

Effects of the combined use of organic fertilizers and microdose fertilization in an agroecological cropping system on the performance of maize (*Zea mays* L.) in the western zone of Burkina Faso

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ABSTRACT: Background: The agricultural sector contributed 13.6% to the Gross Domestic Product in 2022 and thus remains one of the driving sectors of Burkina Faso's economic and social development. Despite this primordial position, Burkinabe agriculture is struggling to ensure sustainable food for all on a continuous basis. Thus, to occupy its place, it must meet several challenges, including its ability to cope with climate change, which has a negative and considerable impact on our ecosystems. Objective: This study was initiated to evaluate the effects of the combined use of organic fertilizers and micro-dose fertilization in an agroecological growing system on corn performance. The objective was to test the effectiveness and efficiency of the use of fertilizers in an agroecological system. The trial was conducted in a completely randomized Fisher block design with 4 repetitions and 9 treatments: T0 (micro-dose) NPK 62.5kg/ha+ Urea 62.5kg/ha, T1(micro-dose+5t/ha compost+ mulch+ zaï), T2(micro-dose+ 5t/ha manure+ mulch+ zaï), T3(micro dose+ 5t/ha compost+ Moringa extract+ mulch+ zaï), T4 (micro-dose+5t/ha compost+ Magnesium sulfate+ mulch+ zaï) , T5(micro-dose+5t/ha compost+ Liquid fertilizer+ mulch+ zaï), T6(Micro-dose+5t/ha manure+ Moringa extract+ mulch+ zaï), T7(micro-dose+5t/ha manure+ Magnesium sulfate+ mulch+ zaï) and T8 (micro-dose + 5t/ha manure + liquid fertilizer + mulch + zaï). Soil chemical parameters, agro-morphological parameters and yields were determined. Results: The results showed significant differences in soil parameters and corn grain and straw yield between treatments. The yield of corn grains from T5 significantly increased by 417% compared to that of the T0 control. In view of these results, organic fertilizers present themselves as an alternative for sustainable agriculture provided that measures are taken to make agroecological products more attractive. Conclusion: At the end of our research work, we suggest to continue this study with moringa leaf extract and to test other types of organic fertilizers in other pedo-climatic zones of Burkina Faso.

Keywords: Compost, manure, magnesium sulfate, moringa, profitability, Burkina Faso.

INTRODUCTION

Agroecology presents itself as a credible alternative for the promotion of sustainable agricultural and food systems. Its notoriety has been built through these practices, which are characterized by a lower impact on the environment. Among them, the use of organic fertilizers and the recycling of all forms of energy occupy a key place. Several studies have presented the highly beneficial effect of the organic matter contained in organic fertilizers on the physicochemical and biological properties of the soil (Sawadogo et al., 2021). Based on local knowledge and the essential role of organic matter in the management of soil fertility, agroecology advocates

the use of all fertilisers based on natural components. It is in this dynamic that some authors have worked on the valorization of organic fertilizers, such as [Sawadogo et al. \(2020\)](#) who showed that compost enriched with *Trichoderma harzianum* and Bokashi as organic fertilizers could be an alternative for sustainable onion production. [Sawadogo et al. \(2021\)](#) came to the same conclusions with the same organic fertilizers on tomatoes. Other studies, in particular those of [Gomgnimbou et al. \(2019\)](#) and [Koulibaly et al. \(2015\)](#), have focused mainly on a well-defined type of organic manure, combined or not with mineral manure, to observe their effects on maize. Thus, it is necessary to diversify the sources of organic matter to increase the productivity of agroecological cropping systems. To do this, several types of fertilizers were combined and compared in this study which concerned maize. The maize option lies in the fact that it is the second most promising sector in Burkina Faso, just after cotton (CCI-B, 2018) and contributes strongly to food security. However, its average yield was around 1671 kg/ha over the period 2012-2021 ([MARAH, 2022](#)), far from the yield potential of varieties popularized by research. In view of the above, one could ask the question of what effects could the combination of different types of organic fertilizers combined with micro-dose fertilization have on soil chemistry and maize yields in an agroecological cropping system? The objective of the study was to contribute to sustainably improving soil fertility and increasing maize yields in an agroecological system.

METHODOLOGY

2.1. Presentation of the study site

The research work was conducted at the INERA Farako-Bâ station. The station can be located at the geographical coordinates 4°20' West longitude, 11°06' North latitude and is located at 405 m above sea level. The climate is Sudanese and the rainy season is between mid-May and mid-October ([Morant, 1984](#)). The soils are leached tropical ferruginous with a sandy-silty texture ([Bado, 2002](#)); with vegetation composed of wooded savannah and grassy savannah ([Guinko, 1984](#)). The average annual rainfall varied between 700 and 1300 mm with an average water height of 1138.78 mm.

2.2. Material

The plant material used for the study consisted of maize. The maize variety used is "SR21". Its grain yield potential is 5.1 t/ha (MRSI, 2014). The different organic fertilizers used are compost, park manure, magnesium sulphate, liquid fertilizer and moringa leaf extract. In this study, two mineral fertilizers (fertilizers) were used. These include: NPK of 14-23-14-6S-1B and Urea of 46% N.

2.3. Méthods

2.3.1. Experimental design

The experimental design used was a Fisher block of four (4) replicates with nine (09) completely randomized treatments. The system included a total of 36 elementary plots, with dimensions of 4 m x 4 m, i.e. 16 m²/elementary plot for a useful area of 576 m². Table 1 presents the different codifications.

Table 1: Processing codifications

Treatments	Composition	Wording
T0 (Control)	NPK 62.5kg/ha + Urea 62.5kg/ha (micro dose)	MD
T1	5t/ha compost + micro dose + Mulching + Zaï	C+MD
T2	5t/ha Park manure + micro dose + Mulching + Zaï	PM+MD
T3	5t/ha compost + Moringa leaf extract + micro dose + Mulching + Zaï	C+EM+MD
T4	5t/ha compost + Magnesium sulphate + micro dose + Mulching + Zaï	C+SM+MD
T5	5t/ha compost + Liquid fertilizer + micro dose + Mulching + Zaï	C+FL+MD
T6	5t/ha Park manure + Moringa leaf extract + micro dose + Mulching + Zaï	PM+EM+MD
T7	5t/ha Park manure + Magnesium sulphate + micro dose + Mulching + Zaï	PM+SM+MD
T8	5t/ha Park manure + Liquid fertilizer + micro dose + Mulching + Zaï	PM+EL+MD

2.3.2. Conduct of the test

In order to remain in an agroecological context, a number of agroecological practices were carried out in the plots during the conduct of the trial.

2.3.3. Data collection

Soil samples were taken before implantation at five points throughout the trial to constitute a composite sample. At harvest, in each elementary plot, six samples were taken, three of which were taken near the pockets along the diagonal and three others along the diagonal crossed between two lines of pockets to constitute a composite sample. The samples were taken from the 0-20 cm horizons and were analyzed at the Soil-Water-Plant laboratory of GRN/SP of INERA, Farako-Bâ research station.

2.3.4. Soil Testing Methods

The soil analyses concerned the pH of the water. The water pH values of the soil samples were determined by the electrometric method with a glass electrode pH meter with a soil/water ratio of 1 / 2.5 ([AFNOR, 1999](#)). The total carbon content was determined according to the method of Walkley and Black (1934) modified by Graham (1948). Total nitrogen was determined by mineralization of organic matter. The nitrogen is transformed into ammonium sulphate and is collected by distillation and titrated to determine its

content. The total nitrogen content was determined according to the Kjeldhal method (1883). Total phosphorus is measured directly on the condensed mineralization (Anderson and Ingram, 1989). The total potassium as well as the available potassium were determined by the method of flame spectrophotometry. The method of Bray I (Bray and Kurtz, 1945) was used for the determination of assimilable phosphorus with an extraction ratio of 1/7. The exchangeable elements are: Na⁺; Mg²⁺; K⁺ and Ca²⁺. The first step is to extract these elements from the soil sample, to recover them in an extraction solution and then to measure the elements present in the solution. The soil test portion on which the exchangeable bases have already been extracted is taken up and washed with denatured alcohol to remove the excess ammonium acetate (Johnson, 1859).

2.3.5. Determination of yields

The weight of 1000 grains, corn grain yields (Ygn) and biomass (Ybm) were weighed using a calibrated load cell and evaluated per yield square.

The grain yield (Ygn) was determined from formula (1):

$$Ygn \left(\frac{\text{kg}}{\text{ha}} \right) = \frac{\text{Average treatment weight (kg)}}{16 \text{ m}^2} \times 10000 \text{ m}^2 \quad (1)$$

The biomass yield (Ybm) was determined from formula (1):

$$Ybm \left(\frac{\text{kg}}{\text{ha}} \right) = \frac{\text{Average treatment weight (kg)}}{16 \text{ m}^2} \times 10000 \text{ m}^2 \quad (2)$$

2.3.6. Statistical analysis

The Excel 2016 spreadsheet was used for data entry and the development of tables and graphs and statistical analyses were carried out using the XLSTAT 2016 software. The Newman Keuls test compared the means at the 5% threshold when the analysis of variance (ANOVA) indicates differences between treatments. The results were expressed as a mean \pm standard deviation.

RESULTS AND DISCUSSION

3.1. Results

3.1.1. Combined effects of organic fertilizers, micro-dose fertilization, mulching and zai on soil chemical parameters

3.1.1.1. Effects on pH, C, N, C/N, assimilable P, K available

Regardless of the treatment, pH, organic carbon, nitrogen and C/N ratio were statistically insignificant (Table 2). However, there was a slight increase in soil pH levels after cultivation, except for the control (4.72) for all treatments compared to those observed prior to cultivation. The same trends were observed with carbon content, nitrogen content and C/N ratio, which also increased after cultivation except for the control treatment. The content of available phosphorus and available potassium have been statistically significant. In fact, the assimilable phosphorus content varied positively in the treatments that received organic fertilizers, especially at the level of T1, which has the highest value (37.55 mg/kg), followed by T5 (36.75 mg/kg). However, it experienced a slight decrease in the control compared to that from the soil before cultivation. In terms of available potassium content, treatments T8 (49.82 mg.kg⁻¹) and T6 (50.64 mg.kg⁻¹) were reduced, including the exclusively mineral T0 control, compared to the pre-culture content. However, the highest levels of available potassium come from the T2 (87.48 mg.kg⁻¹) and T1 (72.02 mg.kg⁻¹) treatments.

Table 2: Characteristics on pH, C, MO, N, C/N, assimilable P, K available

Treatment	pHeau	C (%)	MO	N-total (%)	C/N	Assimilable P	Available K
						mg/kg	mg/kg
Before cultivation	5.15	0.27	0.47	0.029	9.54	18.34	53.28
T0	4.72 ^a ±0.0	0.30 ^a ±0.0	0.519 ^a ±0.0	0.028 ^a ±0.0	9.72 ^a ±0.2	18.26 ^a ±1.6	48.34 ^a ±1
T1	5.52 ^a ±0.2	0.38 ^a ±0.0	0.656 ^a ±0.0	0.035 ^a ±0.0	10.71 ^a ±0.4	37.55 ^b ±6.7	72.02 ^b ±33
T2	5.56 ^a ±0.2	0.38 ^a ±0.0	0.652 ^a ±0.1	0.037 ^a ±0.0	10.22 ^a ±0.3	21.49 ^a ±7.9	87.48 ^b ±29
T3	5.55 ^a ±0.2	0.34 ^a ±0.0	0.583 ^a ±0.1	0.034 ^a ±0.0	9.80 ^a ±0.5	27.66 ^{ab} ±6.5	69.72 ^{ab} ±16
T4	5.45 ^a ±0.3	0.37 ^a ±0.0	0.644 ^a ±0.1	0.036 ^a ±0.0	10.44 ^a ±0.2	30.28 ^{ab} ±21	68.07 ^{ab} ±10
T5	5.40 ^a ±0.1	0.34 ^a ±0.0	0.580 ^a ±0.1	0.038 ^a ±0.0	10.13 ^a ±1.0	36.75 ^b ±15	55.57 ^a ±8
T6	5.26 ^a ±0.5	0.35 ^a ±0.1	0.612 ^a ±0.1	0.035 ^a ±0.0	9.96 ^a ±0.8	29.37 ^{ab} ±7.9	50.64 ^a ±7
T7	5.22 ^a ±0.4	0.42 ^a ±0.0	0.731 ^a ±0.1	0.038 ^a ±0.0	11.08 ^a ±0.5	35.44 ^b ±3.0	68.56 ^{ab} ±22
T8	5.35 ^a ±0.4	0.36 ^a ±0.0	0.616 ^a ±0.1	0.032 ^a ±0.0	11.08 ^a ±0.6	31.65 ^b ±27	49.82 ^a ±5
Probability	0.067	0.428	0.428	0.324	0.098	0.041	0.044
Signification	NS	NS	NS	NS	NS	S	S

NB: Values followed by the same letter, in the same column, are not significantly different at the 5% probability threshold. C: carbon (%); OM: organic matter (%); N-total: total nitrogen (%); C/N: carbon/nitrogen ratio; assimilable Phosphorus (mg/kg); available Potassium (mg/kg). NS: not significant; S: significant.

3.1.1.2. Effects on the exchangeable bases of the soil

The Ca, Mg, K, Na, SBS and CEC of soils taken from treatments are not significantly different, both before and after cultivation (Table 3). However, the values of the parameters have more or less evolved following the addition of organic fertilizers, mulching and zaï. Ca levels increased slightly in other treatments compared to T0(MD) and in the soil prior to cultivation. The highest rate was induced by T5 treatment (MD+C+EM) followed by T2 treatment (MD+PM) with 1.04 cmol kg⁻¹ and 0.97 cmol kg⁻¹, respectively. Mg and K concentrations changed positively following the addition of organic fertilizers, mulching and zai compared to the control as well as in the soil before cultivation. T7 (MD+PM+SM) recorded the largest value (0.62 cmol.kg⁻¹). In contrast to the other parameters, the concentration of Na decreased after culture. The SBE increased slightly after culture except at the T0 treatment level. The values were approximately equal in the soil for treatments that received organic fertilizers, mulching and zai (1.15 cmol.kg⁻¹ <SBE<1.71 cmol.kg⁻¹). CEC has generally increased in soils after cropping. The T7 treatment (MD+PM+SM) recorded the greatest evolution with 3.04 cmol.kg⁻¹, however, it was the treatment that recorded the lowest saturation rate among those that received organic fertilizers, mulching and zaï. It is also observed that the highest saturation rate was obtained by the T3 treatment (MD+C+EM) i.e. 67%. The saturation rate shows statistically significant differences.

Table 3: Characteristics of Soil Exchangeable Bases

Treatment	Ca	Mg	K	Na	SBE (S)	CEC	Rate S.
	cmolc kg ⁻¹	cmolc kg ⁻¹	cmolc kg ⁻¹	cmolc kg ⁻¹	cmolc kg ⁻¹	cmolc kg ⁻¹	V (%)
Before cultivation	0.53	0.12	0.14	0.10	0.89	2.10	42
T0	0.50 ^a ±0,0	0.13 ^a ±0,0	0.13 ^a ±0	0.068 ^a ±0,0	0.81 ^a ±0,1	2.2 ^a ±0,2	36.9 ^a ±5
T1	0.61 ^a ±0.2	0.45 ^a ±0.1	0.18 ^a ±0	0.082 ^a ±0.0	1.33 ^a ±0.1	2.72 ^a ±0.3	49.1 ^{ab} ±6
T2	0.97 ^a ±0.7	0.22 ^a ±0.1	0.22 ^a ±0	0.092 ^a ±0.0	1.68 ^a ±0.8	2.76 ^a ±0.1	61.5 ^b ±3
T3	0.69 ^a ±0.2	0.71 ^a ±0.6	0.18 ^a ±0	0.078 ^a ±0.0	1.66±0.8	2.51 ^a ±0.3	67.0 ^b ±3
T4	0.62 ^a ±0.1	0.69 ^a ±0.5	0.17 ^a ±0	0.080 ^a ±0.0	1.56 ^a ±0.4	2.75 ^a ±0.7	60.6 ^b ±2
T5	1.04 ^a ±0.0	0.47 ^a ±0.2	0.14 ^a ±0	0.065 ^a ±0.0	1.71 ^a ±0.2	2.69 ^a ±0.2	63.6 ^b ±6
T6	0.65 ^a ±0.3	0.42 ^a ±0.1	0.13 ^a ±0	0.052 ^a ±0.0	1.24 ^a ±0.2	2.50 ^a ±0.8	53.3 ^{ab} ±15
T7	0.60 ^a ±0.2	0.33 ^a ±0.1	0.62 ^a ±0	0.056 ^a ±0.0	1.15 ^a ±0.3	3.04 ^a ±0.4	39.7 ^a ±1
T8	0.45 ^a ±0.1	0.7 ^a ±0.4	0.13 ^a ±0	0.078 ^a ±0.0	1.36 ^a ±0.4	2.52 ^a ±0.2	53.8 ^{ab} ±2
Probability	0.216	0.258	0.287	0.226	0.282	0.502	0.039
Signification	NS	NS	NS	NS	NS	NS	S

NB: Values followed by the same letter, in the same column, are not significantly different at the 5% probability threshold. CEC: cation exchange capacity (cmolc kg⁻¹); SBE: sum of exchangeable bases, TS: saturation rate; Ca: calcium, Mg: magnesium, K: potassium, Na: sodium. NS: not significant; S: significant.

3.1.2. Effects on grain and straw yield parameters of maize

The effect of the different treatments on the weight of 1000 grains, the grain and straw yield induced by the fertilizers are presented in Table 4. The analysis found significant differences in yield, straw yield, and weight of 1000 grains at the end of this study (p=0.001, p=0.002, and p=0.015 respectively). The highest grain and straw yields as well as the weight of 1000 grains were obtained with the MD+ compost + liquid fertilizer + mulch + zaï (3020 kg/ha, 4449 kg/ha and 229g), MD+ manure + magnesium sulphate + mulch + zaï (2728 kg/ha, 4791 kg/ha and 219 g) and MD+ compost + moringa leaf extract + mulch + zaï (2614 kg/ha, 4340 kg/ha and 198 g). Grain yields from the T5 and T7 treatments increased significantly compared to the T0 control treatment (584 kg/ha) by 417% and 367% respectively. The straw yields of the T5 and T7 treatments also varied significantly compared to T0 with 221% and 246% respectively. Overall, the treatments that received organic fertilizers, mulching and zaï were more effective than those that received only the micro dose.

Table 4: Effects on Corn Grain and Straw Yield

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	1000 grain weight (g)
T0	584 ^a ± 95	1384 ^a ± 129	156.35 ^a ± 6.53
T1	2156 ^b ± 517	3986 ^b ± 923	199.73 ^b ± 22.61
T2	2114 ^b ± 295	4251 ^b ± 1521	214.66 ^b ± 23.18
T3	2614 ^b ± 946	4340 ^b ± 1477	198.51 ^b ± 2.12
T4	2104 ^b ± 65	3958 ^b ± 794	192.55 ^b ± 3.46
T5	3020 ^b ± 601	4449 ^b ± 875	229.72 ^b ± 26.00
T6	2197 ^b ± 208	3399 ^b ± 623	207.90 ^b ± 12.07
T7	2728 ^b ± 552	4791 ^b ± 912	219.52 ^b ± 0.40
T8	2416 ^b ± 386	4427 ^b ± 514	203.95 ^b ± 11.97
Probabilité	0.001	0.002	0.015
Signification	HS	HS	S

NB: Values followed by the same letter, in the same column, are not significantly different at the 5% probability threshold. NS: not significant; S: significant; HS: Highly significant.

3.2. DISCUSSION

3.2.1. Effects of organic fertilizers, mulching and zai on soil chemistry

Soil analysis showed statistically significant differences at the 5% threshold only in terms of available phosphorus and available potassium. However, in terms of the other parameters, there are slight positive variations. Thus, the acidity of the soils that benefited from the addition of fertilisers and straw decreased slightly with an increase in pH. This increase in pH could be explained by the addition of compost and manure. Indeed, [Fuchs \(2009\)](#) has shown that compost increases the pH value of soils thanks to its calcium content, which partly explains the positive effects of composts, and the contribution of trace elements essential for plant balance. Our results corroborate those of [Mandal et al. \(2013\)](#) who observed the same phenomenon of pH increase after the application of composted and non-composted poultry manure. In addition, the results showed a slight decrease in pH in the exclusively mineral control. This situation could be explained by the acidifying effect of the mineral fertilisers applied. These results corroborate those of [Kaho et al. \(2011\)](#) who reported a decrease in pH following the addition of mineral nitrogen fertilizers. Also, [Lambert \(2000\)](#) showed that fertilizers, including nitrogen in its urea form, could lead to soil acidification. The carbon level and the nitrogen content have increased slightly. These results are due to the combined effect of organic fertilizers and micro doses. Compost, manure and liquid fertilizer would have a beneficial effect on the carbon level and nitrogen contained in the soil. Indeed, the application of composts in agriculture leads to an increase in organic carbon content and total nitrogen in the upper soil horizon ([Larbi, 2006](#)). In addition, it could be explained by the mineralization of the fertilizers which would provide more nutrients to the soil. The work of [Gnankamary \(2007\)](#) has shown the interest of combining manure or compost with mineral fertilizers to facilitate the provision of nutrients to the soil. The results of [Coulibaly et al. \(2012\)](#) indicated that the cultivation of land leads to a disturbance of the environment, with a consequent decrease in the rate of organic matter compared to the initial stock. This is in contradiction with our results, which show an increase in the carbon content after cultivation with the addition of organic manure. These results could be explained by the mulching carried out before sowing, which brought a significant amount of carbon to the plots. The available phosphorus content increases at the level of all treatments compared to that from the T0 (MD) treatment as well as that from the soil before cultivation. These results could be explained by the excess phosphorus provided by compost, manure, liquid fertilizer and moringa leaves. Indeed, the mineralization of the organic form of phosphorus and the effects of organic matter on soil phosphorus have contributed to the increase in the available form of phosphorus during incubation ([Tchegueni et al., 2012](#)). Our results are in agreement with those obtained by [Ciesielski et al., \(2008\)](#) who showed that organic restitution by manure or compost inputs contribute to improving the chemical characteristics of the soil. The available potassium content increased in the cultivated soils except at the level of T0, T6 and T8. Koulibaly (2011) had shown that fertilization improves the potassium content of the soil compared to the unfertilized soil and enriched the environment with nutrients. [Annabi et al. \(2009\)](#) showed that organic fertilization inputs improve available phosphorus as well as available potassium, which could result from improved soil chemistry through improved nutrient retention for crop feed. except for the level of exchangeable bases, the Na rate which fell slightly after culture, there was an increase in the basic saturation rate (Ca, K, Mg) in relation to the increase in pH and cation exchange capacity (CEC). The decrease in Na in soil after cultivation would likely be related to crop uptake. The beneficial role of the organic matter contained in organic fertilizers is thus highlighted on the cation exchange capacity of the soil, which certainly explains the high levels of K, Ca and Mg obtained in all treatments. This beneficial effect of organic fertilisers on exchangeable cations resulted in an increase in the CEC in the soil and in the SBE level. Ultimately, organic fertilizers, mulching and zai have partially improved the chemical properties of the soil. However, the variations observed could improve crop yields.

3.2.2. Effects of organic fertilizers, mulching and zai on maize yields

As far as yields are concerned, cultivation without the addition of organic fertilisers did not promote yield growth. On the other hand, a good variation in yield was observed in the treatments that received the combined fertilizers and the application of mulch and zai. The MD+C+EL and MD+F+SM treatments were the most effective. The yields of these treatments increased significantly compared to that of the T0 control treatment. This performance could be due to the significant amount of elements such as nitrogen and available phosphorus contained in these treatments, which are essential for plant growth and development, and which have an immediate effect on plant development and production. For the treatment with liquid fertiliser, it had to be more soluble and therefore have adequate suitability to be easily absorbed by the plant compared to mineral fertiliser ([Kotaix et al., 2013](#)). These results are similar to those of [Konfé et al. \(2019\)](#) who showed with turbo-bio (liquid organic fertilizer) applicable at the leaf and root levels, that treatments with Turbo-bio have a higher number of fruits and flowers compared to treatments with mineral fertilizer. Similar results were also found by [Deoré et al. \(2010\)](#) through the application of a liquid organic fertilizer on chili pepper. As it is based on magnesium sulphate, its performance could be explained by the additional effect of the latter on manure. Indeed, sulphur acts in synergy with nitrogen and is part of the constitution of chlorophyll ([Niknahad-Gharmakher, 2008](#)). Magnesium is an essential central element of chlorophyll molecules ([Denoroy et al., 2005](#)). Treatment with Moringa leaf extract also performed well compared to the control. This result could be explained by the combined contribution of compost and probably extract from moringa leaves. [Koulibaly et al. \(2015\)](#) showed that the addition of compost, even at low doses, has a positive effect on maize yields. Combining it with moringa leaf extract, which [Fuglie \(2000\)](#) suggests can be used to produce an effective plant growth hormone called zeatin, which can increase the yield of almost any crop by 25-30% ([Price, 2007](#)) would have resulted in improved yield. The same trend is observed with the quantities of straw from maize grown in treatments that received organic fertilisers, straw and zai, which increased significantly compared to that of maize grown exclusively in mineral crops. In addition, MD+C+EL, MD+F+SM and MD+C+EM treatments, as well as grain yields, produced better biomass compared to other treatments. These results generally confirm the trends obtained on agro-morphological growth and development. In addition, these results could be explained by the mulching done at sowing on the plots that have benefited from organic fertilizers. This situation, according to [Yu et al. \(2015\)](#), justifies the addition of organic nitrogenous matter (green manure, organic fertilizer) or mineral matter (urea). In general, the yields obtained are lower than the potential yield of the crop which is 5100 kg/ha ([MRSI, 2014](#)). However, it should be noted that the yields of maize kernels

obtained with treatments based on organic fertilizers combined with micro dose, mulching and zai were higher than those observed in peasant areas, which was 1671 kg/ha over the period 2012-2021 (MARAH, 2022). This shows the beneficial role of fertilizers combined with agroecological practices on the crop.

CONCLUSION

The general objective of this study was therefore to evaluate the effectiveness and efficiency of the use of organic fertilizers combined with micro doses on maize productivity in an agroecological system. It is in this context that several organic fertilizers combined with mulching and zai were evaluated to compare their influences on the agronomic and economic performance of maize. The application of fertilizers improved some chemical parameters of the soil, there were significant differences. The combination of organic fertilizers in micro doses in an agroecological cropping system improves the chemical parameters of the soil. These fertilizers combined with mulching and zai also improved the grain and biomass yield of the corn compared to the control. The combination of organic fertilizers in micro doses in an agroecological cropping system significantly improves maize yields. At the end of our research, we suggest testing other types of organic fertilizers to expand the range of inputs for producers.

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Conflict of Interest:

The authors have not declared any conflict of interest.

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