



RESEARCH ARTICLE

EFFECT OF CROPPING SYSTEMS ON THE NUTRITIONAL VALUES OF CASHEW IN AGRO-ECOLOGICAL ZONES OF CASHEW TREES IN BENIN

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Abstract

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Key words:-

Cashewtree, Nutrients, Organoleptic Cropping System, Benin

Description of subject: Cashew fruits are still exported mainly according to their size and color, but neither of these two characteristics takes into account the nutritional potential of the almond and the cashew apple.

Objective: The present research aims to assess the effect of cropping systems on the nutritional values of apple and cashew kernel.

Materials and Methods: The physico-chemical analyzes were performed in the laboratories and the data were processed using Microsoft Excel 2010 and SPSS v16.0 software. Frequency calculations and analysis of variance (ANOVA) were determined.

Results: A significant variation ($p < 0.05$) of the nutritive phosphorus (16.95 ± 0.21) was obtained in apples in the cropping system (cashew-soybean) against (7.6 ± 0.57) in the pure cashew culture (absolute control) and in cashew kernel (10.25 ± 0.07) in a culture system (cashew-soybean) against (10.15 ± 0.072) in a pure cashew culture system. Variations in taste and odor were observed in the cashew-soybean cropping system. In addition, the cashew-soybean cropping system induced the lowest tannin contents in cashew apples (0.261 ± 0.14) compared to the cashew-cotton cropping system (0.268 ± 0.071).

Conclusion The cashew-soybean cropping system deserves to be encouraged in the context of optimizing cashew yields, exporting nutrients and reducing tannin in almond and cashew apple in Benin.

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Introduction:-

The cashew tree (*Anacardium occidentale* L.) is a plant native to Brazil. Today cashew has become the second export product after cotton in Benin. Whereas, the cashew apple is a product of great food and nutritional value, does not receive special attention by producer-planters and consumers. A large number of constraints still hamper the production of nuts and the consumption of cashew apples in Benin. Cashew nut production in Benin is characterized by a production system where annual crops are systematically associated with the cashew tree during a good part of its vegetation cycle. The succession of annual crops depends both on the level of ground cover by cashew trees and

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on soil fertility. The most light-demanding crops such as cotton, yam, corn is more associated with the start of the cashew tree vegetation. According to (Balogoun *et al.*, 2014), the advantages of these associations according to the peasant perception come down to a good occupation of agricultural space, a diversification of production, obtaining a double income, ease of maintenance of the cashew tree plantation and the benefit that these harvests provide. These low yields can compromise the competitiveness of domestic production if production is not substantially improved by appropriate innovations. According to (AFSSA, 2003), the addition of a nutrient can increase yields only if the element from the soil is the first factor limiting the yield of which the performance of the tree decreases and the result is at the end of nutritional disorders in fruits. Unfortunately, previous studies have not shown in their research the influence of cropping systems on the nutritional and organoleptic values of cashews in Benin. The objective of this work is to assess the effect of cropping systems on the nutritional values of cashew according to the agro-ecological zones of the cashew tree in Benin.

Materials and Methods:-

Description of the study area

The Republic of Benin covers an area of 114.760 km². It is located between 6 ° 15' and 12 ° 25' north latitude and between 0 ° 40' and 3 ° 45' longitude. It stretches from north to south over a length of 700 km. The chronological analysis of the flora of the phytogeography districts and of the climate made it possible to identify four cashew production zones in Benin: the very favorable zone, the favorable zone, the less favorable zone and the marginal zone. Figure 1 shows the geographic location of the study area

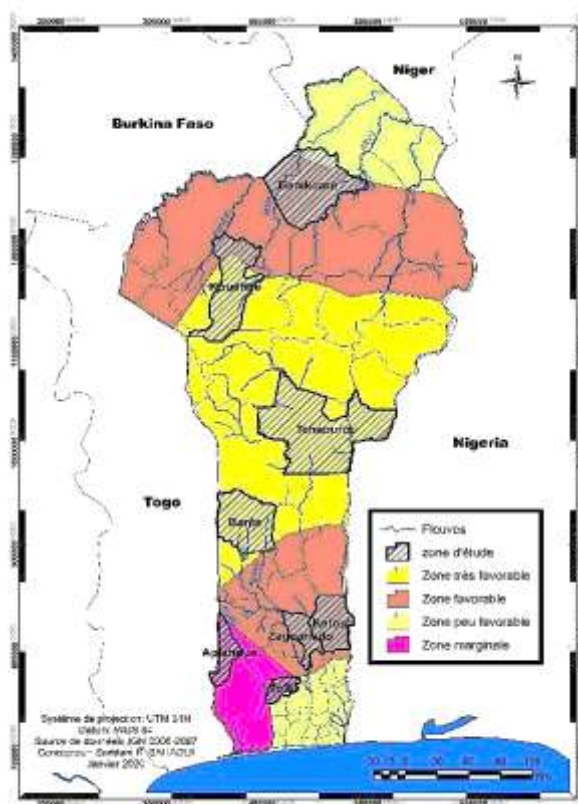


Figure 1: Map of Benin presenting the study areas.

Source: Survey results, 2020

Collection and chemical analyze of cashew almonds and apple according to agro-ecological zones

This analysis made it possible to characterize the nuts according to the different zones. So, samples were collected as follows: Fifteen (15) kilograms of raw nuts were collected and purchased from producers / planters per locality and per zone, ie 15 kg per zone. This collection is carried out in the four zones. From the overall sample of 15 kg constituted by zone, it is taken from the 5 kg homogenized mixture (sampling rate = 33.33%) for the analysis of

nutritional parameters. In sum, 20 kg of nuts were collected. Table 1 shows the research units. The table 1, shows the research units

Agro-ecological zones (ZAE)	Municipalities	Villages	Number of respondents Producers	Number of orchards prospected	Number of trees marked	Samples walnuts and apple
ZTF	Tchaourou	Goro	60	10	120	5
ZF	Banikoara	Founougo	60	10	120	5
ZPF	Zagnanado	Banamè	60	10	120	5
ZM	Aplahoué	Atomè	60	10	120	5
TOTAL			240	40	480	20

ZTF= Very Favorable Agro-Ecological Zone, ZF= Favorable Agro-Ecological Zone, ZPF = Unfavorable Agro-Ecological Zone, ZM =Marginal Agro-Ecological Zone.

Source: Survey results, 2020

Plantmaterial

Regarding the plant material, we used cashew apples. These fruits were harvested in the cashew orchards of ZTF (Tchaourou), ZF (Banikoara), Peu Favorable (Zangnando) and Marginale (Aplahoué). The evaluation of the chemical parameters was carried out at the Laboratory of Soil Sciences, Water and Environment (LSSEE) of the National Institute of Agricultural Research of Benin (INRAB)

Statistical analysis

All physico-chemical determinations were performed in triplicate and the data were processed using Microsoft Excel 2010 and SPSS version 16.0 software with which we performed frequency calculations and analysis of variance (ANOVA). The variability of the organoleptic parameters studied was tested according to the acceptability tests and the descriptive test of cashew apple juice according to the Duncan test.

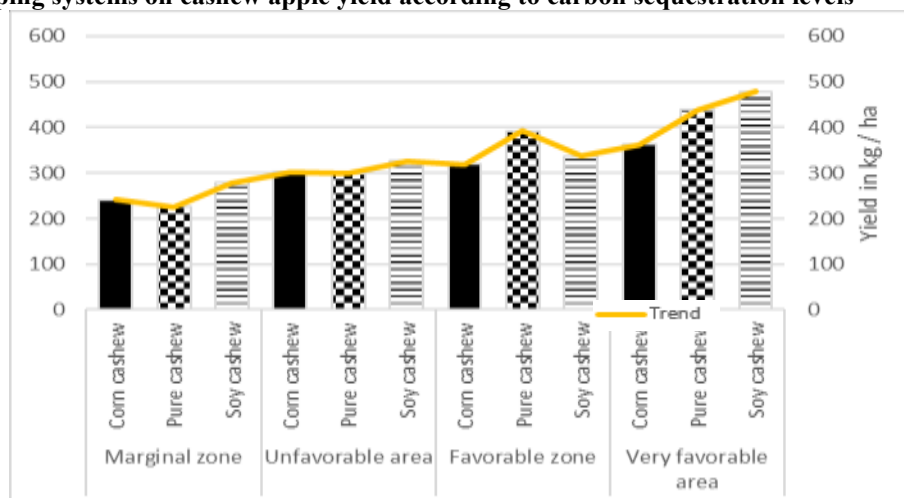
Results:-

Table 2 shows the geographic coordinates of the orchards surveyed within the agro-ecological zones of cashew production in Benin

Sites	Latitude	Longitude	Elevation (m)	Rainfall Regime
Goro	4°42.095 N	9°93.031 E	347	Uni modals
Founougo	4°61.545 N	12°43.873 E	313	Uni modals
Banamè	4°37.197 N	7°96.325 E	336	Bi modals
Atomè	3°67.064 N	7°51.913 E	612	Bi modals

Source: Survey results, 2020

Effect of cropping systems on cashew apple yield according to carbon sequestration levels



Source: Survey results, 2020

Nutritional composition of cashew kernel according to cropping systems according to agro-ecological zones of the cashew tree

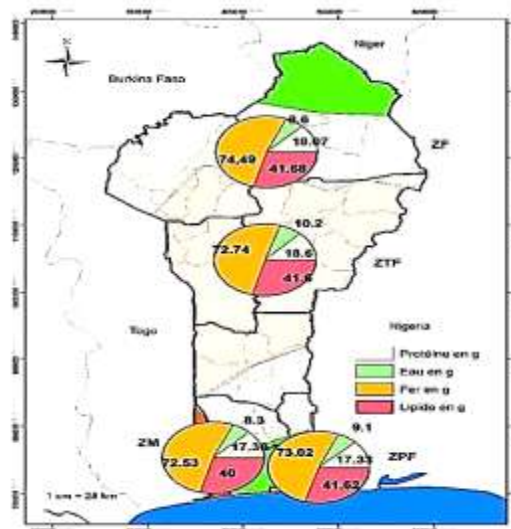
Table 3 shows the nutritional composition of the cashew kernel according to the cropping systems according to the agro-ecological zones of the cashew tree.

ZAE	Culture system	Phosphorus content (g)	Protein Content (g)	Fat content (g)	Calcium content (mg)
ZTF	Pure cashew nut	10.15±0.072a	18.4±0.28a	40.1±0a	17.05±0.07a
	Soy cashew	10.25±0.07 a	18.7±0.14a	43.35 ± 1.77b	17.45±0.21a
	Corn cashew	10.2 ±0 a	18.6±0.42a	41.7±0.57a	17.5±0.42ba
	Cotton cashew	101±0a	18.75±0.21a	41.25±1.34b	17.7±0.28a
	Average	10.175±0.07A	18.6125±0.26A	41.6±1.51A	17.425±0.33A
ZF	Pure cashew nut	10.1±0.14 a	17.7±0.71a	40.5±0.07a	16.7±0.85a
	Soy cashew	7.4±1.13 b	17.9±0a	42.55 ±2.47b	18.15±0.78b
	Corn cashew	8.75±0.63b	18.25±0.78b	41.09 ±1.43a	16.7±0.85a
	Cotton cashew	8.35±0.1b	18.45±0.21b	42.95±0.92b	18.2±0.14b
	Average	8.65±1.14B	18.075±0.51A	41.685±1.65A	17.4375±0.96B
ZPF	Pure cashew nut	7.65±0.78a	16.2±0a	40.89 ±0.27a	16.7±0.71a
	Soy cashew	7.7±0.57a	17.35±0.35b	41.8 ±0.57b	18.3±0.14b
	Corn cashew	10.8±b	17.85±1.06c	42.1±1.84c	18.3±0.18b
	Cotton cashew	9.9±0.42b	17.95±0.21c	4.705±0.45b	17.15±0.071a
	Average	9.0125±1.52A	17.3375±0.86B	41.62375±0.35B	17.612±0.50B
ZM	Pure cashew nut	8.5±0.21a	17.75±0.64a	40.45±0.35a	17.45±0.28a
	Soy cashew	8.4±0.42a	18.1±0.14a	40.35 ±0,071b	17.6±0.42b
	Corn cashew	8.55±0.50a	16.85±0.35b	40.35±0b	17.6±0,42b
	Cotton cashew	8.1±0.00a	16.75±0.64b	40.5±0,42a	17.35±0.071a
	Average	8.375±0.32B	17.3625±0.72B	40.575±0.39B	17.5±0.29AB
	General average	9.053125±1.15	17.846875±0.8	41.370938±1.25	19.084375±8.7

In the same column, the means followed by the same alphabetical letters are not significantly different ($P < 0.05$) according to the Student Newman-Keuls test.

ZTF= Very Favorable Agro-Ecological Zone, ZF= Favorable Agro-Ecological Zone, ZPF = Unfavorable Agro-Ecological Zone, ZM =Marginal Agro-Ecological Zone.

Source: Survey results, 2020



The figure 3, shows the nutritional composition of cashew kernel according to cropping systems according to the agro-ecological zones of the cashew tree

Source: Survey results, 2020

From the analysis of this figure 3 and table 3, it emerges that the cropping systems have an influence on the nutritional values of cashew kernels which vary according to the agro-ecological zones of the cashew tree in Benin.

Nutritional composition of the cashew apple according to the cropping systems according to the agro-ecological zones of the cashew tree

Table 4 shows the nutritional composition of the cashew apple according to the cropping systems according to the agro-ecological zones of the cashew tree

ZAE	Culture System	Phosphorus (mg)	Potassium (mg)	Calcium (mg)	Tannin (g)	Degré Brix
ZTF	Pure cashew nut	7.6 ±0.57a	562.2±0.15a	5±0.14a	0.35±0.21a	15±0.00a
	Soy cashew	16.95±0.21b	566.05±0.07b	4.35±0.07b	0.261±0.14a	17±0.00b
	Corn cashew	8.05±0.35c	568±0.14c	5±0.14a	0.65±0.00b	16±0.00c
	Cotton cashew	13.05±0.21d	568.8±0.20c	5.25±0.08a	0.268±0.071a	20.5±0.71d
	Average	11.4125±4.12A	566.2625±2.73A	4.9±0.37A	0.286±0.37A	17.125±2.23A
ZF	Pure cashew nut	15.5±0.42a	564.2±0.14a	5.35±0.21a	0.311±0.13a	18±0.00a
	Soy cashew	17.5 ±0.50b	567.3±0.16b	4.2±0.16b	0.259±0.14b	16.5±0.71b
	Corn cashew	13. ±0.14c	568.3±0.29c	3.75±0.21c	0.261±0.3c	15±0.00c
	Cotton cashew	12.95 ±0.21d	568.05±0.21c	4.2±0.14d	0.261±0.14c	21.5±0.171d
	Average	14.775±1.98A	566.9625±1.75A	4.375±0.65A	0.260±0.70A	17.75±0.61A
ZPF	Pure cashew nut	11.2 ±0.14a	565.2±0.14a	2.15±0.8a	0.32±0.07a	14±0.00a
	Soy cashew	14,3 ±0.15b	567.3±0.28b	1.3±0.14b	0.259±0.07b	16±0.00b
	Corn cashew	10.15 ±0.07a	567.8±0.14b	2.8±2.26c	0.260±0.28c	15±0.00c
	Cotton cashew	12.45±0.08c	568.35±0.07c	3.65±0.64d	0.261±0.14d	22±0.00d
	Average	12.025±1.65B	567.1625±1.28B	2.475±1.31B	0.59±1.31AB	16.75±3.33B
ZM	Pure cashew nut	14.15 ±0.10a	563.05±1.22a	3.45±0.50a	0.299±0.21a	20.5±0.7a
	Soy cashew	18.2±0.1b	565±0.14b	2.6±0.28b	0.261±0.06b	14.5±0.71b
	Corn cashew	14.2 ±0.14a	564.45±0.21c	4.1±0.28c	0.261±0.14c	16±0.00c
	Cotton cashew	15.15±0.11c	567.3±0.14d	4.35±0.07c	0.261±0.14c	18.5±0.707d
	Average	15.425±1.77A	564.95±1.64C	3.625±0.76B	0.260±1.05B	17.375±2.0B

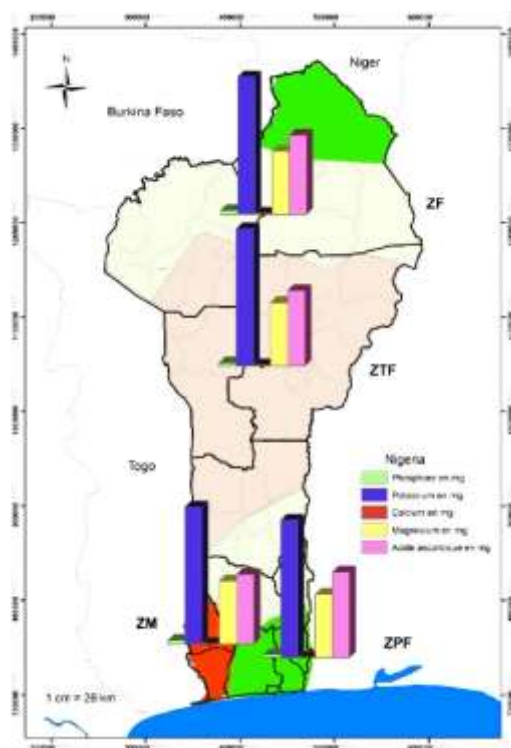
In the same column, the means followed by the same alphabetical letters are not significantly different ($P < 0.05$) according to the Student Newman-Keuls test.

ZTF = Very Favorable agro-ecological zone; ZF = Favorable agro-ecological zone; ZPF = Unfavorable agro-ecological zone; ZM = Marginal agro-ecological zone

Source: Survey results, 2020

From the analysis of the results, it emerges that the chemical composition content of the cashew apple in phosphorus, potassium, calcium, tannin and degree Brix varies according to the cropping systems and production areas (ZAE). For the brix degree, it is the cashew-cotton, cashew-soybean and pure cashew crop systems which have a high content.

The figure 4, shows the nutritional composition of the cashew apple according to the cropping systems according to the agro-ecological zones of the cashew tree



Source: Survey results, 2020

Organoleptic characteristics of cashew apple juice in a cultivation system according to the agro-ecological zones of the cashew tree

Table 5 shows the organoleptic characteristics of cashew apple juice according to the cropping systems according to the agro-ecological zones of the cashew tree

ZAE		ZTF (%)	ZF (%)	ZPF (%)	ZM (%)	Total (%)
Odour	Very strong	48.50	47.00	48.10	46.99	47.67
	Strong	39.00	43.00	43.33	42.62	41.99
	average	12.50	10.00	8.57	10.38	10.34
Sweet taste	Very sweet	56.50	14.00	16.67	18.03	26.36
	sweet	14.00	11.50	14.29	9.84	12.48
	Little sweet	29.50	74.50	69.05	72.13	61.16
Acid taste	Acid	30.00	74.50	69.05	71.04	61.03
	Little acid	59.00	25.50	30.95	28.96	36.19
	Not acidic	11.00	0.00	0.00	0.00	2.77
Astringent taste	Astringent	35.00	44.50	42.86	46.99	42.24
	Little astringent	64.00	53.50	55.24	50.82	55.99
	Not astringent	1.00	2.00	1.90	2.19	1.77

ZTF= Very Favorable Agro-Ecological Zone, ZF= Favorable Agro-Ecological Zone, ZPF = Unfavorable Agro-Ecological Zone, ZM =Marginal Agro-Ecological Zone.

Source: Survey results, 2020

From the analysis of this table 5, it emerges that the organoleptic quality (taste and smell) of cashew apples varies according to the cropping systems and agro-ecological zones.

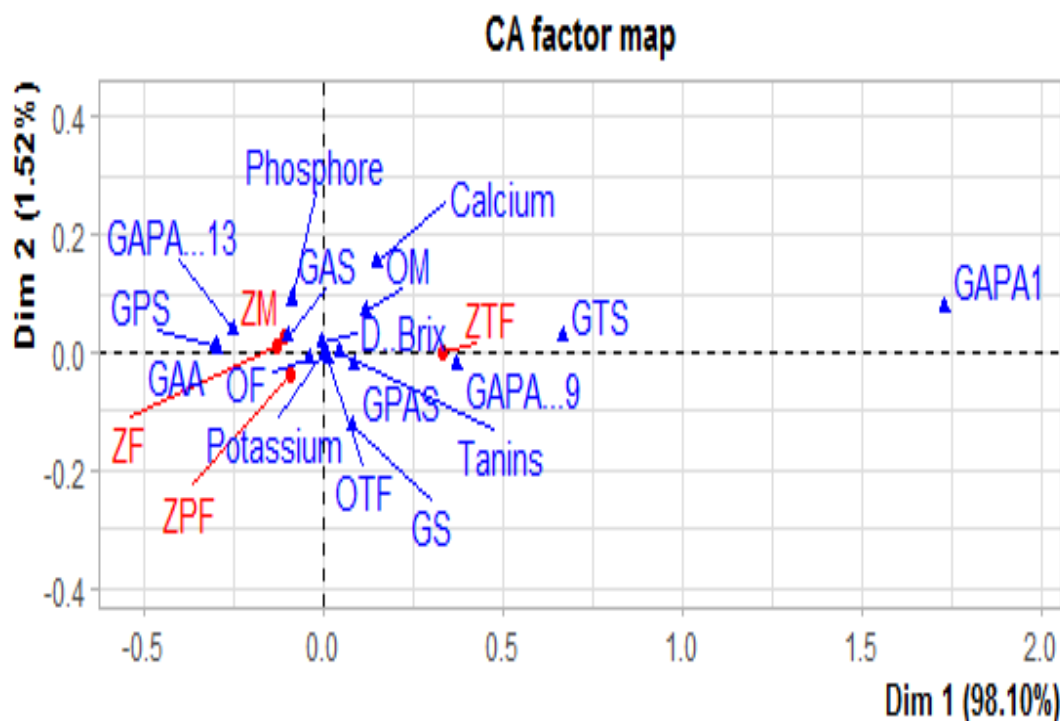
Effect of the agro-ecological zones of the cashew tree on the organoleptic and nutritional characteristics of cashew apple juice

The table 6, presents the links that exist between agro-ecological zones, nutritional values and organoleptic qualities

	Dim.1	Dim.2	Dim.3
Variance	0.037	0.001	0.000
% of var.	98.095	1.516	0.389
Cumulative %	98.095	99.611	100.000

Source: Survey results, 2020

The analysis of the results according to the perceived level of organoleptic quality and the level of phosphorus, tannin, potassium, calcium and glucose content, made it possible to establish a factorial map in order to see the links that can be established between the nutritional values. and the agro-ecological zones of the cashew tree in Benin. The figure 5 shows these links.



Source: Survey results, 2020

The analysis of the results according to the perceived level of organoleptic quality and the level of phosphorus, tannin, potassium, calcium and glucose content, made it possible to establish a factorial map in order to see the links that can be established between the nutritional values. and the agro-ecological zones of the cashew tree in Benin. The figure 5 shows these links. With OTF = Very Strong Odor, OF = Strong Odor, OM = Average Odor, GTS = Very Sweet Taste, GS = Sweet Taste, GPS = Low Sweet Taste, GAA = Acid Taste, GAPA ... 9 = Low Acid Taste, GAPA1 = Taste Not Acid 1, GAS = Taste Astringent, GPAS = Taste Little Astringent, GAPA ... 13 = Taste Not Astringent.

Analysis of the results shows that only apple juice from very favorable production areas (ZTF) have specific characteristics. Apple juices are distinguished by a low Acid Taste (GAPA ... 9), a Very Sweet or sweet Taste (GTS and GS). The nutritional composition is not significantly different between the different agro-ecological zones.

Discussion:-

The results of the physico-chemical analyze of apples and almonds showed a variation in nutritional values depending on the agro-ecological zone and the cropping systems. These variations could be explained by the

difference in genetic material, the type of soil and on the other hand, the age of the cashew trees, the cultivars and the type of cropping system in these agro-ecological zones. These results corroborate with them (Giauque *et al.*) and (Affo, 2005) who have shown an influence of cultivation practices on the quality of apples and cashews in Benin. Our results showed that the cashew-soy cropping system significantly improved the production of cashew nuts and apples regardless of the production age. In fact, Amiot-Carlin *et al.*, 2007 have shown that soils which regularly receive crop residues make it possible to obtain higher nutritional values at the fruit level. The organoleptic quality of cashew apple juice is also an important factor in the assessment of the marketability of cashew juice. Cashew apple juices from the ZTF cashew-soybean cropping systems are better accepted than those from the ZF cashew-maize and cashew-cotton cropping systems. These results demonstrate the association of crops as a cultivation practice for improving the nutritional and organoleptic quality of cashew fruits. Hence the need to install annual crop associations in cashew plantations in Benin in order to prevent nutrient degradation in the soils and in the apple and cashew kernel of the agro-ecological zones of the cashew tree in Benin.

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The research team would like to thank the technicians of the Science Laboratory of the Soil, Water and Environment (LSSEE) in this case Mr. Claude A. A. KANNINKPO without forgetting the processing unit "Val des fruits" located in Parakou which housed the preparation and the hedonic test of apple juice.

Conflict of Interest

The authors have declared no conflicts of interest.

Conclusion:-

This research has enabled us to understand the evolution of the physico-chemical parameters of apple and cashew kernel depending on the cropping systems and agro-ecological zones of the cashew tree. So, the association of annual soya-based cultivation with cashew trees can increase the productivity of the cashew tree in Benin. This form of land management technology is fundamental for the sustainable management of cashew plantations in order to improve the nutritional values of almonds and cashew apples in Benin.

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