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RESEARCH ARTICLE

COMPARATIVE ANALYSIS OF THE ECONOMIC AND FINANCIAL PERFORMANCE OF INTENSIVE RICE-GROWING SYSTEMS AND CONVENTIONAL RICE-GROWING SYSTEMS IN THE COMMUNES OF MALANVILLE AND KARIMAMA IN NORTHERN BENIN

***[1]Abdel K. KODA DJERMA ADAM, [2]Alexis HOUGNI and [1]Jacob A. YABI**

[1]Laboratory for Analysis and Research on Economic and Social Dynamics (LARDES), Faculty of Agronomy, Doctoral School of Agronomic and Water Sciences (EDSAE), University of Parakou (UP) Po Box 123 Parakou, Benin
[2]Associate Professor, National Institute of Agricultural Research of Benin (INRAB), 01 Po Box 884 Cotonou, Benin

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***Corresponding author:**
Abdel K. KODA DJERMA ADAM

ABSTRACT

With the strong global population growth, coupled for some time now with the appearance of the health and security crises and the war in Ukraine, the global economy in general and that of Benin in particular, is destabilized. This has led to a surge in commodity prices, with rice in the spotlight almost doubling in its import price. At the same time, in Benin, the rice potential is poorly exploited. In this context, the objective of the study was to compare the economic and financial performance of the Intensive Rice and Conventional Rice farming systems at the level of farmers in the communes of Malanville and Karimama in northern Benin.To achieve this, univariate analysis and mean comparison based on the two-sample Wilcoxon test were carried out on 368 respondents to compare the differences in the means of each performance index between the two types of rice farming systems. The results indicate that for rice farmers who both practice the complete technology packages of systems, the difference in averages is not significant for total costs, gross product in value, gross and net margins; and the Benefit-Cost Ratio. On the other hand, there was a highly significant difference at the 0.1% level for Average Labor Productivity and a very significant difference at the 0.01% level for the Internal Rate of Return. Based on these results, the study postulates that in order to improve the economic and financial performance of the IRS, access to inputs needs to be further facilitated.

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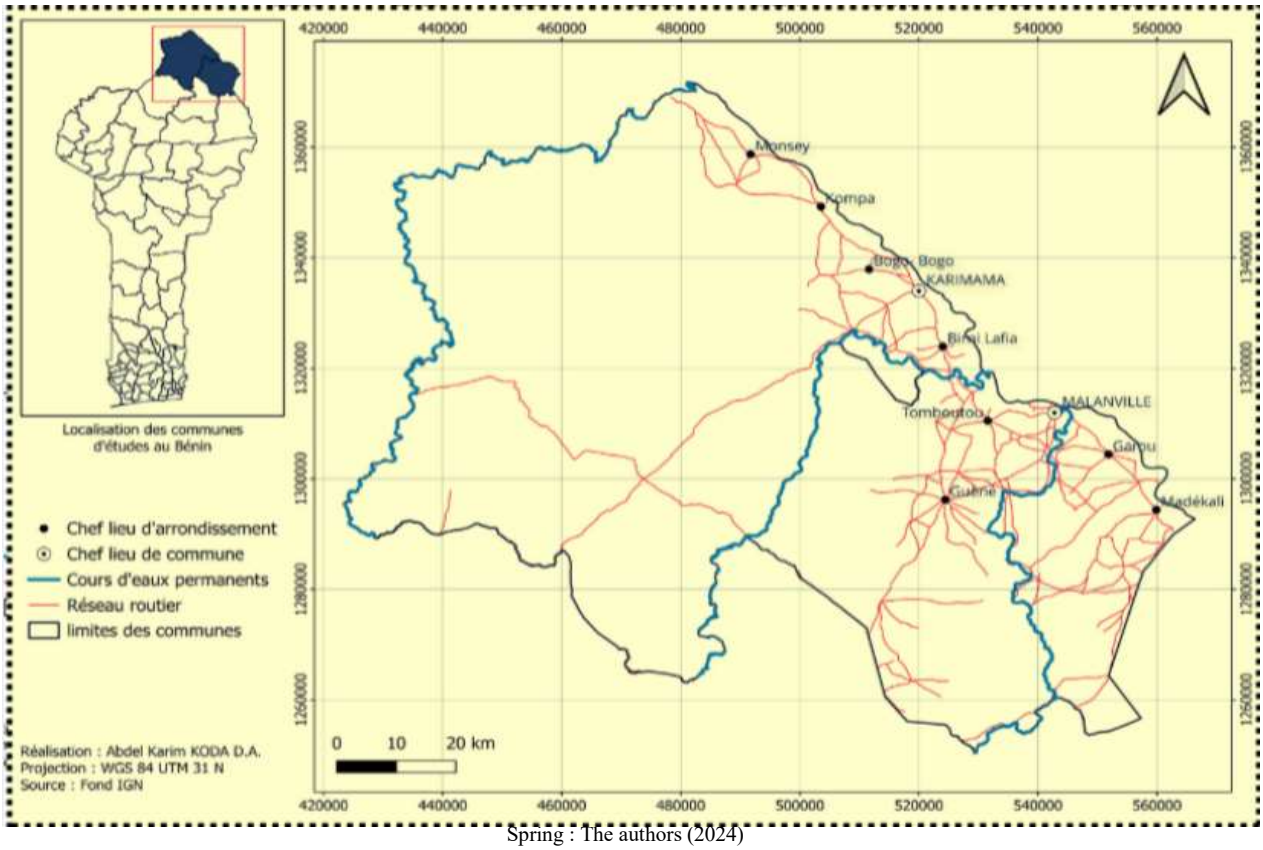
INTRODUCTION

Rice (*Oryza sativa* L.) is the world's leading cereal used for human consumption with an annual production volume estimated at 517 million metric ton in 2021 (FAO, 2023); andthus represents a serious option to combat food insecurity. According to Seck *et al*. (2013), rice consumption in Africa is growing faster than any other food product due in particular to the strong population growth, the rapid increase in urbanization and the evolution of eating habits. In Benin, the place that rice occupies in agricultural development policies is no longer in doubt. Indeed, rice is one of the thirteen (13) priority sectors in the Strategic Plan for the Development of the Agricultural Sector (PSDSA). Despite the progress made by the Beninese State, the supply of rice still cannot meet demand. According to data from the Directorate of Agricultural Statistics (DSA), the volume of rice production in Benin increased from 361,336 metric ton in 2017 to 519,667 metric ton in 2021 (an increase rate of approximately 44%) for a total area of 126,748 hectares and an average yield of 4.1 metric ton per hectare (MAEP, 2021). At the same time, the potential in arable land for rice is estimated at around 375,000 hectares (MAEP, 2019) with edaphic and climatic conditions favorable to improving productivity. According to data from the National Institute of Statistics and Demography (INStaD, 2023), for the first quarter of 2023, rice ranks second among the ten (10) main imported products with an estimated volume of 288,105.7 tons and for an amount of 77.9 million CFA. This strong dependence on imports unbalances the trade balance and therefore constitutes a serious threat to sovereignty and food security. One of the alternatives proposed to farmers to replace the conventional rice cultivation system (CRS) is the intensive rice cultivation system (IRS), which despite its many advantages still has an adoption rate of 7% (CRCOPR/ROPPA, 2022). The objective of this study is to carry out a comparative analysis of the economic and financial performances of the two production systems. The basic hypothesis formulated in the framework of this study is: the economic and financial performance of the IRS is significantly superior to that of the Conventional Rice Farming System (CRS).

MATERIALS AND METHODS

Study area: The study was carried out in the communes of Malanville and Karimama, located in the far north of the Republic of Benin, between the parallels 11°50' and 12°25', north latitude and the meridians 2°43' and 3°20', east longitude (Figure 1). These two communes constitute the Niger Valley Agricultural Development Pole. This area covers a total area of 9118 km² and is crossed by the Niger River and its tributaries, including the Alibori, Sota and



Spring : The authors (2024)

Figure 1. Map of the study area with watercourses and boroughs

Mékrou rivers; which offers it great possibilities in terms of rice, market gardening and fish production (Guidibi & Ahoyo, 2006; Toko *et al*., 2011). As such, it constitutes the largest rice basin in the country (MAEP, 2021). The vegetation consists of wooded savannah and large grassy strata (Adomou, 2005). As for the climate, it is of the Sudano-Sahelian type with a rainy season and a dry season (Guidibi & Ahoyo, 2006).

Sampling and data analysis: The study was carried out on a sample of 368 rice farmers chosen randomly from a parent population of 9,228 farmers, distributed among 68 Village Rice Producer Cooperatives in 40 villages.

The sample is determined according to the formula of Cochran (1963), below:

$$n_0 = \frac{Z^2 pq}{e^2}$$

with :

- no: represents the minimum sample size without the known population correction factor,
- Z: corresponds to the confidence level (for a 95% confidence level, z = 1.96)
- e : corresponds to the tolerated margin of error (e = 5% near)
- p: represents the estimated portion of the population presenting the characteristic (when unknown, we use p = 0.5)
- q: is equal to 1-p and represents the confidence level.

Applying the finite population correction factor allows us to calculate the actual sample size n according to the following equation.

$$n = \frac{n_0 N}{n_0 + (N - 1)}$$

with N the size of the parent population

The data were collected through individual interviews based on a questionnaire administered to each of the respondents.

In addition, focus groups were organized to triangulate and ensure the quality of certain data collected, including yields, unit sales price of paddy, input costs, salaried labor; and the average quantity of man-days of work required for each stage of the technical production itinerary according to the two production systems. Finally, the quantitative analysis was done using a two-sample Wilcoxon test on R software, in order to compare the means.

METHODS

In this study, the analysis was based on different economic and financial indices that were calculated at the level of a sub-sample of the basic sample. These include the twenty-six (26) farmers who adopted the complete IRS technology package and the five (5) who only practice the conventional rice farming system. The choice of the different ratios used to establish the comparison was inspired by similar work carried out by several authors, including Yabi *et al*. (2016), Labiyi *et al*. (2018); Degla *et al*. (2020); Sanon *et al*. (2021); and Yegbemey *et al*. (2023). These ratios are: total production costs, gross products in value, gross and net margins; average labor productivity; Profit-Cost Ratio; Internal Rate of Return.

The different formulas used to calculate each of the ratios are:

- The total cost :$TC = VC + FC(1)$. Variable costs (VC) are costs that fluctuate depending on the volume of production or the level of activity. In this section we find the costsrelated to the purchase of paddy seeds, labor for maintaining the plots; and the costs of transporting the harvest.Fixed costs (FC) correspond to costs that are not linked to production volume.
- The gross product in value (GPV) which corresponds to the yield (Yield) multiplied by the unit sales price (USP). It corresponds to the total amount of paddy rice sold and self-consumed, i.e.: $GPV = Yield \times USP$ (2)
- The Gross Margin (GM) which corresponds to the gross product in value reduced by variable costs. That is: $GM = GPV - VC(3)$

- Net Margin (NM) also called net profit or profit and which is calculated by subtracting the total cost (TC) from the gross product value (GPV) or by subtracting the fixed costs (FC) from the gross margin (GM). It should be noted that the net margin is expressed in CFA/ha and is therefore obtained through the following formula: $NM = GPV - TC\ or\ GM - FC(4)$ the Benefit-Cost Ratio (BCR) which is a ratio used to perform financial analysis, and which corresponds to the total amount that a farmer earns by investing a monetary unit. This ratio is calculated by the following formula: $BCR = NM \div TC$ (5). It expresses the financial gain resulting from the investment of a unit of capital (Yegbemey *et al*., 2023). To interpret this ratio, it must be compared to "1". Three scenarios may arise: i) if BCR > 1, in this case, the production of paddy rice according to the two production systems is financially profitable because 1 CFA invested would induce a gain of more than 1 CFA; ii) if BCR < 1, the production is not financially profitable because 1 CFA invested generates less than 1 CFA; iii) if BCR = 1, in this case there is neither gain nor loss. This situation does not suit the operator but it remains better in the case where BCR< 1.
- The ratio of Average Net Labor Productivity (ANLP) which corresponds to the net margin per unit of family labor used by the operator for production. It is calculated by the following formula: $ANLP = NM \div FL(6)$, with FL the total quantity of family labor used (in Man.Day/ha). It is expressed in CFA/Man. Day. For the analysis, the ANLP ratio will be compared to the price of a Man.Day of salaried labor in force in the study area. If ANLP is higher than the price of a Man. Day of salaried labor in the study area, then it would be deduced that the activity is economically profitable in terms of the salary obtained. Otherwise, the activity would be declared unprofitable in terms of the salary paid.
- The Internal Rate of Return (IRR) which is considered as an indicator of financial profitability analysis and which is obtained by the following formula: $IRR = \frac{NM-FL}{TC}(7)$. It should be noted that the total costs do not take into account the value of the family labor used; value which is obtained by multiplying the daily price which is practiced for the salaried labor in the study area by the total quantity of family labor used.

Univariate analysis of each performance index was performed at the two groups, and a Wilcoxon two-sample mean comparison test was performed to compare the means of each performance index between the conventional rice farming system (CRS) and the intensive rice farming system (IRS).

RESULTS AND DISCUSSION

Of the 368 farmers surveyed, about 7% adopted the full IRS technology package and continue to practice CRS, while 1.36% continued to practice CRS exclusively (Table 1). The remaining 91.57% comprised those who adopted a five-principle IRS in addition to practicing CRS. This result proves that despite the benefits of IRS, farmers still continue to practice both production systems. The IRS adoption rate obtained is consistent with that obtained from a study on the evaluation of IRS in Benin (CRCOPR/ROPPA, 2022) and well below the rate of 47.8% obtained by Fayama (2021), in a study on the determinants of the adoption or not of the System of Rice Intensification (IRS) in the Karfiguela valley in Burkina Faso. The univariate statistics of the different performance indices at the level of the two groups, namely the adopters of the CRS and the IRS, are presented below (Table 2). It appears that the production of one hectare (ha) of paddy rice induced a total production cost of 566,692 ±163,352 CFA in the IRS against 295,700 ±88,147 CFA in the CRS; a significant difference of 270,000 CFA (Table 2). This result corroborates those obtained by Diedhiou (2019) and Gbenou (2013) who proved that the total production cost is higher at the IRS level than at the conventional system level. This result could be explained among other things by the high cost of plowing, the high quantity of organic manure required by IRS, the labor requirements for transplanting and maintaining plots and water control which requires enormous costs to be borne by the operator. Concerning the Gross Product in Value (GPV), it is on average 1,066,200±201,325CFA for the IRS against 378,200±113,349CFA for the CRS, i.e. approximately triple the value obtained in the CRS. This result is similar to that obtained by Sanon *et al*. (2021) and allows us to conclude that the high production costs in the IRSare largely covered by the gross profit from production.

Table 1. Number of farmers by technology package category

Adoption	Frequencies	Percentage
Exclusive CRS practice	5	1.36
Adoption of a IRS principle only	22	5.98
Adoption of 2 IRS principles and practice of CRS	66	17.93
Adoption of 3 IRS principles and practice of CRS	83	22.55
Adoption of the 4 principles of IRS and practice of CRS	94	25.54
Adoption of the 5 principles of IRS and practice of CRS	72	19.57
Adoption of the 6 principles of IRS and practice of CRS	26	7.07
Total	368	100

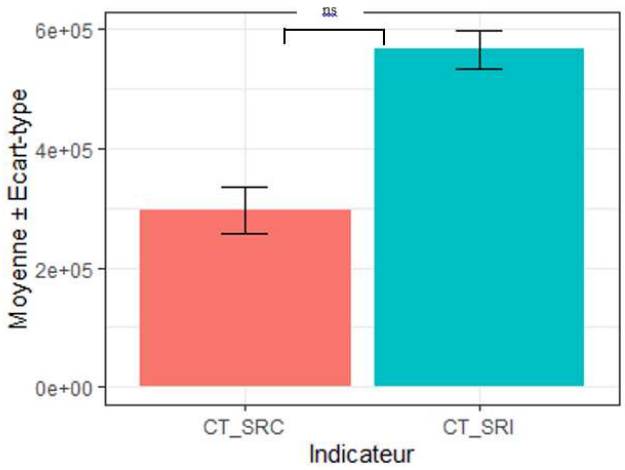
Spring: The Authors (2024)

Table 2. Univariate statistics of the different performance indices

Ratios	Type of production system	Number	Average	Standard Deviation	Min	Max
TC	CRS	5	295,700	88,147.32	195,000	400,000
	IRS	26	566 692	163,352.02	310,000	1,010,000
GPV	CRS	5	378 200	113,349.35	262,500	516,000
	IRS	26	1,066,200	201,324.98	688,000	1565200
GM	CRS	5	132,500	35,211.86	91,500	166,000
	IRS	26	645,469.23	145,616.07	419,600	904,500
NM	CRS	5	82,500	28,980.60	41,500	116,000
	IRS	26	499,507.69	127,954.84	289,600	784,500
ANLP	CRS	5	2553.59	765.14	1482.14	3411.76
	IRS	26	4462.45	1115.17	2508.26	6705.13
BCR	CRS	5	0.28	0.07	0.19	0.35
	IRS	26	0.96	0.39	0.4	1.91
IRR	CRS	5	0.05	0.06	-0.05	0.1
	IRS	26	0.31	0.16	0.06	0.7

Spring: The Authors (2024)

As for the average gross and net margins of the two production systems, they are all positive. This result proves that the production of paddy rice following the two production systems remains an economically profitable activity in the study area; although a difference is observed relatively more important between the two systems. Indeed, the values of the two indices are respectively 645469±145,616 CFA in the IRS against 132,500±35,212 CFA in the CRS (i.e. approximately five times the value obtained in the CRS) and 499,508±127,955 CFA in the IRS against 82,500±28,981 CFA in the CRS (i.e. more than six times that obtained in the CRS).



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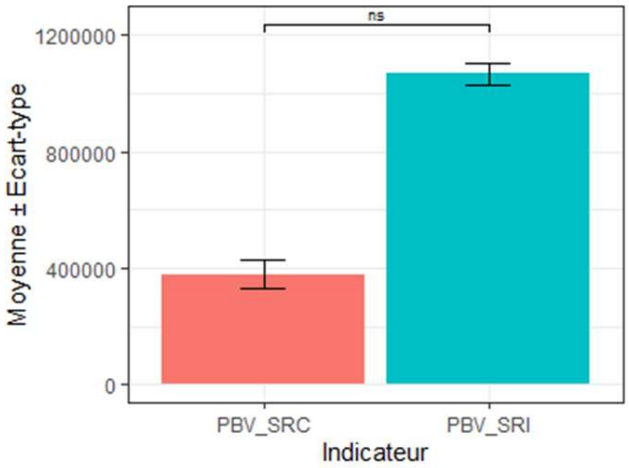
Legend: The error bars represent the standard deviation from the mean. The symbolism above the graphs indicates whether the averages are significantly different:
-ns: Not significant if: p > 0.05
-*: Significant at the 0.05 threshold
-**: Quite significant at the 0.01 threshold
-***: highly significant at the threshold of 0.001
-****: Very significant at the 0.0001 threshold
-CT : Total Costs
-SRC : Conventional Rice farming System (CRS)
-SRI : Intensive Rice farming System (IRS)
-Moyenne±Ecart-Type : Mean±Standard Deviation
-Indicateur : Indicator

Figure 2. Comparison of Total Cost Averages



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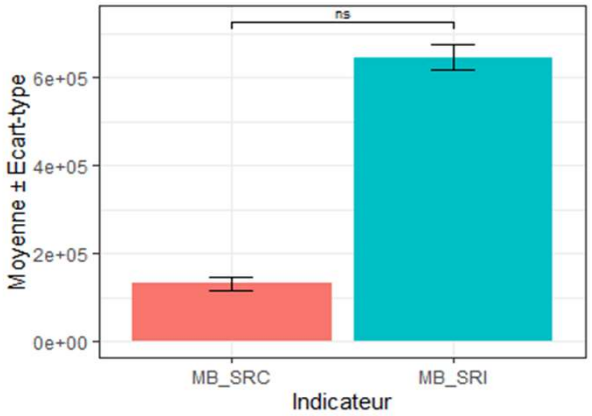
Legend
- PBV : Gross Product in Value (GPV)
- ns: Not significant : p > 0.05

Figure 3. Comparison of Gross Product Averages in Value

These two ratios prove that the Gross Product in Value calculated in each of the two production systems compensates well for the total costs (variable and fixed). The results obtained are consistent with those of Sadou (1996), Yabi *et al.* (2012a), Adjiba *et al.* (2019), and Yegbemey *et al*. (2023) in studies on economic analyses of production system son rice, corn, sesame and fonio in northern Benin. The Average Labor Productivity (ALP) ratio is 4462±1115CFA/HJ in the IRS against 2556±765CFA/HJ in the CRS.



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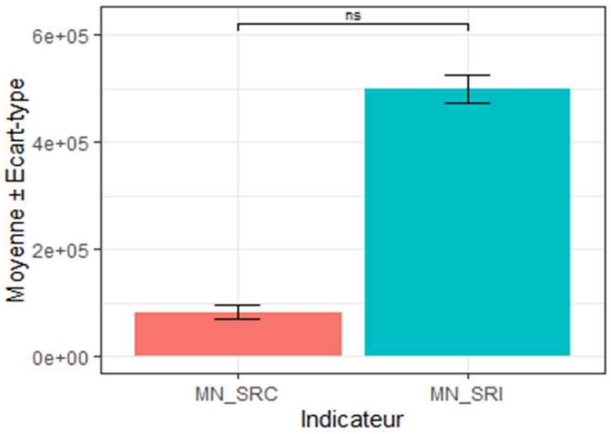
Legend
- MB : Gross Marging (GM)
- ns: Not significant : p > 0.05

Figure 4. Comparison of Gross Margin Averages



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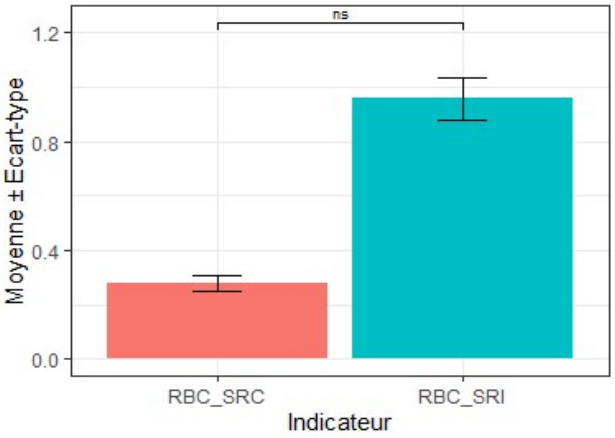
Legend
- MN : Net Margin (NM)
- ns : Not significant : p > 0.05

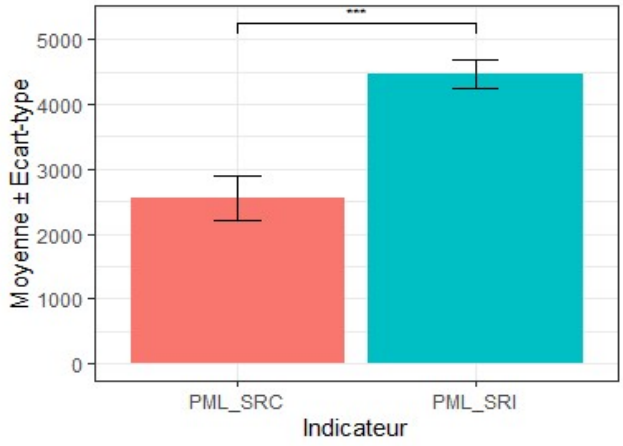
Figure 5. Comparison of Net Margin Averages



Spring: The Authors (2024)
Legend :
- *RBC : Benefit-Cost Ratio (BCR)*
- ns: Not significant : p > 0.05

Figure 6. Comparison of Averages of Benefit-Cost Ratio

This result obtained in the IRS is significantly higher than the average amount of 2750CFA paid for a Man. Day of salaried labor in the study area. This proves that the activity is economically profitable from the point of view of salary obtained for the IRS. The farmer would gain from working in his own rice-growing site than from selling his labor elsewhere. On the other hand, for the CRS, the farmer should make the opposite decision. The results obtained in the case of the IRS are similar to those obtained by several authors. These include: Yabi *et al*. (2012b), in a study on rice growing in the North-East of Benin; Sigue *et al*. (2019), in a study conducted in Burkina Faso and which focused on the combination of Micro-Dose, Zaï, and Manure techniques; applied to sorghum, maize and millet crops; and Yegbemey *et al*. (2014), in a study which focused on conventional maize cultivation.

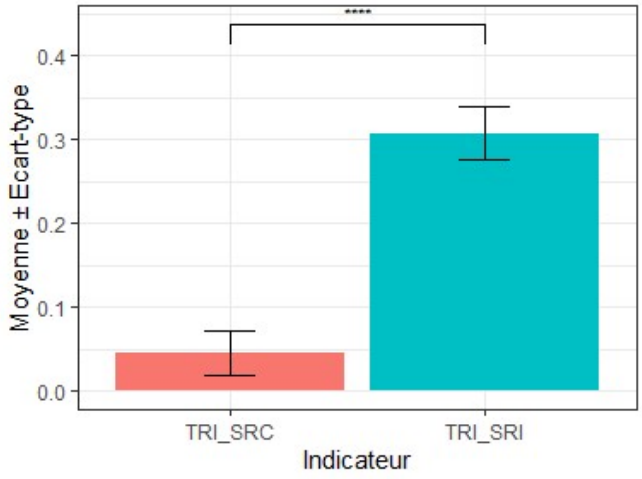


Spring :The Authors (2024)

Legend :

- PML : Average Net Labor Productivity (ANLP)
- ***: highly significant at the threshold of 0.001

Figure 7 : Comparison of Average Labour Productivity Ratio Averages



Spring :The Authors (2024)
Legend :
-TRI : Internal Rate of Return (IRR)
-****: Very significant at the 0.0001 threshold

Figure 8. Comparison of Internal Rate of Return Averages

On the other hand, Yabi *et al*. (2012a) and Chanou (2007) reached opposite results in their studies on the economic profitability of maize, rice and peanut production under different Integrated Soil Fertility Management practices in the commune of Ouake, in the North-West of Benin; and on rice cultivation in the commune of Gogounou in the North-East of Benin. Furthermore, Adjiba *et al*. (2019), in a study on the economic performance of corn production in conventional and organic farms in northern and central Benin, showed that both production systems are profitable from the point of view of labor remuneration. Compared to the Benefit-Cost Ratio, it is 0.96±0.39 for the IRS versus 0.28±0.07 for the CRS. Indeed, an investment of 1 CFA in production following the IRS generates 0.96 CFA which seems very limited while for the CRS, the same investment generates 0.28 CFA, which seems very low. These results are consistent with those of Depieu *et al*. (2017) in a study on the diagnosis of lowland rice cultivation systems in Gagnoa in Ivory Coast; who obtained ratios of 0.18 in the lowland without irrigation and 0.34 in the lowland system with irrigation. On the other hand, the results are contrary to those obtained by Yabi *et al*. (2016), Adjiba *et al*. (2016), and Sanon (2021); who reached values significantly higher than 1. Finally, regarding the Internal Rate of Return (IRR), it is 0.31±0.16 in the IRS against 0.05±0.06 in the CRS. Considering the interest rates practiced by the Decentralized Financial Systems in the study area (between 18% and 20.4% per year), the capital investment in the IRS (31%) is economically profitable. The farmer would therefore gain from investing his capital in the production of paddy rice according to the IRS than from placing it in a DFS at the rates indicated above in the hope of earning interest. On the other hand, the decision should be the opposite in the CRS where the IRR is 5% which is significantly lower than the average interest rate practiced in the area. The rate obtained under the IRS is significantly higher than that obtained by Yabi *et al.* (2012b) which is 0.01 in a study on rice production in the commune of Malanville in Benin, and by Labiyi *et al*. (2019) for the use of stone cords and compost for millet cultivation in the commune of Mani in Burkina Faso who also obtained a rate of 0.17. Furthermore, the Wilcoxon test performed made it possible to compare the mean values of the different ratios presented above in order to verify whether they differ significantly from one another (Figures 2 to 8). It is clear from reading these results that the differences in means between the CRS and the IRS are not significant for total costs (figure 2), the Gross Product in Value (figure 3), the Gross and net Margins (figures 4 and 5) and the Profit-Cost Ratio. On the other hand, a highly significant difference at the 0.1% threshold was noted for the Average Labor Productivity (figure 7) and very significant at the 0.01% threshold for the Internal Rate of Return (Figure 8).

CONCLUSION

Rice production under both systems (IRS and CRS) is economically profitable. Apart from the very high total costs for the Rice Intensive System, all other ratios are significantly higher than those obtained with the conventional system. It was noted that the Rice Intensive System presents respectively significant and very significant differences in averages at the level of Average Labor Productivity and Internal Rate of Return. Farmers in the study area would benefit from working in their own rice-growing sites under the IRS rather than selling their labor elsewhere. They therefore have an interest in adopting the IRS, which is better than the CRS. The results would be better if they are supported in terms of plowing and transplanting operations, particularly through mechanization, and in terms of access to quality seeds. The study also postulates that to improve the rate of adoption of IRS, it is necessary to review the content of the popularization themes by emphasizing more the economic and financial dimension of IRS rather than limiting itself to the yield and production costs which are often given to farmers as an argument for adopting IRS in Benin.

Conflict of Interest statement: The authors declare that there is no conflict of interest related to the conduct and publication of this research work.

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