Research Article

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THE IMPACT OF PLANT VARIETY AND POPULATION DENSITY ON THE GROWTH, PHYSIOLOGICAL AND YIELD RESPONSE OF MAIZE (ZEA MAYS) IN A TROPICAL RURAL AREA IN YAOUNDE-CENTER REGION OF CAMEROON

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ABSTRACT

The high domestic demand for maize, which can be considered as a significant contributor to ensuring food security and health potential in Cameroon, contributed to motivate the interest to undertake this study and the resultant findings of the research. The study aims to investigate the result effect of maize variety and population density on the growth, physiological and yield response as well as the impact of adoption of improved maize varieties in Yaounde (vii) sub division center region of Cameroon. The five treatments (inter- row spacing) were: Treatment 1 (T115cm 195200 plants per hectare),Treatment 2 (T220cm-71400 plants per hectare), Treatment 3 (T325cm 57100 plants per hectare),Treatment 4 (T430cm47600 plants per hectare),Treatment 5 (T535cm40100 plants per hectare), Treatments were arranged in a randomized complete Block Design. Commercial N P K (20:10:10) fertilizer was applied after the development of five leaves by the plant. This research was conducted between June and July 2021. There were three blocks each with a surface area of 40 meters square. Each block was divided into three raised ridges. Each ridge measured 200cm by 0.5m. The ridges were separated from the adjacent ridge by 0.5m. Maize seeds were sown per intra- row spacing on 13th of June 2021 after having observed consecutive rainfall. Data was collected on physiological, morphological and yield parameters. The data was subjected to ANOVA and the ordinary least square technique was the mean segregated method used to determine factors that influence maize yield. The results show that different intra- row spacing influence morpho-physiological abilities such as plant emergence, plant height, stem collar diameter, leaf area index, plant vigor and the yield parameters involving weight of cobs at harvest irrespective of the variety of the maize. Maize is the agronomic grass species that is most sensitive to variation in plant density. For each production system, there is a population that maximizes grain yield. This present an overview of the factors that affect optimum plant population, emphasizing on row spacing and variety on development and discussing important traits that have contributed to increase in yield of modern hybrids to specific, inter row spacing for maximum economic yield.

Key words: ANOVA: analysis of variance, ordinary least square techniques

RÉSUMÉ

La forte demande intérieure de maïs, considérée comme un facteur important de sécurité alimentaire et de santé au Cameroun, a motivé l'intérêt suscité par cette étude et les résultats obtenus. L'étude vise à étudier l'effet de la variété de maïs et de la densité de population sur la croissance, la réponse physiologique et le rendement, ainsi que l'impact de l'adoption de variétés améliorées de maïs dans la sous-division de Yaoundé (VII), région du Centre, au Cameroun. Les cinq traitements (espacement inter-rangs) étaient les suivants : Traitement 1 (T115 cm - 195 200 plants par hectare), Traitement 2 (T220 cm - 71 400 plants par hectare), Traitement 3 (T325 cm - 57 100 plants par hectare), Traitement 4 (T430 cm - 47 600 plants par hectare), Traitement 5 (T535 cm - 40 100 plants par hectare). Les traitements ont été organisés selon un dispositif en blocs randomisés complets. Un engrais commercial N P K (20:10:10) a été appliqué après le développement de cinq feuilles par la plante. Cette recherche a été menée entre juin et juillet 2021. Il y avait trois blocs d'une superficie de 40 mètres carrés chacun. Chaque bloc était divisé en trois billons surélevés. Chaque billon mesurait 200 cm sur 0,5 m. Les billons étaient séparés du billon adjacent

de 0,5 m. Les graines de maïs ont été semées selon un espacement intra-rang le 13 juin 2021 après avoir observé des précipitations consécutives. Des données ont été collectées sur les paramètres physiologiques, morphologiques et de rendement. Les données ont été soumises à une ANOVA et la technique des moindres carrés ordinaires était la méthode de ségrégation moyenne utilisée pour déterminer les facteurs qui influencent le rendement du maïs. Les résultats montrent que les différents espacements intra-rang influencent les caractéristiques morphophysiologiques telles que la levée, la hauteur, le diamètre du collet, l'indice foliaire, la vigueur et les paramètres de rendement, notamment le poids des épis à la récolte, quelle que soit la variété de maïs. Le maïs est l'espèce de graminée agronomique la plus sensible aux variations de densité de plantation. Pour chaque système de production, il existe une population qui maximise le rendement en grains. Cet article présente un aperçu des facteurs qui influencent la population optimale, en mettant l'accent sur l'espacement et la variété au cours du développement, et en analysant les caractéristiques importantes qui ont contribué à l'augmentation du rendement des hybrides modernes, en fonction d'un espacement spécifique entre les rangs pour un rendement économique maximal.
Mots clés : ANOVA : analyse de la variance, techniques des moindres carrés ordinaires

I: INTRODUCTION

In Cameroon maize is considered as a strategic crop for poverty reduction, food security and economic development by many scholars (*Mamu et al. 2014;* Ntsama Etoundi and Kamgnia Dia 2008) since its introduction in Cameroon around the sixteenth century by Portuguese (*Egbe et al. 1995*), the maize production has gone crescendo mainly as a result of increasing cultivated areas rather increasing productivity. Estimated at about 13303tons in 2013 (FAO,2016). the maize production provides lively hood for more than three million of all small rural farmer and account for about 25 billion FCFA each year (*manu et al, 2014*; Ntsama Etoundi and Kamgnia Dia, 2008): cultivated everywhere within the country maize is staple food crop for many Cameroonians. It is consumed over diverse plate (roasted corn, boiled corn, fufu corn, pap and sanga according to the preferences of different ethno-Linguistic groups (N3 ossie *et al,*2010) despites; the heavy role the maize plays within Cameroon society, it production still remain limited face to the increasing demand resulting from high population growth although the maize production have been increasing in Cameroon, this increase has occurred as a result of augmentation of cultivated areas instead increasing maize productivity or any sustainable policy to face with the limited maize production should focus on increasing maize productivity past studies identify low soil fertility insect attack and disease such as streak and the foliar diseases, the irregularity and sometime insufficiency of rain, lack of improved seeds suited to certain zones, the low availability of inputs, the low use of input and the drought as possible factors associated to low crop productivity (*Cairns et al, 2013*; Nkamleu, 2004) Among these factors, the lack of improved seed maize varieties are generally, distinguished: Open pollinated varieties and hybrid obtained from two pure varieties. In Cameroon, the first improved maize varieties were developed in 1987 by the agricultural Research institute for development (IRAD) through the national cereals research and extension (NCRE) Project (Ntsama Etoundi and Kamgnia Dia, 2008 from the date, numerous improved maize varieties have been developed and released within and out of the country and assisting producers. All these programs with PNAFM as leader and other actors such as MINADER, IRAD, Cooperatives etc. from the distribution channels of improved maize varieties in Cameroon. Despites the efforts of popularization of improved maize varieties by the government, the maize yield has remained static and was estimated at 1.95 tons per hectare in 2014 (FAO, 2016) This has raised the suspicion of rural farmers on the capacity of improved maize varieties to enhancing the maize yield.

Maize is a key ingredient in animal feed, industrial raw material and the basic for food security in many parts of the world especially in the sub Saharan Africa. Since 1980s maize has become the new cash crop for many farmers and families who now diversify their crop production because of the new trend market force due to the inability of famers to produce enough maize in order to satisfy the growing urban population (ministry of planning general census 2017. Maize contribution to food security in Africa, Cameroon and Yaounde identify drivers transforming food system and then apply to the cereal value chains and disentangle their effects on food security According to (Adebowel (2004) sighted that the demand for maize exceeded the supply as a result of it additional use as baking and brewing industries. More over maize production is dominated by small holder farmers using traditional manual method and simple input technology in low land labour productivity (FAO, 1999) but harvest at current level will still fall short of demand (FAO STAT 2010) unless vigorous measures are to enhance yield growth. The crop provides over 20% of total calories in human diet (Hyman et al, 2008). Production of maize in Cameroon is affected by a number of constraint including an away of abiotic and biotic stresses poor soil fertility, lack of access to key improve inputs low level of production technique and poor post-harvest management etc. This crop is the most important staple food to some regions in Cameroon, which observed often, extreme low average yield approximately 1.5 tons per hectare as compare to 3 tons of hectare in developed countries (Department of agriculture statistics ministry of agricultural and rural development 2019). This study assess the effectiveness of three varieties of maize on five different planting distances on the growth and physiological responses of maize and it focuses on the following growth and physiological parameters: emergence, plant vigor, leaf area index, plant height, stem collar diameter, number of plant at maturity weight of cobs at harvest. The duration of the experiment was three month five days for cobs maturity. To assess the influence of plant variety on the growth, physiological and yield indicators of maize (zea mays),To assess the influence of plant population density on the physiological and yield indicators of maize variety;To assess the influence of plant variety on the growth and yield indicator of maize (Zea mays),To establish a relationship between maize variety and population density of zea mays.

II.Materials and Methods

This study will make available information to the farmers house hold of Nkolso,o village in Yaounde (vii) municipality on recommended appropriate intra-row spacing of 25cm for variety CMS 8704 and 30cm spacing for variety CMS 8501 and 20cm for variety ACRO 06 for maximum maize kernel production and even to villages in the same agro-ecological zone plant The study will be of great important to the Cameroon government through the ministry of agriculture and rural development as it will create awareness on the recommended intra- row spacing through its extension services to the farmers which will boost the yield of maize in the country, and it will also help to boost the economy and greater satisfaction to her fast growing population. Furthermore it will also guide students and researchers serving as a base or foundation for further research on the topic.

There is an ongoing debate about how best to feed the growing world population in the long run and associated implication for research and development, known today as green revolution to secure the supply of staple food. Whereas the importance of diversifying and improving people's diets. We contribute to this debate by reviewing the case of maize production and maize value chain and its contribution to food security in Cameroon and yaounde vii municipality. The review highlight maize production will be increasingly impaired by abiotic and biotic factors such as land degradation, water scarcity, and climate change and soil nutrients depletion. There are promising innovations to increase and maintain productivity, but constraint in adopting these innovations have to be over come through access to improved seeds variety. Finance, training and continuous sensitization of recommended planting techniques.

The experiment was conducted at Nkolso'o a village located in Yaoundé (vii) sub division of the Centre region of Cameroon. Nkolso'o lies north of Nkolbessong. It has a population of about 18036 inhabitants (statistics from the health district of Nkolso'o census 2020 shows that; the geographical coordinates of Nkolso'o are longitude: 10.432113, 3.31 north and Latitude 5.4873028, 11.30 east of the equator and the principal activity of the inhabitants include business of various domains with little agricultural practices like maize, fruits and vegetables for home consumption. This research was conducted from June 13th to September 5th 2021. The soil in the village is a ferralitic types which are as a result of highly weathered and leached soils of the humid tropic enrich in iron and aluminum. Primary minerals are generally absent except quartz, and the dominant secondary mineral, are some combination of kaolinite, gibbsite and hematite the climate of Yaoundé varies with it four season as follows: July 26 degree Celsius September: 27 degree Celsius, October 28 degree Celsius in Yaoundé, the wet season is warm and over cast, the dry is hot and mostly cloudy. The temperature typically varies from 67 degree F. to 87 degree F. The map of Nkolso'o the rainfall average 154.1mm within the total 144 days of rainfall in the month of October with 293.6mm

Determination of optimum plant population and the use of improved varieties in combination with appropriate agronomic practices are important components of maize production for maximizing productivity. The study was conducted in 2017 and 2018 under supplementary irrigations at Gulliso district western Ethiopia to determine the effect of variety and intra-row spacing on yield of maize. The experiment was conducted in factorial arrangement of four intra-row spacing(20cm, 25cm, 30cm, 35cm) with three maize varieties (BH546). SHONE and BHQPY 545) The interaction of varieties and intra-row spacing was highly significance ($p>0.01$) on yield component and yield of maize. The highest (1.75) average number of ears per plant was recorded from varieties spacing BH546 and BHOPY545 at 35cm intra-row spacing. The highest (35cm) ear length was recorded from BH546 at 35cm intra-row spacing. General leaf area index, stand count ears per plant, ear length and ear diameter showed a decreasing intra-row spacing based on these result, it can be tentatively concluded that variety BH546 could be used at plant density of 53.3333 plant ha-1 and 25cm intra-row spacing is best to get the highest green cobs yield of maize under supplemental navibation during the off season in the study areas; Figure 1-3. Figure 4 presents the different varieties.

Figure 1: Map of cameroon showing Yaounde

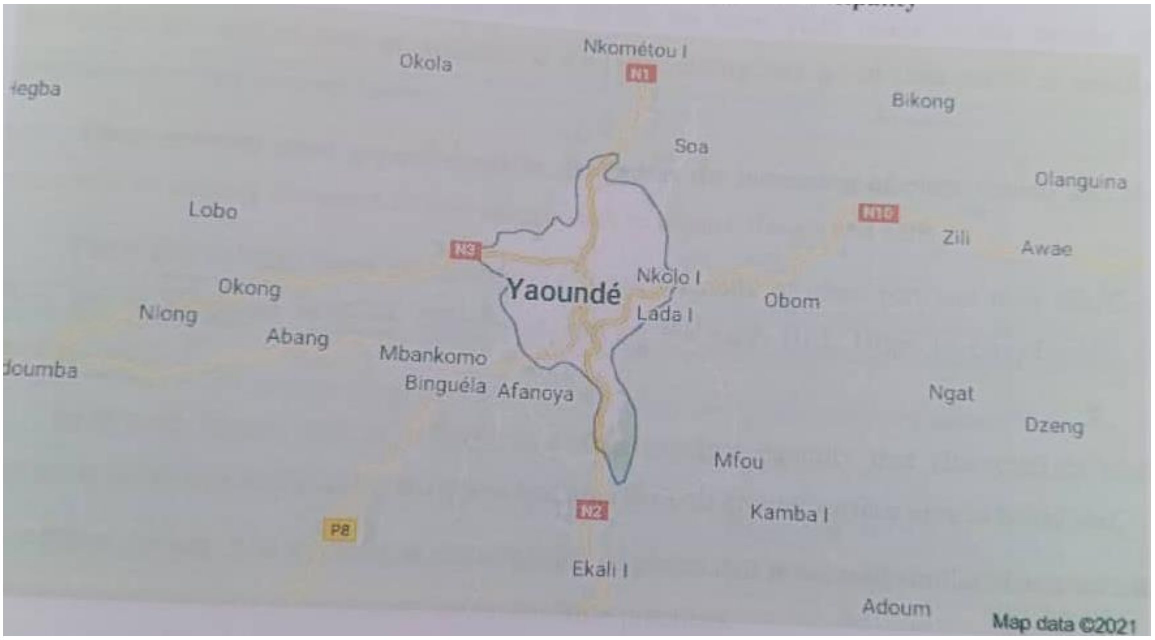


Figure 2: Map of Yaounde showing Yaounde vii municipality

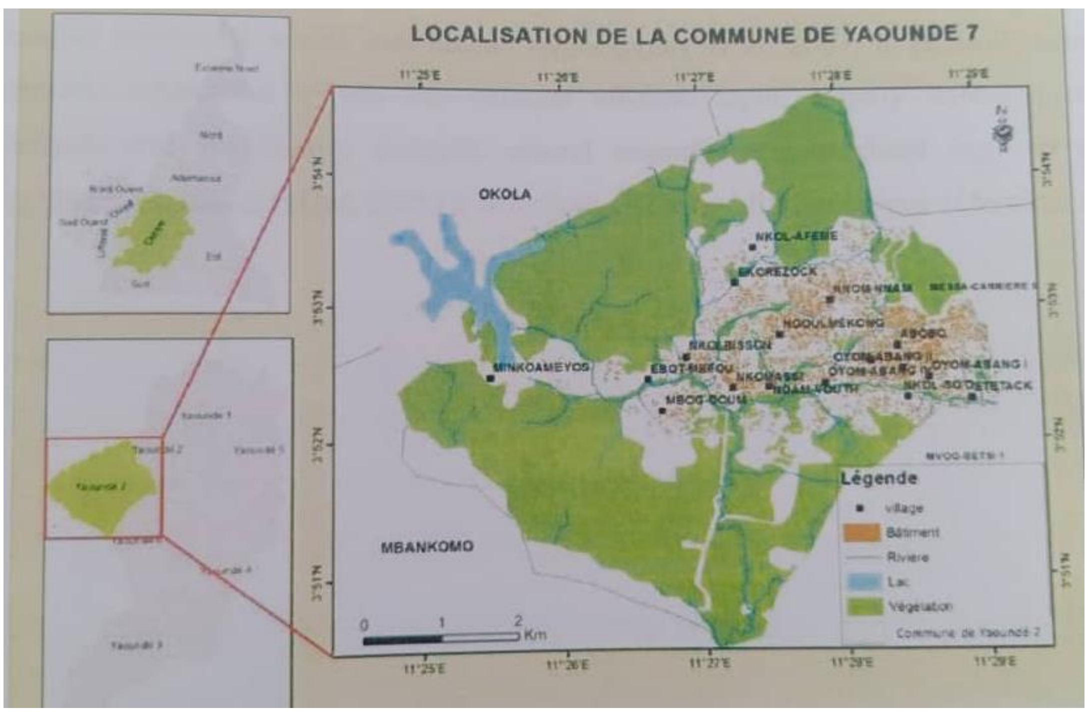


Figure 3: Location map of the study area

ACRO 06 Variety CMS 8704 Variety CMS 8501 Variety

Figure 4: Some of the varieties that can influence optimum plant population density

Since the emergence of the green revolution, investment in agriculture has resulted in the development and dissemination of many improved crop variety (ICV) for cultivation for farmers worldwide. The development of these improve crop Variety (ICV) is geared toward increasing farm productivity and income reducing hunger and malnutrition and minimizing food insecurity. particularly among developing economies like Cameroon. However research have shown that in small holder farming communities in developing countries, adoption of ICV including improved maize varieties (IMV) is relatively low. The study investigate the determinant of adoption and adoption intensity of IMV in the center region of Cameroon. Emperical finding from the study confirms that fauner's socioeconomic characteristic. Institutional and policy factor significantly influences adoption and adoption intensity of IMV

The impact of adoption of improved maize varieties on yield, food security and or poverty. (Ntsama Etoundi and kamgnia Dia 2008, Nabasirye et al. 2012, Manue et al. 2014, Khonje et al 2015;, Takam fongang, 2016). Although most studies have stressed the positive impact associated with adoption of improved maize varieties the result are less reliable, these studies are always localized and do not take into account the entire economy. Indeed, a technology may perform better in one area and not in another one or perform better today and not tomorrow because of one reason or another. This is the case of improved maize varieties which are greatly susceptible to climate condition and soil characteristic which constantly change over time. Thus, localized impact evaluation seeking to assess the impact of new technologies such as improved maize varieties should be complimented by a macro and long term impact evaluation in order to determine not only the long term impact of adoption of new technologies but also to avoid falling into fallacy of composition. According, this study seek to fill this gap by analyzing the macro and long term impact of adoption improved maize varieties on maize yield in Cameroon. The study therefore recommends that farm level strategies oriented towards the adoption of ICV, in general, is very crucial to enhance productivity growth in Cameroon agricultural economy. As the world population is expected to reach 9.1 billion by 2050, the production of food mainly staple crops is expected to increase accordingly, especially for the 870 million people who are currently in food secure (International Finance Corporation [IFC], (2013). This suggests that the dominant role of agriculture as the primary source of food and employment creation in the developing economies should be stepped up. A study by Alexandratos and Bruinsma (2012) indicated that agricultural production needs an increase of 60% by 2050 to meet the world's consumption demands. This expected growth means that small holder's farmers who are the principal conduit of agricultural production have a significant role to play in sub-Saharan Africa as majority of the population is agriculture dependent with above 55% in the rural areas (IFC, 2013). Agriculture in Cameroon is a crucial sector contributing about 45% to GDP and employing more than 70% of the labour force (FOA, 2015).The contribution of agriculture in achieving the Millennium Development Goal (MDG) of halving poverty and hunger by the end of 2015 was quite impressive. For instance, between 1992 and 2013, the national poverty level in Cameroon thus achieving MDG) target Cooke, Hague and Mckay, 2016).

However the sector remains predominantly small scale with over 82.5% of rural house involved in producing about 80% of the output through rudimentary method leading to low productivity (FAO,2015;Cameroon statistics service 2014) particularly in some part of the economy about 35% of people still live under 1.25 US dollars per day (FAO,2015). The vital sector consisting of major crops such as cocoa, cassava plantain, oil palm, maize, and other cereals and fruits. The sector has been fluctuating regarding its contribution to GDP. This suggest that the agricultural economy. Among the cereal crops maize is considered the most critical crop accounting for about 50% of the total cereal production with an estimated 2.1 million house hold involved in its cultivation (FAO,2014). Maize has been cultivated in Cameroon since late 16th century and was formally a significant food crop in the Northern and Southern part of the country. Today maize is an essential staple food produced by the vast majority of the rural households across the five agro ecological zones of Cameroon: Sudano Sahelian, Guinean high savannah, Western high land and the monomial rainforest.

The poultry and livestock sector largely depend on maize for their survival since it forms a substantial component of livestock and poultry feed, the crop is used for the preparation of other material such as corn starch, corn flakes, maltodextrins corn oil, corn syrup, and product of fermentation and distillation industries despite the significant contribution of maize to the Cameroon economy, growth in the sector has come as a result of expansion in the area of land cultivated rather than productivity. The low productivity could partly be ascribed to low adoption of IMV which limit the revenue of farmers and subsequently lead to poverty and food insecurity: yet there is a paucity of studies explaining the economic relationship between farm house hold socio economic factors and adoption of improved maize variety. Moreover, adoption of both the improved and the local variety of maize. The present study provides an understanding of the determinant of improved maize variety adopted and its intensity in the ten regions of Cameroon. Roger (1962) defines adoption as the use and continue use of innovation. His study employed random utility frame work in analyzing adoption and intensity of IMV. It is assumed that a maize farmer is a rational producer and will therefore make a rational production decision. They have a choice of planting only local variety or only IMV or a combination of the two with the aim of making maximum profit.Adoption can be defined as the use and continue use of innovation (Rogers, 1962). The study, employed random utility framework in analyzing adoption and intensity of improved maize variety. We assumed that a maize farmers is a rational producers and will, therefore, make a rational production decision.

Considering, that maize farm household have choices of planting only local variety; only improved maize variety (IMV) or a combination of the two, farm households aim to make maximum profit from their choices by the various choices available to them. The requirement of an ith maize farmers to choice any package m is that wij > πmM + j following previous and recent studies (Balta and Doyle, 2001; Diro, Ker, and Sam, 2005: Hanemann, 1984) the expected benefit zji that a farmer derives from the adoption of package j is a latent variable determined by observed households and farm specific characteristics and can be specified as *ji =XiBj + U Where Xi is observed covariate and oij is the error term capturing unobserved characteristics.The study employed a quantitative approaches to collect data for analyses using the growth rate model to measure how different treatments influenced the growth indicators of maize varieties.

1 MODEL SPECIFICATION

The model calculates the average weekly growth rate for the four different growth indicators by taking the change in each indicator and dividing it by the number of plants measured per treatment.

GRI =X1 + X2...X divided by the number of plant

DESCIPTION OF THE VARIABLES IN THE MODEL

GRI = the growth rate of indicators considered for measuring growth, including plant height, leaf area index, stem collar diameter and plant vigor. A description of each of these parameter.

Plant height: (cm) a meter ruler was used to measure the growth level from ground to the collar of the upper leaf with developed leaf sheath on the 5th July 2021(three months after planting. Six plants were sample from each block.

Plant collar diameter: Stem diameter was measured at tasseling (2.5 month after planting). The circumferences were measured at 2/3 the plant height and using the relationship given below to estimate the stem diameter (d) $d = C/\pi$ where: $\pi=3.14$. Sampling for the stem diameter was done in the same manner as that of plant height.

Leaf area index (LAI). Leaf area index was determined by the nondestructive length by method described by Saxena and Singh. (1965) using the relation LA = 0.75 (Length x width) where 0.75 is Joe constant. Sampling for leaf area was done in the same manner as that of plant heigh

Plant vigor: Pant vigor was estimated using a three coded scale standard: poor 1. verage 3, and good =5. Plant vigor measurement were carried out on the 30th July 2021 sampling for plant vigor was done in the same manner as that of plant height as presented in table I and II.

Table 1 Pant vigor scale, Source: field work

Scale	Description
1= poor	Thin plants, stunted with poor vigor
3-Average	Average vigor plant
5 = Good	Very vigor plant

Plant earliness: plant earliness was done through observation of leaves and cobs per replica, per variety compared to emergence to find out the number of days taken by a variety of maize.

Number of plant at harvest: plant number at harvest was done by counting standing maize stems per replica and per treatment of the three varieties.

Number of cobs: Number of cobs per plant at harvest was done by counting good matured cobs per each replica per variety.

Weight: The weight of cops per variety was done by weighing using a scale balance of 15 cobs per variety of maize.**Table II**

Table II:A summary of all steps followed and the methods used in carrying out the study

<u>PHASE 1: PREPARATORY PHASE</u> • Site description • Land description **<u>PHASE 2: EXPERIMENTAL WORK</u>** • Experimental material • Experimental design and description • Establishment of the experiment **Data collection** **<u>Primary data</u>** • Controlled field experiment CRN=3X3X5=45)-to assess growth and physiological response **Desk review of related literature** <u>PHASE 3 DATA ANALYSIS</u> 1 Statistical analysis • Ordinary least square technique • ANOVA-to test for significant differences between the means of growth parameters • Least significant difference (LSD) and segregate means Statistical tool: SPSS version 21

2 Phase 1 PREPARATORY PHASE

3.2.1 Site Description

The experiment was at Nkolso'o a village located in the center region of Cameroon with a population of 18035 inhabitants (MINASSATE, 2020 census) and it lies on latitude 10.4321113 and longitude 5.4873028 from the equator.

3.3 Land preparation

The experiment area was cleared using a cutlass. The grass was then raked to the border of the experimental area where it was piled up. The stock of grass and shrubs were off rooted using a dig axe. The soil was plough with hoes and expose stone were picked and gathered at the border of the plot. Using a line the plot was demarcated and the ridges pegged out. The ridges were then constructed along the line.The results are presented from figures 5 to 21 and Tables III to VIII.

Figure 5: Land preparation for planting, Source:Field work

Table III: Materials used for the experiment ,Source: Field work June 2021

N	MATERIAL	ACTIVITY
01	Cut lasses	It is used for clearing of the experimental plot, cutting and preparing of pegs
02	Rake	Used to gather the experimental plot and leveling of the experimental unit.
03	Hoe	Was used for tilling of the plot, formation of ridges weeding and molding
04	Woody pegs	To demarcate the experimental unit and alignment of the plot
05	Measurement tape of 50m long / A graduated ruler of 5m long	They are used for measuring the various dimensions of the experimental plot, the length, width, diameter, paths, and plant height and leaf area index.
06	Boots and jump suit	As protective wear while working and also to avoid the spread of diseases from elsewhere to the farm
07	Scale balance	Used to weigh maize cobs at harvest

3: Experimental Design and Description

The experiment was arrange in a randomized complete block design with 3 replication and 5 treatment. The replication of three varieties of maize that receive the five treatment. Each ridge of experimental unit measures 2m by 0.5m given an experimental area of 1 meter square. Each of this treatment was replicated three times three times the maize seed varieties (CMS. 8704, CMS 8501, and ACRO,06) obtained from IRAD NKOLBISONG already treated with powder fungicide (spectracide immunox). Against soil pathogens. The main materials that were used for the experiments were:

Germination after days five days of planting

Figure 6: Germination after days five days of planting

4. Experimental treatment

Table IV: Treatments and plant spacing used in the experiment

Treatment (T)	Intra-row spacing
T1	15cm X 0.5
T2	20cm X 0.5m
T3	25cm X 0.5m
T4	30cm X 0.5m
T5	35cm X 0.5m

5: DATA COLLECTION

Data was collected at vegetative stages and at harvest. Data collected at vegetative stages were: plant emergence, plant height, leave area index, plant vigor and earliness of variety. Data collected at harvest stage were: Numbers of plant, Numbers of cobs and cobs weight.Data collected was subjected to statistical analysis using IBM SPSS version 21. A one way data analysis of variance was used to compare the mean of various growth parameters among the treatments. Means where ordinary least square technique was used to determine the factors that influence maize yield taking into consideration factors such as stem diameter, plant height, and plant vigor, leaf area index.The validation of the outcome was taken into concern. The layout of the experimental research was constructed and submitted to the supervisor for inspection in which features, content and constructed strength were checked. Face validity was ensured as research supervisor checked that instrument was well constructed and was eligible to elicit the intended information. Content and construct validity were also ensured as the research supervisor carefully examined the instrument to see that the experimental layout was constructed following the research objective and following documented literature. Upon effecting the identified correction, the tools were submitted for support confirming it worth as data eliciting instruments the experimental design and sampling were designed respecting the principle of consistency with the research objective, to the research question taking into consideration the issue related to the problem and goals of the study on the subject. There was a tool defense later a pre defense conducted by the campus to ensure the reliability of the experimental design and sampling and to detect error in the experiment, and question which were considered vague were restructured to meet my objectives.

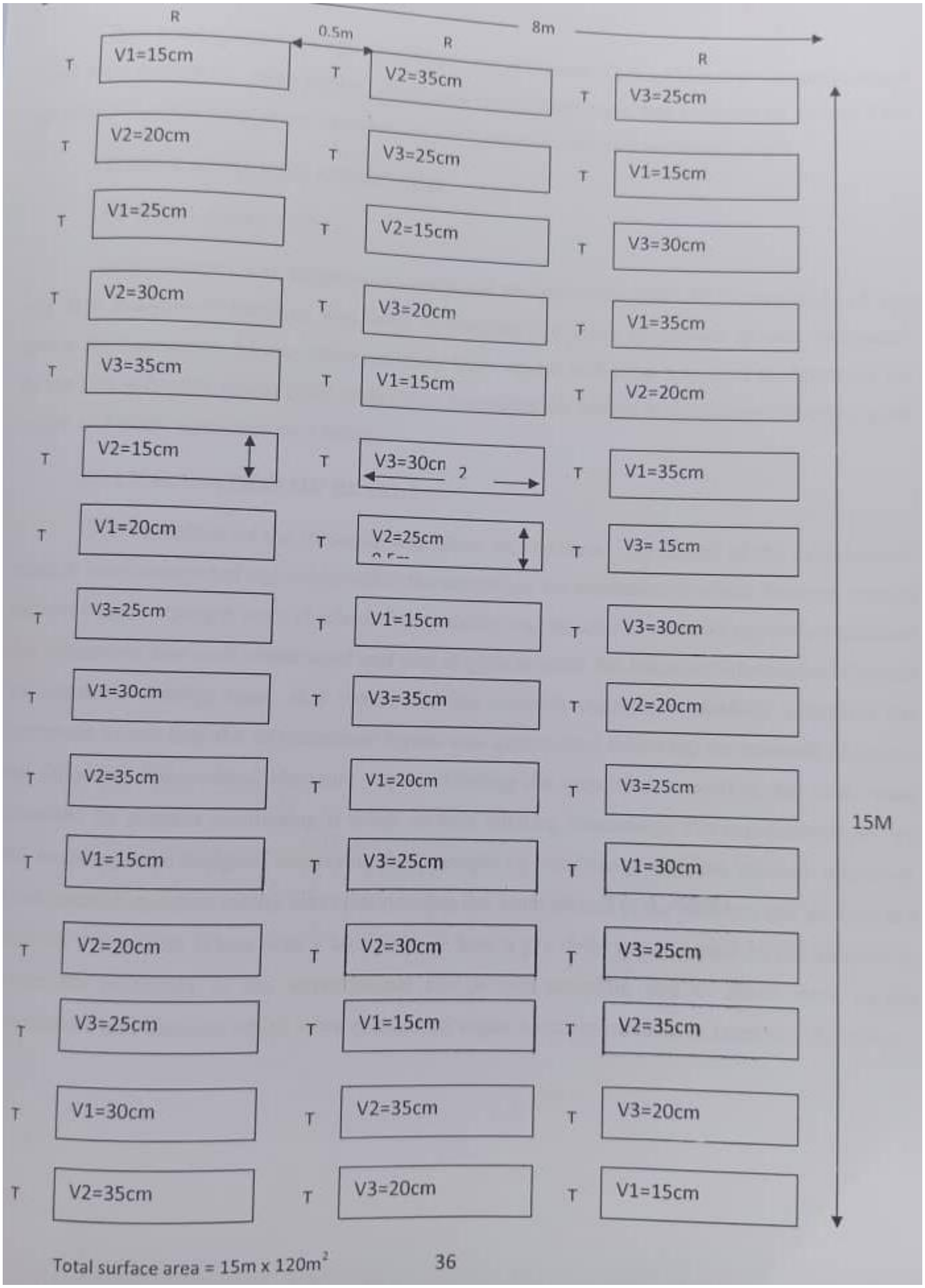


Figure 7:Experimental disposition

III.Results and discussion

The effect of plant variety on the growth, physiological and yield response of maize (Zea mays).

The result show that maize variety CMS 8704 responses best to growth indicators on the different population densities and treatment as presented on the bar charts as to CMs 8501 and ACR006 on plant height, stem, germination, plant vigor, leaf area index and weight of cobs.The number of plants that emerge was different with the three varieties of maize. It was highest with CMS 8704 in treatment two, three and treatment five (20, 25 and 35 cm spacing respectively). Where CMS 8501 had similar emergence rate. The difference in emergence might have been due to the viability of the seeds or other environmental factors such as soil structure, soil moisture, viability of seeds is a genetical factor in seeds. The study was in accordance with Tanye Denise Achiri (2017) who obtained the same result in the study of influence of maize density on morpho-physiological and yield parameters in Bali

The number of plants was highest at 15cm crop spacing on variety CMS 8704 and least on variety CMS8501 at 20cm spacing. At this spacing there is high competition for sunlight, plant elongation usually occurs at high population densities. This might have been the case of this result. Lerbenberg (2016) found that plant height was influenced by density. Plant height increases with increase in plant density.Plant vigor was highest at crop spacing of 25cm on variety CMS 8705 and least on variety CMS8501 in the crop spacing of 15cm. At 25cm spacing, there was low competition for soil nutrient, sunlight, soil moisture and appropriate feeding zone. This might have been due to maximum utilization of soil fertility and environmental factors. Plant vigor measures the visual appraisal of toughest and thickness of plants Ashraf (2009)

The leaf index was highest in the crop spacing of 25cm and 35cm n variety CMS 8704 and followed on variety. ACRO 06 in the 20cm crop spacing. In our study leaf area, index was calculated based on length and width and multiply by Joe constant (K=0.75). Our result is similar to that recorded by Telio Kagho and Garderner, 1987 in their study of response of maize to plant population densityThe stem diameter was highest in the 25cm crop spacing of variety CMS 8704 and at 35cm crop spacing on variety ARO 06 and variety CMS 8501 in the crop. Spacing of 25cm and 35cm there was low competition for nutrients, maximum sunlight and appropriate feeding zone. This might have been due to maximum utilization of soil fertility and environmental factors. Plant density generally influenced agronomic characteristics of maize.

The highest number of plants at maturity were recorded in the crop spacing of 20cm spacing on variety CMS8704 and 25cm on the three varieties of maize.CMS 8704, 8501 and ACRO 06. The least number of plants was recorded in treatment 1 of 15cm crop spacing.The weight of 15 cobs taken from each treatment and variety were different. The highest cobs weight was recorded in treatment 3(25cm) and treatment 4 (35cm) on variety CCMs 8704 and the least cobs weight was recorded in treatment 1 (15cm) on variety CMS 8501. This might have been due to increase in temperature, soil nutrients and water availability for photosynthetic activities in the plant and appropriate feeding zone. The findings revealed that the maize variety ACR006 had the largest stem under all the treatments or conditions with an average diameter of 1.34cm followed by the variety CMS8704 with an average diameter of 1.28cm and the maize variety CMS8501 had the smallest stem diameter with an average size of 1.2cm. This illustrated on the diagram below.

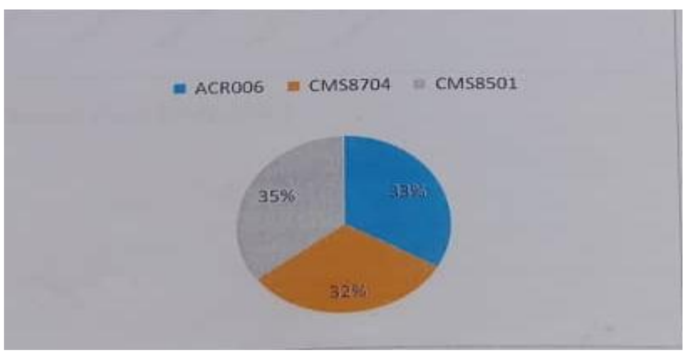


Figure 8: Pie chart of maize variety Diameter of the Maize Stems (Source: Field Study, 2021)

The research results also shows that in the first treatment, the maize variety ACR006 had the largest stem with a diameter of 1.3cm and the variety CMS8501 had the smallest stem with a diameter of 0.9cm. In the second treatment, the maize variety CMS8501had the largest stem with a diameter of 1.4cm and the variety ACR006 had the smallest stem with a diameter of 1.1cm. In the third treatment, the variety CMS8704 had the highest stem with a diameter of 1.5cm and the variety CMS8501 had the smallest stem with a diameter of 1.2cm. In the four treatments the variety ACR006 had the largest stem with a diameter of 1.4cm and the maize, Variety CMS8704 had the smallest stem with a diameter of 1.2cm. In the last treatment, the maize variety ACR had the largest stem with a diameter of 1.5cm and the variety CMS8501 had the smallest stems with a diameter of 1.2cm. This depicted on the diagram below;

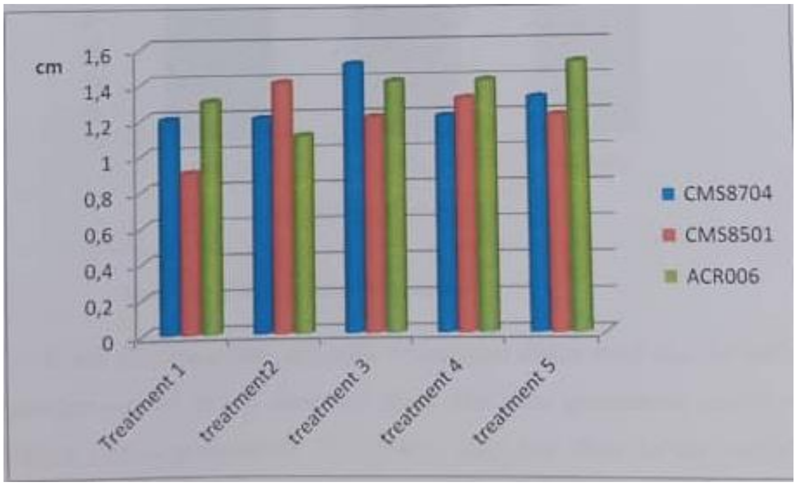


Figure 9: **Diameter of the maize stem under different treatment** (Source: Field Study, 2021)

1: Percentage Germination

The research findings revealed that the maize variety CMS8704 had the highest germination rate after five days in all the treatments with an average germination rate of 93.58%. The Maize variety CMS8501 was the second most germinated seeds with an average germination rate of 76.9% and the variety ACR006 had the low germination rate of 63.64%. This is illustrated on the diagram below;

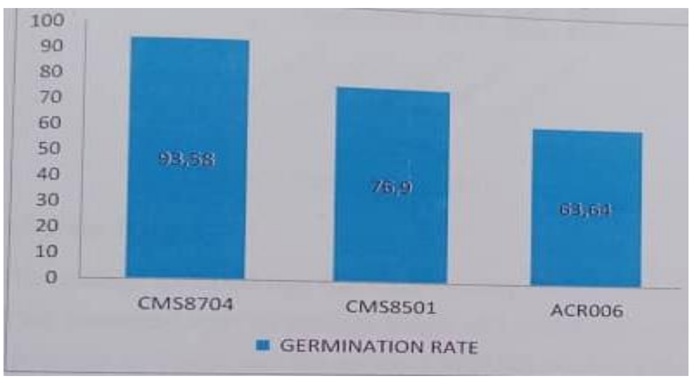


Figure 10: Bar chart representing maize variety germination in percentage
Source: Field work September

In the first treatment, the most germinated maize seed was the variety CMS8704 with a germination rate of 84.6% after five days. The least germinated variety in this treatment was CMS8501 with a germination rate of 46% after five days. In the second treatment, the most germinated maize seed was still the variety CMS8704 with a germination rate of 100% after five days. The least germinated seed under this condition was ACR006 with a germination rate of 50% and the germination rate of the seed variety CMS8501 increased under this second condition to 80%. In the third treatment, the seed variety CMS8704 was still the most germinated seed with a germination rate of 100%, followed by the CMS8501 variety with a germination rate of 75% and the variety ACR006 was the least germinated seed variety after five days. In the fourth treatment, the varieties CMS8501 and ACR006 had the same germination rate of 83.5% after five davs and the seed variety CMS8704 had the least germination rate of 83.3% after five days. In the last treatment, the maize varieties CMS8704 and CMS8501 had a 100% germination rate after five days and the variety ACR006 had a germination rate of 80% after five days. This is illustrated on the diagram below

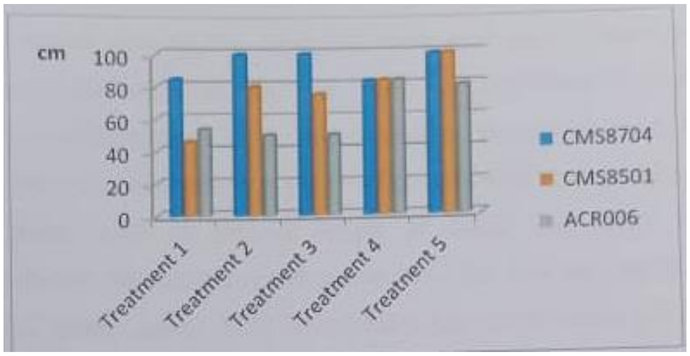
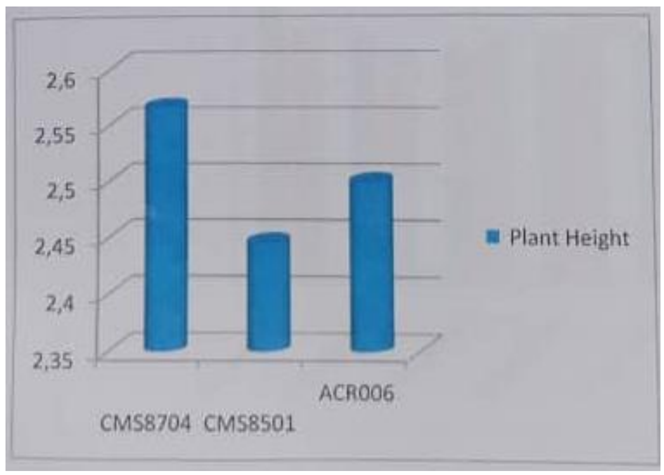


Figure 11: Germination Rates of the Different Maize Varieties in percentage
(Source: Field Study, 2021)

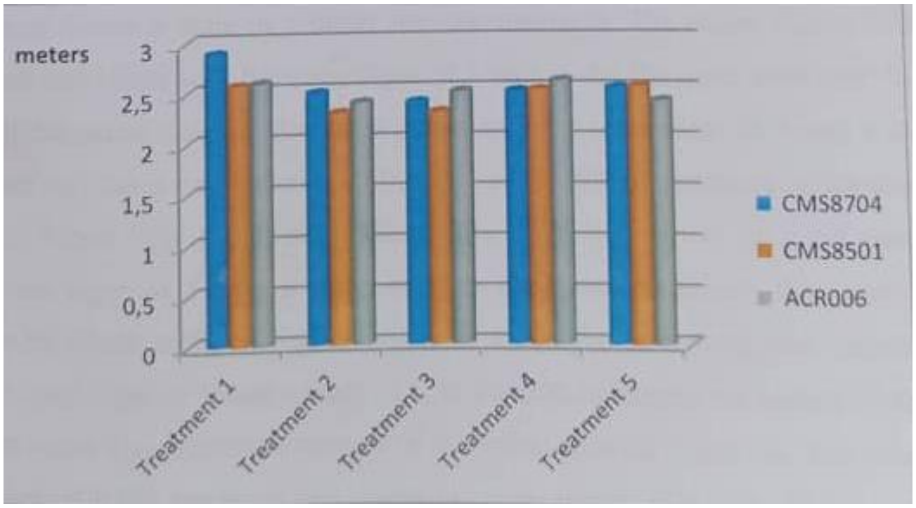
4.3 Plant Height

The findings revealed that the maize variety CMS8704 produced the tallest maize plants under all the treatment with an average height of 2.56cm, followed by the variety ACR006 with an average height of 2.5cm and the variety CMS8501 produced the shortest maize plants with an average height of 2.4cm. This is shown on the diagram below;



<u>Figure 12:</u> Bar chart representing plant height
(Source: Field Study, 2021)

Also, under the first treatment the maize variety CMS8704 produced the tallest maize plant with a height of 2.9csm followed by the ACR006 variety with a height of 2.6cm and the variety CMS8501 produced the shortest maize plant with a height of 2.566cm. In the second treatment, the variety CMS8704 still produced the tallest maize plants with a relatively shorter height of 2.5cm followed again by the variety ACR006 with still a relatively smaller height of 2.4cm as compared to the first treatment. The maize variety CMS8501 produced the shortest maize plants in the second treatment. In the third treatment, the maize variety ACR006 produced the tallest maize plants with an average height of 2.5cm followed by the variety CMS8704 which produced maize plants with an average height of 2.4cm and lastly the maize variety CMS8501again produced the shortest maize plants as in the first and second treatment. In the fourth treatment, the maize variety ACR006 produced the tallest maize plants with an average height of 2.6cm followed by CMS8501 that produced maize plants with an average height of 2.51cm and lastly, the variety CMS8704 produced the shortest maize plants with an average height of 2.5cm.In the fifth treatment, the maize variety CMS8501 produced the tallest maize plants with an average height of 2.54cm followed by the variety CMS8704 which produced plants with an average height of 2.53cm and the variety ACR006 produced the shortest maize plants with an average height of 2.4cm. This is shown on the Diagram below;



(Source: Field Study, 2021)

Figure 13: Height of the Maize Plants under Different Treatments in meters

2: Vigor of the Maize Plants

The findings revealed that the maize variety CMS8704 produced the most vigorous maize plants with an average of 4.4 over a scale of 5 followed by the CMS8501 variety which produced maize plants with an average of 3.6 over a scale of 5 and the variety ACR006 produced the least vigorous maize plants with an average of 3.5 over a scale of 5. This is illustrated on the diagram below;

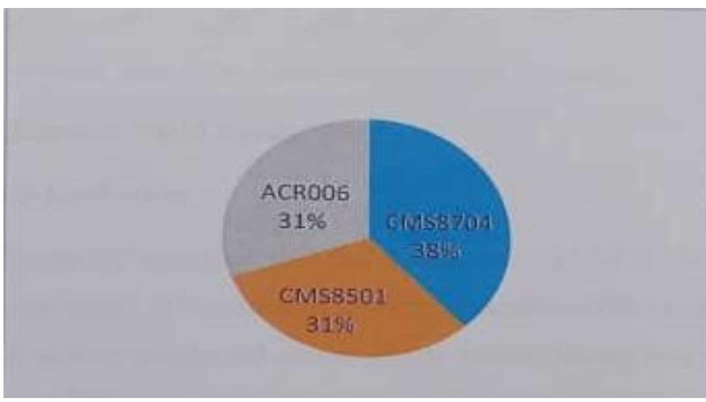
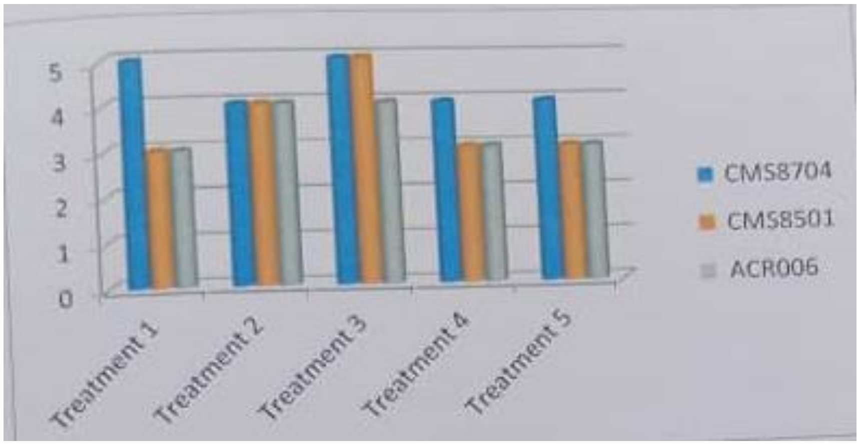


Figure 14: Pie chart representing plant vigor Maize Plants Vigor (Source: Field Study, 2021)

Again, the survey also revealed the maize variety CMS8704 produced the most vigorous maize plants of 5 over a scale of 5 under the first treatment. The maize variety CMS8501 and ACR006 produced plants with the same vigor of 3 each under the same treatment. In the second treatment, all the maize varieties produced plants with the same vigor of 4 over a scale of 5. In the third treatment, the maize varieties CMS8704 and CMS8501 produced maize plants with the same vigor of 5 each over a scale of 5. Meanwhile, the maize variety ACR006 produced maize plants of lower vigor of 4 over a scale of 5. In the fourth treatment, the variety CMS8704 produced maize plants with the highest vigor of 4 and the remaining two varieties produced plants of the same vigor of 3 over a scale of 5. In the fifth treatment, the variety CMS8704 again produced the most vigorous maize plants Of 4 over a scale of 5 and the two others varieties CMS8501 and ACR006 produced less vigorous maize plants of 3 each. This is shown on the diagram below;



<u>Figure 15:</u> Bar chart representing plant vigor (Source: Field Study, 2021)

3. Leaf Area

The study revealed that the maize variety CMS8704 produced plants with the largest leaf surface area under all treatment with an average surface area of 859.2cm² followed by the variety CMS8501 which produced maize plants whose leaves had a surface area of 790.3cm² and lastly the variety ACR006 produced maize plants with the smallest leaf surface area of 753.85cm². This is shown on the diagram below;

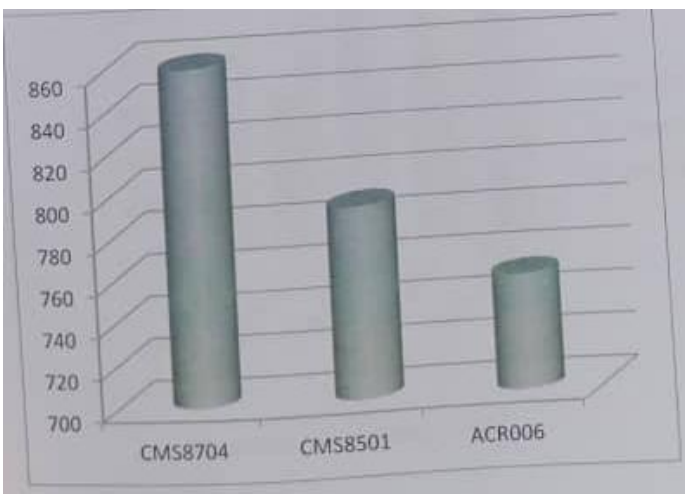


Figure 16:**(Source: Field Study, 2021)**

In the first treatment, the maize variety CMS8704 produced maize plants with the largest leaves surface area of 816.75cm² followed by the variety CMS8501 which produced maize plants with leaves surface area of 540cm² and lastly the variety ACR006 which produced maize plants with leaves surface area of 369cm². In the second treatment, the variety ACR006 produced maize plants with the largest leaves surface area of 990cm² followed by the CMS8501 variety which produced plants with leaves surface area of 614em and lastly CMS8704 with produced plant with leave surface area of 612cm². In the third treatment, the maize variety CMS8704 produced maize plants with the largest surface area of 1155cm² followed by the variety CMS8501 with leaves surface are of 900cm² and the variety ACR006 produced maize plants with the smallest leaves surface area with an average leaf surface area of 626cm². In the fourth treatment, the maize variety CMS8704 produced plants with the largest leaf surface area of 990cm² followed by the variety CMS8501 which produced plants with a leaf surface area of 907.5cm² and the smallest leaf surface area of 668.25cm² was produced by the variety ACR006. In the fifth treatment, the maize variety CMS8704 produced plants with the largest leaf surface area of 1170cm².

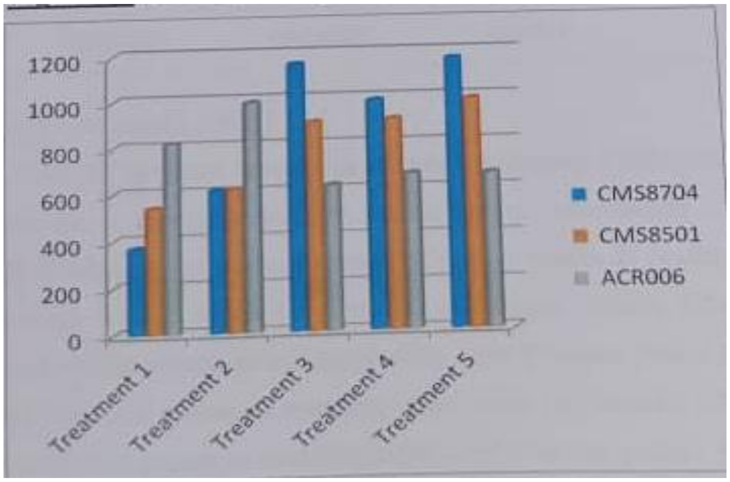


Figure 17: Bar chart representing Leaf area index cm³ (Source: Field Study, 2021)

4. Number of Plants at Maturity

The study revealed that, the maize variety CMS8501 produced the highest number of maize plants at maturity with exactly 6.6 maize plants or approximately 7 maize plants under all treatment. The maize varieties CMS8704 and ACR006 produced the same number of maize plants at maturity with each variety producing exactly 5.6 Maize plants or approximately 6 matured maize plants under all treatments.

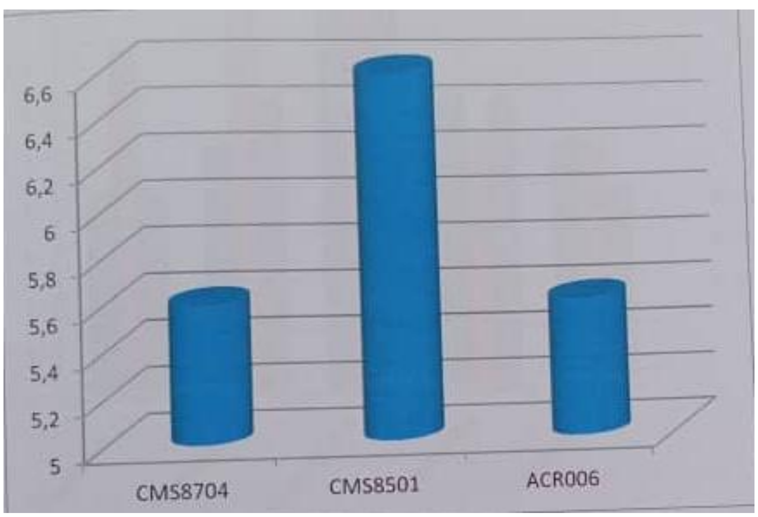


Figure 18: Number of Maize Plants at Maturity under all Treatment (Source: Field Study, 2021)

Also, in the first treatment the maize variety CMS8501 produced the highest number of maize plants at maturity with 7 maize plants. Meanwhile, the maize variety CMS8704 and ACR006 produced the same number of maize plants at maturity with each variety producing 4 maize plants. In the second treatment, the maize variety CMS8501 still produced the highest number of maize plants at maturity with over 8 maize plants followed the ACR006 variety that produced 6 maize plants at maturity and lastly the variety CMS8704 which produced the least number of maize plants at maturity with over 5 maize plants. In the third treatment, all the maize varieties produce the same number of mature plants with each variety producing 8 matured maize plants. In the fourth treatment, the maize variety CMS8501 produced the highest number of mature maize plants with over 6 mature maize plants. Meanwhile, the other two varieties CMS8704 and ACR006 produced the same number of matured maize plants.

In the fifth treatment, the varieties CMS8501 and CMS8501 produced the same number of mature plants with each variety producing 5 matured maize plants. While, the variety ACR006 produced the least number of matured plants with only 4 matured maize plants. This is illustrated on the diagram below;

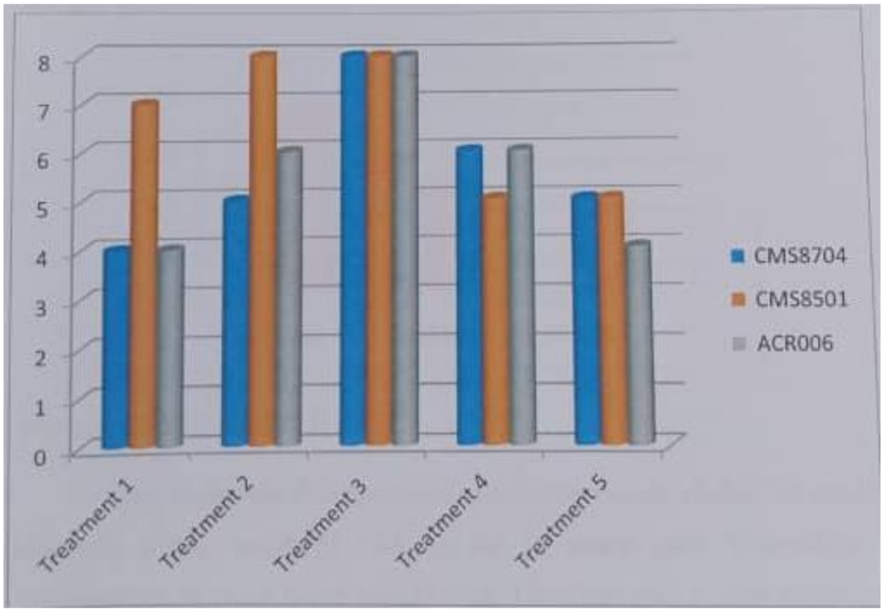


Figure 19: Bar chart representing number of plants at maturity
(Source: Field Study, 2021)

5. Weight of 15 Cobs of Maize per variety.

The findings showed that the maize variety CMS8704 produced maize with the highest weight with 15 cobs of the maize having a weight of 1.65 Kg followed by the variety CMS8501 for which 15 cobs of the maize produced from this variety yield 1.5 Kg. The maize produced from the ACR006 variety had the lowest weight with 15 cobs of the maize having a weight of 1.44 Kg. This is shown on the graph below.

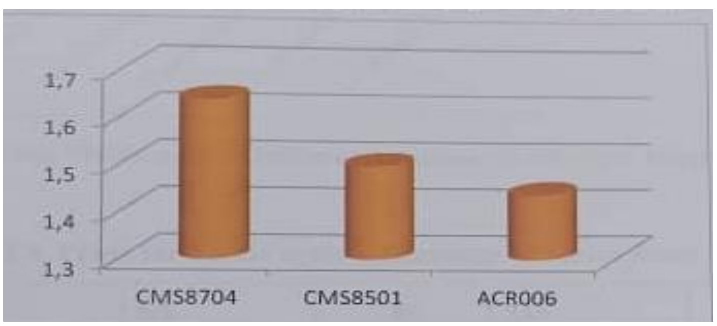


Figure 20: **Weight of 15 Cobs of Maize Produced under all the Treatments**
(Source: Field Study, 2021)

Also, under the first treatment the maize variety CMS8704 produced maize cobs with a relatively higher weigh of 1.63 Kg for 15 maize cobs. Meanwhile, the variety CMS8501 produced maize plant lower weight with 15 of the maize cobs weighing 1.4Kg. In the second treatment, the variety CMS8501 produced maize cods with the highest weight with 15 of the maize cobs weighing 1.5 Kg and the two other varieties CMS8704 and ACR006 produced maize cobs with relatively smaller weight with 15 maize cobs in each weighing 1.4 Kg. Under the third treatment, the variety CMS8704 produced maize cobs with the highest weight with 15 of the maize cobs weighing 1.8 Kg. Meanwhile, the other two varieties ACR006 and CMS8501 produced maize cobs with the same weight with 15 of the maize cobs weighing 1.5 Kg. Under the fourth treatment, the variety CMS8704 produced maize cobs with the highest weight with 15 of the maize cobs weighing 1.8 Kg. Meanwhile, the variety ACR006 produced maize cobs with relatively smaller weight with 15 of the maize cobs weighing 1.4 Kg. Under the fifth treatment, the variety CMS8704 produced maize cobs with the highest weight with 15 of the maize cobs weighing 1.6 Kg. Meanwhile, the variety ACR006 produced maize cobs with relatively smaller weight with 15 of the maize cobs weighing 1.4 Kg. This is illustrated on the diagram below;

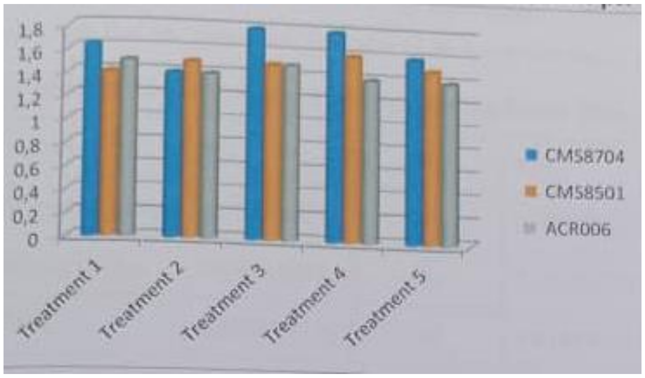


Figure 21: Bar chart showing weight of 15 cobs of maize per variety
Yield of the Maize under Different Treatments (Source: Field Study, 2021)

Table IV: ANOVA Table for Yields against Diameter of Maize Stem

Source	SS	df	MS	F	Prob>F
Between Group	0.66120003	5	0.013224001	0.63	0.6813
Within Group	0.188453315	9	0.020939257	-	-
Total	0.25457331	14	0.018183808	-	-

The above table shows that the calculated value of F- statistic is 0.63 which is less than the table value of 2.615 at 5% level with degree of freedom F (5, 9) hence we conclude that the difference in maize yield due to diameter of the stem is insignificant.

Table V: ANOVA Table of Maize Yield against Maize Plant Vigor

Source	**SS**	**df**	**MS**	**F**	**Prob>F**
Between Group	0.062639993	2	0.03131997	1.96	0.1837
Within Group	0.191933	12	0.0159944	-	-
Total	0.254573	14	0.018183808	-	-

Source: Field Study (2021)

The above table shows that the calculated value of F-Statistic is 1.96 which is less than the table value of 3.88 at 5% level of significance with degree of freedom F (2, 12) hence we conclude that the difference in maize yield due to the maize plant vigor is insignificant.

Table VI: ANOVA Table of Maize Yield against the Maize Plant Height

Source	**SS**	**df**	**MS**	**F**	**Prob>F**
Between Group	0.05624009	8	0.00703001	0.21	0.9757
Withi Group	0.1983309	6	0.03305551	-	-
Total	0.2545573318	14	0.018183808	-	-

Source: Field Study (2021)

The above table shows that the calculated value of F-Statistic is .21 which is less than the table value of 4.46 at 5% level of significance with degree of freedom F (8, 6) hence we conclude that the difference in maize yield due to the maize plant height is insignificant.

Table VII: ANOVA Table of Maize Yield against Maize Leaf Area

Source	**SS**	**df**	**MS**	**F**	**Prob>F**
Between Group	0.16790666	11	0.015264242	0.53	0.817
Within Group	0.0866652	3	0.2888444	-	-
Total	0.254573318	14	0.18183808	-	-

Source: Field Study (2021) factors that influence maize yield taking into consideration ;diameter of maize stem, plant height, plant vigor and leaf area. The results are illustrated in the table below;

Table VIII. Ordinary least square

Variable	Coefficient	t-value	t-critical	p-value	Decision
Leaf area	0.0003305	2.55	2.228	0.029	Significant
Plant Vigor	0.0788441	2.21	2.228	-0.052	No Significant
Plant height	0.4055748	1.89	2.228	0.087	No Significant
Diameter of maize plant	0.195245	1.08	2.228	0.305	No Significant
constant	-0.2998813	-0.44	2.228	2.228	

R2=0.5847

From the above regression results, the leaf area of maize has a positive relationship with yield that is an increase of the leaf area of the maize plant increases yield. The coefficient of the impact of maize leaf on yield is 0.0003305 indicating that an increase on the leaf surface area by 1 unit will lead to a 0.0003305 increase in yield. Also, the relationship between the maize leaf and yield is significant at 5% level of significant since the calculated t-value (2.55) is greater than the critical t-value (2.226).

The research also reveals that plant height has a positive relationship with yield that is an increase in plant height lead to an increase in yield. The coefficient of the impact of plant height on yield is 0.455748 indicating that an increase in plant height by 1 unit will lead to a 0.455748 increase in yield. However, the relationship between is not statistically significant at 5% level of significant since the calculated t-value (1.89) is less than the critical t-value (2.226).

In addition, the research also reveals that maize plant vigor has a positive effect on yield that is an increase in plant vigor can lead to an increase in maize yield. The coefficient of the impact of plant vigor on yield from the regression analysis is 0.0788441 Indicating than an increase in the plant vigor by lunit lead to a 0.0788441 increase in maize yield. However, the relationship between the maize plant vigor and yield is not statistically significant since the calculated t-value (2.21) is less than the critical t-value (2.226). Furthermore, the study reveals that the diameter of the maize stem has a positive relationship with yield that is an increase in the diameter of the maize stem will lead to an increase in maize yield. The coefficient of the impact of the diameter of the maize stem on yield is 0.1952945 indicating that an increase in the diameter of the maize stem by unit will lead to a 0.195245 unit increase in maize yield. However, the relationship between the diameter of the maize stem and yield is not statistically significant since the calculated t-value (1.08) is less than the critical t-value (2.226).

IV.CONCLUSION

The main objective was to access the effects of plant variety, population density and the relationship between varieties on the growth and yield indicators of maize. The result shows that variety CMS 8704 at treatment 3 and treatment 4 indicates a significant difference on various growth and yield indicators. It was closely followed by variety CMs 8501. It is noted that variety CMS 8704 had productive advantage potentials over other varieties placed under the same environment conditions.

In addition the highest significant growth rate, largest stem thickness, leaf size, plant heights, highest weight of cobs and number of cobs. Better yield can be obtained when the plant spacing of treatment three and four are frequently applied by farmers. Plant densities of 57100 plants per hectare of 25cm spacing and 30cm with 47600 plants per hectare. The ideal plant spatial arrangement is that which provides the best plant distribution in an area, maximizing the intra- specific competition for water, light and nutrients. Changes in plants spatial arrangement effects plant architecture growth and development pattern, radiation interception by the canopy influencing photosynthesis rate, carbohydrates production and consequently yield. Increasing plant density is the main method and key management to enhance the grain yield, preventing lodging, and premature senescence in high planting density, and screening and enhancing the density- tolerance of maize variety is the main goal of agronomy. Differential response of maize hybrids to high plant density greatly affect the dry matter accumulation and its allocation to maize kernel depending upon various traits responsible for crowding stress tolerance of which ear characteristic are pivotal. Density, resistance as a quality appraisal of certain variety permits the construction of a simple and accurate method to determine this value useful to plant breeding. Therefore a quantitative method should be put in place to test several maize varieties planted in this study like many others has concluded that truly, maize plant density is an important agronomic component which influences both morphological and yield indicators. Therefore, based on farmer's objectives, appropriate intra-row spacing is needed for optimal utilization of scarce resources such as light, water, nutrient and space.

An appropriate variety that will response to growth and yield indicators for maximum grain yields. And also to establish a compatible relationship between population density, growth and yield components for maize to Cameroonian farmers.We recommend variety CMS 8704 with plant density of treatment 3 (25cm) = 571000 plants per hectare. At this density and this variety the farmers obtain high yields and high plant tissue biomass as justified in LAI vigor, plant height stem diameter which could be part of fodder.Farmers should adopt the planting of recommended improved maize variety identified for their geological location for easy adaptation and high productivity. Early maturing variety or hybrids should be encouraged through research centers as to meet the farmers need.The Cameroon government encourage researchers to identify variety suitable to varying inter-row spacing per agro ecological zone.

Seeds production centers and certified seed farmers should be timely as maize cultivation in Cameroon is based on rain fed.Irrigation schemes should be encouraged as to embark on continuous production cycle that will increase productivity.The government through the extension services should create continuous awareness to farmers on row spacing equidistant for maize, for better nutrients uptake.The product Further research is encouraged for the other varieties suitable to the various agro ecological zones in Cameroonm. Policy makers should consider revising policies related to maize productivity, storage, processing and transformation with added value. Researchers grants should be produced to encouraged farmers take up the initiative and scale-up improved maize varieties.Government extension services should focus on creating awareness on improved maize variety on of maize.The government should construct improved storage facilities such as silo, baggings and cribs in regions of maize productionThe government should construct processing and transformation industries in the country.

References

(Ritchie & Handway, 1992) maize shoot apex is differentiated in to a tassel primodium when the plant has six to seven expanded leaves at 40 to 50cm tall.

(Gardener et al, 1995) under high densities less solar radiation reaches the growing po

(Tetio-kagho and Gardener, 1988b) increasing plant density increases leaf area index and consequently water consumption

(Westgate, 1994) water shortage coincides with the period of 2 to3 weeks bracketing with silking dramatically reduced grain yield

[IFC], 2013, Staple crop expected to increase for the 870 million people who are currently food insecure in the sub Saharan Africa

19 (Smale Byerlee and jiyne, 2011) Walker et al, 2014 indicated just about 35% of land under cultivation in Africa are located to improved crop varieties

Abuzar. M & Saclozai.G 2011 Effect of plant population densities on yield of maize Journal of Animal and plant science Jan 20211/21 (4) (4)

Achiri T.D (2018) Agronomic and yield parameters of CHC 202 maize (Zea mays L.) Variety Influence by Different Doses of Chemical Fertilizer (NPK) in Bali Nyong North West Region Cameroon journal of soil science and plant nutrition 2 (4) 001; 10.9734/AJSSPN/2017/39583

Adjei V & Kyerematen.R. 2018 Impacts of changing climate on maize production in transitional zone of Ghana. American journal of climate change vol 7 No 3, Sept 2018.

Alexandratos and Bruinsma (2012) indicate that agricultural production needs an increase of 60% by 2050 to meet the world consumption demand.Apple academic press

Department of agricultural statistics MINADER, 2019 extreme low yield approximately 1.5 tons per hectare as compared to 3 tons per hectare in developed countries

Eckhoff, et al 2003 Maize contain 8 to 12% protein

Edgbe et al, 1995 maize production has gone a crescendo as a result of increasing cultivated area than increasing production

Epule. T E. (2015). *Ed Marc. A. Maize production Responsiveness to land use change and climate trend Quebec: Canada*

FA O, 2015 Agriculture in Cameroon contribute to 33% of the GDP employing more than 70% of the labour force

FA O, 2015, Cameroon statistics service, 2014 The sector remains predominantly small scale or rural household involved in producing about 80% of the output through rudimentary methods leading to low productivity

FAO statistics (1999) Maize production will not be able to satisfy the fast growing population. Downloaded *from https// WWW. FAO.org World food and agricultural statistics (1999)*

FAO, 2014 Maize yield in Cameroon is at 1.95 tons per hectare

FAO, 2016 estimated productivity at 13303 tons per in 2013

FAOSTAT, 2010, Harvest at current level will still fall of demand unless vigorous measures are taken to enhance yield

Folefack A. (2017) *Comparing the benefits between producing maize for seeds or consumption in Cameroon Downloaded from https//www.tropiculture.org*

Haegole et al. 2014 The agronomic practices implemented in a population system should allow the selected germplasm to react positively under favorable environmental conditions

Hammad. U.M & Harun-AR.R. (2014) *Economic study on maize production in Bangladesh Lambert academic publishing*

Hyman et al, 2008 The crop provides over 20% of total calories in human diet

IF C, 2013 In sub Saharan Africa a majority of the population is agriculture dependent with 55% in the rural areas

Jennifer chait (2015) Definition of the term yield

Lowe et al, (1997, also Moxey et al, 1998 skills needed to build up social capital

Mafouason- HNA (2020) production constants, farmers preferred characteristics of maize varieties in the Bimodal Humid forest zone of Cameroon and their implications for plant breeding Downloaded from *https// Link,* Springer .com Agricultural Research 9, 497-507 (2020)

Manu at al, 2014; Ntsama Etoundi & Kamgnia Dia, 2008 maize cultivation is everywhere in Cameroon, a staple food crop for many Cameroonian

Manu et al, 2004, Ntsama Etoundi and Kamgna, Dia, 2008 Maize in Cameroon is considered as a strategic crop for poverty reduction, food security and economic development

Mc Donald (1998) Changes in government policy

Meyo. E. (2020) Assessing the impacts of variables inputs costs on maize production in Cameroon Downloaded from https//WWW.Scrip org. Agricultural sciences Vol No 11 Nov 2020

Ministry of agriculture and rural development, 2013; F A O, 2013 national average yield of maize are 1.93 metric tons per hectare
Molua. E. L. (2006) Climate trends in Cameroon implication for agricultural management Dowwn loaded from https// online library Wiley.com
Munang. R. & Revigton. M. (2008) *Climate variability and maize production in Cameroon*.
Mvond E & Mbey 1 *Assessing the impacts of variable inputs costs on maize production in Cameroon, Downloaded from https//www.Scrip org.*
Ngoune L.T. (2020.) Estimation of maize (Zea mays L.) Yield per harvest area.
Nis, 2020, In Cameroon the agricultural sector contributes a large proportion of the gross domestic product
Ntsama Etoundi &Kamgnia Dia, 2008, Nabasirye et al, 2015 Takam Fongangi 2016 Impact of adoption of improved maize varieties on yield, food security and or poverty.
Ntsama. E., Mirielle. S. & Kamgnia. D 2011. Determinants of the adoption of improved varieties of maize in Cameroon: Case of CMS 8704 Downloaded at https// mpra.Ub Uni-muenchen. de/37783/MPRA Paper No 37783 12/2/2014.Nzossie et al, 2010 maize production still remain limited face to the increasing demand by the high population growth.
Olson and Sanders, 1988 high plant densities are required for a particular variety.
Pender and Mertz, 2006, Halberg et al, 2006, Shifferaw et al, 2009 choosing the right system for agriculture requires a pragmatic approach that focuses on what is feasible to farmers
ARD) was involved in
Pretty (1997) Impetrative frames of agricultural actors and institutional development as by the physical outcome of the environmental management
Pretty at al, 2003, Lee, 2005 Sustainable agriculture and its practices
Rati Kanta.M & Gon zaler. H (2021) Advanc Advances in maize science botany, production and crop improvement
Roger, 1962 Definition of adoption
Rouf. T. S (2016). Maize or corn (Zea mays) is important cereal crop of the world. Downloaded from https//www. Tanclfon line. Com doi.
Sangoi et al, 2002 The optimum plant population depends on several crucial factors such as soil fertility, soil water holding capacity
Sangol, 1993 the small number of thermal units accumulated per day makes it grow slowly.
Silva, 1992Singapore Journal of tropical geography Nov 2008 29 (3) pp 357-370.
Solaimalia. P & Anantharaju. S Production, protection and post-harvest technology CRC Press Taylor & Francis Group
Solonesk. S. (2014) Pesticides-toxic Aspects Ed by Macelo. L.
Wenda. B.S (2020) Assessing the contribution of micro credit Financing to maize production in Mezam Division, North West Region of Cameroon. International journal of Agricultural Economics 5 (1): DO: 10: 10. 11648/ [. ijae. 2020050].
Wilkin, 2010 farm subsidies should be conditioned by compliance with basic environmental standard
Zegar, 2003 Sustainable agriculture and d rural development (S