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Impacts of Agroecological Technologies Adoption on Agricultural Yield and Income for Millet and Cowpea Producers from Maradi and Zinder Regions in Niger

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Abstract

This article assesses the impacts of agroecological technologies adoption on the agricultural yields and incomes for millet and cowpea producers in Niger from both Maradi and Zinder regions. For this purpose, a set of descriptive statistics methods are applied to data collected from 1950 producers from 80 villages. Results indicate that the density of semi, HPK variety, compost and IT 90 variety are the most adopted agroecological technologies with respective adoption rates of 87%, 69%, 64.3% and 64%. Moreover, results show that millet producers that adopted agro-ecological technologies have on average multiplied by 2.00 and 2.96 times their production, in Zinder and Maradi regions respectively. Besides, findings reveal that cowpea producers that adopted agro-ecological technologies have on average multiplied by 2.00 and 3.21 times their production, in Zinder and Maradi regions respectively. Finally, results support that the improvement in millet and cowpea yields has led to increase in producers' total income by 2 and 3 times respectively in Zinder and Maradi regions. Since agroecological technologies improve agricultural yields and income, we suggest policy makers to recommend their adoption and diffusion.

Keywords

Agroecological Technologies, Agricultural Yields, Agricultural Income, Niger

1. Introduction

Agriculture is the main activity of more than 87% of people who lives in Niger [1]. This activity faces enormous difficulties related to climatic hazards (spatio-temporal irregularity of rainfall) and soil poverty, which largely explains low yields and strong variations in agricultural production. This drop in yields is also attributed to a number of factors. More precisely, this concerns the weak supervision of producers, the inaccessibility to agricultural innovations and the low use of improved varieties [2] [3] [4].

Although, many integrated soil fertility management technologies have been developed in the region, very few farmers use them. Indeed, the low use of improved production techniques has caused a continuous decline in agricultural production per capita [5]. Productivity improvement should be considered. This improvement can only be achieved through the use of technologies that can not only increase soil fertility but also optimize the yield of crops including millet (*Pennisetum glaucum* L. Br.) and cowpea (*Vigna ungiculata* L. Walp) which are the main crops cultivated by producers. Since 2014, the project to support food security through agro-ecological intensification has been working in the regions of Maradi and Zinder to popularize a package of agro-ecological technologies (improved seeds, compost, RNA, Zai, alternating strip cultivation, biopesticide, biological control, PICS bags) through the conduct of demonstration fields. This study aims to assess the effect of agroecological technologies on the agricultural yield and income of millet and cowpea producers in the Maradi and Zinder regions.

2. Materials and Methods

2.1. Study Sites

The study was carried out in both Maradi and Zinder regions. There are 80 villages in the project area, including 60 villages from Maradi and 20 villages from Zinder. The two regions are located in the central part of Niger and experienced Sahelo-Sudanian climate where annual rainfall goes from 350 mm to 500 mm.

2.2. Sampling

The size sample of the study is constituted of 1095 producers, including 37.96% of women who were trained by the project.

2.3. Questionnaire

The questionnaire used is a digital ODK collect program. The survey was conducted using tablets to collect responses from targeted producers. The survey is subdivided into several parts including: 1) the socio-economic characteristics of respondents, 2) the adoption of disseminated technologies, 3) the number of producers who use and continue to use the disseminated technologies, 4) yield and income before and after the use of technologies, 5) producers' perception of

agro-ecological technologies.

2.4. Data Collection and Analysis

Data collection was done with Kobo collect software using tablets. The analysis of variances was used to compare the level of education of producers, the sources of income, the level of adoption of technologies and the peasant perception of technologies between the two regions. The t-test was used to compare returns and revenues obtained before and after the use of technologies. These analyses were performed with the SPSS 22 software.

3. Results and Discussion

3.1. Producer Characteristics

The analysis of the level of education shows that on average 76% of producers are educated and the remainder 24% are illiterate. Specifically, 99.3% of producers from Zinder are educated while only 54.2% of producers from Maradi region are educated. The analysis of the data reveals significant differences between educated and illiterate producers between the two regions. Indeed, 91.8% of all producers from the region of Zinder are Quranic while those of Maradi account for 24%. Also, the percentage of illiterates is 36.8% in the Maradi region, while it is 0.7% in the Zinder region (Table 1).

3.2. Effect of dose and Treatments (Production Residue and Cow Dung) on Growth Parameters

The two-factor analysis of variance (Table 2) shows that stem length, collar diameter, and leaf number are strongly influenced by the interaction of treatment type and rate.

Irrespective to agricultural income, alternatives are available to producers to earn their life. There are some important sources of income for them such as: trade, daily work, livestock and crafts (Table 2). Other less important sources of income exist such as the exodus to the Maghreb, Nigeria or the cities of Niger the market gardening and begging. Analysis of the data in Table 2 also reveals that 10.3% of respondents find their income solely from agriculture.

Table 1. Producer's education level.

Education Level	Maradi	Zinder	Average	Average Significance	
Quranic study	24.0	91.8	48.1	462.66	***
Alphabetized	27.0	05.4	19.3	75.06	***
Primary	09.2	01.3	06.4	26.43	***
Secondary	03.0	0.8	02.2	05.71	**
Illiterate	36.8	0.7	24.0	179.41	***

**$p < 0.05$; ***$p < 0.001$.

3.3. Agricultural Yields and Crop System in Regions

Data analysis in Table 3 shows that millet yield before technology use is 391.57 kg/ha for the Maradi region and 355.51 kg/ha for the Zinder region. There is therefore no significant difference between the two regions without technologies (t: 1.562, dl: 754, p 0.001). The millet yield after the use of technologies is 1160.45 kg/ha and 741.62 kg/ha respectively for the Maradi and Zinder region. It is thus 2.96 times higher than the yield before use of technologies in the Maradi region and 2.10 times higher for the Zinder region. The use of technologies therefore has a significant influence on yield for the two regions (t: 6.104, dl: 753, $p < 0.001$) with an increase of 768.88 kg/ha for Maradi and 386.11 kg/ha for Zinder compared to yield without technologies.

Table 2. Other sources of producer income.

Income sources	Maradi	Zinder	Average	χ^2	Average Significance
Trade	63.1	11	44.6	275.83	***
Breeding	10.6	58.2	27.6	284.44	***
Daily work	42.4	11	31.2	115.16	***
Handicraft	34.5	0.3	22.3	169.7	***
Market gardening	0.6	20	7.5	136.87	***
Begging	20.3	0	13.1	90.98	***
Exodus to cities Niger	17.3	1	11.5	65.35	***
Exodus to Algeria	5.5	0	3.6	22.37	***
Exodus to Libya	8.4	0	5.4	34.39	***
Exodus to Nigeria	10.5	6.4	9	5.09	**
Nothing	5.7	18.7	10.3	46.16	***

**p < 0.05; ***p < 0.001.

Table 3. Average yield (kg/ha) of millet and cowpea by region.

Region	Yield before	Yield after
	Millet	
Maradi	391.57 ± 202.957	1160.45 ± 595.146
Zinder	355.51 ± 430.271	741.62 ± 1283.997
t-test	t = 1.562. dl = 754. p > 0.119	t = 6.104. dl = 753. p < 0.001
	Cowpea	
Maradi	276.45 ± 162.593	889.87 ± 615.755
Zinder	283.14 ± 285.167	569.46 ± 523.011
t-test	t = −0.412. dl = 759. p > 0.680	t = 7.232. dl = 758. p < 0.001

For cowpea, the yield before the use of technologies is relatively identical between the two regions: 276.45 kg/ha for Maradi and 283.14 kg/ha for Zinder. After using technologies this yield account for 889.87 kg/ha in Maradi and 569.46 kg/ha in Zinder. The difference is thus significant (t: 7.232, dl: 758, $p < 0.001$) with an increase of 320.40 kg/ha in favor of the region of Maradi. In addition, the use of technologies allows to increase the cowpea yield by 613.42 kg/ha in the Maradi region and 286.32 kg/ha in the Zinder region.

Table 4 and Table 5 show millet and cowpea yields by cropping system. Without technologies, millet yield is 373.56 kg/ha and cowpea yield is 279.79 kg/ha. Statistical analysis shows a significant difference by crop system ($F = 8.92$ $dl = 2$ $p < 0.001$) of millet and cowpea ($F = 26.40$ $dl = 2$ $p < 0.001$) due to the use of technologies. The yield of millet under Zai is thus 1.08 and 1.43 times higher than that in band and pure respectively. Also, the yield of cowpea in Zai is 1.05 and 1.51 times higher than in strip and pure respectively. On the other hand, the respondents recorded increases in millet yield of 474.88 kg/ha, 754.42 kg/ha and 844.88 kg/ha with the system in pure, band and Zai respectively compared to the yield before the use of technologies. For cowpea, increases of 323.68 kg/ha in pure culture, 587.47 kg/ha in strip and 634.96 kg/ha in Zai are obtained in relation to yield without the use of technologies.

Analysis of the data in Table 6 shows that millet yield with technology (950.81 kg/ha) is 2.5 times higher than without the use of technology (373.56 kg/ha). For

Table 4. Average millet yield (kg/ha) by crop system.

System	Yield before	Yield after
In pur	373.56 ± 316.614	848.44 ± 1147.911
In band		1127.98 ± 696.983
In Zai		1218.44 ± 534.395
t-test		$F = 8.92$ $dl = 2$ $p < 0.001$

Table 5. Average yield (kg/ha) of IT90 cowpea by cropping system.

Systèmes	Yield before	Yield after
In pur	279.795 ± 223.88	603.48 ± 425.801
In band		867.27 ± 688.744
In Zai		914.76 ± 540.538
t-test		$F = 26.40$ $dl = 2$ $p < 0.001$

Table 6. Average yield of millet and cowpea (kg/ha) before and after Agroecological Technologies Adoption.

Crops	Yield before	Yield after
Millet	373.56 ± 316.614	950.81 ± 939.57
Cowpea	279.795 ± 223.88	729.665 ± 569.383

cowpea, yield with technology is 2.6 times higher than without technology. This means that the application of technologies significantly improves crop yields. Yields increased by 60.71% for millet and 61.65% for cowpea.

3.4. Farm Income of Surveyed Producers

The data analysis shows that without the technologies, the agricultural income of Maradi producers is 1.37 times higher than that of Zinder producers. Thus, the use of technologies has allowed Maradi producers to record an increase in income of 110,615 CFA francs, 2.12 times that of their peers in Zinder. In addition, the use of technologies increased the income of Maradi producers by 142,874 CFA francs and that of Zinder respondents by 50,359 CFA francs compared to income before the use of technologies (Table 7).

Moreover, the use of technology has allowed producers to obtain income (169,510 CFA francs) 2.83 times higher than without technology (59,766 CFA francs). Thus, this increase in income is estimated at 64.74%.

Rate of adoption of agricultural technologies

Analysis of the data in Table 8 shows that the rate of technology adoption

Table 7. Agricultural income per hectare (CFAF).

Region	Income before	Income after
Maradi	66,212 ± 55,989	209,086 ± 151,320
Zinder	48,112 ± 44,059	98,471 ± 78,885
Average	59,766 ± 52,751	169,510 ± 140,387
t-test	t = 5509; p < 0.05	t = 13,458; p < 0.001

Table 8. Technology adoption by region.

Technologies	Maradi	Zinder	Average	χ^2	Average Significance
Variety IT90	62.8	66.2	64	1.19	ns
Variety HKP	68.2	70.5	69	0.61	ns
Sowing density	85.7	89.5	87	3.23	ns
Biopesticid	56.5	58.7	57.3	0.56	ns
Biological control	54.8	67.9	59.5	18.14	***
Compost	76.6	42.1	64.3	130.51	***
RNA	51.9	71.3	58.8	38.88	***
Strip culture	36.5	19.7	30.5	33.07	***
Zai	7	0.3	4.6	25.81	***
PICS bag	28.9	0.8	18.9	129.94	***
More than 3 technologies	96.3	98.7	97.2	5.28	**

**p < 0.05, ***p < 0.001, ns: not significant.

varies from 87% to 4.6%. Adoption rates of more than 50% were recorded with the following technologies: seedling density, improved varieties HKP and IT90, compost, biological control, RNA and biopesticide. The weakly adopted technologies are: strip cultivation, PICS bag and Zai. Thus, 97.2% of producers adopted more than 3 technologies with a significant difference between the two regions at the threshold of 5%. In addition, there are significant differences between the two regions when it comes to adoption of biological control technologies, compost, NAS, strip cultivation, Zai and PICS bag.

4. Discussion

Technologies to improve production have been developed in the Maradi and Zinder region, with the aim of boosting farmers' production to a satisfactory level. The use of these technologies is established with farmers with a diverse level of education, more than 22% of producers are illiterate, 48.1% of producers have attended Koranic school and finally 25.7% of producers do not exceed the primary level. These results confirm those of [6] reporting in a study conducted in Burkina Faso in the three communes of Djibasso, Dori and Ziou, respectively 100%; 91.11% and 80.61% of producers not educated and close to those of [7] where they report only 14.2% of producers are literate on in their studied sample. Apart from agriculture as the main activity, producers formulate alternatives to meet their daily needs, trade, daily work, livestock and crafts. However, the data collected show that the millet and cowpea cultivation using technologies would be very important in the regions of Maradi and Zinder. The yield of millet before the use of technologies is 391.57 kg/ha for the Maradi region and 355.51 kg/ha for the Zinder region. Millet yield after technology use ranged from 1160.45 kg/ha to 741.62 kg/ha respectively for the Maradi and Zinder region, averaging 1010.67 kg/ha. The yield was therefore 2.96 times higher than before technology use in the Maradi region and 2.10 times higher for the Zinder region. The use of technologies therefore has a significant influence on yield between the two regions with an increase of 768.88 kg/ha for Maradi and 386.11 kg/ha for Zinder compared to performance without technologies. These results are similar to the study conducted by [8] noting that the yield of millet and sorghum improved with the application of the microdose fertilizer technique and join those of [9] and [10] reporting yield increase with the application of new agricultural technique. According to [11], the majority of producers (62.2%) in the region do not practice any control technology on cowpea, which explains the low regional average cowpea yield of 368 kg/ha [12] and 298 kg/ha cowpea [13]. The results obtained from cowpea cultivation before the use of technologies are relatively close to the [13] and [12], 276.45 kg/ha for Maradi and 283.14 kg/ha for Zinder. With the use of technologies, the yield ranged from 889.87 kg/ha in Maradi and 569.46 kg/ha in Zinder, averaging 776.04 kg/ha. The yield was therefore 3.21 times higher than the yield before the use of technologies for the Maradi region and 2.01 times more important for the Zinder region. Cowpea yields increased

by 613.42 kg/ha in the Maradi region and 286.32 kg/ha in the Zinder region. These results corroborate those of [14], reporting a significant increase in yield in the use of technologies including the aqueous extract of Neem seeds in rural areas in the Zinder region. The respondents recorded increases in millet yield with the application of different production systems, the yield is 474.88 kg/ha, 754.42 kg/ha and 844.88 kg/ha with the system in pure, band and Zai respectively in relation to the yield before the use of the technologies.

For cowpea, increases of 323.68 kg/ha in pure culture, 587.47 kg/ha in strip and 634.96 kg/ha in Zai are obtained in relation to yield without the use of technologies. These data are similar to those of [15] reporting that stone cords and zai, associated with microdose, improve production.

These yields obtained in both regions are higher than those recently announced in national statistics which are 371 kg/ha for cowpea and 658 kg/ha for millet [12]. The disparity in yield between two regions is explained by the control of technologies application by producers of Maradi as those of Zinder. In addition, the Maradi region has benefited from several interventions in the transfer of agricultural technologies than the Zinder region. The agricultural income of the producers of Maradi without the technologies is 66,212 FCFA against that of Zinder which is 48,112 FCFA, with an average income of 59,766 FCFA. These results are different from those found by [14] in a study conducted in the Zinder and Maradi region, reporting an average income of 58,900 CFA francs from cowpea cultivation in the Zinder region and 25,000 CFA francs per ha in the Maradi region. Moreover, the application of technologies allowed producers to obtain income (169,510 CFA francs) 2.83 times higher than without technology (59,766 CFA francs). Thus, this increase in income is estimated at 64.74%. The adoption of the technology by producers was highlighted in the study area. Thus, 97.2% of producers adopted more than 3 technologies with a significant difference between the two regions at the threshold of 5%. In addition, there are significant differences between the two regions in the adoption of biological control technologies, compost, NAS, strip cultivation, Zai and PICS bag.

5. Conclusion

It emerges from this study that millet and cowpea are important speculations of Nigerien family farming. The yield of these crops is low due to biotic pressures and edaphic constraints. The adoption of agroecological practices for millet and cowpea production plays an important role in the development of these crops and the improvement of their yield and household agricultural income. The adoption rate of these technologies has improved significantly compared to previous years with over 90% of respondents adopting at least 3 agroecological technologies. Promoting the use of agroecological techniques can help producers reduce pest losses and increase yields and income. Thus, research to support producers seems necessary to improve the adoption rate of PICS and Zai bags

which are still low. Continue the vulgarization of these technologies using the participatory concept of peasant school field.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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