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Study of Intercropping System Castor Bean and Legumes on Seeds Yield and Yield Related Traits in Two Agroecological Zones of Cameroon

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Original Research Article

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Abstract: The experiment was conducted under field conditions at Ngaoundéré and Bertoua, respectively in the Sudano-Guinean and Bimodal Forest zones in Cameroon and during the two consecutive cropping seasons of 2015 and 2016. Randomized complete block design with three replications was used and seven treatments: monocrop castor bean, soybean, cow bean and common bean; intercropping system castor bean-soybean, castor bean-cow bean and castor bean-common bean. Plants growing and production parameters was assessed. Comparison of the performance of each farming system was made on the basis of the Land Equivalent Ratio (LER). Results indicate that castor bean and Legumes productivity varies depending intercropping system, study zone and experimentation years. Castor bean seeds yield in intercropping with soybean, cow bean and common bean are 10.09, 13.52 and 17.88% folds greater than castor bean in monocrop. Castor bean is significantly ($p< 0.05$) more productive in Sudano-Guinean zone (seeds yield: 160.97±1.93 Kg/ha) compared to Bimodal Forest zone (143.76±2.05 Kg/ha) of Cameroon and inversely for Legumes. Castor bean and Legumes productivity is better in 2015 than 2016. LER varies from 1.05 in intercropping system castor bean-soybean in 2016 to 1.33 in intercropping system castor bean-common bean in 2015. Intercropping system castor bean-Legumes are advantageous for Cameroonian farmers. However intercropping castor bean-common bean is more effective compared to both castor bean-soybean and castor bean/cow bean systems. The Sudano-Guinean zone of Adamaoua Cameroon is more favourable for castor bean growth during Legumes growth in Bimodal Forest of East Cameroon better. By cultivating castor bean in intercropping with Legumes, Cameroonian peasants contribute not only to fight against climate change but also to ensure food security.
Keywords: Intercropping System, Castor Bean, Legumes, Cameroon.

INTRODUCTION

Intercropping is the growing of two or more crops simultaneously on the same field [1]. Intercropping can be used by small farmers to increase the diversity of their product and the stability of their annual output through effective use of land and other resources [2]. Intercropping is used in many parts of the world for the feed crops production [3]. Successful, intercropping corn and soybean has been reported since the early 1900s in North America [4]. In this respect, several scientists [5], have been working with Cereal-Legumes intercropping systems in sub-Saharan Africa and proved its success compared to the monocrop. In this region, one of the most important reasons for smallholder farmers to intercrop is to minimize measures against total crop failures and to get different produces to take for his farm food and income [6]. Intercropping systems use more efficient growth factors because they capture more radiation and make better use of the available water and nutrients, reduce pests, diseases and suppress weeds, favour soil physical conditions and improve bean fertility for plant growth [7].

Castor bean (*Ricinus communis* L.) is a bean seed plant with bean content between 40 and 60% [8]. Castor bean is widely used for its lubricating properties and medicinal purposes. In industry, castor bean is used for the manufacturing of biofuels, soaps, lubricants, hydraulic and brake fluids, paints, dyes, coatings, inks, cold-resistant plastics, waxes and polishes, nylon, pharmaceuticals and perfumes [9]. Castor bean is considered to be native to tropical Africa [10], but it is cultivated in many tropical and subtropical regions of the world [11]. India alone exports 80% of castor bean and therefore largely dominates the market. Brazil, China, India and the countries of the former Soviet Union are the major producing countries. Seeds yields in these countries are generally low, between 400 and 900 kg/ha [12]. The yield of castor bean genotype reported in the literature varied from 2000 to 2620 Kg/ha in France [13] and 1500 to 2500 Kg/ha in Italy [14]. However, since castor plants have not been

systematically cultivated in Cameroon, information about the performance and the yield of the crop are lacking. Such data are necessary in order to explore the feasibility of the castor bean as an alternative crop in Cameroon agriculture.

The castor bean seed yield depends on the genotype but is also affected by the environmental conditions and cultural practices [15]. In this respect [6], study variability for grain and bean yield and yield related traits of castor bean accessions in two savannahs agro-ecological zones of Northern Cameroon and reported that castor plants could be adapted satisfactorily on Sudano-Guinean and Sudano-Sahelian climates with seeds yield ranged between 3450±276 and 8614±611 Kg/ha respectively for Motso1 and Ndoutourou accessions. Also, theses authors study the effects of intercropping systems of castor bean, maize and common bean on their growth and seeds yield in the Sudano-Guinean zone of Cameroon and found that intercropping of the common bean with castor bean is favourable for both plants. In the intercropping system castor bean/common bean, an increase in seeds yield for both castor bean/common bean is observed, 43% and 14%, respectively [5]. At the best of our knowledge, no study has been interested in the growth and yield of castor plants in the Bimodal Forest climate of Cameroon and their intercropping system effects with various Legumes. In Cameroon for instance, farmers normally growth three dominant legumes in years: soybeans, cow bean and common bean. Intercropping castor bean with these plants will not only provide a cash flow to farmers but also can improve their yields, particularly for Legumes which need tutors for a better growing. Legumes are known to fix atmospheric nitrogen, thus enriching bean fertility, and helping to meet the N needs of plants [16]. Several authors [5], found that some Legumes species performed better than others. Therefore, the present study aimed to evaluate and improve the growth and yield of castor bean, soybeans, cow bean and common bean plants under the intercropping systems in the Bimodal Forest and Sudano-Guinean zones of Cameroon.

MATERIALS AND METHODS

Description of experimental zones

The field study took place in the years 2015 and 2016 in two agro-ecological zones of Cameroon: Sudano-Guinean and the Bimodal Forest climates in Adamawa and East regions respectively. In Sudano-Guinean zone, study was carried out at Bini-Dang locality in the experimental farm of Laboratory of Biodiversity and Sustainable Development of University of Ngaoundere Cameroon situated at 7 ° 24,671 'North Latitude, 13 ° 34' 238" East longitude and 1155.8 m Altitude. The vegetation of experimental area was herbaceous savannah dominated by *Imperata cylindrica* and *Pennisetum purpureum*. There are some shrubs such as *Annona senegalensis*, *Hymenocardia acid* and *Terminalia* spp. In the Bimodal Forest climate, the study was conducted in the locality called Birpondo situated at 4 ° 60'9"North Latitude, 13 ° 3'4" East Longitude and 668 m Altitude. The experimental area cultivated is herbaceous savannah dominated by *Imperata cylindrica*.

Seeds Sample

The principal treatments comprised Ndoutourou accession of castor bean, soybean seeds variety (Goiania), cow bean seeds variety (Fekem) and common bean seeds variety (GLP 190). Castor bean seeds were obtained from the SODECOTON of Garoua in Cameroon, a governmental industry interested in the production of the castor bean. The seeds were all brown in colour with black lines [5]. Legumes seeds were bought on the local market of Ngaoundéré. They are produced by Technician and then imported and distributed in Cameroon by SEMAGRI (Figure 1). This variety was chosen for its early germination, its present great adaptability to the rainy season and has short reproduction cycle (90 days average). Using variety presented short reproduction cycle is advantageous for farmers in that they may have several harvests per year if he has off-season crops.

A: Castor bean seeds (Ndoutourou accession)	**B:** Soybean seeds variety (Goiania)	**C:** Common bean seeds variety (GLP 190)	**D:** Cow bean seeds variety (Fekem)

Fig-1: Plant seeds studied

Experimental design

The experimental design consisted of 07 treatments (monocrop of castor bean, soybean, common bean and cow bean; intercropping castor bean/soybean; castor bean/common bean and castor bean/cow bean) lay out randomly and repeated in three blocks. Each of the 21 elementary plots had a usable area of 18 m^2 (6 m × 3 m). The total area of the trial was 252 m^2. Mono

crop and intercrop castor bean were planted in three columns separated at 1 m distance each). Mono crop soybean, cow bean or common bean was planted in five columns separated 0.5 m. The distance between two consecutive plants within each column was 0.5 m for soybeans, cow bean and common bean. In intercropped system soybean, cow bean and common bean were planted at 0.5 m each castor bean plants.

Data recorded and statistical analysis

Seedling emergence and survival plants rates were recorded two weeks after sowing and flowering stage respectively. During the vegetative stage, a random sample of 30 plants per treatment was taken at regular intervals of 14 days and the plants height and number of leaves per plant were evaluated. At flowering stage, a random sample of 15 plants per treatment was taken and the dry biomass and stem diameter at the collar were measured. At maturity, the number of bunches per plant, the number of fruits per bunch and the seeds yield (Kg/ha) were evaluated. Comparison of the performance of each farming system was made on the basis of the land equivalent ratio (LER). The LER compares the cultural intercropping and monocropping. It is calculated as follows: LER = (Yield of A in intercropping + Yield of B in intercropping)/ (Yield of A in monocropping + Yield of B in monocropping). If LER = 1, there is no difference between the two modes of culture ; if LER <1, there is a loss of yield in intercropping ; if LER> 1, there is a productive advantage of the intercropping.

Means and confidence intervals were determined from triplicate measurements. Data were subjected to variance analysis following by the Duncan multiple range tests when any significant effect was observed. The statistical software 'Statgraphics plus' was used for this proposes.

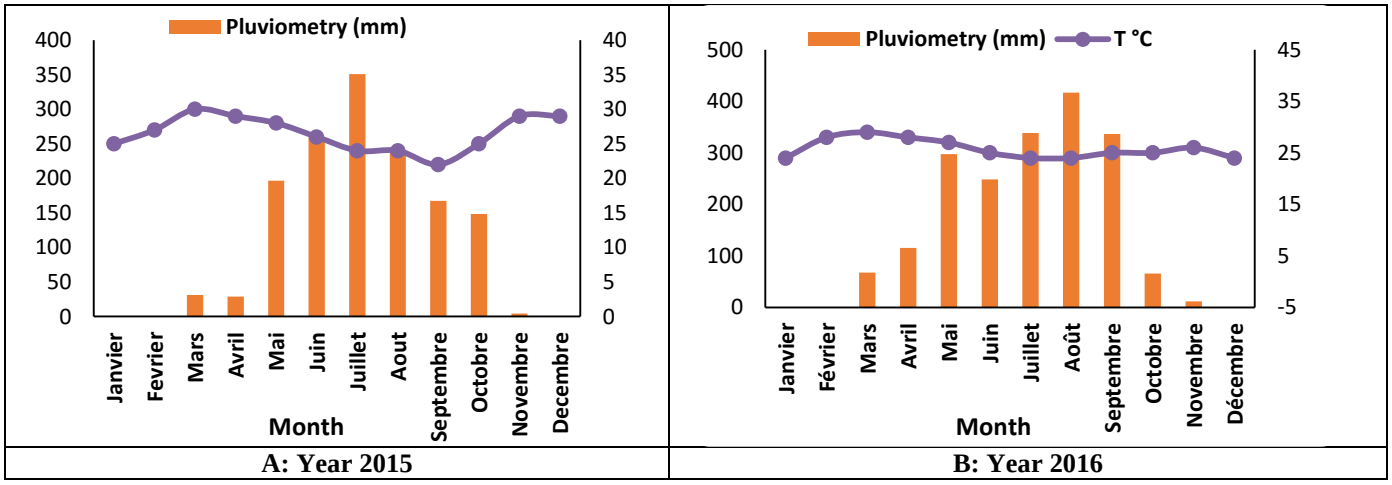
RESULTS AND DISCUSSION

Characteristics of Sudano-Guinean and Bimodal Forest zones of Cameroon

Temperature and precipitation

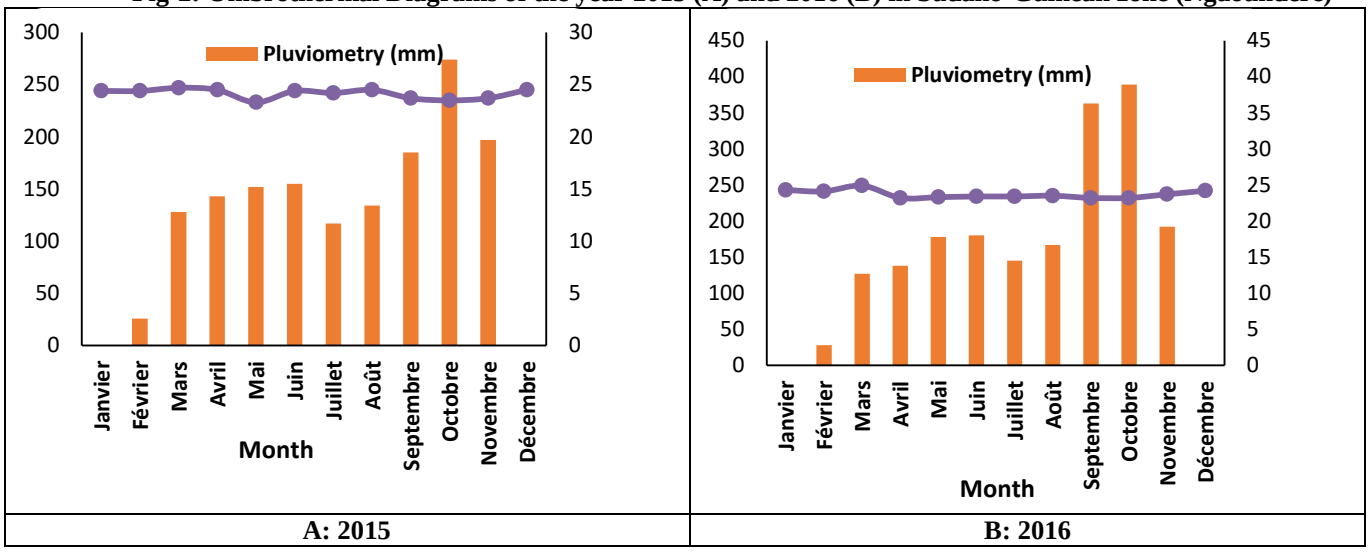
Mean annual temperature and total annual precipitation were respectively 26.5 °C; 1424.9 mm in 2015 and 25.75 °C; 1898.6 mm in 2016 in Sudano-Guinean zone of Adamawa Cameroon, thus suggesting that the difference between the both study years on temperature and precipitation was 0.75 °C and 473 mm respectively (figure 2). In Bimodal Forest of East Cameroon, mean annual temperature and total annual precipitation were 24.15 °C; 1510.7 mm and 23.70 °C; 1907 mm in 2015 and 2016 respectively thus suggesting that the difference between the years 2015 and 2016 on mean annual temperature and total annual precipitation was respectively 0.45 °C and 396.3 mm (figure 3). In Bimodal Forest zone of East Cameroon exhibited the highest total annual precipitation (1708.85 mm) and the lowest mean annual temperature (23.9 °C) while the lowest total annual precipitation (1661.75 mm) and the highest mean annual temperature (26.12 °C) are observed in Sudano-Guinean zone of Adamawa Cameroon. Furthermore, it has been observed that climate of both study zone varies according to the year of experimentation thus suggesting that experimentation season could influence plant growth and development. In these regards, the effects of the year of experimentation on plants productivity in our study zones need to be investigated.

Climate change is perturbing agricultural seasons in the world. In 2008, the total annual precipitation and mean annual temperature was 24.3 °C and 1091.9 mm respectively in Sudano-Guinean zone of Adamawa Cameroon, thus suggesting that the difference between total annual precipitation was 569.85 mm compared to 2015 and 2016, thus suggesting that our study zones are affected by climate change. Climate is an important parameter for agricultural production. Very low or high rainfall can hinder plant growth, thus limiting plant productivity. In recent years, the instability of total annual precipitation and mean annual temperature is observed with negative consequences climate stability that disrupts the agricultural calendar and low plant productivity [17]. In addition, [18], study the effects of temperature and rainfall on food production in Southern Cameroon and indicate that both atmospheric parameters (temperature and rainfall) influence agricultural production. In this respect, the higher temperature and precipitation observed respectively in Sudano-Guinean and Bimodal Forest zones of Cameroon could influence plant productivity, but this need to be investigated.



A: Year 2015 B: Year 2016

Fig-2: Ombrothermal Diagrams of the year 2015 (A) and 2016 (B) in Sudano-Guinean zone (Ngaoundéré)



A: 2015 B: 2016

Fig-3: Ombrothermal Diagrams of the year 2015 (A) and 2016 (B) in Bimodal Forest Zone (Bertoua)

Physico-chemical properties of soil of studied sites

Table1 summarizes the physico-chemical properties of soil (texture, pH, nitrogen and phosphorus) of studied sites at the localities of Bini-Dang and Birpondo in Sudano-Guinean and Sudano-Sahelian zones respectively. The analysis of variance shown that there are significant ($p< 0.05$) difference between the both soils from Bini-Dang and Birpondo localities on studied parameters. Soil from Bipondois more acid (pH = 3.7) and richer in phosphorus (0.67 mg/100g of MD) than that from Bini-Dang. Soil from Adamawa Cameroon is richer in nitrogen (1.68 mg/100g of MD) than that from East Cameroon region. The difference observed between the soil physicochemical properties of both study sites suggests that plant growth would vary depending on these localities but this needs to be studied. In fact, acid pH contributes to slowing the organic matter mineralization considerably and reduce the available nitrogen quantities. Neutral pH allows to accelerate organic matter mineralization and nitrogen release [19]. In this study, bean from Bipondo locality is more acid (3.7±0.01) than that from Bini-Dang (4.1±0.01), thus suggesting that organic matter mineralization would be more accelerate in Bini-Dang than Bipondo, justifying the high nitrogen content in the soil from Bini-Dang. In this respect, plant productivity would be higher in Bini-Dang locality compared to Bipondo, but the study the influence of both zones on plant growth is necessary. Several authors reported that plants as *Ricinus communis* L. (castor bean) growth well on soil with higher nitrogen content.

Phosphorus is an essential element for living organisms. In plants, it plays an important role in many biological processes such as growth, photosynthesis and nitrogen absorption [20]. In this respect, recent studies have shown that cow bean [21] and common bean [22] presents a greater nitrogen fixation when there is phosphorus in the soil. In addition, [23] reported that when soil is poor in phosphorus, Legumes present low nodulation capacity, consequently low azote absorption. In this study phosphorus content of soil from Bipondo is higher than that from Bini-Dang locality, thus suggesting that Bipondo locality would be better for

Legumes growth compared to Bini-Dang but this need to be investigated.

Table-1 : Physico-chemical properties of soil from study sites

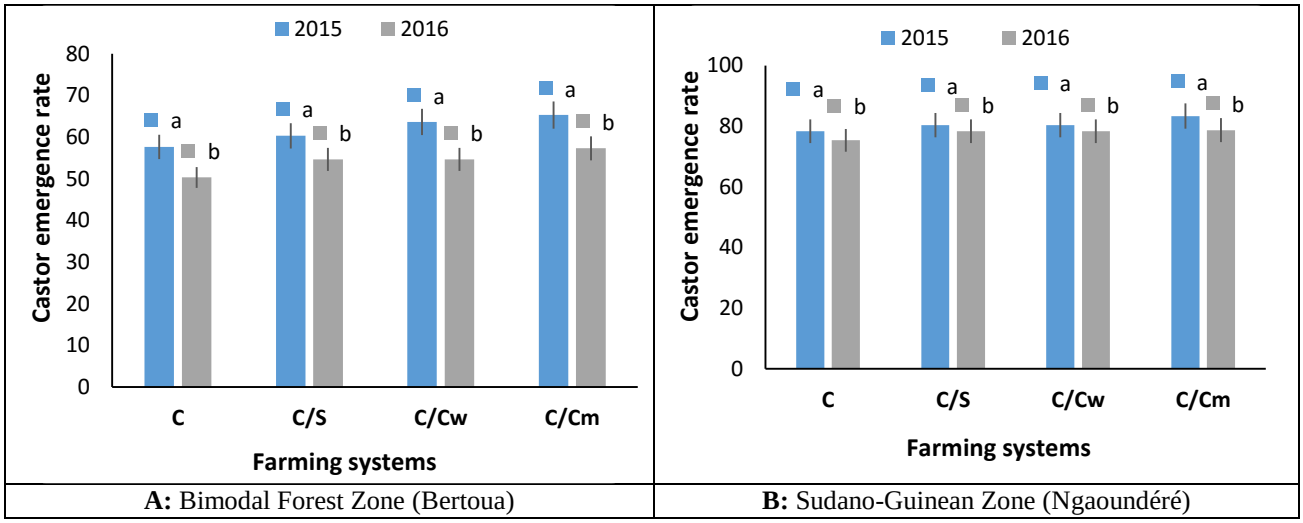
Locality	Bini-Dang (Ngaoundéré)	Birpondo (Bertoua)
Texture	Clay soil	Sandy soil
pH	4.1±0.01[a]	3.7±0.01[a]
Nitrogen (%)	1.68±0.02 [a]	0.12±0.01[a]
Phosphorus (%)	0.05±0.01[a]	0.06±0.01[a]

Values of a line followed by the same later are not significantly different

Seedling emergence rate

Seedling emergence rate of castor bean at 14 days after sowing

Figure 2 presented the seedling emergence rate of castor bean at 14 days after sowing (DAS). There is no significant difference between intercropping system on this parameter. However, the zone of study, influence significantly ($p < 0.05$) the seedling emergence rate of castor bean. The seedling emergency rate is higher in Sudano-Guinean zone (80.58% and 77.67% respectively in 2015 and 2016) compared to Bimodal Forest of East Cameroon (61.5% and 54.25% respectively in 2015 and 2016). Results obtained in this study are in conformity with data found in literature. Indeed, [15], study the Adaptation and yielding ability of castor plant (*Ricinus communis* L.) genotype in a Mediterranean climate and reported that seedling emergence of castor bean varies between 11 and 26 days after and seedling emergency rate varies according to the year of experimentation and study area. In addition, several authors [24], reported that seedling emergence of castor bean is observed at 15 days after sowing and the mean value of seedling emergency rate was 54.8%. In this study, the seedling emergency rate of castor bean was observed at 14 days after sowing. The beneficial effect of Sudano-Guinean zone of the Adamaoua Cameroon region on an emergency rate of castor seeds would be justified by the fact that, clay soil of Sudano Guinean zone would favour seedling emergence of castor bean compared to sandy soil of Bimodal Forest Zone of East Cameroon, thus justifying that the seedling emergence rate depends on environmental conditions. Moreover, [15], revealed in their studies that high soil temperatures at planting time conduct to shorter emergence periods of castor bean plants. On the basis of this theory, the favourable period for castor bean sowing extends from June to July in both study zones. In this study, sowing took place in June in Sudano-Guinean zone and July in the Bimodal Forest zone of East Cameroon, thus justify the greatest value of seedling emergence rate of castor bean observed in this study.



A: Bimodal Forest Zone (Bertoua) | **B:** Sudano-Guinean Zone (Ngaoundéré)

Fig-4: Seedling emergence rate of castor bean

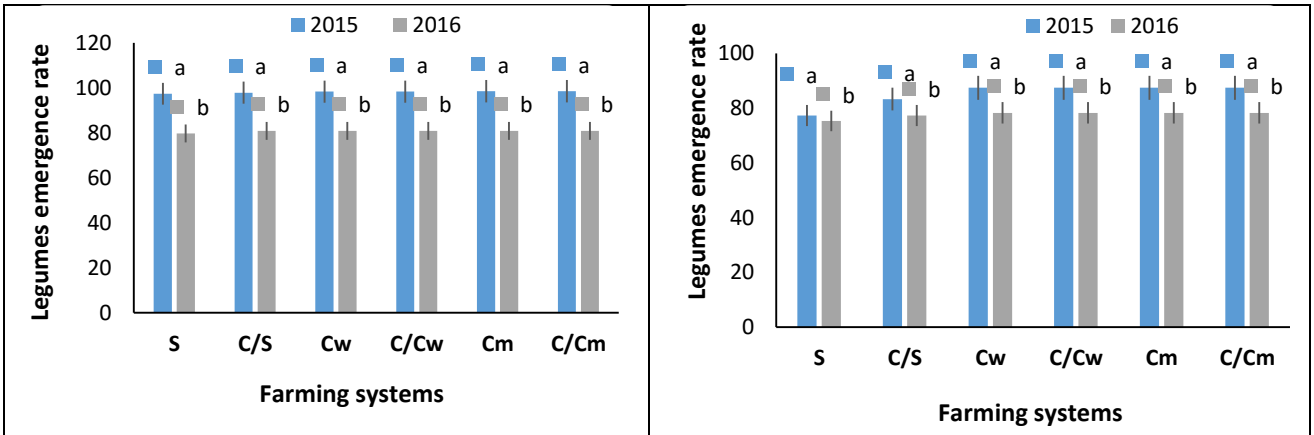
C: monocrop castor bean; C/S: intercropping castor bean-soybean; C/Cw: intercropping castor bean-cow bean; C/Cm: intercropping castor bean-common bean. Values of the bands followed by the same letter in a farming system are not significantly different.

Seedling emergence rate of Legume: soybean, cow bean and common bean

The seedling emergence rates of soybean, cow bean and common bean are presented in Figure 4. There is no significant difference between intercropping systems on seedling emergence rates of Legumes, however, both study zones (Sudano-Guinean zone of the Adamaoua Cameroon and Bimodal Forest zone of East) as well as the year of experimentation significantly ($p < 0.05$) influence the seedling

emergence rate of legumes. The average emergence rate of legume plants is higher in the Bimodal Forest zone of East Cameroon compared to the Sudano-Guinean zone. Results obtained on seedling emergence of Legumes corroborate the data found in literature. Indeed, [25] reported that seedling emergence of cow bean took place between 3 and 7 days after sowing with an emergence rate ranging from 83 to 100%. In this study, seedling emergence of cow bean was observed at 5 days after sowing in each of both study zone, suggesting that climatic and edaphic conditions of both study zone would not influence the time of seedling emergence of cow bean in this study. In addition, results obtained on seedling emergence of the common bean those of [26] and [27] who reported that generally common bean emergence took place between 6 and 14 days after sowing with a seedling emergence rate ranged from 79 to 82%. In this study the emergence of common bean seeds was observed at 7 days after sowing. Data obtained on seedling emergence of soybean in this study is in conformity to [28] who reported that generally the seedling emergence of soybean took place at 7 days after sowing and the emergence rate varies from 70 to 90%. In this study seedling emergence of soybean was observed at 7 days after sowing. It was observed in this study that the Sudano-Guinean climate of Adamaoua Cameroon is more favourable for seedling emergence of castor bean compared to Bimodal Forest climate while the greatest value of seedling emergence of Legumes was recorded in Bimodal Forest of East Cameroon. This suggests that Legumes used in this study and castor bean which is an Euphorbiaceae would growth better under different climatic and edaphic conditions. Indeed, in Sudano-Guinean zone, the climate is characterized by low temperature (23.70 °C in 2016) and higher total annual precipitation (1907 mm in 2016) while mean annual temperature and total annual precipitation were respectively 26.5 °C and 1898.6 mm in 2016.

In this study, there is no difference between intercropping systems on seedling emergence of plants used, thus suggests that space between two consecutive plants in an elementary plot is sufficiently large in order to prevent competition Legumes and castor bean at the first stage of their development. Overall, seedling emergence rates of castor bean and Legumes used in this study are significantly ($p < 0.05$) higher in 2015 than 2016, thus suggests that climatic variations observed in both study zone would influence seedling emergence of plants, but their effects on plant growth and yield need to be investigated.



A: Bimodal Forest Zone (Bertoua) | **B:** Sudano-Guinean Zone (Ngaoundéré)

Fig-5: Emergence rate of Legumes

S: Soybean; **Cw:** Cow bean; **Cm:** Common bean; **C/S:** intercropping castor bean-soybean; **C/Cw:** intercropping castor bean-cow bean; **C/Cm:** intercropping castor bean-common bean

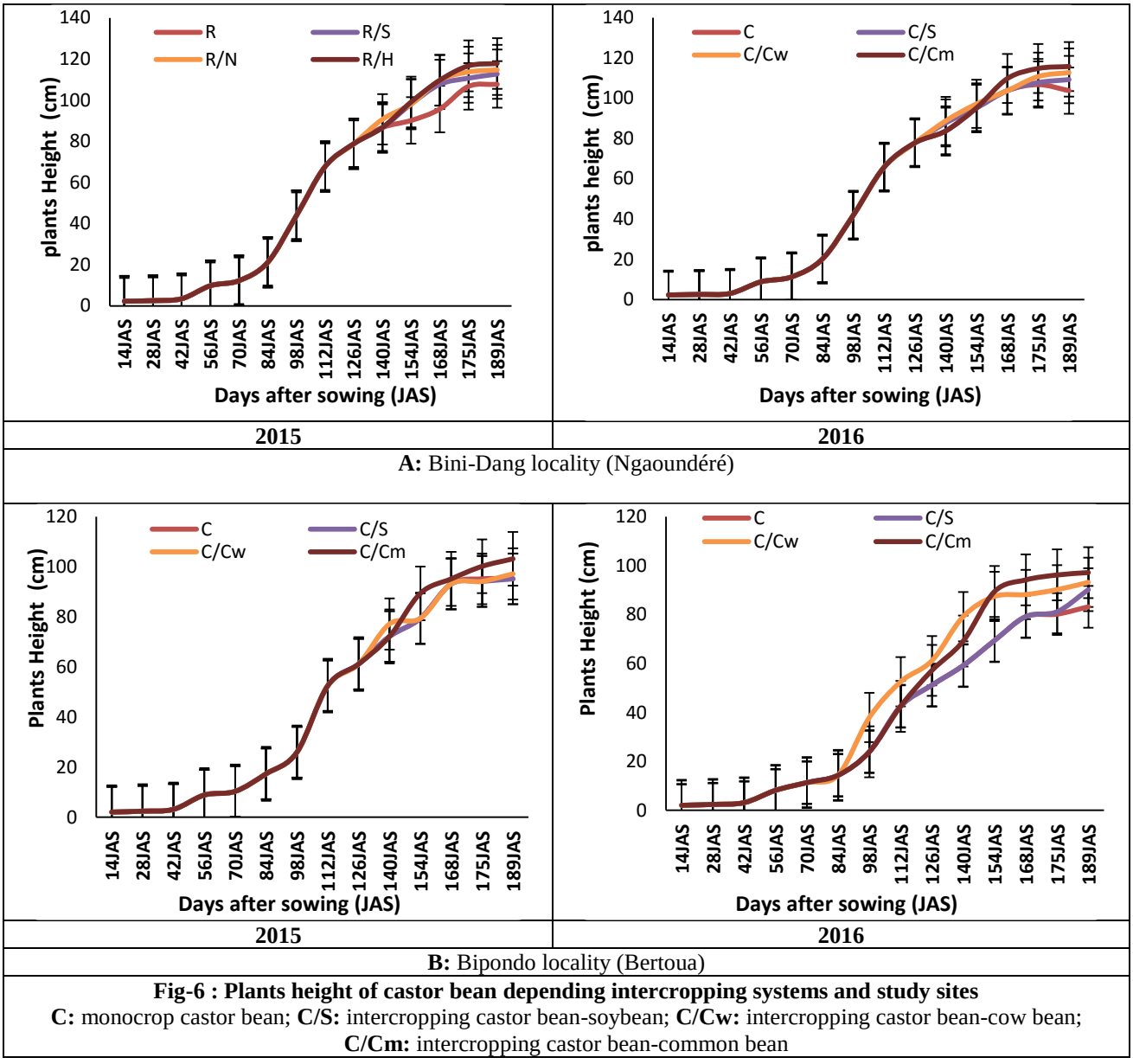
Values of the bands followed by the same letter in a farming system are not significantly different.

Effects of intercropping systems on plants height and number of leaves per plant of castor bean

Figures 6 and 7 shows respectively the plant height and number of leaves per plant of castor bean depending intercropping system, experimentation site and the year of experimentation. The statistical analysis of the data show that intercropping system and experimentation site influence no significantly these parameters at 56 days after sowing. However the difference starts to be significant ($p < 0.05$) between the different intercropping systems and both study sites on plants height and number of leaves per plant at 70 days after sowing. Overall, the curve expressing castor bean growth parameters according to time exhibited the appearance of sigmoidal curve : the growing increases slowly during the first 70 days after sowing, and then it increases exponentially between 70 and 175 days after sowing. After this date, castor bean growth slowly in each of both study sites. This result is in conformity to [5] who study the variability for grain and bean yield and yield related traits of castor bean accessions in two savannahs agroecological zones of Cameroon and revealed that the trend in high growth followed a sigmoid curve equation.

Variation on plants height of castor bean

At maturity, the height of the castor bean varies from 90.15 ± 1.04 cm in monocrop in the Bimodal Forest Zone of East Cameroon in 2016 to 115.75 ± 1.17 cm in intercropping system castor bean/common bean in the Sudano-Guinean zone of Adamawa Cameroon in 2015. Results obtained at the height of castor bean are comparable to data reported in literature. Indeed [5], reported that the height of the castor bean varies between 1.1 and 2.1 m depending genotype and study zone. In addition, [15] study the potential of adaptability of 19 genotype of castor bean on Mediterranean climate and revealed that plant high ranges from 0.79 m to 2.30 m depending genotype, study sites and the year of experimentation. Plants height is an important parameter in the harvesting process. This is how [15] reported that the harvesting of castor bean fruits is easy when plant height is less than 2 m. Overall, in this study, castor bean height is less than this value (2 m), thus suggesting that harvesting the fruits of Cameroonian castor bean accession used in this study would be easy. The Sudano-Guinean zone of Adamaoua Cameroon exhibited the highest plant height (108.25 ± 1.23 cm) while the smallest (86.65 ± 1.23 cm) was observed in Bimmodal Forest of East Cameroon. Concerning the influence of intercropping systems on plant height, the highest plant height (108.49 ± 1.17 cm) is observed in intercropping system castor bean/common bean while castor bean in monocrop exhibited the smallest plant height (97.45 ± 1.23 cm).



2015 **2016**

A: Bini-Dang locality (Ngaoundéré)

2015 **2016**

B: Bipondo locality (Bertoua)

Fig-6 : Plants height of castor bean depending intercropping systems and study sites

C: monocrop castor bean; **C/S:** intercropping castor bean-soybean; **C/Cw:** intercropping castor bean-cow bean; **C/Cm:** intercropping castor bean-common bean

The heights of castor bean in intercropping castor bean/soybean and castor bean/cow bean are 101.82 ± 1.04 cm and 104.45 ± 1.23 cm respectively. The beneficial effects of Legumes on the height has been demonstrated [29, 30, 5, 31].

Both years of experimentation influence significantly ($p < 0.05$) the height of our local castor bean, thus suggesting that this Cameroonian castor bean is sensitive to climate variations observed between the years 2015 and 2016, thus justifying this result.

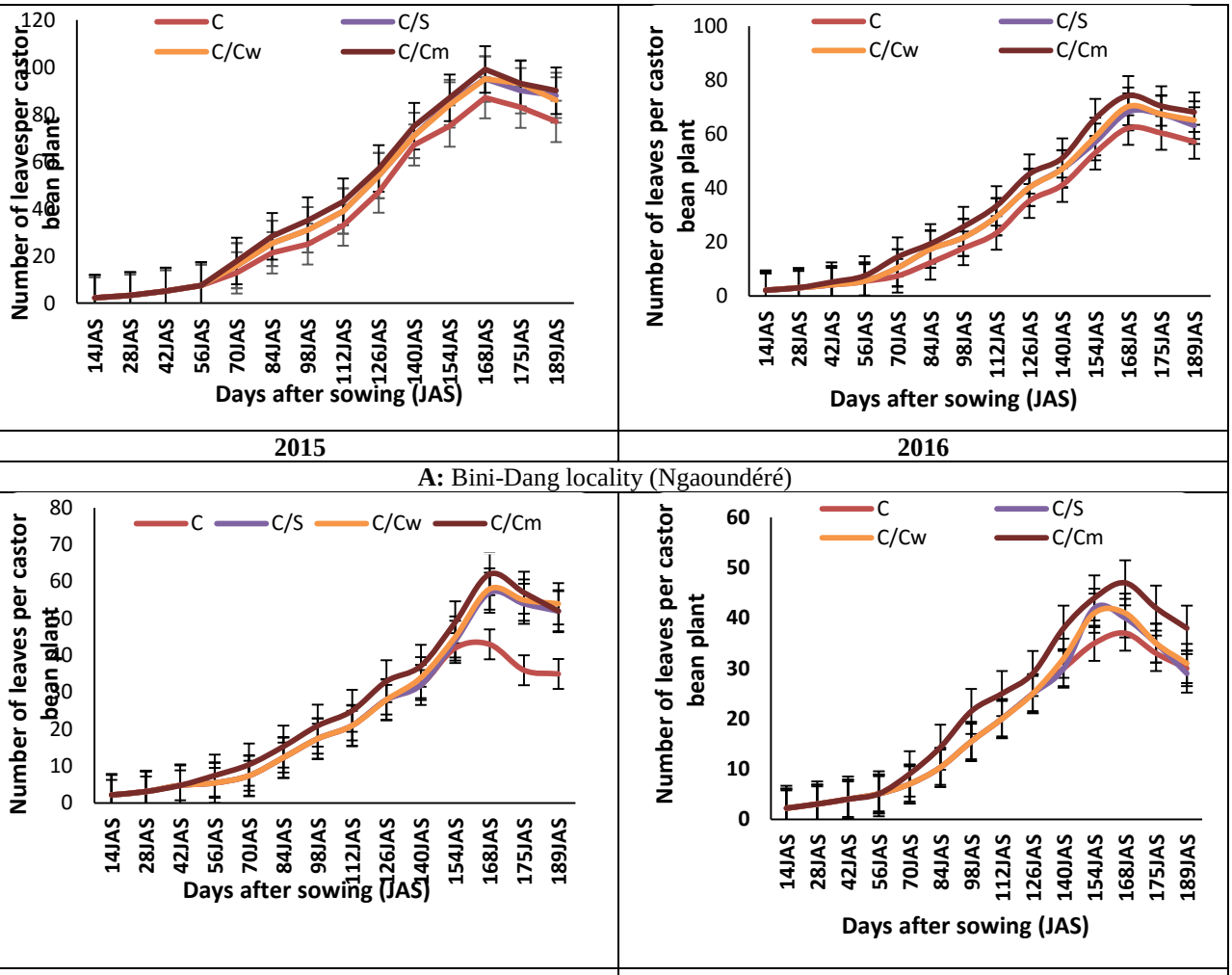


Fig-7 : Variation in number of leaves per castor bean plant depending intercropping systems and study sites
C: monocrop castor bean; C/S: intercropping castor bean-soybean; C/Cw: intercropping castor bean-cow bean; C/Cm: intercropping castor bean-common bean

Variation on a number of leaves per plant of castor bean

At maturity, the number of leaves per plant of castor bean ranges from 30.21 ± 1.03 for castor bean in monocrop in Bimodal Forest of East Cameroon to 99.03 ± 1.27 in intercropping system castor bean/common bean in Sudano-Guinean zone (figure7).

This result corroborates to [37] who revealed that annual castor bean accession reach maturity between 140 and 170 days after sowing. In this study, the maximum number of leaves per plant of castor bean is obtained at 154 days after sowing. The increase of leaf production could play a very important role in Adamawa-Cameroon region in the fact that it could limit sunstroke, thus increases bean humidity and reduce erosion. These leaves represent a biomass that degradation can release mineral elements needed for plant nutrition.

Regarding the intercropping systems on the number of leaves per plant of castor bean, the intercropping system castor bean/common bean exhibited the greatest number (62.03±1.27) while the smallest number (49.78±1.21) is observed on castor bean in monocrop. The number of leaves per castor bean plants in intercropping system castor bean/soybean and castor bean/cow bean are intermediate and are 58.03±1.04 and 59.03±1.23 respectively.

The both study zone presented an influence on plant height and number of leaves per plant of our local castor bean accession. This is in conformity with data found in literature. Indeed, several authors [15, 5] reported that castor bean growth varies depending genotype, experimental site and year of experimentation. There was a positive and significant ($p < 0.05$) correlation between plant height and number of leaves per plant ($r = 0.97$, $p < 0.05$) and between the number of leaves per plant and seeds yield of castor bean ($r = 0.76$, $p < 0.05$).

In this work, the Sudano-Guinean zone of Adamawa Cameroon region exhibited the highest plant height and number of leaves per plant of castor bean thus suggesting that seeds yield of this oleaginous would be higher in Bini-Dang compared to Birpondo locality, but this need to be investigated. Several authors [32, 5] reported that there are positive and significant correlation between plant height, leaf production and seeds yield. Indeed, more leaf production is greater, more photosynthetic intensity is important and consequently, seeds yield production is higher. The beneficial effect of intercropping systems using Legumes has been demonstrated [5].

The beneficial effect of intercropping system castor bean/common bean compared to castor bean/cow bean and castor bean/soybean would be explained by the fact that common bean would fix more N atmospheric than both Legumes cow bean and soybean in our study localities, thus justify the beneficial effects of intercropping system castor bean/common bean on plants height and leaf production. However, it would be interesting to make a comparative study of the amount of Nitrogen fixed by these three legumes (common bean, soybean and cow bean) in our study zones. In addition, some authors [33] evaluated the nitrogen effect on the growth and physiology of castor bean and revealed that maximum growth and development rates of castor plants were achieved at 7.0 g N/kg much higher than many other crops grown under similar nutrient conditions, thus justifying the beneficial effect of intercropping castor bean/Legumes on plant growth. Globally plant height and number of leaves per plant of castor bean are 1.2 folds less than castor bean in intercropping.

Effect of intercropping on dry biomass of castor bean plants and diameter of stem

Table 2 shows the dry biomass and stem diameter of plants at the collar at maturity (175 days after sowing) depending intercropping system, study zone and the year of experimentation. In general, the analysis of variance revealed that intercropping castor bean/Legumes increases significantly ($p < 0.05$) these growth parameters. In addition, both study zone influence significantly ($p < 0.05$) the dry biomass and stem diameter of plants.

In this study, the dry biomass of castor bean ranged from 15.16 ± 0.29 g in castor bean in monocrop in Bimodal Forest of East Cameroon in 2015 to 37.64 ± 0.33 g in intercropping system in the Sudano-Guinean Zone of Adamaoua Cameroon in 2016. Overall, the dry biomass of castor bean from intercropping system castor bean/Legumes is 1.3 folds greater than that from castor monocrop. There is a positive and significant correlation ($r = 0.92$, $p < 0.05$) between dry biomass of castor bean plants and seeds yield. This result obtained on dry biomass of castor bean is not in conformity to [34] who studied the influence of mycorrhizae on castor bean productivity in Georgia state in the United States of America and revealed that dry biomass of plants varies between 0.26 and 1.34 g. However, this value is low compared to that reported by [5] who found that the dry biomass of Ndoutourou accession of castor bean grown in the field in Adamaoua Cameroon region ranges from 0.05 to 0.17 kg.

In this study, stem diameter of castor bean at collars varies from 0.89 ± 0.4 cm in monocrop in Bimodal Forest Zone of Cameroon in 2015 to 1.61 ± 041 cm in intercropping system in the Sudano-Guinean zone of Adamaoua-Cameroon. These results obtained on stem diameter of castor bean corroborate in party the data found in literature. Indeed, [54], study the agronomic characterization of some local Cameroonian castor bean accessions in North Cameroon and revealed that the stem diameters of plants at the collar vary from 1.2 and 4.7 cm. [5] reported that the stem diameter of castor bean varies from 1.1 cm for Ndoutourou accession to 3.3 cm for Motso 2 accession. Overall, the stem diameter of castor bean from intercropping system castor bean/Legumes is 1.7 folds greater than that from monocrop. There is a positive and significant correlation ($r = 0.35$; $p < 0.05$) between stem diameter of castor soil at collar and seeds yield.

Number of bunches per plant, number of fruits per bunch and seeds yield of castor bean plants

Table 3 summarizes the number of bunches per plant, number of fruits per bunch and seeds yield of castor bean plants according to intercropping system, study sites and years of experimentation in 175 days after sowing. In general, the analysis of variance revealed that intercropping castor bean/Legumes increases significantly ($p < 0.05$) these production parameters. In addition, also both study zone influence significantly ($p < 0.05$) these parameters. There is no significant difference between various intercropping systems castor bean/Legumes on these production parameters.

Table-2: Dry biomass and diameter of the stem at collar

Parameters	Dry biomass (g)		Diamètre au collet (cm)	
Year	**2015**			
AEZ	ZFB	ZSG	ZFB	ZSG
C	19.16±0,33[a]	27.33±0,33[b]	0.89±0,41[a]	0.97±0,19[a]
C/S	23.85±0,17[b]	31.37±0,17[c]	1,53±0,41[a]	1,57±0,19[a]
C/Cw	25,35±0,17[b]	33,67±0,17[c]	1,55±0,27[a]	1,67±0,19[a]
C/Cm	29,37±0,33[d]	37,64 ±0,33[e]	1,57±0,14[a]	1,7±0,33[a]
Year	**2016**			
AEZ	ZFB	ZSG	ZFB	ZSG
C	15.16±0,29[a]	25.33±0,27[c]	0.87±0,28[a]	0.92±0,17[a]
C/S	19.83±0,19[b]	29.32±0,19[d]	1.43±0,33[a]	1.47±0,17[a]
C/Cw	19.87±0,19[b]	30.35±0,19[d]	1.49±1,33[a]	1.57±0,17[a]
C/Cm	23.57±0,29[c]	34.37±0,33[e]	1.54±0,28[a]	1.61±0,41[a]

C: monocrop castor bean; C/S: intercropping castor bean-soybean; C/Cw: intercropping castor bean-cow bean; C/Cm: intercropping castor bean-common bean; ZSG: Sudano-Guinean Zone; ZFB: Bimodal Forest Zone; AEZ: Agroecologique zone. Values of bands followed by the same letter are not significantly different.

In this study the number of bunches per plant from 2.66 ± 0.13 in monocrop in Bimodal Forest Zone of Est Cameroon in 2015 to 5.67 ± 0.17 in intercropping system castor bean/common bean in Sudano-Guinean Zone of Adamaoua Cameroon in 2016. These results obtained on a number of bunches per castor bean plant corroborate in part of the data found in the literature. Indeed. [35] study the physical characters of Cameroonian castor bean from North Cameroon and revealed that the number of bunches per plant varies from 2 to 21. In other [5], report that the number of bunches per castor bean plant varies from 3.9 to 5.6 depending castor bean accession and study zone. Overall. The number of bunches per castor bean plant from intercropping system castor bean/Legumes is 1.43 folds greater than that from monocrop. There was a positive and significant correlation ($r = 0.79$; $p < 0.05$) between the number of bunches per plant and castor bean seeds yield, thus suggesting that castor bean seeds yield from intercropping system castor bean with soybean, cow bean or common bean would be higher than that from monocrop.

The number of fruits per bunches of castor bean varies from 74.33±0.33 in monocrop in Bimodal Forest zone of Cameroon in 2015 to 118.67±0.27 in intercropping castor bean/common bean in the Sudano-Guinean Zone of Adamaoua Cameroon in 2016. Overall, the number of fruits per bunch from intercropping system castor bean/Legumes is 1.13 folds higher than that from castor bean in monocrop. There was a positive and significant correlation ($r = 0.84$; $p < 0.05$) between the number of fruits per bunch and seeds yield.

In this work, the seeds yield of castor bean ranges from 128.18±1.27 Kg/ha in monocrop in the Bimodal Forest Zone of Cameroon in 2016 to 181.57±1. 12 Kg/ha in the intercropping system castor bean/common bean in the Sudano-Guinean Zone of Adamaoua Cameroon in 2015. The results obtained on castor bean seeds yield are low compared to data reported in the literature. According to [36], the European Union has carried out in France the culture of some clones of castor bean with seeds yield ranges from 2 to 3 t/ha. [37] revealed that the seeds yield of castor bean vary from 1000 to 3000 kg/ha. In addition, Studies by [38] showed that the seeds yield of castor bean growth in intercropping with cow bean, ground nuts or sesame vary from 1000 to 1200 kg/ha. The seeds yield of castor bean growth in intercropping with common bean is 1.08; 1.13 and 1.41 folds higher than those cow bean from intercropping castor bean with soybean, cow bean and castor bean in monocrop. Several authors [8, 36], reported that castor bean is grown for its seeds with higher content in oil.

It was observed in this work that the both study zone (Bimodal Forest and Sudan-Guinean zones), the intercropping system castor bean/Legumes and the year of experimentation significantly ($p < 0.05$) influenced growth parameters, seeds yield and yield related traits of our local castor bean. These results are in accordance with data found in the literature. Indeed, several authors [15, 8], reported that castor bean yield varies depending genotype, study zone and the year of experimentation. In this study. Castor bean grows better under the Sudan-Guinean climate of Adamaoua Cameroon compared to the Bimodal Forest zone of East Cameroon. This result can be explained by the fact that both study zone does not present the same climatic conditions as well as edaphic characteristics.

The climate and soil conditions in the Sudano-Guinean zone seemed to favour castor bean growing. In fact, the Soudan-Guinean climate is less humid ; the bean has an argillaceous texture, rich in nitrogen and

the pH is less acid while the Forest Bimodal soil is more acid, it has a sandy texture and is poor in nitrogen (table 1). According to [39] castor plant growth well in a little shade environment where soil is rich in organic manure, well drained and has a neutral pH. In addition, [33], reported that castor bean growth well in soil rich in nitrogen.

The intercropping with Legume seems to increase significantly ($p < 0.05$) the castor bean growth. This beneficial effect of intercropping on castor bean growth has been demonstrated. Legumes live in symbiosis with Rhizobium bacteria. These bacteria fix atmospheric nitrogen in the bean, thus contribute to increasing bean nitrogen content, thus justifying the high productivity of castor bean in intercropping with soybean, cow bean and common bean. This is in line with [55] who studies the role of Legumes on bean fertility in Burkina Faso and reports that Legumes (cow bean and common bean) fix significant amounts of nitrogen, thus causing increased yield from 70 to 100% of non-fixing cultures. Similarly the study of [29], on intercropping corn and common bean on plants yield in Canada reported that this intercropping significantly ($p < 0.05$) increased the yield of maize compared to monoculture. In addition several authors [30, 40] reported that the intercropping of Legumes with other vegetable species revealed that the intercropping improved the yield of plants that cannot be fixed atmospheric N compared to monocrop. Furthermore, in this study, the intercropping system castor bean/common bean improve better castor bean productivity compared to intercropping castor bean/common bean or cow bean. This result suggests that the quantity of N fixed by common bean is higher than that fixed by soybean and cow bean, but the quantity of N fixed by these three Legumes in our study zone need to be investigated.

Overall, in this study the year 2015 exhibited significantly ($p < 0.05$) the best yield of castor bean compared to 2016, thus justifying by the variation of chemical properties of soil (table 1) and climatic conditions (figure 1) observed between both 2015 and 2016 years of experimentation. The study of [18] on the effects of temperature and rainfall on food production in South Cameroon revealed that climate influences plant production and the high temperatures and precipitation may be harmful to some crops.

Table-3: Seeds yield and yield related traits of castor bean

Parameters	Number of bunches per plant		Number of seeds per bunch		Seeds yield (Kg/ha)	
Year	**2015**					
AEZ	ZFB	ZSG	ZFB	ZSG	ZFB	ZSG
C	2.66±0,13^{a}	3.33±0,27^{a}	88.67±0,13^{a}	97.67±0,27^{b}	136.51±1,17^{a}	141.51±2,19^{b}
C/S	3.72±0,33^{a}	5.67±0,23^{a}	95.33±1,33^{b}	115.53±0,23^{c}	148.18±1,27^{b}	168.18±1,33^{c}
C/Cw	3.92±0,33^{a}	5.67±1,33^{a}	95.67±0,27^{b}	115.67±0,13^{c}	151.51±0,92^{b}	178.18±2,27^{d}
C/Cm	4,97±0,27^{a}	5,72±0,13^{a}	98,33±1,19^{b}	118,67 ±0,27^{c}	168,18±1,27^{c}	181,51±1,12^{e}
Years	**2016**					
AEZ	ZFB	ZSG	ZFB	ZSG	ZFB	ZSG
C	2.66±0,33^{a}	3.33±0,27^{a}	74.33±0,33^{a}	88.16±0,17^{b}	128.18±1,27^{a}	137.18±1,67^{b}
C/S	3.16±0,17^{a}	5.16±0,13^{a}	88.33±0,17^{b}	101.16±0,33^{d}	136.51±1,17^{b}	151.51±0,97^{c}
C/Cw	3.37±0,17^{a}	5.37±0,29^{a}	90.67±0,27^{b}	107.67±0,33^{d}	137.18±1,27^{b}	161.51±1,33^{d}
C/Cm	4.13±0,27^{a}	5.67±0,17^{a}	94.16 ±0,23^{c}	110.33±0,17^{e}	143.84±1,21^{c}	168.18±1,17^{e}

C: monocrop castor bean; C/S: intercropping castor bean-soybeans; C/Cw: intercropping castor bean-cow bean; C/Cm: intercropping castor bean-common bean; ZSG: Sudano-Guinean Zone; ZFB: Bimodal Forest Zone; AEZ: Agroecologique zone. The values of the bands followed by the same letter are not significantly different.

Effect of intercropping systems on legumes productivity depending intercropping system, agroecological zone and years of experimentation

Plant height and number of leaves per plant

Table 4 summarizes plants height and number of leaves per plant of soybean, cow bean and common bean at maturity (98 days after sowing) according to intercropping systems, study zone and the year of experimentation. In general, there is no significant difference between intercropping systems on both these growth parameters. However, plant height and number of leaves per plant of Legumes studied are higher in intercropping with castor bean than soybean, cow bean and common bean in monocrop.

In this study, plants height of Legumes ranged from 25.03 ± 0.27; 27.27 ± 0.33 and 21.37 ± 0.33 cm for soybean, cow bean and common bean respectively in monocrop in the Sudano-Guinean Zone of Adamaoua Cameroon in 2016 to 34.92 ± 0.33; 35.84 ± 0.27 and 28.88 ± 0.19 cm respectively in the Bimodal Forest Zone of East Cameroon in 2015. Furthermore, the number of leaves per plant of legumes varies from 22.92 ± 1.04 at 54.27 ± 0.17 and 24.61 ± 1.04 respectively for soybean cow bean and common bean in monoculture in the Sudano-Guinean Zone of Adamaoua Cameroon in 2016 to 34.33 ± 0.21; 63.33 ± 0.14 and 30.33 ± 0.27 cm respectively in the Bimodal Forest zone of East Cameroon in 2015.

In this study, the Bimodal Forest zone of East exhibited the greatest plants height and leaf production of Legumes compared to Sudano-Guinean zone of Cameroon. Furthermore, plant height and number of leaves per plant recorded in 2016 is less than those exhibited by the year 2015.

The results obtained in this study of plant height and number of leaves per plant of Legumes corroborate the data found in the literature. Indeed, the study of [41] on the effects of seedling density on growth and yield of five varieties of cow bean in Cameroon revealed that the plant height and number of leaves per plant of cow bean vary from 32.18 to 110.7 cm and from 19.5 to 115.85 respectively [42], revealed that cow bean plant height varies from 12.5 to 13.4 cm. In addition, [43] study the effect of the combination of Rhizobium and mycorrhizal on foliar production and physicochemical properties of cow bean leaves in Adamaoua Cameroon and reported that the number of leaves per cow bean plants at maturity ranges between 15 and 25. Globally, in this study plants height and number of leaves per cow bean plant are 1.04 folds higher in intercropping with castor bean than monocrop.

Results obtained on plant height and number of leaves peers plant of the common bean corroborate data recorded in the literature [44] reported that common bean plants high ranges from 21 to 220 cm. In addition, [26], revealed that the number of leaves per plant of the common bean varies from 2.77 to 12.53. In addition, [27], reported that the number of leaves per plant of common bean ranges from 9 to 15. In this study, plant height and number of leaves per plant of common bean growth in intercropping with castor bean are 1.07 and 1.04 fold greater than monocrop. Results obtained on plant height and number of leaves per plant of soybean in both study zone are lower than data found in the literature. Indeed, some authors [28, 45], revealed that plant height of mature soybean varies from 60 to 105 cm. Data obtained on leaf production of soybean in the two study zones are greater than those reported by [46] who revealed that the number of leaves per plant of mature soybean ranges from 17 to 23. In this study. Plant height and number of leaves per plant of soybean in intercropping with castor bean are respectively 1.04 and 1.07 fold greater than monoculture of soybean.

Table-4: Plant height and number of leaves per plant of Leguminous at 98 days after sowing

Parameters	Plants height		Number of leaves per plant		Plants height		Number of leaves per plant	
Year	**2015**				**2016**			
AEZ	ZFB	ZSG	ZFB	ZSG	ZFB	ZSG	ZFB	ZSG
S	33.19±0,33^{c}	29.23±0,33^{b}	32.67±0,4^{c}	28.36±1,04^{b}	29.03±0,29^{c}	25.03±0,27^{b}	27.23±0,28^{b}	22.92 ±1,04^{a}
C/S	34.92±0,33^{c}	30.87±0,33^{b}	34.33±0,21^{c}	30.67±1,04^{b}	29.92±0,29^{c}	25.12±0,33^{b}	29.54±0,28^{b}	24.61 ±1,04^{a}
Cw	34.52±1,19^{c}	30.58±0,33^{b}	61.33±0,2^{e}	57.67±0,13^{d}	31.13±0,23^{c}	27.27±0,17^{b}	59.12±0,27^{d}	54.27±0,17^{c}
C/Cw	35.84±0,27^{c}	31.87±0,17^{b}	63.33±0,14^{e}	59.33±0,19^{d}	32.83±1,19^{c}	28.32±0,21^{b}	61.43±1,33^{d}	57.47±0,17^{c}
Cm	27.27±0,37^{b}	23.64±0,33^{a}	29.67±0,41^{b}	25.67±1,04^{a}	25.57±0,29^{b}	21.37±0,33^{a}	28.54±0,28^{b}	24.61 ±1,04^{a}
C/Cm	28.88±1,19^{b}	24.92±0,33^{a}	30.33±0,27^{b}	27.88±0,19^{a}	26.88±0,23^{b}	22.92±0,17^{a}	29.13±0,27^{b}	25.27±0,17^{a}

S: soybean monocrop; Cw: Cow bean monocrop; Cm: Common bean monocrop; C/S: intercropping castor bean-soybean; C/Cw: intercropping castor bean-cow bean; C/Cm: intercropping castor bean-common bean; AEZ: Agroecologique zone; ZSG: Sudano-Guinean Zone; ZFB: Bimodal Forest Zone;
Values of the line followed by the same letter are not significantly different

Effects of intercropping on seeds yield and yield related traits

Table 5 summarizes the production parameters (number of fruits per plant, number of seeds per fruit and seeds yield) of Legumes at 98 days after sowing depending agroecological zone, intercropping system and years of experimentation. The analysis of variance shown that there is no significant difference between cow bean, soybean or common bean in intercropping with castor bean and Legumes in monocrop on production parameters. However, both study zone and the year of experimentation influenced significantly ($p < 0.05$) the seeds yield and yield related traits of Legumes.

In this study, the number of fruits per plant of Legumes ranged from 59.33 ± 0.27, 59.37 ± 0.29 and 7.57 ± 0.29respectivelyfor soybean, cow bean and common bean in monocrop in Sudano-Guinean Zone of Adamawa Cameroon in 2016 to 75.97 ± 0.27, 78.72 ± 0.33 and 12.92 ± 0.33 respectively in intercropping in the Bimodal Forest Zone of East Cameroon in 2015. There is a positive and significant correlation ($r = 0.55$, $p < 0.05$) ; ($r = 0.56$, $p < 0.05$) and ($r=0.78$, $p < 0.05$) between the number of fruits per plant and seeds yield respectively for soybean, cow bean and common bean. The results obtained on the number of fruits per plant of cow bean in this study corroborate those of [47] on the positive effect of phosphate fertilization on cow bean yield in Tunisia who reported that the number of fruits per plant of cow bean ranged from 8 to 48. In addition

[25, 48], revealed that the number of fruits per cow bean plant varied from 9 to 86 and from 8 to 57 respectively.

Results obtained on a number of fruits per common bean plant in this study corroborate the data found in literature. Indeed [26], reported that the number of fruits per plant of the common bean varied from 5 to 9. The value obtained on a number of fruits per plant of soybean in both study zone is lower than that obtained by [49] who found that the number of fruits per plant of soybean varied from 12 to 90 [28, 45]. Reported that the number of fruits per soybean plant at maturity varied between 13 and 98. Overall in this work, the numbers of fruits per plant of soybean, cow bean and common bean were 1.04, 1.04 and 1.05 fold greater than monocrop.

In this study, the number of seeds per fruits ranged from 2.33 ± 0.17, 7.33 ± 0.33 and 3.33 ± 0.17 respectively for soybean, cow bean and common bean in monocrop in the Sudano-Guinean Zone of Adamaoua Cameroon in 2016 to 2.67 ± 0.19, 7.67 ± 0.21 and 3,967 ± 0.27 respectively in intercropping in the Bimodal Forest zone of Cameroon in 2015. There is a positive and significant correlation ($r = 0.30$, $p < 0.05$); ($r = 0.32$; $p < 0.05$) and ($r = 0.38$; $p < 0.05$) between the number of seeds per fruit and seeds yield respectively for soybean, cow bean and common bean. Results obtained in this study on the number of seeds per fruit of cow bean corroborate those of [47] who reported that the number of seeds per fruit of mature cow bean varied from 7 to 10. The studies of [48] and [25], revealed that the number of seeds per fruit of cow bean at maturity varied from 7 to 12. Value obtained on the number of seeds per fruit of the common bean is greater than that found by [26] who reported that the number of seeds per fruit of common bean ranged from 2.44 to 2.46. Several authors [49,28,45], revealed that the number of seeds per fruit of soybean at maturity varied from 2 to 3. Overall, in this study the number of seeds per plant of soybean in intercropping is 1.01 folds greater than monocrop.

In this study the seeds yield of legumes ranged from 175.67±0.27, 168.33±0.17 and 177.67±0.27 Kg/ha respectively for soybean, cow bean and common bean in monocrop in Sudano-Guinean zone of Adamawa Cameroon in 2016 to 195.67±1.33, 196.67±0.27 and 185.67±0.13 Kg/ha respectively in Bimodal Forest zone of East Cameroon in 2015. The values obtained on Legumes seeds yield in this study are lower than data found in literature. Indeed [50], on intercropping cereals and cow bean in N'Djamena (Chad) and reported that cow bean seeds yield ranged from 1000 to 7000 kg/ha. [41, 25], reported that cow bean seeds yield ranged from 7 to 12 t/ha. Furthermore [44], revealed that common bean seeds yield varied from 0.75 to 0.99 t/ha. In addition [46], reported that soybean seeds yield at maturity ranged from 1 to 2.5 t/ha. [28, 45] reported that the seeds yield of soybean at maturity varied respectively from 2.5 to 40 t/ha. Globally in this work, the seeds yield of soybean, cow bean and common bean in intercropping are respectively 1.06, 1.06 and 1.07 fold greater than monocrop. The lower values of Legumes seeds yield obtained in this study would be justified by the fact that no fertilizer has been applied to our plants in order to optimize plant growth and seed yield. Several authors [51, 32], revealed that fertilizer improve soil fertility and increase plant productivity.

Overall, in this study, Legumes yield is significantly ($p < 0.05$) higher in 2015 than 2016, thus justifying by the change observed between years 2015 and 2016 of experimentation. The difference between both study years on temperature and precipitation in Sudano-Guinean zone of Adamaoua of Cameroon was 0.75 °C and 473 mm respectively. The difference between the years 2015 and 2016 on mean annual temperature and total annual precipitation was respectively 0.45 °C and 396.3 mm in Bimodal Forest Zone of East Cameroon (figure 2). In addition, [18], study the effects of temperature and rainfall on food production in Southern Cameroon and reported that climate conditions influence plant productivity in Southern Cameroon region. Also, these authors revealed that higher temperatures and rainfall can be contributed to decreasing plant growth.

The beneficial effect of intercropping on plants growth and production of Legumes (soybean, cow bean and common bean) would be explained by the fact that in intercropping castor bean/Legumes, castor bean creates a favourable microclimate for legumes growth and also plays the role of a tutor for our Legumes. In addition castor bean would repel pathogen agents. Would reduce damage of plant diseases, but this need to be investigated. The cultural intercropping is thus revealed as a necessary tool for improvement of cropping systems.

Table-5: Number of fruits per plant, number of seeds per fruit and seeds yield of Leguminous

Parameters	Number of fruits per plant		Number of seeds per fruit		Seeds yield (Kg/ha)	
Year	**2015**					
AEZ	ZFB	ZSG	ZFB	ZSG	ZFB	ZSG
S	74.66±0,13^{b}	63.33±0,27^{a}	2.67±0,13^{a}	2.33±0,27^{a}	192.33±0,13^{b}	178.33±0,17^{a}
C/S	75.97±0,27^{b}	65.67±0,13^{a}	2.67±1,19^{a}	2.67±0,33^{a}	195.67±1,33^{b}	181.67±1,33^{a}
Cw	77,33±1,33^{b}	60,72±1,33^{a}	7,67±0,27^{a}	7,33±0,13^{a}	195,67±0,13^{b}	183,33±0,27^{a}
C/Cw	78,72±0,33^{b}	63,97±0,23^{a}	7,67±1,33^{a}	7,33±0,23^{a}	196,67±0,27^{b}	186±0,17^{a}

Cm	9,72±0,27[b]	9,27±0,13[a]	3,33±1,19[a]	3,33±0,33[a]	185±1,33[b]	171,67±1,33[a]
C/Cm	9,92±1,33[b]	9,72±1,33[a]	3,67±0,27[a]	3,67±0,13[a]	185,67±0,13[b]	172,33 ±0,27[a]
Years	**2016**					
AEZ	ZFB	ZSG	ZFB	ZSG	ZFB	ZSG
S	70,66±0,33[b]	59,33±0,27[a]	2,33±0,33[a]	2,33±0,17[a]	185,67±0,33[b]	175,67±0,27[a]
C/S	73,13±0,27[b]	61,67±0,17[a]	2,67±0,27[a]	2,67±0,17[a]	189 ±0,27[b]	177,67±0,17[a]
Cw	73,37±0,17[b]	57,37±0,29[a]	7,33±0,27[b]	7,33±0,33[b]	189 ±0,33[b]	177,67±0,27[a]
C/Cw	75,16±0,17[b]	59,16±0,13[a]	7,67±0,17[b]	7.67±0,33[b]	192.33±0,19[b]	179±0,21[a]
Cm	9.13±0,27[a]	7.67±0,17[a]	3.33±0,23[a]	3.33±0,17[a]	173.67±0,27[b]	168.33±0,17[a]
C/Cm	9.37±0,17[a]	7.57±0,29[a]	3.67±0,27[a]	3.67±0,33[a]	174.33±0,33[b]	169±0,27[a]

S: soybean monocrop; Cw: Cow bean monocrop; Cm: Common bean monocrop; C/S: intercropping castor bean-soybean; C/Cw: intercropping castor bean-cow bean; C/Cm: intercropping castor bean-common bean; AEZ: Agroecologique zone; ZSG: Sudano-Guinean Zone; ZFB: Bimodal Forest Zone;
Values of the line followed by the same letter are not significantly different

Land Equivalent Ratio of intercropping system depending on agroecological zone and years of experimentation

Table 6 summarizes the Land Equivalent Ratio (LER) of intercropping castor bean/Legumes according to agroecological zone and the year of experimentation. In this study, LER varies from 1.04 in intercropping castor bean/soybean in 2015 to 1.33 in intercropping castor bean/common bean in 2015 in Soudano-Guinean Zone of Adamawa Cameroon. These results obtained on LER corroborate data found in literature. Indeed, several authors [52,53,5] revealed that the LER of Legumes and non-fixing azote plants are higher than 1.LER is basically defined as the ratio of the surface productivity in intercropping culture to that in Monocrop. It compares the yield of intercropping system with the yields of crops alone system. LER>1, suggesting that the intercropping is effective while LER< 1 suggesting that the intercropping is not benefited. In this study, LER of all farming systems studied are higher than 1, thus suggesting that the castor bean-soybean, castor bean-cow bean and castor bean-common bean farming systems are benefited in our study zone. Globally, castor bean/common bean exhibited the higher value (1.18) of LER while the lowest value (1.03) is observed on castor bean/soybean farming systems. Result obtained on LER in this study suggests that castor bean/common bean farming system is more benefit than other farming system while castor bean/soybean farming system is the less effective for peasants of the East and Adamawa Cameroon region. The beneficial effect of castor bean/common bean farming system compared to other farming systems studied suggests that common bean would fix more azote than soybean and cow bean in our study zone, but this need to be assessed.

Table-6: Land Equivalent Ratio depending agroecological zone and experimental year

AEZ	ZFB			ZSG		
	C/S	C/Cw	C/Cm	C/S	C/Cw	C/Cm
2015	1.09	1.12	1.13	1.04	1.05	1.33
2016	1.05	1.08	1.11	1.03	1.04	1.18
Average	1.07	1.1	1.12	1.03	1,045	1.25

C/S: intercropping castor bean-soybean; C/Cw: intercropping castor bean-cow bean; C/Cm: intercropping castor bean-common bean; AEZ: Agroecological zone; ZSG: Sudano-Guinean Zone; ZFB: Bimodal Forest Zone.

CONCLUSION

This study aimed to evaluate and improve the growth and yield of castor bean, soybean, cow bean and common bean plants under the intercropping systems in the Bimodal Forest and Sudano-Guinean zones of Cameroon. Growing and production parameters of plants have been assessed. Comparison of the performance of each farming system was made on the basis of the Land Equivalent Ratio (LER). Results show that plant productivity varies depending intercropping system, study zone and experimentation years. Castor bean seeds yield in intercropping with soybean, cow bean and common bean are 10.09, 13.52 and 17.88%folds greater than castor bean in monocrop. Castor bean is significantly ($p< 0.05$) more productive in Soudano-Guinean zone (seeds yield: 160.97±1.93 Kg/ha) compared to Bimodal Forest zone (143.76±2.05 Kg/ha) of Cameroon and inversely for Legumes. Castor bean and Legumes productivity is better in 2015 than 2016. LER varies from 1.05 in intercropping system castor bean/soybean in 2016 to 1.33 in intercropping system castor bean/common bean in 2015. Intercropping system castor bean-Legumes are [47] official for Cameroonian farmers. However intercropping castor bean/common bean is more effective compared to both castor bean-soybean and castor bean-cow bean. The Sudano-Guinean zone of Adamaoua Cameroon is more favourable for castor bean growth during Legumes growth in Bimodal Forest of East Cameroon better. By cultivating castor bean in

intercropping with Legumes, Cameroonian peasants contribute not only to fight against climate change but also to ensure food security. Further research will be emphasized on the effects of intercropping farming on physicochemical properties of castor bean and Legumes seeds.

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