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Increased Yields and Economic Productivity of Tropical Pig Farms

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Abstract: In prospect of a better knowledge of the influence of environment and production system, the yield and economic productivity of 60 pig farms were valued and compared in 3 zones and 3 production systems. The main results showed that the yield per sow (11,18±1,8) is well more important (p<0,05) with the semi-intensive or improved peasant system, compared to traditional peasant system (10,48±1,9) and fully controlled intensive or modern system (10,23±1,7). The estimated marginal average is higher in Western Highlands (11,14±1,9), followed by humid forest (10,76±1,6) and finally, northern regions (10,42±2,2). Disparities were observed also in all production systems and zones about the sign of the gap. The spread was much more dispersed in the north, with a standard deviation rather higher than the average standard deviation of the sample, indicating a zone favorable to the development of pig production. However, if the traditional peasant system allows to achieve a significantly lower yield than economic productivity in the Western Highlands, it remains the most appropriate in northern regions. Meanwhile, by linking yield and economic productivity, the study highlighted a lack of economic objectivity among farmers. The profitability analysis, as to, revealed that recovery period is relatively short with the modern system, compared to traditional and improved peasant systems but, remains comparable in all production zones.

Keywords: Investment, Productivity, Break-even, Growth, Production System

1. Introduction

The fundamental participation of agriculture in economic growth consists in the increase of its productivity through which a decreasing proportion of the resources available to nations is allocated to the satisfaction of the food needs of their populations, guarantee of economic and political stability, especially in emerging countries. According to forecasts by the United Nations Agriculture and Food Organization [8], the planet will have to feed 9 billion people by 2050. To ensure food security in the current context of global changes such as climate change, degradation of natural resources, population growth, etc., it becomes imperative to act on the lever of the increase in agricultural yields especially in tropical Africa and particularly in Cameroon where production capacities zone still very low to be able to boost production and compensate for the growing protein deficit [8].

1.1. Theoretical Framework

The race to maximize yield is the subject of strong controversy, with nothing less than a profound transformation of the global system of agricultural research and development [11]. If the agronomists' are unanimous on the urgency to increase yields where they low, they differ on the method to be adopted (take inspiration from the productivist model of the green revolution or invent ecologically intensive agriculture?). Economists and historians, on their part, view the process of farm productivity growth from different perspectives. In any event, all other things being equal, the increase in agricultural yields is achieved by strengthening the capacities of production units which can result either by intensification (modernization of the productive apparatus) or integration (increase in dimensions and work). In practice, agricultural yields are generally increasing for small

quantities, becoming constant, then decreasing for very large quantities. There is therefore an "optimal volume" or break-even threshold which enables the exploitation to improve the economic productivity of labour. The analysis of this production equilibrium makes allows to understand the relationship between revenues (incomes), expenditures (costs) and profits (benefits) per unit produced and to situate the farm in its yield zone. Those relating to the recovery period provide an estimate of the time required for a farm to take possession of the capital invested in view of the cash flows generated and the discount or current interest rate. State of knowledge and development prospects

In the livestock sub-sector, recent economic data on the meats consumption of the different farmed species [7, 12] show that pork, with more than 40% of consumption constitutes, with poultry, two species that can be relied on to increase meat production and cope with the growing protein deficit. In Asia, for example, where nearly half of the world's pig population is found, pig plays a major role in the agricultural economy and the economy as a whole as a meat producer and contributes, to a large extent, to the reduction of the growing food deficit [7]. In sub-Saharan Africa and precisely in Cameroon, it is of significant importance in the food intake of urban populations and plays an essential role in the tradition of certain peoples such as wedding ceremonies, funerals, etc. Although practiced largely extensively, there is an intensification of production systems with livestock growth of 5-10% (FAO, 2007). Hence the need to encourage the production of this animal species. However, the studies carried out in this field in tropical Africa, mostly focus on the characterization of the farms, constraints on the development of production, etc., ignoring the crucial effect that hinders the increase in yields in this sector [6, 15]. Those carried out with a view to identifying the production management methods used by farmers reveal that they do not always aim to maximize short-term profit in the allocation of their resources, but to guarantee savings that can be easily mobilized in case of necessity and food substance under the most unfavorable conditions [9]. However, a good knowledge of the economic interest of increasing yields is a prerequisite for the proposal of efficient and effective methods to reduce the gap between potential and current yields in the production of this animal species. Besides, this change in yield is commonly used as an indicator of rationality for comparisons between zones and production systems [16]. Comparisons between zones take into account agroecological and socio-economic differences. Those concerning production systems relate to the volume and quality of the investment.

1.2. Purpose of the Study

The purpose of this study is to provide a better understanding of the influence of the agri-ecological environment and the production system of pig yield, which is a prerequisite for the improvement of production and the economic productivity of the pig farm labour. Specifically, it aims to assess the current pig yield and determine the breakeven /bankruptcy threshold in terms of equilibrium production and recovery period. Knowledge of the break-even/bankruptcy threshold could generate economic interest in yield increase and gap reduction between potential and current yields and then, improves production and economic productivity.

2. Methodology

The study was carried out during a research operation on the characterization of pig farms conducted between March 2019 and April 2020 among 60 breeders established in the 3 main agroecological zones likely to influence pig production in Cameroon [12]: the Western Highlands (WH) characterized by a modified Sudano-Guinean climate, 1400-2000 m altitude, temperatures 16-27°C, rainfall 1800-2000 mm, rainy season: mid-March to mid-October; the humid forest (HF) where the climate is of the Guinean type, altitude varying between 400-600 m, temperatures 20-34°C, rainfall 1500-2500 mm, relative humidity 92% and the northern regions (NR) whose climate is of Sudano-Sahelian type, temperatures 17-45°C, rainfall 500-1200 mm, savannah and steppe vegetation). To conduct these surveys, the locations of Bamenda and Mbouda (Western Highlands), Yaoundé and Meyom-messala (Humid Forest), Zouaye and Yagoua (Northern Regions.), were chosen on the basis of the importance of their breeding activities [14]. A quota of 20 farms per zone, randomly and independently, was chosen on the basis of their availability to answer questions and having a coherent system of collecting technical and economic data (Table 1).

Table 1. *Distribution of farms and breeding herd according to the production system and zone.*

Production systems	Production zones			
	Western highlands	Humid forest	Northern regions	Total
Traditional peasant	5 (23)	13 (51)	14 (42)	32 (116)
Improved farmer	6 (29)	4 (24)	4 (15)	14 (68)
Modern	9 (403)	3 (127)	2 (15)	14 (545)
Total	20 (455)	20 (202)	20 (72)	60 (729)

() = Number of sows rezoned.

The culling farms identified were classified according to the production system used, by reference to the number of sows, feeding and housing systems, health monitoring: The extensive or traditional peasant system (TPS), linked to the peasant lifestyle, is characterized by generally low numbers (1-5 sows), an unrationed diet consisting only of waste, a basic shelter and a lack of health monitoring. The semi-intensive or improved peasant system (IPS), characterized by 6-15 sows, a permanent wooden shelter, a better balanced diet (50% comes from 50% waste) and a one-time health follow-up. Finally, the fully controlled intensive or modern system (MS) is characterized by more effective, complete food (100% feed), decent housing and permanent health monitoring The information gathered using a semi-structured questionnaire and supplemented by direct interviews and observations per system and production zones, were related to the number of sows present, the number of calves per year and piglets weaned per calve. Number of piglets sold or self-consumed by litter, the amount of fixed and charges, the selling prices of the products. The estimated variable costs

and margins were based on the operating activity account, all of which were evaluated in FCFA per piglet produced. Non-market food ingredients such as crop and kitchen waste, etc., were assessed at their marginal rate of substitution.

The average annual total physical yield per sow was estimated as follows:

$$Average\ annual\ total\ physica\ yield\ (ATP) = \frac{Total\ Physical}{number\ of\ sows} \quad (1)$$

The budget method, considered as one of the data processing procedures for obtaining the information necessary for the choice of investment, was used to estimate the breakeven / bankruptcy threshold in terms of equilibrium production and recovery period of a farm according to the following expressions:

$$Equilibrium\ production\ (EP) = \frac{I_0}{(CF*)/u} \quad (2)$$

$$\text{Recovry period}\ (t) = -\left[\ln\left(1 - \frac{r \times I_0}{CF^*}\right) \Big/ lh(1+r)\right] \quad (3)$$

EP=Equilibrium production

t = Recovery period

I_0 = initial investment

CF*= cash-flow moyen annuel

r = Interest rate

After collection and codification, the data thus collected were subjected to the ANOVA analysis by the ordinary least square (OLS) adapted to the case of experimental devices with unbalanced numbers [15] and, the separation of the averages using the Dunkan test at 95% confidence interval. Numbers assigned the same index zone not significantly different and, in brackets, the number of sows (see tables). The presentation, analysis and discussion of the results zone contained in the following developments.

3. Results: Presentation and Analysis

A description of the characteristics of the statistical distribution of the 4 variables retained in this study made it possible to highlight the level of activity of the farms listed in the main pig production zones.

1. Average total physical yield per sow (ATP)

As can be seen from Table 2 summarizing the average total physical yield per sow, the zone and production system, more or less significantly, influence sow productivity.

Table 2. *Average total physical yield per sow depending on the system and the production zones.*

Production systems	Production zone s			
	Western highlands	Humid forest	Northern regions	Estimated marginal mean
Traditional peasant	10,91±1,8^{a} (23)	10,54±1,7^{a} (51)	10,28±2,1^{a} (42)	10,48±1,9^{a} (116)
Improved farmer	12,20±1,8^{b} (29)	11,76±1,4^{b} (24)	11,87±2,3^{b} (15)	11,98±1,8^{ba} (68)
Modern	10,55±1,9^{a} (403)	10,37±1,2^{a} (127)	8,55 ±0,4^{a} (15)	10,23±1,7^{a} (545)
Estimated marginal mean	11,14±1,9^{a} (455)	10,76±1,6^{a} (202)	10,42±2,2^{a} (72)	10,77±1,9 (729)

() = Number of sows.

Separation of averages using Duncan's 95% confidence interval test revealed that the average total physical yield per sow is relatively higher in the western highlands, followed by humid forest and finally, the north. No significant difference was observed between production zones. At the same production zone, it was significantly higher ($p < 0.05$) with the improved peasant system, compared to the modern and traditional peasant systems which remained appreciably ($p > 0.05$) comparable among them. When the system and production zones are taken into account, the highest yield ($p < 0.05$) was recorded with the improved peasant system in the western highlands and significantly the lowest with the modern system in the north. Point out that the marginal average yield was relatively more dispersed in the north with a standard deviation rather greater than the average standard deviation of all production zones and, less dispersed in the humid forest, with a standard deviation rather lower than the sample mean. It was also less dispersed with the improved traditional and modern systems, with a standard deviation rather lower than the marginal mean.

2. Economic productivity or average equilibrium production per sow

Analysis of Table 3, showing break-even productivity or average equilibrium production per sow, revealed that the production system and zone also influence the economic productivity of the sow.

Table 3. *Economic productivity of the sow according to the system and the production zones.*

Production systems	Production zones			
	Western highlands	Humid forest	Northern regions	Estimated marginal mean
Traditional peasant	10,08±0,8^{a} (23)	10,78±1,8^{a} (51)	10,26±1,6^{a} (42)	10,44±1,6^{a} (116)
Improved farmer	12,83±2,0^{b} (29)	11,60±1,7^{b} (24)	10,55±0,9^{a} (15)	11,83±1,8^{b} (68)
Modern	10,38±1,8^{a} (403)	10,63±1,6^{a} (127)	9,20 ±1,0^{b} (15)	10,26±1,6^{b} (545)
Estimated marginal mean	11,04±2,0^{a} (455)	10,93±1,7^{a} (202)	10,21±1,4^{a} (72)	10,72±1,7 (729)

() = Number of sows.

However, with an equal production system, the average equilibrium production per sow is relatively higher in the western highlands, followed by the humid forest and finally, the northern regions. The result of Duncan's 95% interval test confirmed that no significant difference was observed between the different production zones. For an equal production zones, the comparison between production systems showed that the average equilibrium production per sow is significantly higher ($p<0.05$) with the improved peasant system, compared to the modern and traditional peasant systems which have remained substantially comparable ($p>0.05$) between them. When considering the different production systems and zones, the highest equilibrium production ($p<0.05$) was recorded with improved peasant systems in all production zones especially in the western highlands, monitoring of traditional and finally modern farming systems where it was lowest ($p<0.05$) in the northern regions. Note also that the equilibrium production was more dispersed in the western highlands, with a standard deviation rather greater than the average standard deviation of the sample. On the other hand, it remained less dispersed in the northern regions, with a standard deviation rather lower than the average standard deviation of all the zones. However, the comparison between the economic or potential yield and the current yield of the sow (deviations) makes it possible to appreciate the differences thus observed in the production systems and zones.

3. Gaps depending on the production system and zones

The analysis of the difference between the current physical total yield and the economic or potential productivity of sow, as illustrated in Figure 1, revealed that the level of production of the farms varies from one zone to another, depending on the production system.

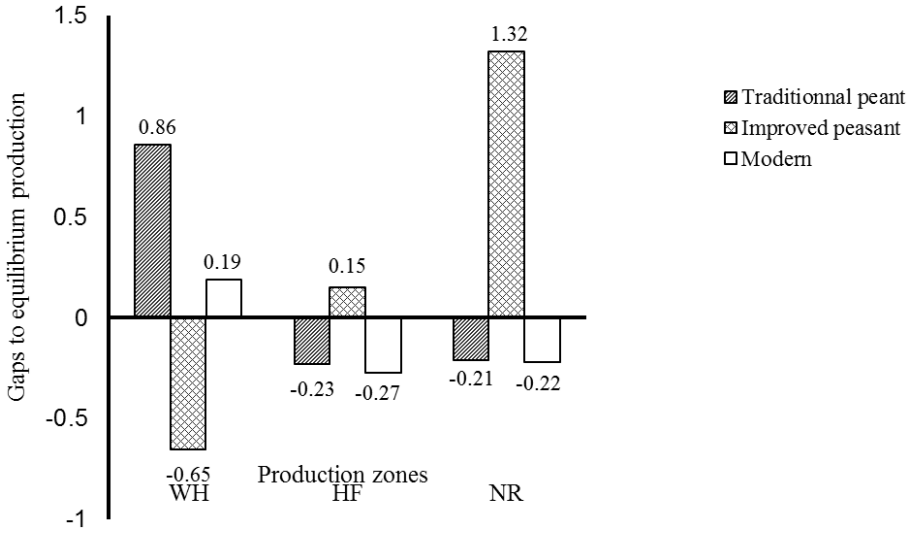

Figure 1. *Gaps depending on the system and the production zones.*

As a reminder, the underlying assumption is that a current total physical return lower than the economic return (negative gap or bankruptcy) reflects a situation of irrationality in the allocation of available resources. Conversely, (positive gap), it is rather an operation that achieves productivity gains. The comparison of the estimated marginal averages from the Duncan's test at 95%, revealed that the gap between the current yield and the equilibrium production is relatively higher and of negative sign in the western highlands, as opposed to the humid forest and northern regions where it is lowest and of opposite sign. Regardless of the production zones, the estimated average marginal deviation was relatively highest and negative with the modern system. On the other hand, it was the weakest and of positive sign with the improved and modern peasant systems. When considering different production systems and zones, the greatest positive difference was recorded with the improved peasant system in the north, followed by the traditional peasant system in the western highlands. On the other hand, it was negatively highest with improved peasant systems in the western highlands. No significant difference was observed between the different production systems and zones. It should be noted that the spread was much more dispersed in the north, with a standard deviation rather higher than the average standard deviation of the sample, indicating a zone favorable to the development of pig production. It remained less dispersed in the western highlands, with a standard deviation rather lower than the marginal mean.

4. The recovery or payback period at profitability / bankruptcy threshold

The evaluation of the payback period at the profitability / bankruptcy threshold (Figure 2) allowed an estimate of the level of economic productivity of labor in the pig farm according to the system in the different production zones.

As a reminder, the recovery period is a static criterion for evaluating the profitability of an income-generating activity which allows to determine the speed of capital turnover. The shorter this delay, the more profitable the activity. Duncan's test, 95% interval, showed no significant difference between

the different subgroups. However, for the same zones, the marginal average payback period was relatively shorter with the modern production system, compared to traditional and improved peasant systems where it was the longest. Regardless of the production system, the relatively shorter marginal average recovery time was recorded in the western highlands, followed by humid forest and finally, the northern regions. When considering production systems and zones, the average recovery period was directly related to the value of the investment in the western highlands, unlike the humid forest and northern regions where it was more or less heterogeneous. It is plausible to consider here, depending on the level of investment, several profiles of actors each having a specific behavior. With the exception of the improved traditional system in the western highlands, the recovery period was, on the whole, less dispersed with a standard deviation rather lower than the average standard deviation of the sample.

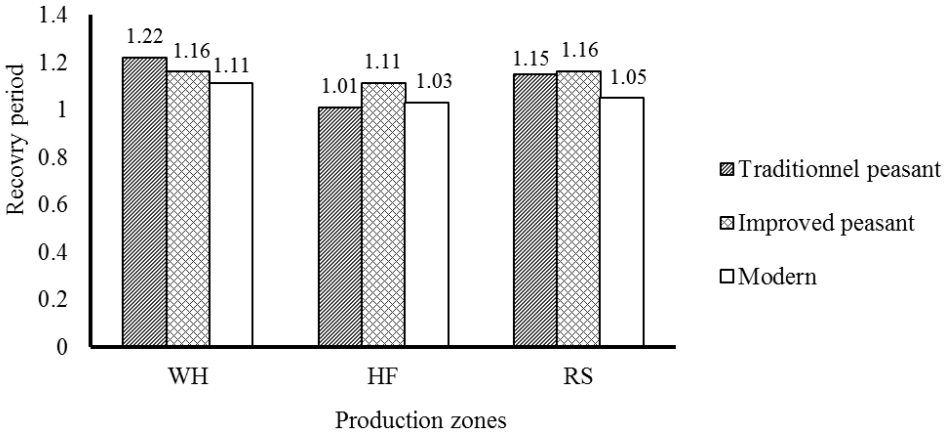

Figure 2. *Recovery period at profitability / bankruptcy threshold according to the production system and zone.*

4. Discussion

Growth in the economic productivity of agriculture supposes an optimal increase in output per unit of resources used to produce goods and services. The empirical verification of this hypothesis, by analyzing the economic performance of pig farms, showed that the average total physical yield per sow, under current production conditions, although higher than the level achieved elsewhere, remained below the equilibrium production in the majority of production systems and zones. Work done elsewhere indicated that pig production in sub-Saharan Africa mainly concerns small scale farmers with breeding herds ranging from 4-5 sows and average yield of 5-10 piglets per sow [8] and [6]. However, the great prolificacy of this animal species. It is to breed twice a year with litter sizes of up to 16 piglets per sow [1]. However, it is interesting to note the disparities hidden by the average of 11 piglets obtained in this study and the influence of the conditions of pig production. This low productivity recorded in most pig farms would be due to the structure of production units and process and the very objectives of farmers. on the one hand, and on the other, to the objectivity of breeders. Analysis of the structure of production units showed that the size of the breeding herd, recorded in all production areas, is quite small as seen elsewhere [8, 13]. It should be noted, however, that there is some intensification of production systems, especially in the western highlands where the breeding herd reaches an average of about 40 sows. This may be due to the fear of a possible outbreak of African swine fever (ASF), which remains endemic in the western highlands and rainforest [12]. However, the yield is still increasing from the traditional peasant system to the improved peasant system, but decreases with the modern or fully controlled system, which is consistent with the practice of agricultural production. The production process, for its part, involves a variety of influential factors, the importance and nature of which vary depending on the system and the area of production [4]. The food and housing system used by producers in all production areas is not such as to promote higher yields. The pigs, in most cases, were fed with less than 5% feed due to lack of financial means. This result is consistent with the findings of Rahman et al. [18] in the Azawa Mizoram-India district, who argue that feeding pigs with the remaining food and grain by-products associated with crop residues is a way to reduce the cost of production but, with a negative impact on the economic growth performance of livestock. Yet, pig feeding is the key factor that determines the yield of pig farming [3, 6] and [10]. More than 70% of animals were housed in local materials with questionable hygiene conditions. However, several authors [1, 3, 5] recognize that housing patterns as well as health monitoring play a key role in increasing yields and, by spillover effect, the economic productivity of labor. The inability of producers to maximize the genetic potential of the predominant 'all-rounder' breed, as identified on farms, could also explain the low yield recorded, a conclusion relayed by [5]. Analysis of the objectivity of farmers in allocating their resources has shown that pig farming is, in most cases, practiced more by vocation than for reasons of profitability. It must be recognized that in sub-Saharan Africa

in general and particularly in Cameroon, the practice of pig farming meets concrete objectives, among others, the constitution of savings that can be easily mobilized in case of necessity and the prediction of the traditional ceremonies. of certain tribes such as weddings, funerals, etc. [16]. Analysis of the break-even or bankruptcy threshold has highlighted the possibility of rationalization presented by this animal species [19]. In fact, pork has the advantage of providing, over a short period of time, cash flows capable of covering the initial capital. The recovery period, recorded across all production systems and zones, was relatively short. However, it was relatively longer in the peasant production system with, yet, a negligible financial risk [3].

Overall, the results of this study showed that modernization of production infrastructure is a lever for increasing yields [2]. However, the restructuring of the traditional peasant production system seems better suited for improving economic productivity under the current conditions of pig production. For this reason, the vast majority of pig farmers have expressed the wish to see their farms' productive capacities strengthened through financial assistance to increase the breeding herd and boost production.

5. Conclusion and Perspectives

The purpose of this study was to assess and compare the current performance of pig farms, a prerequisite for the proposal of effective methods to improve production and economic productivity. The main results obtained showed that the annual average physical total yield per sow is relatively high but varies according to the production systems and zones. It is higher with the improved peasant system, compared to modern and traditional peasant systems. It is relatively more important in the western highlands, followed by humid forest and finally, the northern regions. However, by linking total physical yield and number of breeding females, the same results revealed that the northern regions, long sheltered from African swine fever, constitute a very favorable zone for increasing yields. The analysis of deviations from equilibrium production, revealed that more than 70% of pig farms produce below the breakeven/bankruptcy threshold. However, disparities were observed in all production systems and zones about the sign of the gap. However, if the improved peasant production system allows for a significantly high current total physical yield and lower than the equilibrium production in the western highlands, it remains nevertheless the most suitable system for increasing yields in the northern regions. The profitability analysis, as to, revealed that recovery period is relatively short with the modern system, compared to traditional and improved peasant systems but, remains comparable in all production zones.

In the end, the break-even/bankruptcy thresholds analysis allowed to highlight the lack of economic objectivity of pig producers in terms of production management, which hampers the development of production of this animal species. However, the interests of producers and consumers would be to increase farm yields beyond the break-even point. However, the analysis of the efficiency of production units showed that it is possible to expect an increase in yields but, provided that a number of fundamental constraints which constitute the keystone of sustained growth in pig production. More specific studies aimed at setting a rigorous and coherent system for collecting technical and economic data could be envisaged with a view to improving the contribution of this study to the sustainable support for the production of this animal species in sub-Saharan Africa in general and Cameroon in particular

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