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Optimizing Compost Supply Methods for Enhanced Crop Yields in the Zinder Region of Niger

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This article aims to study the effect of the compost application method on grain yields of cereals (sorghum and millet) and legumes (cowpea and peanuts) in the Zinder region of Niger. The study sites are characterized by four municipalities; Albarkaram, Dakoussa, Zinder 4 and Hamdara. The data collected concerned socio-economic characteristics, compost application methods, yields with and without compost.
The results characterize the views of 87 people in total. They are made up of 97.7% men and only 2.3% women. These respondents constitute 93.1% married, 4.6% single and 2.2% widows/widowers. The group variable has five levels. The addition of compost to the field on the fly with 4 effective, the micro dose in the field with 18 effectives, the addition on the broadcast to the garden with 6 effective, the use of any two of these methods with 31 effectives and the using any

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three of these methods with 28 as effective. The descriptive statistics show a physical difference between the yield of millet with the use of broadcast compost (319.5) in the field and in the gardens (295.5) and that of the use of compost by micro dose (1467.83). The result is also different between the yield of sorghum from the gardens with the broadcast method (88.5) and that of the same speculation from the fields (609.16) with the micro dose compost addition method. The results of the analysis show a significant difference between the yields of millet from the micro dose at the field level and those from spreading in the garden. Likewise, a significant difference is observed between the yield of millet in the garden from spreading and that which comes from spreading the combined micro dose in the same environment.

Keywords: Fertilization; productivity; fertilizer supply; grain production; combined micro; economy.

1. INTRODUCTION

Agriculture remains a key contributor to Niger's economy, representing around 40% of GDP and employing nearly 80% of the active population [1]. Despite this importance and its strong domination by cereal crops, it struggles to feed the Nigerien population due to its very low productivity [2]. The main cereals grown are sorghum, millet, corn and rice. They constitute the basic food of the population [3]. The low yields of these crops are often due to unfavorable rainfall conditions, poor soils and poor management of their fertility [4]. Indeed, the late installation, temporary interruptions or early end of rains cause losses of 11% of Niger's annual cereal balance [5]. In addition, land degradation, which is an increasingly worrying phenomenon in agricultural areas of the country, accentuates the instability of agricultural production. The effect of fertilizer applications tends to limit yields due to the low organic matter content of the soil. After 12 to 15 years of continuous cultivation, the level of organic matter drops to 0.6%, which is the threshold for soil non-response to mineral fertilizers [6].

The production and valorization of composts from household waste are expanding in the United States and Europe [7,8], and positive effects on crop yields have been obtained under several conditions. Soil and climate [9]. Even if the composts obtained are not yet used on a large scale in agriculture, much research has demonstrated that additions of these products increase the levels of organic matter, the cation exchange capacity, the number of microorganisms and their activities [8]. Compost additions also improved soil structure and water retention and reduced density [10]. Other studies indicated that compost additions for six years did not affect the diversity and functions of the microorganisms in the soils studied [8].

The use of small quantities of fertilizer associated with organic manure makes it possible to obtain more or less stable and higher yields than those obtained with exclusively mineral manure [11]. It is therefore urgent to find alternatives to restore the structure of our degraded soils. Given this, we must include organic fertilization for a good structure of our soils [12]. Reasonable fertilization will restore the soil and provide plants with the necessary elements they will need at the right time and in sufficient quantity. However, the production capacity for organic matter on farms remains low compared to the very high needs, which implies efficient use of it. This efficiency of the use of MO is reflected in the doses provided, the methods of application, but also the periods of application. It is in this context that the REDSAACC project intervenes in these localities in the Zinder region to contribute to achieving food security. Thus, this study is part of the activities of this project in the Zinder region. It aims to study the effect of the compost application method on agricultural yields of sorghum, millet, cowpea and peanuts in the Zinder region of Niger.

2. MATERIALS AND METHODS

The sites used for this study are those at which the REDSAACC project conducted training on the production and methods of applying compost to crops. These are the municipalities of Albarkaram, Dakoussa, Zinder 4 and Hamdara. The rainfall in these municipalities is marked by low precipitation leading to the descent of the isohyets towards the South and a large spatio-temporal variability compared with the other municipalities in the Zinder region.

The soils correspond to sub-arid tropical soils, lithosols on poorly drained sandstones, poorly evolved soils on sandy formations with highly individualized sesquioxides (Fe2O3), tropical ferruginous soils, hydromorphic soils, raw mineral soils and vertisols on sandstone and sedimentary clays. hardened, halomorphic soils and basin soils.

The vegetation gradient linked to the rainfall gradient and the nature of the soils is characterized by sylvo-pastoral type plant formations (Guiera senegalensis, Acacia nilotica, Acacia raddiana, Balanites aegyptiaca, Leptadenia pyrotechnica, Boscia senegalensis, etc.), agro- pastoral (Prosopis africana, Sclerocarya birrea, Faidherbia albida, etc.) and rupicole (Hyphaene thebaica, Borassis aethiopum, etc.).

2.1 Methods

The data collected concerns socio-economic characteristics, compost application methods, yields with compost and yields without compost. These collected data were entered into a microcomputer using SPSS software. They were then subjected to an analysis of variance using the same software. The means of the different treatments were separated by Fisher's LSD test at the 5% threshold to compare their effects.

The compost used comes from domestic animal droppings. The dosage of use was not considered during the present study. The latter may not be uniform from one producer to another. This opens a gap for research by conducting the experiment with pilot producers with dose control.

3. RESULTS

3.1 Socioeconomic Characteristics

The investigation concerned 87 people in total. They are made up of 97.7% men and only 2.3% women. These respondents constitute 93.1% married, 4.6% single and 2.2% widows/widowers.

The household size of the respondents is between 6 to 10 people for 42.4% of respondents and respectively 29.9% and 27.7% for 1 to 5 people and more than 11 people in the household. 96.6% of respondents have Agriculture as their main activity while 3.3% do fishing, masonry or teaching.

Effects of the compost application method on yields: Through this analysis, we look for existing relationships between variables. For this, the multivariate analysis of variance (MANOVA) was carried out. We seek to discover the relationships that exist and are significant between crop yields after use of compost through its method of application.

Table 1 shows that the group variable has five levels. The addition of compost to the field on the fly with 4 effectives, the micro dose in the field with 18 effectives, the addition on the broadcast to the garden with 6 effectives, the use of any two of these methods with 31 as effectives and the using any three of these methods with 28 as effective.

Table 1. Relationships between crop yields after use of compost through its method of application

		Value label	N
Method of supplying ccompost	On the fly (field)	On the fly (field)	4
	At the micro dose (field)	At the micro dose (field)	18
	On the fly (garden)	On the fly (garden)	6
	Two methods	Two methods	31
	Three methods	Three methods	28

Table 2. Test for equality of box covariance matrices

M de Box	52,415
D	2,399
ddl1	20
ddl2	12446,610
Sig.	,000

Table 3. Pairwise comparisons

Dependent variable			Difference of means (I-J)	Standard error	Sig.	95% confidence interval of the difference	
						Lower bound	Upper limit
Rdt_Mil After	On the fly (field)	At the micro dose (field)	-1148,333	405,860	,059	-2319,229	22,562
		On the fly (garden)	24,000	473,943	1,000	-1343,311	1391,311
		Two methods	-617,919	390,081	1,000	-1743,292	507,453
		Three methods	-932,661	392,462	,198	-2064,902	199,581
	At the micro dose (field)	On the fly (field)	1148,333	405,860	,059	-22,562	2319,229
		On the fly (garden)	1172,333	346,119	,011	173,790	2170,876
		Two methods	530,414	217,577	,169	-97,289	1158,117
		Three methods	215,673	221,817	1,000	-424,264	855,609
	On the fly (garden)	On the fly (field)	-24,000	473,943	1,000	-1391,311	1343,311
		At the micro dose (field)	-1172,333	346,119	0,011	-2170,876	-173,790
		Two methods	-641,919	327,473	,534	-1586,671	302,832
		Three methods	-956,661	330,306	,048	-1909,584	-3,738
	Two methods	On the fly (field)	617,919	390,081	1,000	-507,453	1743,292
		At the micro dose (field)	-530,414	217,577	,169	-1158,117	97,289
		On the fly (garden)	641,919	327,473	,534	-302,832	1586,671
		Three methods	-314,741	191,425	1,000	-866,996	237,513
	Three methods	On the fly (field)	932,661	392,462	,198	-199,581	2064,902
		At the micro dose (field)	-215,673	221,817	1,000	-855,609	424,264
		On the fly (garden)	956,661	330,306	,048	3,738	1909,584
		Two methods	314,741	191,425	1,000	-237,513	866,996
Rdt_sorgho after	On the fly (field)	At the micro dose (field)	-491,417	296,419	1,000	-1346,579	363,745
		On the fly (garden)	29,250	346,143	1,000	-969,364	1027,864
		Two methods	-392,831	284,895	1,000	-1214,745	429,083
		Three methods	-390,536	286,634	1,000	-1217,467	436,395
	At the micro dose (field)	On the fly (field)	491,417	296,419	1,000	-363,745	1346,579
		On the fly (garden)	520,667	252,787	,426	-208,618	1249,951
		Two methods	98,586	158,907	1,000	-359,856	557,028
		Three methods	100,881	162,004	1,000	-366,496	568,258
	On the fly (garden)	On the fly (field)	-29,250	346,143	1,000	-1027,864	969,364
		At the micro dose (field)	-520,667	252,787	,426	-1249,951	208,618

Dependent variable			Difference of means (I-J)	Standard error	Sig.	95% confidence interval of the difference	
						Lower bound	Upper limit
		Two methods	-422,081	239,170	,813	-1112,078	267,917
		Three methods	-419,786	241,238	,856	-1115,752	276,180
	Two methods	On the fly (field)	392,831	284,895	1,000	-429,083	1214,745
		At the micro dose (field)	-98,586	158,907	1,000	-557,028	359,856
		On the fly (garden)	422,081	239,170	,813	-267,917	1112,078
		Three methods	2,295	139,807	1,000	-401,043	405,633
	Three methods	On the fly (field)	390,536	286,634	1,000	-436,395	1217,467
		At the micro dose (field)	-100,881	162,004	1,000	-568,258	366,496
		On the fly (garden)	419,786	241,238	,856	-276,180	1115,752
		Two methods	-2,295	139,807	1,000	-405,633	401,043
Rdt_niebe after	On the fly (field)	At the micro dose (field)	-120,833	196,656	1,000	-688,181	446,514
		On the fly (garden)	181,000	229,645	1,000	-481,519	843,519
		Two methods	-95,323	189,010	1,000	-640,612	449,967
		Three methods	-75,357	190,164	1,000	-623,975	473,261
	At the micro dose (field)	On the fly (field)	120,833	196,656	1,000	-446,514	688,181
		On the fly (garden)	301,833	167,709	,756	-182,002	785,669
		Two methods	25,511	105,425	1,000	-278,637	329,659
		Three methods	45,476	107,480	1,000	-264,600	355,552
	On the fly (garden)	On the fly (field)	-181,000	229,645	1,000	-843,519	481,519
		At the micro dose (field)	-301,833	167,709	,756	-785,669	182,002
		Two methods	-276,323	158,674	,854	-734,094	181,449
		Three methods	-256,357	160,047	1,000	-718,088	205,374
	Two methods	On the fly (field)	95,323	189,010	1,000	-449,967	640,612
		At the micro dose (field)	-25,511	105,425	1,000	-329,659	278,637
		On the fly (garden)	276,323	158,674	,854	-181,449	734,094
		Three methods	19,965	92,753	1,000	-247,625	287,556
	Three methods	On the fly (field)	75,357	190,164	1,000	-473,261	623,975
		At the micro dose (field)	-45,476	107,480	1,000	-355,552	264,600
		On the fly (garden)	256,357	160,047	1,000	-205,374	718,088
		Two methods	-19,965	92,753	1,000	-287,556	247,625
Rdt_peanut after	On the fly (field)	At the micro dose (field)	-437,361	223,333	,536	-1081,670	206,947
		On the fly (garden)	-71,250	260,796	1,000	-823,640	681,140

Dependent variable			**Difference of means (I-J)**	**Standard error**	**Sig.**	**95% confidence interval of the difference**	
						Lower bound	**Upper limit**
		Two methods	-210,766	214,650	1,000	-830,025	408,492
		Three methods	-351,161	215,960	1,000	-974,199	271,878
	At the micro dose (field)	On the fly (field)	437,361	223,333	,536	-206,947	1081,670
		On the fly (garden)	366,111	190,459	,580	-183,357	915,579
		Two methods	226,595	119,726	,619	-118,811	572,001
		Three methods	86,200	122,059	1,000	-265,937	438,338
	On the fly (garden)	On the fly (field)	71,250	260,796	1,000	-681,140	823,640
		At the micro dose (field)	-366,111	190,459	,580	-915,579	183,357
		Two methods	-139,516	180,199	1,000	-659,384	380,352
		Three methods	-279,911	181,757	1,000	-804,276	244,454
	Two methods	On the fly (field)	210,766	214,650	1,000	-408,492	830,025
		At the micro dose (field)	-226,595	119,726	,619	-572,001	118,811
		On the fly (garden)	139,516	180,199	1,000	-380,352	659,384
		Three methods	-140,395	105,335	1,000	-444,284	163,494
	Three methods	On the fly (field)	351,161	215,960	1,000	-271,878	974,199
		At the micro dose (field)	-86,200	122,059	1,000	-438,338	265,937
		On the fly (garden)	279,911	181,757	1,000	-244,454	804,276
		Two methods	140,395	105,335	1,000	-163,494	444,284

The descriptive statistics as indicated in Table 4 in the appendix show a physical difference between the yield of millet with the use of broadcast compost (319.5) in the field and in the gardens (295.5) and that of the use of compost by micro dose (1467.83). The result is also different between the yield of sorghum from the gardens with the broadcast method (88.5) and that of the same speculation from the fields (609.16) with the micro dose compost addition method.

Box's test for equality of covariance matrices is significant at 5%. With a very significant probability according to Table 2. This confirms that the compost application method has an effect on crop yields.

The multivariate test (Table 5) shows that all the tests proposed by the software give P-values greater than 0.05, which explains an association between methods of adding compost and the yield after use of the compost. Roy's Largest Root test shows that 19.3% of the variability observed in yield is explained by the method of compost application while Wilks' Lambda test shows that 6.1% of the variability observed in the yield is explained by the method of compost application.

The results in Table 3 show that between the yields of millet from the micro dose in the field and those from the gardens by broadcasting, there is a significant difference. The average yield is 1172.333 with a confidence interval of 173.790 to 2170.876. Likewise, a significant difference is observed between the yield of millet by broadcasting in the garden and that which comes from the use of two combined methods. The average yield is 956.66 with a confidence interval of 3.73 to 1909.58.

4. DISCUSSION

The socio-economic results showing that men are more important in the surveyed sample (97.7%), are similar to those by [8]. The predominance of married people (93.1%) in this article is almost the same used [9]. The same author found the same results as us on the constitution of household size. The composition of our sample according to the main activity of the respondents is, however, different from that found by Balle [8].

The descriptive statistics showed a physical difference between the yield of millet with the use of broadcast compost (319.5) in the field and in the gardens (295.5) and that of the use of compost by micro dose (1467. 83) these results are close to those found by Ainika [10]. The difference in yields found between the yield of sorghum from the gardens with the broadcast method (88.5) and that of the same speculation from the fields (609.16) with the micro dose compost addition method corroborates those of Musa [11].

Our results showed that between millet yields from the micro dose in the field and those from the gardens by broadcasting, there is a significant difference; these results are close to those found by Bresson et al. In 2021 [12]. On the other hand, the average yield is 1172.333 with a confidence interval of 173.790 to 2170.876 found by our study are different from those found by Islam et al. 2012 [13]. The study showed a significant difference is observed between the yield of millet by broadcasting in the garden and that which comes from the use of two combined methods, this is the same as [14-18]. The average yield found is different from the one we found (956.66 with a confidence interval of 3.73 to 1909.58).

5. CONCLUSION

From these results, we can conclude that the compost application methods having the most effect on crop yield are those of broadcasting in the garden and that of micro-dose in the field. The microdose method in the field has more effect on millet yield.

Farmers making combined use of two of the different methods also have a significant yield on millet crops in gardens.

The dosage of use is not considered during the present study, so the research can conduct trials with pilot producers with dose control.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Table 4. Descriptive statistics on crop yields according to compost application method

Method of supplying ccompost		Average	Standard deviation	N
Rdt_mil after	On the fly (field)	319,50	302,048	4
	At the micro dose (field)	1467,83	1139,326	18
	On the fly (garden)	295,50	377,160	6
	Two methods	937,42	629,798	31
	Three methods	1252,16	585,444	28
	Total	1075,78	795,172	87
Rdt_sorgho after	On the fly (field)	117,75	124,837	4
	At the micro dose (field)	609,17	734,885	18
	On the fly (garden)	88,50	101,890	6
	Two methods	510,58	520,376	31
	Three methods	508,29	478,279	28
	Total	483,07	543,193	87
Rdt_niebe after	On the fly (field)	315,00	399,124	4
	At the micro dose (field)	435,83	284,068	18
	On the fly (garden)	134,00	187,510	6
	Two methods	410,32	477,581	31
	Three methods	390,36	236,533	28
	Total	385,74	355,085	87
Rdt_peanut after	On the fly (field)	56,25	85,184	4
	At the micro dose (field)	493,61	545,543	18
	On the fly (garden)	127,50	140,632	6
	Two methods	267,02	276,529	31
	Three methods	407,41	467,899	28
	Total	339,77	413,372	87

Table 5. Multivariate tests

Effet		Value	D	dof of the hypothesis	ddl error	Sig.	Partial eta squared
originally ordered	Trace of Pillai	,513	20,813	4,000	79,000	,000	,513
	Wilks lambda	,487	20,813	4,000	79,000	,000	,513
	Trace of Hotelling	1,054	20,813	4,000	79,000	,000	,513
	Roy's Largest Root	1,054	20,813	4,000	79,000	,000	,513
Method of reportingcompost	Trace of Pillai	,231	1,256	16,000	328,000	,224	,058
	Wilks lambda	,777	1,305	16,000	241,987	,194	,061
	Trace of Hotelling	,278	1,348	16,000	310,000	,167	,065
	Roy's Largest Root	,239	4,902	4,000	82,000	,001	,193

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