de l'anacarde. RONGEAD.

Ricau, P., 2019. The west african cashew sector in 2018: General trends and country profiles, Nitidæ Landscape and Value Chains.

Rongead, 2010. L'out-turn ou comment mesurer la qualité de l'anacarde ?

Roy, A., M. Viswanath, L. Gowthami and S.P. Nanda, 2021. Training : A tool for canopy management in fruit crops. P*harma Innov. J.,* SP-10: 361-364.

Rufato, L., L.D.R. Marchioretto, J.C. Orlandi, M.F. Michelon, A. De Rossi, G.F. Sander and T.A. de Macedo, 2019. Lateral Branch Induction At Nursery With Growth Regulators in 'Maxi Gala' Apple Trees Grafted on Four Rootstocks. *Sci. Hortic*., 253: 349-357.

Uchoi, A., S. Balakrishnan, N. Gopal and D. Uma, 2018. Impact of canopy management on flowering and yield attributes of cocoa (Theobroma cacao L.) under tropical condition of Tamil Nadu. *Int. J. Chem. Stud.,* 6: 629-663.

Uddin, M.S., M.F. Hossain, M.S. Islam, M.M. Hossain and M.S. Uddin, 2014. Effect of post-harvest pruning on the control of tree size and yield of mango. *Bull. Inst. Trop. Agric. Kyushu Univ.*, 37: 41-46.

Waghmare, G. M. and Joshi, G. D. 2008. Response of mango (*Mangifera indica* L.) to light pruning for vegetative and flowering flushes. Indian J. Agri. Sci. 78: 651-654.

Yeshitela, T.A., P.J.A. Robbertse and P.J.C.B. Stassen, 2005. Effects of pruning on flowering , yield and fruit quality in mango (Mangifera indica). *Aust. J. Exp. Agric.*, 45: 1325-1330.