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Assessment of the effect of production systems for new maize varieties (Zea mays L.) on the income of farming households in northern Benin

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Abstract

Maize plays a key role in ensuring food security and creating wealth, particularly for rural populations in northern Benin. However, productivity for this crop remains low. Therefore, it is essential to adopt new maize varieties to improve yields and meet the region's growing food requirements. This study aims to evaluate the effect of new maize varieties on the income of farming households in Borgou. The study is based on a random sample of 300 producers selected in northern Benin. The multiple correspondence analysis (MCA) method was used to characterise the production systems for the new maize varieties. In addition, profitability was assessed using several economic indicators, including net margin, average labour productivity, internal rate of return and the benefit-to-cost ratio. Three production systems for new maize varieties were identified: the four-month variety production system (System 1), the three-month variety production system (System 2) and the two-month variety production system (System 3). Of these, the production system for three-month varieties is superior in terms of economic profitability compared to the production systems for four- and two-month varieties. These results suggest the need to focus research and development efforts on improving three-month maize varieties, with the aim of optimising food security and the economic well-being of farmers in northern Benin. This article proposes an empirical typology of production systems based on new maize varieties (two-, three- and four-month varieties), thereby moving beyond traditional approaches that generally focus solely on yields or cultivation practices. This classification highlights distinct production strategies depending on the variety's growth cycle. The study makes a major contribution by showing that economic profitability is not necessarily correlated with the length of the production cycle. Contrary to certain common assumptions, according to which short cycles are more profitable due to their speed, the results reveal that the system based on three-month varieties appears to be the most economically efficient, thus constituting a finding that is both original and potentially counter-intuitive.

Keywords: Production system; improved varieties; maize; Northern Benin
Classification JEL : Q13
Paper type: Empirical Research

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1. Introduction

In Benin, the agricultural sector plays a significant role in the economy. Activities in this sector primarily focus on crop production, including a variety of food crops (Hinnou and *al.*, 2022). These crops are essential for the population's food and nutritional security, with cereals predominating in Benin (Montcho *et al.*, 2023). Maize (Zea mays L.), which is cultivated extensively throughout the country, accounts for almost 70% of the land devoted to cereal crops (Akossou *et al.*, 2016). Therefore, agricultural diversification and food production are now considered priorities by stakeholders in the agricultural sector (Sossou *et al.*, 2024). With this in mind, Benin is committed to promoting other promising sectors, particularly maize. Currently, maize is the country's primary food crop, far surpassing rice and sorghum (Ibikoule *et al.*, 2024). As a staple food source for the population, maize is also a lucrative crop (Tchekessi *et al.*, 2021). Even when production is primarily for subsistence, a significant proportion is sold on the market, enabling households to generate the income they need to survive (Adiaha *et al.*, 2016).

In northern Benin, it is increasingly incorporated into crop rotations on plots following the cotton harvest (Yemadje *et al.*, 2025). Maize is now considered both a cash crop and a subsistence crop (Baco, 2019). In fact, corn production, estimated at 1,580,750 tons for 2020, remains insufficient at the national level to fully meet growing demand, which justifies the implementation of measures aimed at increasing it (MAEP/DSA, 2021). This production is also subject to significant fluctuations, rising from 1,286,060 tons in 2015 to 1,580,750 tons in 2020 (MAEP/DSA, 2021), reflecting the sector's unstable performance. At the same time, yields remain relatively low and have declined over certain periods, falling from 1,422 kg/ha in 2011 to 1,281 kg/ha in 2015, with an average of 1,347 kg/ha (PSDSA, 2017). These national figures mask significant disparities among farms and production systems, particularly in high-production areas such as Borgou. This trend is mainly attributed to the effects of climate variability and change, as well as inappropriate choices of maize varieties. However, thanks to extension efforts, maize producers are implementing various adaptation strategies. Extension services, particularly through the establishment of demonstration plots, contribute not only to improving farmers' knowledge of production systems but also to strengthening their capacity to adopt innovative agricultural practices (Aniagyei *et al.*, 2024). However, despite these average yields, at the end of the production process, producers from these different types of systems sell their crops at the same prices.

Empirical studies on the maize sector in Benin and in similar contexts highlight significant progress, while still leaving certain gaps. On the one hand, several studies have identified the factors explaining low maize productivity, particularly through the analysis of technical, institutional, and socio-economic constraints (Ibitola *et al*., 2019). On the other hand, further research has broadened the discussion by addressing the competitiveness of local maize in markets (Hasanah and Fauziyah, 2025), as well as supply dynamics in relation to food security issues, especially in Northern Benin (Yabi *et al.*, 2013). Moreover, more targeted contributions have shed light on specific determinants: Kolapo *et al*. (2022) demonstrated the influence of land access arrangements on productivity, while Yessifou *et al.* (2021) examined the factors driving the adoption of improved maize varieties. For his part, Degla (2020) provided a comparative analysis of the economic performance of different production systems. However, despite the richness of these studies, their approach often remains fragmented, addressing certain determinants in isolation without simultaneously integrating the socio-economic, entrepreneurial, and structural dimensions of performance. Therefore, there is a need for a holistic analysis to better understand the interactions among these different factors. Consequently, the research question is to what extent the production systems of new maize varieties are characterized and what their level of profitability is. This study aims to analyse the effect of such production systems on the income of farming households in Borgou.

2. Literature Review

2.1. Empirical Framework

Recent empirical literature on farm typologies in Sub-Saharan Africa first highlights a marked structural heterogeneity of agricultural holdings, as documented by authors such as Jayne *et al.* (2022), Hassall *et al.* (2023), and Otieno (2020). These studies show that farms differ significantly in terms of access to resources (land, capital, labor), production systems, and levels of market integration, which justifies the use of typologies as both an analytical and decision-support tool. In particular, recent research emphasizes the coexistence of small, low-capital family farms alongside farms transitioning toward more intensified or commercial forms, thereby revealing differentiated agricultural trajectories. From a methodological standpoint, recent empirical studies mainly rely on multivariate quantitative approaches, including Principal Component Analysis (PCA), Correspondence Analysis (CA), and Hierarchical Cluster Analysis (HCA), as demonstrated in several applications in West Africa. These methods allow farms to be grouped based on a set of variables combining socio-economic and technical characteristics. However, some recent contributions, particularly within the "typologies for action" framework (Kahwai *et al.*, 2025), advocate for hybrid approaches that combine statistical analyses with local expertise in order to make typologies more operational and relevant for agricultural policymaking. Empirical findings tend to converge toward the identification of recurrent typologies, often structured around three to four main groups: subsistence farms, intermediate or diversified farms, semi-commercial farms, and commercial or entrepreneurial farms. Recent studies, especially in West Africa, also highlight typologies based on the degree of crop–livestock integration or on climate change adaptation strategies, as shown by Assani *et al.* (2024) and Germer *et al.* (2023). These classifications reflect differentiated logics of resource allocation, innovation, and risk management.

Despite these advances, several limitations are noted in the recent literature. On the one hand, typologies remain highly dependent on the variables selected and the statistical methods used, which limits comparability across studies. On the other hand, they are often static, capturing a situation at a given point in time without accounting for the dynamic transformations of farms, particularly under the influence of climate change, market conditions, or agricultural policies. Moreover, institutional and territorial dimensions, as well as interactions with value chains, remain insufficiently integrated into empirical analyses. Overall, the recent empirical literature shows that farm typologies constitute a relevant analytical tool for understanding agricultural diversity in Sub-Saharan Africa and guiding interventions. However, their scope remains constrained by methodological and operational limitations. Current research directions are moving toward more dynamic, participatory, and integrated approaches capable of better capturing farm trajectories and linking economic, social, and environmental dimensions, thereby enhancing their usefulness for the design of appropriate and sustainable agricultural policies.

Recent empirical literature on agricultural profitability indicators in Sub-Saharan Africa (SSA) highlights a diversity of approaches used to assess the economic performance of farms. Studies generally distinguish indicators such as factor productivity (land, labor, capital), net profits, gross margins, and economic ratios such as the value–cost ratio. Research by Kassogué, (2020), Maniriho, (2021), and Rached *et al.*, (2021) shows that productivity whether partial or total is a key indicator of agricultural profitability, as it reflects the efficiency of resource use and its direct impact on farmers' incomes. Furthermore, several empirical studies emphasize the importance of conventional financial indicators, particularly net profit and cost–benefit

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analysis, in evaluating the profitability of agricultural technologies. According to FAO analyses and recent studies on soil management, profitability is generally assessed based on actual monetary flows (revenues and costs), incorporating variables such as market prices, input costs, and wages. Indicators such as the benefit–cost ratio and net present value are frequently used to assess the economic viability of agricultural innovations, including the use of fertilizers or soil conservation techniques (Ben Saali and Belkacemi, 2023). However, recent literature underscores that agricultural profitability in SSA is highly context-specific and variable, depending on agroecological conditions, market dynamics, and public policies. Several empirical studies show that certain agricultural technologies may be profitable in one context but not in another, due to variations in prices, transaction costs, or biophysical constraints. In addition, structural factors such as access to credit, infrastructure, and agricultural services significantly influence productivity and, consequently, farm profitability (Goudjo, 2023). Despite these contributions, important limitations remain in the literature. On the one hand, the indicators used are often partial and fragmented, focusing either on productivity or profits without systematically integrating social and environmental dimensions. On the other hand, empirical approaches frequently overlook risks (climatic and economic) and uncertainties, even though these strongly influence farmers' decisions. Moreover, some cost–benefit analyses ignore essential elements such as the degradation of natural capital or environmental externalities, which can bias the assessment of actual profitability. Overall, recent empirical literature shows that the evaluation of agricultural profitability in Sub-Saharan Africa relies on a plurality of complementary indicators that remain insufficiently integrated. Current research advocates for more holistic and dynamic approaches that combine economic, social, and environmental indicators in order to better capture the overall performance of farming systems. The challenge is therefore to move beyond a strictly financial view of profitability and to incorporate dimensions of sustainability and resilience, which are essential in African agricultural contexts characterized by high levels of uncertainty.

2.2.Agricultural Production Systems Theory

Agricultural Production Systems Theory, rooted in agronomy and rural economics, is based on a systemic approach that considers the farm as an organized and dynamic set of interacting elements. Inspired notably by the contributions of Chambers, (1980), through his work on participatory approaches in rural settings, Krull and Borlaug, (1970), through the Green Revolution, this approach has progressively become established in research on agriculture in developing countries since the 1970s. Within this framework, a production system is generally defined as the combination of production factors and outputs within the farm, which is viewed as a unit in which the farmer implements a set of technical and economic choices in order to achieve specific objectives, particularly profit maximization. Thus, one refers to the production system specific to each farmer, shaped by their decisions and constraints. However, this farm-centered conception can be broadened. A more comprehensive approach emphasizes the social dimension of production systems, as well as their stability and transformations. In this context, the diversity of production systems, often analyzed through typologies, becomes a central object of study. In this vein, Reboul, (1976) defines the agricultural production system as a mode of combining land, labor, and means of production, common to a group of farms and characterized by the nature of outputs, the qualification of labor, and the proportions of factors used.

Building on this perspective, some authors propose further expanding the concept. Allaire and Blanc, (1982) introduce the notion of a "social production system," highlighting the coexistence within a single farm of multiple production processes organized according to a certain techno-economic coherence. This approach underscores that a production system cannot be reduced to a simple combination of factors but instead reflects a structured organization of activities. Similarly, Badouin, (1987) provides conceptual clarification by distinguishing several nested

levels of analysis. He differentiates, in particular, the cropping and livestock systems, which refer to the combination of activities, from the production system, which concerns the allocation and use of productive resources. He also introduces the notion of the farming system, which relates to the organization of production, including forms of ownership, labor organization, and modes of product distribution. Furthermore, Mazoyer, (1985) proposes an even broader conceptualization by introducing a hierarchy of notions ranging from technical operations to the agrarian system. He groups these concepts under the generic term "agricultural systems," allowing for a comprehensive understanding of production processes, their transformations, and their variations across time and space. In this framework, the production system occupies an intermediate position, linking production factors to outputs.
In this context, typologies and classifications emerge as essential tools for analyzing the diversity and dynamics of production systems. Some typologies are based on combinations of outputs, such as the OTE and OTEX classifications developed by the European Economic Community, while others rely on more stable structural criteria. These approaches often draw on statistical data, particularly from agricultural censuses. However, as noted by Labouesse, (1986), the statistical approach has both strengths and limitations. While it captures farm diversity at a large scale, it tends to overlook the systemic dimension by reducing production systems to simple combinations of factors. In reality, a production system is characterized by internal interactions and synergies among its components, as well as by its capacity to respond to change and evolve. Therefore, detailed analyses of system functioning, often based on case studies or monographic approaches, are complementary to statistical analyses, with each providing distinct insights.
Finally, agricultural production systems theory highlights the central role of innovation and adaptation. Farms continuously evolve in response to environmental constraints and opportunities, including climate change, price fluctuations, and institutional transformations. This dynamic confirms the non-static nature of agricultural systems. Nevertheless, this approach has certain limitations. On the one hand, its implementation can be complex due to the multiplicity of variables involved and the data requirements. On the other hand, it may underestimate power relations and social inequalities that influence farmers' decisions. Despite these limitations, agricultural production systems theory provides a relevant analytical framework for understanding the determinants of farm performance and diversity, leading to the formulation of the following research hypotheses:

3. Materials and Methods

3.1. Study Area

This study was conducted in the Borgou department, located in northern Benin. The choice of this study area is not solely based on its status as a major cereal-producing zone (Agossadou et *al.*, 2023), but is also justified by its representativeness of the country's agricultural production systems, particularly with regard to rainfed crops such as maize. Indeed, Borgou exhibits agro-climatic characteristics typical of central and northern Benin, with a Sudanian climate marked by seasonal alternation and annual rainfall ranging between 900 and 1300 mm, which is favorable for cereal production. Furthermore, the diversity of soils (tropical ferruginous, ferralitic, and sandy-clay soils) and production systems observed in this area allows for the analysis of a wide range of farming practices, thereby enhancing the analytical relevance of the site for studying farm typologies. In addition, data accessibility and the presence of institutional support mechanisms, particularly through the Territorial Agricultural Development Agencies (ATDA), facilitated the collection of reliable and diverse data.
The study specifically focused on three municipalities in Borgou, namely N'Dali, Parakou, and Tchaourou, where agriculture constitutes the main economic activity of the population (Labiyi

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et al., 2018). The selection of villages within these municipalities was carried out following an exploratory phase conducted in collaboration with ATDA agents, in order to ensure the relevance and representativeness of the surveyed sites.

3.2.Sampling

Farms producing improved maize varieties constitute the units of analysis in this study. The database of maize producers in the selected municipalities was obtained from the Territorial Agricultural Development Agency (ATDA4), which made it possible to estimate the size of the target population. Based on this, the sample size was determined using the Schwartz formula, commonly applied in empirical studies:

$$n = \frac{t^2 * P(1-P) * N}{t^2 * P(1-P) + (N-1) * y^2}$$

Where:

n:	Sample size;	**N:**	Size of the target population;
P:	Proportion of farmers surveyed (50% by default in agricultural settings);	**t:**	Sampling confidence interval (1.96);
y:	Sampling error margin (5%).		

The application of this formula resulted in a total sample of 300 producers distributed across the three municipalities, thereby ensuring an acceptable level of statistical representativeness of the study population. It should be noted that the sample size calculation is based on a 5% margin of error, which corresponds to the conventional threshold commonly used in scientific research. This choice ensures an appropriate balance between precision and feasibility, given the available resources, accessibility of survey areas, and time constraints for data collection.
Furthermore, in each municipality, three villages were selected based on specific criteria, namely: (i) the presence of maize producers, (ii) village accessibility, and (iii) the use of improved varieties by producers. Based on these criteria, the selected villages are Tchatchou, Sanson, and Goro in the municipality of Tchaourou; Arafat, Bah-Mora, and Korobororou (Second District) in the municipality of Parakou; and Sirarou, Ouénou, and Wèrèkè in the municipality of N'Dali. However, this village selection strategy, based on qualitative and non-random criteria, may introduce selection bias.

Table 1: Number of producers surveyed by village

Municipalities	Villages	Number of producers surveyed
Tchaourou	Tchatchou	53
	Sanson	40
	Goro	30
Parakou	Arafat	20
	Bah-Mora	23
	Korobororou	27
N'dali	Sirarou	45
	Ouénou	32
	Wèrèkè	30
Total	**300**	

Source: Authors

Indeed, accessible villages with effective adoption of improved varieties do not necessarily reflect the entire population of maize producers, particularly those located in remote areas or those who have not adopted these innovations. Therefore, this limitation should be taken into account when interpreting the results, which cannot be generalized to all farms in the study area without caution. The sample structure shows a strong predominance of men (89 %), which may constitute a limitation in terms of gender representativeness. Indeed, although this distribution may partly reflect the reality of maize production systems in the study area, it also suggests a possible under-representation of women producers. Women may, however, exhibit specific characteristics regarding access to resources, technical choices, and production strategies. Consequently, this unbalanced distribution is likely to influence the results of the analysis and limit their scope, particularly with respect to the consideration of gender dynamics.

3.3.Data Collection

The main data collected pertain to the sociodemographic characteristics of maize farmers. This includes factors such as age, level of education or literacy, membership in a cooperative, and the number of years of experience in agricultural production. In addition, information on contact with support structures and the distance between the home and the location where improved maize seed is purchased was also collected. Furthermore, the data covers methods of soil preparation, plowing, planting, pest control, weeding, and harvesting. It also covers the varieties grown, the use of fertilizers and pesticides, as well as the costs of purchasing inputs, labor, and transportation. The data collection was carried out in October. In order to minimize biases related to the declarative nature of the data, particularly social desirability bias and self-reporting errors concerning income and production costs, several methodological precautions were taken. First, interviews were conducted in a climate of trust, ensuring the confidentiality of responses and the anonymity of respondents, in order to reduce potential overstatement or understatement of the information provided. Second, sensitive questions were formulated in an indirect and progressive manner, which helped to encourage more sincere responses. Finally, cross-checking of information was carried out whenever possible, notably through complementary discussions with some producers and field observations, in order to improve the reliability of the data collected via KoBoCollect.

3.4.Data Analysis

The fundamental principle of typology is to group households sharing similar characteristics into distinct "types," which can then be compared to other "types." The objective is to identify agricultural technologies or other development interventions that could benefit one particular type but not another, in order to appropriately direct agricultural innovations (Hammond and *al.*, 2020). Thus, the typology becomes a decision-making tool enabling targeted interventions based on the specific problems of each agrarian system. Indeed, approaches to developing typologies differ depending on the objectives sought, the nature of the available information or data, and the discriminating criteria selected to characterize farming systems. In the agricultural literature, statistical typologies are widely adopted (Kuentz-Simonet *et al*., 2013; Mwabila *et al*., 2023) using a variety of approaches, such as Principal Component Analysis (PCA), Multiple Correspondence Analysis (MCA), Discriminant Factor Analysis (DFA), Mixed Data Factor Analysis (MFDA), as well as classification methods such as K-means and Ascending Hierarchical Classification (AHC). However, typologies can be structured according to various perspectives, such as the structural typology, which is based on the means of production available on the farm; the functional typology, which stems from the decisions made by the farmer to achieve his production objectives; the typology based on performance criteria, often associated with the previous two; analytical typology, constructed from the identification of discriminating indicators derived from the farms themselves; and statistical typology, obtained from factor analyses of available empirical data, including (Bélières *et al*., 2017; Akpatcho *et al*., 2022). Some of these approaches rely exclusively on quantitative data, while others incorporate both quantitative and qualitative data (mixed data). In this research, the approach of so-called functional typologies-based on the sequence of decisions made by the farmer to achieve their objectives, which govern livestock systems-will be adopted. The most commonly encountered variants of operational typologies are: (1) functional typologies centered on the farmer's projects and situation (i.e., what are their objectives and strategies?); (2) functional typologies based on farmers' "systems of practices" (i.e., what is the producer seeking? For what results? To do what? How does he achieve these results?); and (3) functional typologies linked to the evolutionary trajectories of farms (i.e., how did the farmer get where he is? What major events have marked his history? How did this play out?) (Jouve, 1986) .

In this specific case, the typology based on "systems of practices" will be adopted, incorporating a Multiple Correspondence Analysis (MCA). In this case, the typology based on "systems of practices" was constructed using a Multiple Correspondence Analysis (MCA), followed by a Hierarchical Ascending Classification (HAC). The choice of the number of classes was based on both statistical and interpretative criteria. From a statistical perspective, the examination of the dendrogram derived from the HAC made it possible to identify a significant jump in aggregation distances, indicating a clear break in the structuring of groups at the level of three classes. This cut-off point reflects an optimal balance between within-class homogeneity and between-class heterogeneity. The choice of three classes is also supported by the analysis of the explained variance (inertia) from the MCA. The retained factorial axes capture a sufficient share of the total information, thereby ensuring the robustness of the classification. Structuring the data into three groups preserves a satisfactory proportion of the explained variance while avoiding excessive fragmentation, which would reduce the readability of the results. This choice was reinforced by the interpretative relevance of the resulting classes. The three identified groups exhibit distinct and coherent profiles in terms of agricultural practices and socio-economic characteristics of the farms, thereby strengthening the analytical validity of the typology. After identifying the various maize production systems practiced in Borgou, profitability indicators were applied. The literature proposes several methods for evaluating the profitability of an activity or production system. These methods include, in particular, the Policy s Analysis Matrix (MAP), the balance sheet-based method, as well as methods using the income statement or the farm account (Akpo *et al*., 2021; Djibril and Boubacar, 2021; Hinnou *et al*., 2021). According to Hollmann *et al*., (2020), the operating statement is the simplest. It is an accounting document that summarizes all of a company's expenses and revenues for a given period known as the fiscal year. In its standard form, the income statement is presented as a table showing the intermediate management balances. These interim management balances include the Gross Margin, Value Added, Gross Operating Surplus, Operating Income, and Net Operating Income. These various figures help to better interpret the result, which is an indicator of profitability.

To assess the contribution of current corn production systems to the net farm income of farmers who adopt them, the net farm income earned by adopters of each production system will be calculated. Next, Student's t-test will be used to compare the means and evaluate the differences in income among adopters of each corn production system.

The definitions and mathematical formulas for the various farm account indicators are as follows (Agossadou *et al*., 2023) :

✓ ***Gross Value Added (GVA):***

Gross output represents the total value of products resulting from a production process. Its calculation includes internal flows (such as production for own use) as well as products not yet sold at market price, that is, at the price at which the producer could sell their output on the market. Using the following notation: Q for the total quantity of a good produced, Qv for sold production, Qa for self-consumed production, Qnv for unsold production, and P for the unit selling price of the good, the gross value added (GVA) is determined by:

$$\boldsymbol{PBV = Q * P = (Qv + Qa + Qnv) * P = S * Rij * P}$$

Where S is the total area under production in hectares, Rji is the yield in kg/ha, and P is the unit selling price of the finished product in CFA francs/kg.

- ***Intermediate Consumption (IC)***

Intermediate consumption (IC) represents the goods and services fully consumed during the production process or over a reference period. It includes items such as purchases of raw materials and goods, labor costs, supplies and services, transportation and travel expenses, as well as various administrative costs.

- ***Value Added (VA)***

Value Added (VA) represents the difference between gross output and the value of intermediate consumption (IC). The formula for VA is as follows:

$$VA = PBV - CI$$

- ***Net Margin (NM)***

The net margin is calculated (Paraïso *et al*., 2012; Yabi *et al*., 2012) by subtracting total costs (TC) from gross value added (GVA) or by subtracting fixed costs (FC) from gross margin (GM). It is expressed in CFA francs per hectare using the following formula:

$$\mathbf{NM = GRV - TC = GRV - VC - FC = GM - FC}$$

It represents the producer's net profit. If the net margin is positive, it is concluded that the gross revenue covers all total costs (variable + fixed) and that the producer is economically viable. Conversely, if the net margin is negative, then the gross revenue does not cover all total costs. In this case, production is not economically profitable. It should be noted that very high fixed costs would result in a negative net margin (Paraïso *et al*., 2012).

- ***Average Labor Productivity (ALP)***

Average labor productivity (ALP), also known as the Average Labor Remuneration Rate (ALRR), is defined as the net margin per unit of family labor used in production (Yabi *et al*., 2012). According to Yabi *et al.,* (2012); Paraïso *et al*., (2012); ; and Ayena and Yabi, (2013), it can be expressed by the following mathematical formula:

$$\mathbf{PML = MN/MOF} \text{ (in CFA francs/day)}$$

Where:
MN: the net margin of the production activity (in CFA francs/ha).
MOF: the total amount of family labor used in man-days per hectare (MD/ha). Indeed, if PML > p (p = price p of one man-day of hired labor paid in the study area), then the activity is profitable in terms of wages earned. Otherwise, it is not.

- ***Internal Rate of Return***

The internal rate of return (IRR) is an indicator used to assess the quality of an investment (Vartanyan and Hovasafyan, 2021). It expresses the net margin per unit of invested capital (Paraïso et al., 2011). Total invested capital is viewed in terms of production costs and the value of family labor (Paraïso *et al*., 2012). The value of family labor (VFL) is obtained by multiplying the physical quantity of total family labor by the average price of hired labor in the study area. The IRR is expressed as a percentage. Since interest rates vary from one institution to another, the IRR is compared to the average interest rate derived from the various SFD structures. Thus, if the IRR is higher than the average interest rates, production is economically profitable from the perspective of the investment in total production costs; whereas if the IRR is lower than the average interest rates, soybean production is not economically profitable from the perspective of invested capital. Therefore, a producer who takes out a loan at an interest rate exceeding the average rate will not be able to repay the interest from the net margin obtained from production.
IRR = NM / (TC + WACC)

- ***Profit/Cost (P/C)***

The Benefit-Cost Ratio is a financial analysis indicator that expresses the financial profit

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obtained from the investment of a unit of capital (Yabi *et al.*, 2012; Sigue *et al.*, 2019). Let D be the total profits obtained after a total investment (also called gross value) and CT the total of all production costs expressed in value, including family labor. The formula is as follows:

$$RBC = \frac{\mathrm{D}}{\mathrm{CT}}$$

The RBC is interpreted by comparing it to the value "1." The two possible scenarios that can be observed are: (i) RBC > 1, in which case maize production is financially profitable because 1 FCFA invested generates more than 1 FCFA; (ii) RBC < 1, in which case maize production is not financially profitable because it does not allow for the recovery of the invested capital. Although the profitability indicators used (MBV, VA, MN, PML, IRR, RBC) are well suited to the study context and widely applied in the national literature, their comparability with international standards such as Gross Margin Analysis or Benefit-Cost Analysis promoted by institutions like the Food and Agriculture Organization (FAO) or the CGIAR may be limited. Indeed, certain methodological differences in the definition and calculation of economic aggregates may affect the direct comparability of the results with those of studies conducted in other contexts.

The use of the Student's t-test to compare means across systems requires that certain assumptions be met, notably the normality of distributions and the homogeneity of variances. In this study, although these assumptions were not systematically verified beforehand, the high standard deviations observed in the ANOVA results suggest possible distributional asymmetry and/or heteroscedasticity. Consequently, the results obtained from parametric tests should be interpreted with caution. To enhance the robustness of the analysis, it would have been appropriate to conduct normality tests (e.g., Shapiro–Wilk) and tests for homogeneity of variances (Levene's or Bartlett's test), or to use alternative non-parametric methods, such as the Kruskal–Wallis test for comparing multiple groups.

4. Results

4.1.Socioeconomic Characteristics of maize Producers

Table 2 presents the sociodemographic characteristics of the maize farmers surveyed by study area. Depending on the study municipalities, variables such as gender, marital status, educational level, membership in a maize group or association, ethnicity, age, household size (Men and Women), number of agricultural workers, and land area vary significantly. In contrast, literacy, experience in agricultural production, and household size (children) do not vary significantly across the study municipalities.

The respondents surveyed in this study include both men and women. The vast majority of farm managers are generally men, accounting for 89 % of the study sample, compared to 11 % women. The vast majority of farm managers are men, accounting for 89 % of the sample, compared to only 11 % women. This strong male predominance reflects persistent inequalities in access to productive resources (land, capital, inputs) and decision-making roles within agricultural systems in Sub-Saharan Africa. The results of the Chi-square test indicate that there is a statistically significant relationship between gender and the production systems studied. Indeed, since the p-value is below the 1% threshold, the observed differences are not attributable to random variation but reflect structural disparities between men and women in their distribution across production systems. Thus, gender constitutes a discriminating factor of production systems in the study area. The low representation of women in the sample (11 %) is therefore an important finding that should be interpreted in light of the literature on gender in African agriculture, which highlights the relative marginalization of women in access to resources and their concentration in agricultural activities that are often less valued or less intensive.In terms of marital status, 98 % of producers are married, with 66 % in monogamous relationships and 32 % in polygamous ones. The results of the Chi-square test indicate that there is no statistically significant relationship between the variables analyzed and the production systems. Indeed, since the p-value is higher than the 5 % threshold, the observed differences between groups can be attributed to random variation rather than a structural effect. The remaining producers are either widowed or divorced, regardless of the municipality. Approximately half of the producers surveyed have received no formal education (53 %). Those who received formal education reached at most lower secondary school (17 %), and few of them managed to reach upper secondary school or higher, at 5 % and 2 %, respectively. The same trend is observed in all study municipalities; however, in N'dali, no farmer managed to reach the higher level. The results of the Chi-square test indicate that there is no statistically significant relationship between the level of education and the production systems studied. Indeed, since the p-value is higher than the 5 % threshold, the observed differences between groups are not sufficiently strong to be considered structural and may be attributed to random variation. Thus, although the level of education varies across individuals, it does not constitute a significant discriminating factor of production systems in the study area. In parallel with formal education, literacy rates are as follows: 81 % illiterate and 19 % literate. The Chi-square test results indicate that there is no statistically significant relationship between literacy status and the production systems studied. Regarding membership in a maize group or association, there is significant variation from one municipality to another. In contrast to the municipalities of Parakou and Tchaourou, where more than 60 % of maize producers are members of a group, more than 60 % (75 %) of producers in N'dali are not members of a maize group or association. The results of the Chi-square test indicate a highly statistically significant relationship between the municipality of residence and membership in a producer group. Since the p-value is below the 1% threshold, the observed differences between municipalities are structural and not attributable to random variation.

This study considers as ethnic groups not only the most common ones in northern Benin (Bariba, Boo, Dendi, Ditamari, Zerma, Peulh, Lokpa, Nagot) but also some of the most common ones in Benin (Adja, Fon, Mahi). The vast majority of producers surveyed in these municipalities (N'dali, Parakou, and Tchaourou) are Bariba, with respective rates of 91 %, 79 %, and 75 %. Following the Bariba are the Dendi, with an overall frequency of 6 %. It is therefore evident that maize production is an activity practiced by the indigenous population. The results of the Chi-square test indicate that there is no statistically significant relationship between ethnicity and the production systems studied. Indeed, although some differences in distribution are observed across ethnic groups, the p-value being above the 5% threshold suggests that these variations are not sufficiently strong to be considered structural and may be attributed to random variation. Thus, ethnicity does not constitute a significant discriminating factor of production systems in the study area.

Overall, the average age of producers is 40 years. Regarding the distribution by commune, producers in N'dali are the youngest at 38 years, and those in Tchaourou are the oldest at 42 years. The results of the ANOVA indicate that there is a statistically significant difference in the average age of producers across municipalities. Indeed, since the p-value is below the 5% threshold, the observed variations are not attributable to random chance. This means that producers' age truly varies from one municipality to another, suggesting differentiated demographic profiles across the study areas. This heterogeneity may reflect local dynamics of agricultural settlement, generational succession, or differences in access to productive resources that influence the entry of young people into agricultural activities.The surveyed producers have an average of 16 years of experience in agriculture and 13 years of experience in maize production. In the study area, it is observed that men and women in households in N'dali and Parakou are all involved in farming activities, unlike households in Tchaourou, where the number of men and women involved is one less than the total number of household members.

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Producers farm a total of 13 hectares, of which an average of 10 hectares is devoted to maize production.

Table 2: Socioeconomic statistics of maize producers

Qualitative variables	**Modalities**	**Study area**			
		N'dali	**Parakou**	**Tchaourou**	**Total**
Gender	**Female**	15	12	10	11
	Men	85	88	90	89
	Chi-square test	*x^2 =15.385; df = 2; p=0.000*			
Marital status Married	**Divorced**	1	1	0	0.7
	Married – monogamous	61	66	72	66.3
	Married – polygamous	34	33	28	31.7
	Widower/Widow	4	0	0	1.3
	Chi-square test	*χ^2 = 10.567; df = 6; p = 0.103*			
Level elementary	**None**	57	50	53	53.3
	Elementary	27	23	18	22.7
	Upper Elementary	12	22	17	17
	Upper Secondary Level 2	4	4	7	5
	High	0	1	5	2
	Chi-square test	*x^2= 13.398; df = 2; p = 0.098*			
Literacy	**No**	80	78	84	80.7
	Yes	20	22	16	19.3
	Chi-square test	*x^2= 1.197; df = 2; p = 0.550*			
Membership in a corn group or association	**No**	25	64	75	54.7
	Yes	75	36	25	45.3
	Chi-square test	*x^2 =55.712; df = 2; p=0.000*			
Ethnicity	**Adja**	0	2	0	0.7
	Bariba	91	79	75	81.7
	Boo	0	1	1	0.7
	Dendi	5	8	5	6
	Ditamari	1	0	0	0.3
	Fon	0	1	1	0.7
	Lokpa	0	2	1	1
	Mahi	0	0	1	0.3
	Nagot	1	5	8	4.7
	Peulh	1	2	8	3.7
	Zerma	1	0	0	0.3
	Chi-square test	*x^2= 29.802; df = 20; p = 0.073*			

	Quantitative variables				
Variables	**Study area**				**ANOVA test**
	N'dali	**Parakou**	**Tchaourou**	**Total**	
Age	38 (±9)	40 (±9)	42 (±11)	40.11 (±9.84)	F = 5.093; P= 0.007
	Experience in agricultural production				
Agriculture	16 (±9)	14 (±9)	17 (±10)	15.61 (±9.17)	F = 2.213; P= 0.111
Corn	14 (±9)	12 (±8)	13 (±9)	13.19 (±8.35)	F = 1.713; P= 0.182
	Household size				
Male	5 (±4)	4 (±4)	4 (±2)	4.18 (±3.36)	F = 2.637; P= 0.073

Women	3 (±2)	3(±2)	3(±2)	3.01 (±2.36)	F = 3.788; P= 0.024
Child	3 (±2)	3 (±3)	3 (±3)	3.02 (±2.53)	F= 0.524; P= 0.593
	Agricultural assets				
Male	5 (±4)	4 (±4)	3 (±2)	3.83 (±3.40)	F = 6.697; P= 0.001
Female	3 (±2)	3 (±2)	2 (±2)	2.70 (±2.18)	F=10.430; P= 0.000
Child	2 (±2)	2 (±3)	1 (±1)	1.59 (±2.05)	F = 4.405; P= 0.013
	Area				
Available	15 (±13)	10 (±9)	15 (±15)	13.28 (±12.56)	F = 5.015; P= 0.007
Cultivated	11 (±9)	8 (±7)	10 (±8)	9.78 (±7.96)	F = 4.361; P= 0.014

(): standard deviation ; ***Source : Authors***

4.2.Characteristics of production systems for new maize varieties

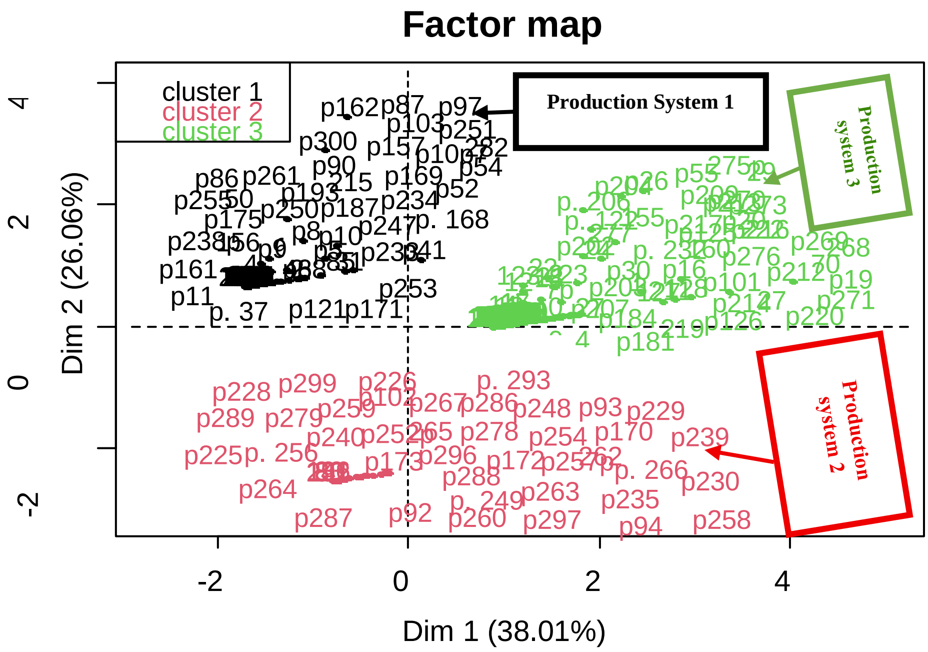
The results from Figure 2 of the MCA show that the first two dimensions explain 64.07 % of the total inertia, which constitutes an acceptable level of explanation for interpreting the data. However, although this proportion is satisfactory, it remains moderate and calls for a more in-depth analysis of variable contributions in order to better understand the structure of the factorial space. In this regard, examining the contributions of variables to the factorial axes makes it possible to identify the most discriminating variables. The first factorial axis is mainly structured by variables related to the level of intensification of agricultural practices, including the use of inputs (mineral fertilizers, improved seeds), access to agricultural equipment, and the use of labor. This axis thus reflects a contrast between low-input production systems and more intensive systems oriented toward market production. The second axis is dominated by variables related to the socio-economic and organizational characteristics of farms, such as experience in maize production, access to extension services, and the area planted with maize. It highlights differentiation linked to the degree of institutional integration and access to information and resources. The remaining 35,93 % of unexplained variance is due to factors not accounted for in the analysis. Analysis of the MCA results shows that the first group (SP1) represents approximately 37 % of the total sample, while the second production system (SP2) accounts for 15 % of the respondents, and finally, approximately half 48 % constituted the third production system (SP3).

The first maize production system (SP1) consists of 112 producers, or 37 % of the total sample. This system comprises farmers growing the TZPBSRW maize variety, with plow use being predominant. The TZPBSRW variety is characterized by a maturity period of approximately 4 months. Only 15 % use tractors for plowing, compared to 80 % who use plows; 36 % use chemical fertilizers, compared to 34 % who use organic matter. No one in this group uses improved seeds; they always use seeds from previous harvests. In this category, maize farmers have an average of 12 years of experience in maize production. The average total area planted by these farmers during the study period is 8 hectares, of which 3 hectares are allocated to maize production. These maize producers engage in small-scale maize production on a significant area, and their production system can be characterized as one based on the TZPBSRW variety, using moderate amounts of chemical and organic fertilizers (Table 3).

The second system (SP2), comprising 45 corn growers, accounts for 15 % of the total sample and is characterized primarily by growers who use multiple varieties, notably EVDT97STRW and AK94, which are valued for their yield and adaptation to local climatic conditions. The EVDT97STRW variety requires approximately 90 to 100 days before harvest, while the AK94 variety can be harvested after approximately 85 to 95 days. Hybrids such as "*Kabamanoj Red*"

and the white hybrid are also popular among producers. The "*Kabamanoj Red*" and white hybrids have a maturation period of approximately 90 to 110 days, offering flexibility in harvest timing. In contrast, 15% and 14% of producers in this group use chemical fertilizers and tractor, respectively. In this category, corn producers have an average of 11 years of experience in corn production. The average total area planted by these producers is 8 hectares, of which they allocate 3 hectares to corn production. These producers engage in small-scale corn production on a significant scale. Given their characteristics, producers in System No. 2 can be classified as those producing improved corn without the use of organic fertilizer (Table 3).
Production System 3 (PS3) consists of 143 producers, or 48% of the total sample. Farmers in this production system use chemical fertilizers in moderate amounts along with organic fertilizers. They are large-scale producers who grow maize using modern techniques. Producers in the category using the Synée 2000 variety focus exclusively on this option, which is recognized for its advantageous agronomic characteristics. This variety is prized for its ability to adapt to various growing environments, making it a preferred choice for farmers. The maturity period for the Synée 2000 variety is approximately 75 days, allowing producers to harvest quickly and optimize their crop cycles. About 80 % of the members of this group use tractors for plowing, compared to 20 % who use plows; 49 % use chemical fertilizers, and 66 % use organic fertilizers. Within this group, corn producers have an average of 15 years of experience in corn production. The average total area planted by these producers is 11 hectares, with 5 hectares allocated to corn production. These producers engage in large-scale corn production on significant acreage (Table 3).

Figure 2: Projection of surveyed corn producers along factor axes 1 & 2 and ascending hierarchical classification of production systems for new varieties.



Source: Authors

Table 3: Frequencies (%) of variables describing production systems

Variables	Modalities	SP1	SP2	SP3
Cultivated corn variety	EVDT97STRW; AK94; hybrid known as "Kabamanoj red" and white hybrid	0	15	0
	Synée 2000	0	0	47.7
	TZPBSRW	37.3	0	0
Use of fertilizers Chemical	YES	35.8	15.3	49
Use of organic matter	YES	34.4	0	65.6
Use of Plow	YES	80	0.00	20
Use of a tractor	YES	14.6	13.5	71.9
	Quantitative variables			
Experience in corn production		12.4 (±9.2)	10.64 (±5.72)	14.6 (±8.13)
Total area under cultivation (ha)		8.47 (±8.11)	8.17 (±5.28)	11.3 (±8.31)
Corn acreage (ha)		3 (±2.84)	2.95 (±1.64)	5.27 (±4.82)

PS: production system ; (): standard deviation ; ***Source : Authors***

4.3.Economic and financial profitability of production systems

The average area planted with corn by the respondents is 4 hectares, with a yield of 1,109 kg/ha. Per hectare, they spent an average of 138,250 CFA francs. A specific analysis by production system reveals that producers in systems 1 and 2 had approximately the same average total area (3 ha for PS1 and 3 ha for PS2), which is smaller than the 5 ha cultivated by producers in the third system. This difference in average total area between the cropping systems is statistically significant at the 1% level. The average yield obtained differs from one production system to another with a slight statistically significant variation: 1,076 kg/ha for PS1, 1,137 kg/ha for PS2, and 1,127 kg/ha for PS3.

Table 4: Quantitative variables related to farms

Characteristics	Production system			Total	Test
	SP1	SP2	SP3		
Corn acreage (ha)	3 (2.84)	2.95 (1.64)	5.27 (4.82)	3.97 (4.005)	F = 17.162; P= 0.000
Yield (kg/ha)	1,075.53 (362.33)	1,136.66 (264.89)	1,127.01 (453.65)	1,109.24 (396.85)	F = 0.653; P = 0.021
Variable cost/ha	116,974.98 (63,886.89)	120,884.27 (54,297.22)	135,574.11 (46,966.37)	126,489.46 (55,468.09)	F = 3.834; P=0.023
Fixed Cost/ha	3,090.77 (10,486.98)	7,157.40 (17,416.54)	1,182.28 (4,911.61)	2,728.55 (9,530.33)	F = 6.156; P= 0.002
Total Cost/ha	120,065.76 (65,659.69)	128,041.68 (60,910.27)	136,756.39 (47,439.91)	138,249.98 (163,991.30)	F = 1.592; P = 0.205
Total cost/quantity of corn (FCFA/kg)	122.01 (78.97)	118.74 (71.60)	142.68 (88.99)	148.55 (310.31)	F = 1.295; P = 0.275

(): standard deviation

Source : Authors

Furthermore, the average variable cost and average fixed cost for producing one hectare of maize amount to 126,489 CFA francs and 2,729 CFA francs, respectively. These production expenses vary from one production system to another. Indeed, variable costs and total production costs increase progressively as one moves from system 1 to system 3, via system 2. Analysis of variance (ANOVA) reveals that these differences in the means of variable production costs between production systems are statistically significant at the 10% level. The cost per kilogram of maize produced, however, was lower among producers in System 2 at 119

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FCFA/kg and higher than among producers in System 3 at 143 FCFA/kg, with producers in System 1 falling in between (Table 4).
The various components of total variable cost showed that equipment rental costs, as well as warehouse rental costs, each account for 1 % of total variable cost regardless of the production system. Input costs contribute 61 % to the total variable cost of systems 1 and 2 but 78 % to that of system 3. Salaried labor, meanwhile, accounts for 30 %, 31 %, and 17 % of the total variable cost for systems 1, 2, and 3, respectively (Table 5). These results indicate that, in the study area, the costs of agricultural inputs and salaried labor are very high.

Table 5: Components of total variable costs and their proportions

Components of variable cost	Observed percentages			
	SP1	SP2	SP3	Total
Equipment rental costs as a percentage of total variable costs	1	1	1	1
Warehouse costs in Total Variable Costs	1	1	2	1
Salaried labor costs as a percentage of total variable costs	30	31	17	22
Feed costs as a percentage of total variable costs	10	7	6	7
Input Cost as a Percentage of Total Variable Cost	61	61	78	69

Source : Authors

Table 6 presents net margins per hectare, yields, benefit-cost ratios, and Internal Rates of Return for three production systems, as well as an overall average. Production System 1 shows a net margin of 85,390 CFA francs/ha with a standard deviation of 53,837 CFA francs, indicating some variability. Production System 2 stands out with the highest net margin of 118,625 CFA francs/ha, but its larger standard deviation of 85,515 CFA francs suggests higher profitability accompanied by increased variability. Production System 3 has a net margin of 101,111 CFA francs/ha with a standard deviation of 94,238 CFA francs, indicating solid performance but also high variability. Analyzing the overall results, the average net margin for all systems is 96,244.41 CFA francs/ha with a standard deviation of 87,387 CFA francs. The statistical test values (F = 0.597; P = 0.551) show that there are no significant differences between the net margins of the various production systems. This suggests that, although some systems may be more profitable, overall performance does not vary significantly, which could influence producers' decisions regarding the adoption of one system over another.
Regarding average family labor productivity, Production System 1 shows an average family labor productivity (PML) of 2,424 FCFA/day with a standard deviation of 1,335, indicating some variability. Production System 2 shows the highest PML at 2,825, but with a significant standard deviation of 2,522, suggesting a wide range of performance within this system. Production System 3 has a PML of 2,781 CFA francs/day with a standard deviation of 1,819, also indicating good productivity but with notable variability. The average productivity across all systems is 2,626 CFA francs/HJ with a standard deviation of 1,924. The statistical test values (F = 1.512; P = 0.043) indicate that there is a significant difference between the productivities of the different systems. This suggests that, although some systems may offer better productivity.
The table also presents the benefit-cost ratios (BCR) for the three production systems. Production System 2 has the highest ratio with a BCR of 2.54, indicating that it generates significantly more benefits relative to the costs incurred. In contrast, Production System 1 has the lowest ratio at 1.86, suggesting lower profitability. The results of the statistical test (F = 47.90; P = 0.000) indicate a significant difference between the production systems, reinforcing the idea that Production System 2 is the most efficient.
Finally, the Internal Rates of Return (IRR) for the three production systems show that Production System 2 stands out with an IRR of 1.48, generating the highest returns relative to the investments made. Production System 1 has an IRR of 0.86, suggesting lower profitability,

while Production System 3 achieves an intermediate IRR of 1.03. The results of the statistical test (F = 86.34; P = 0.000) confirm that there are significant differences between the IRRs of the different systems.

Table 6: Economic Profitability Indicators

Performance indicators	Production System			Overall	Test
	SP1	SP2	SP3		
Net Margin (FCFA/ha)	85,389.92 (53,836.59)	118,624.98 (85,514.79)	101,111.07 (94,238.25)	96,244.41 (87,387.11)	F = 0.597; P = 0.551
Average Productivity of the Family Workforce (PML)	2,424.40 (1,335)	2,825.43 (2,520.65)	2,781.29 (1,818.76)	2,625.66 (1,923.57)	F = 1.512; P= 0.043
Benefit-Cost Ratio (BCR)	1.86 (0.76)	2.54 (1.13)	2.05 (1.35)	1.99 (1.23)	F=47.90; P=0.000
Internal Rate of Return (IRR)	0.86 (0.77)	1.48 (1.19)	1.03 (1.00)	0.96 (0.53)	F=86.34; P=0.000

(): standard deviation ; ***Source : Authors***

5. Discussion

The use of new maize varieties improves yield in the study area. The three-month variety production system (production system 2) yields the highest yield at 1,137 kg/ha, closely followed by the two-month variety production system (production system 3) at 1,127.01 kg/ha. The four-month variety production system (production system 1) recorded the lowest yield at 1,075.53 kg/ha. The standard deviations shown in parentheses also indicate variability in yields, with production system 2 having the lowest variability (264.89 kg/ha), suggesting greater production stability in this system. The overall average yield is 1,109.24 kg/ha; it falls between the yields of systems 2 and 3, indicating a generally satisfactory performance in maize production. This suggests that, although each system has its own characteristics, maize production remains overall profitable and efficient in the study area. The difference in yields between the systems underscores the importance of choosing the right production system to maximize yields, while taking into account the variability factors that can affect performance. The yield obtained in this study is lower than that reported by Yemadje *et al.*, (2025) in the north of the country, where average yields were relatively high, reaching approximately 4,487 kg/ha.

Regarding the economic profitability of maize production, profitability indicators show that it is advantageous in terms of net margin, which is positive for both all producers and each of the three production systems. However, there is no significant difference between net margins when comparing the production system for three-month varieties (production system 2) (118,624 FCFA/ha) with that for two-month varieties (production system 3) (101,111 FCFA/ha) and that for four-month varieties (production system 1) (85,389 CFA francs/ha), as indicated by the test for comparison of means (p=0.597). This result can be explained by the fact that, although the production system for three-month varieties has a higher average yield, it is in the production system for two-month varieties that the average production cost is highest. These results indicate that the profitability of maize production in terms of net margin is, however, a reality that contradicts the previous findings of studies by Adegbola *et al.*,(2011) and Degla, (2020) on maize production in northern Benin. Regarding the average productivity of family labor (PML), the results show that family labor is well compensated, as the PML far exceeds the average wage rate of 2,000 CFA francs per man-day in the study area. When comparing the three production systems, the results reveal a significant difference in means (p=0.002) between the PML of the four-month variety production system (production system 1) at 2,424 CFA francs/man-day, that of the three-month variety production system (production system 2) at

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2,825 CFA francs/man-day, and finally that of the two-month variety production system (production system 3) at 2,625 CFA francs/man-day. Despite this difference, it appears that, regardless of the production system, the maize producers surveyed have every interest in focusing on work within their own farms rather than selling their labor outside the farm in the study area. This could encourage producers to favor the three-month system to maximize profits while ensuring competitive compensation for family labor. This result corroborates the work of Kumar and *al.*,(2013) and by Paulino-Flores *et al*., (2017).
In terms of the benefit-cost ratio (BCR), maize production is profitable for all three production systems as well as for each individual system. This means that one franc invested in maize cultivation generates a gross income of more than one franc. However, the differences in mean BCRs among the three production systems (p=0.000) reveal that profitability is particularly pronounced in the production system using three-month-cycle varieties (production system 2), compared to the other two production systems. This finding confirms the results of Mamam *et al*., (2016). When examining the internal rate of return (IRR), the results indicate that maize production is also profitable according to this indicator, as it significantly exceeds the 12% interest rate prevailing in the study area, both at the aggregate level of producers and within the different production systems. This finding means that, currently, financing maize production through loans is advantageous, as it generates sufficient income to cover the interest payments associated with these loans. Thus, engaging in maize production not only ensures immediate profitability but also opens up prospects for sustainable growth for farms (Tapsoba, 2024). Agricultural farms operate in a highly uncertain environment characterized by climatic hazards, price volatility of agricultural products and inputs, as well as limited access to markets and financial services (Shah and Alharthi, 2024). These structural constraints increase the risk of loan default and significantly affect the actual profitability of agricultural investments (Khan *et* al., 2024).

6. Conclusion

This study aimed to analyze maize production systems in Northern Benin through a typological approach grounded in the theory of agricultural production systems. The results highlight a strong diversity of farming practices, structured around three main production systems corresponding to maize varieties with two, three, and four-month cycles. This diversity reflects differentiated farmers' strategies, oriented either toward immediate food security or toward intensification and profit maximization. At the theoretical level, the study confirms the relevance of the theory of agricultural production systems as an analytical framework for understanding farms as coherent sets of interactions between technical choices, economic constraints, and institutional contexts. It also shows that production systems cannot be reduced to a simple combination of factors, but should rather be understood as dynamic configurations shaped by farmers' adaptive strategies. The combined use of Multiple Correspondence Analysis (MCA) and typological classification thus captures the complexity and heterogeneity of farming systems in rural areas.
Empirically, the results reveal that the three-month maize production system performs better economically, suggesting an optimal trade-off between production duration and profitability. In contrast, the two-month system, although widely adopted, appears to respond more to short-term constraints than to profit maximization objectives. These findings highlight the importance of the trade-offs made by farmers between food security, resource constraints, and economic objectives. In terms of policy implications, these results call for differentiated agricultural support policies. It is necessary to promote the most economically efficient production systems, particularly the three-month maize variety system, through improved access to quality seeds, agricultural inputs, and extension services. Furthermore, strengthening agricultural advisory

and extension systems could enhance the dissemination of more profitable practices. In addition, financing mechanisms adapted to production cycles should be developed to support productive investments in farming systems.

This study opens several avenues for future research. It would be relevant to analyze the evolution of production systems over time in order to better understand trajectories of agricultural intensification. Future research could also incorporate a more in-depth qualitative approach to explore farmers' decision-making processes, particularly in relation to social, cultural, and institutional constraints. Finally, analyzing the effects of agricultural public policies on production system choices would further deepen the understanding of agricultural dynamics in Northern Benin.

References

(1). Adegbola, P.Y., Aloukoutou, A., Diallo, B., 2011. Analysis of the competitiveness of local maize in Benin. West African Food Security Research Strengthening Program (PRESAO), SRAI Component, Summary.

(2). Adiaha, M.S., Agba, O.A., Attoe, E.E., Ojikpong, T.O., Kekong, M.A., Obio, A., Undie, U.L., 2016. Effect of maize (Zea mays L.) on human development and the future of man–maize survival: A review. World Scientific News 59, 52–62.

(3). Agossadou, H., Degla, P., Agalati, B., 2023. Analysis of the economic performance of farmers in the Malanville irrigated perimeter under different water distribution systems. Moroccan Journal of Agronomic and Veterinary Sciences 11, 168–174.

(4). Akossou, A.Y., Attakpa, E.Y., Fonton, N.H., Sinsin, B., Bosma, R.H., 2016. Spatial and temporal analysis of maize (Zea mays) crop yields in Benin from 1987 to 2007. Agricultural and Forest Meteorology 220, 177–189.

(5). Akpatcho, H.L., Crinot, G., Sinha, M., Adegbola, P.Y., Yabi, J.A., 2022. Analysis of the evolution of the typology of cotton farms engaged in agroecological transition in Benin and agroecological practices. Agronomie Africaine 34, 479–491.

(6). Akpo, F.I., Dohou, M.D., Houessingbe, Z., Yabi, J.A., 2021. Comparative analysis of soybean production systems based on the use of inoculum in a context of sustainable land management in Central Benin. International Journal of Innovation and Applied Studies 32, 230–239.

(7). Allaire, G., Blanc, M., 1982. Agricultural policy and peasantry. In: Lacroix A. (1981). Transformation of agricultural labor processes.

(8). Aniagyei, J., Bakang, J.-E.A., Tham-Agyekum, E.K., Arhin, M., Asiedu, P., 2024. Employing agricultural extension delivery services for improving cocoa bean quality. Cogent Social Sciences 10, 2333431.

(9). Ayena, M., Yabi, J.A., 2013. Typology and economic profitability of farms participating in farm management advisory services.

(10). Baco, M.N., 2019. The current role of maize in farming systems in Northern Benin. Bulletin of Agricultural Research of Benin (BRAB) 2, 19–30.

(11). Badouin, R., 1987. Economic analysis of agricultural production systems. Cahiers des Sciences Humaines 23, 357–375.

(12). Bélières, J.-F., Rasolofo, P., Rivolala, B., Ratovoarinony, R., Ratsaramiarina, O., Rabevohitra, B.N., David-Benz, H., 2017. Development of farm typologies at the subnational level in Madagascar: Lake Alaotra and Menabe region. WAW Madagascar Program (FAO/CIRAD Protocol), Antananarivo.

(13). Ben Saali, T., Belkacemi, K., 2023. The role of financial indicator analysis in evaluating corporate financial performance: Case of "ELECTRO-INDUSTRIES" of Azazga (PhD Thesis).

(14). Chambers, R., 1980. Basic concepts in the organization of irrigation.
(15). Degla, K.P., 2012. Economic and financial profitability of cotton farms based on Integrated Soil Fertility and Pest Management in Northern Benin. Bulletin of Agricultural Research of Benin 26–35.
(16). Degla, P.K., 2020. Comparative analysis of the economic performance of maize production systems in the municipality of Banikoara in Northern Benin. Science of Life, Earth and Agronomy 8.
(17). Djibril, I.G.M., Boubacar, S., 2021. Analysis of the economic profitability of rainy-season market gardening in the municipalities of Imanan and Tagazar in Niger.
(18). Goudjo, G.G., 2023. Access to finance and productivity of family farming in Benin: Case of small farms (PhD Thesis).
(19). Hammond, J., Rosenblum, N., Breseman, D., Gorman, L., Manners, R., van Wijk, M.T., Sibomana, M., Remans, R., Vanlauwe, B., Schut, M., 2020. Towards actionable farm typologies: Scaling adoption of agricultural inputs in Rwanda. Agricultural Systems 183, 102857.
(20). Hasanah, P.D.U.N., Fauziyah, E., 2025. Competitiveness of local corn 'Manding' after the 2022 fertilizer subsidy policy change. Indonesian Journal of Agricultural Science 30, 612–620.
(21). Hassall, K.L., Baudron, F., MacLaren, C., Cairns, J.E., Ndhlela, T., McGrath, S.P., Nyagumbo, I., Haefele, S.M., 2023. Construction of a generalized farm typology to support selection, targeting, and scaling of on-farm research. Computers and Electronics in Agriculture 212, 108074.
(22). Hinnou, C.L., Kossoko, O.-C.D., Adekambi, A.S., Agbotridja, V.D., 2021. Effects of agropastoral systems on the financial profitability of maize production in Northern Benin. Agronomie Africaine 33, 45–56.
(23). Hinnou, L.C., Obossou, E.A.R., Adjovi, N.R.A., 2022. Understanding mechanisms of access to and management of agricultural machinery in Benin. Scientific African 15, e01121.
(24). Ibikoule, G.E., Lee, J., Godonou, L.A., 2024. Smallholders' vulnerability in the maize market: Analysis of marketing channels to improve the role of cooperatives in Benin. Heliyon 10.
(25). Ibitola, O.R., Fasakin, I.J., Popoola, O.O., Olajide, O.O., 2019. Determinants of maize farmers' productivity among smallholders in Oyo State, Nigeria. Greener Journal of Agricultural Sciences 9, 189–198.
(26). Jayne, T.S., Wineman, A., Chamberlin, J., Muyanga, M., Yeboah, F.K., 2022. Changing farm size distributions and agricultural transformation in sub-Saharan Africa. Annual Review of Resource Economics 14, 109–130.
(27). Jouve, P., 1986. Principles for constructing farm typologies in different agrarian contexts. Cahiers de la Recherche Développement 48–56.
(28). Kassogué, B., 2020. Agricultural policies and agricultural productivity in Mali (PhD Thesis).
(29). Khan, F.U., Nouman, M., Negrut, L., Abban, J., Cismas, L.M., Siddiqi, M.F., 2024. Constraints to agricultural finance in developing countries: A systematic literature review. International Journal of Agricultural Sustainability 22.
(30). Kolapo, A., Didunyemi, A.J., Aniyi, O.J., Obembe, O.E., 2022. Adoption of sustainable land management practices and effects on maize productivity in Nigeria. Resources, Environment and Sustainability 10, 100084.
(31). Krull, C.F., Borlaug, N.E., 1970. Utilization of plant collections in breeding and production.

(32). Kuentz-Simonet, V., Lyser, S., Candau, J., Deuffic, P., Chavent, M., Saracco, J., 2013. Variable clustering approach for typology construction: Case of an agriculture–environment survey. Journal of the French Statistical Society 154, 37–63.
(33). Kumar, A., Jat, S.L., Kumar, R., Yadav, O.P., 2013. Maize production systems for improving resource-use efficiency and livelihood security. Directorate of Maize Research, New Delhi.
(34). Labiyi, I.A., Yegbemey, R.N., Olodo, V.D., Yabi, J.A., 2018. Soil fertility management practices and economic performance of maize producers in Northern Benin. University of Parakou Journal 8, 115–124.
(35). Labouesse, F., 1986. Moroccan agriculture in the early 1980s: Situation and perspectives. Méditerranée 59, 93–101.
(36). MAEP/DSA, 2021. Agricultural campaign statistics 2019–2020 and outlook for 2020–2021.
(37). Mamam, T.S., Gauthier, B., Afio, Z., Aliou, S., 2016. Evaluation of technical efficiency of maize-based production systems in Benin. European Scientific Journal 12.
(38). Maniriho, A., 2021. Productivity, efficiency, and profitability of small farms in Rwanda (PhD Thesis).
(39). Montcho, M., et al., 2023. Productivity of dual-purpose crops and food security of small dairy farmers in Benin under climate variability. International Journal of Biological and Chemical Sciences 17, 2810–2821.
(40). Mwabila, M.L., et al., 2023. Typology of family farms and cassava retting technology in DR Congo. ESI Preprint 15.
(41). Paraïso, A., et al., 2011. Profitability analysis of fonio production in Boukombe, Benin. Journal of Scientific Research, University of Lomé 13.
(42). Paraïso, A.A., et al., 2012. Perceptions and adaptation of beekeepers to climate change in Northwest Benin. African Crop Science Journal 20, 523–532.
(43). Paulino-Flores, M., et al., 2017. Sustainability of hybrid and native maize systems. Journal of Cleaner Production 150, 287–293.
(44). Rached, Z., et al., 2021. Profitability and productivity of cereal farms: Case of durum wheat in Tunisia. New Medit 20, 107–124.
(45). Reboul, C., 1976. Production systems and farming systems. Économie Rurale 112, 55–65.
(46). Shah, J., Alharthi, M., 2024. Factors influencing farmers' adoption of risk management strategies. Journal of Integrative Agriculture 23.
(47). Sigue, H., et al., 2019. Effect of microdose technology on economic performance of farms in Burkina Faso. African Crop Science Journal 27, 331–349.
(48). Sossou, R., et al., 2024. Agricultural policy reforms in Benin since 1960: A systematic review. International Journal of Innovation and Applied Studies 43.
(49). Tapsoba, M.G., 2024. Strengthening the contribution of agricultural value chains to economic growth in Burkina Faso.
(50). Tchekessi, C.C., et al., 2021. Technological and socio-economic study of akandji, a maize-based traditional food in Benin. International Journal of Biological and Chemical Sciences 15.
(51). Vartanyan, O., Hovasafyan, N., 2021. Guidelines for calculating internal rate of economic return for energy investments.
(52). Yabi, J.A., et al., 2012. Economic profitability of rice systems in Malanville, Benin. BRAB Special Issue.
(53). Yabi, A.J., et al., 2013. Analysis of maize production and supply for food security in Borgou, Benin. African Journal of Agricultural Research 8.

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(54). Yemadje, P.L., et al., 2025. No-tillage and intercropping improve yield and profitability of maize–cotton systems in Northern Benin. Experimental Agriculture 61.

(55). Yessifou, A.J., et al., 2021. Determinants of adoption of improved maize varieties in Northern Benin. African Science 18.