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Effects of agroecological transition cropping systems on grain sorghum and cowpea yields in the Nando region of Burkina Faso.

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ABSTRACT
Objective: to evaluate the effects of agroecological transition cropping systems on grain sorghum and cowpea yields.
Methodology and results: A trial was set up at the Saria Environmental and Agricultural Research Station using a completely randomized block factorial design. Factors evaluated included (i) cropping system, (ii) crop variety, (iii) fertilization, and (iv) pest control type. Results showed yield increases of 56.99% for grain sorghum grain and 49.26% for stover in sole grain sorghum plots compared to intercropping system. The combination of the different factors led to an increase of grain sorghum grain yield but stover yield was not significantly affected. For cowpea, the results showed that grain yield in sole production sole cropping was 280.84 kg greater than yield obtained in plots where cowpea was intercropped with grain sorghum. A 36.78% increase in cowpea grain yield was observed in plots that received the improved variety compared to those where the local variety was used. However, the study showed a 317.27% increase in stover yield for the local variety compared to the improved variety. The combination of the different factors tested in this study resulted in substantial cowpea yields of 1,075.05 kg ha^{-1} for grain and 5,672.73 kg ha^{-1} for stover. The factor of microdose mineral fertilization and pesticide treatment did not have any significant specific effects on grain sorghum and cowpea yields.
Conclusion and application of results: to achieve high grain sorghum yields, growing of sole cropping with microdose mineral fertilization can be recommended regardless the sorghum variety; to achieve high grain yields of cowpea, growing of improved varieties in sole cropping with microdose mineral fertilization and chemical or biological controls of pests can be recommended; to achieve high stover yields of cowpea, the use of improved varieties in sole cropping with microdose mineral fertilization and chemical or biological control of pests can be recommended; to achieve higher total yields of grain sorghum and cowpeas, intercropping grain sorghum and cowpeas with microdose mineral fertilization is recommended. .
Keywords: agroecological transition, Burkina Faso, cowpea, cropping systems, grain sorghum

INTRODUCTION

Intensive production systems resulting from the implementation of the green revolution, which requires the use of various tillage methods and enormous quantities of synthetic mineral inputs from agricultural industries, have certainly contributed to increasing agricultural yields (Goïta, 2014). However, these intensive production systems have also contributed to increasing the vulnerability of agroecosystems (Coulibaly, 2018). In Burkina Faso, the rural sector plays an important role in the economy, with agriculture (including livestock and forestry) which contributed 16.3% of Gross Domestic Product (GDP) in 2023 (AfDB, 2025). Agriculture production in this part of the world is not immune to the real existing consequences related to the conventional agricultural practices that negatively affected production base. According to Semporé (2021), cereal and legume production in the country is currently facing problems of land degradation, thus leading to an increase in the use of chemical inputs. The massive use of chemical fertilizers and pesticides degrades water quality and also contributes to greenhouse gas emissions (Dayamba *et al*., 2019). Giving such a situation, producing more to feed a rapidly growing population while preserving the foundations of agricultural production is a challenge for Burkina Faso. Agroecology (AE), which aims to promote foundations for an agricultural production system based on the functionalities offered by ecosystems, is therefore increasingly being advocated as one of the fundamental paths to ecological sustainability. Studies have examined the effects of some agroecological practices in Burkina Faso. To this end, researches have focused on assessing the effects of zaï and stone rows on crop yields and soil biology in Burkina Faso (Yaméogo *et al*., 2013). Coulibaly (2018) also investigated issues related to the optimization of agroecological practices and indicators in eastern Burkina Faso. Other studies have evaluated the effectiveness of organic plant protection products compared to chemical products (Toé *et al*., 2022), as well as the effects of types of crop combinations in rural areas using improved or local varieties (Ganeme *et al*., 2021). Few studies have focused on assessing the synergistic effects of combining organic inputs with good agricultural practices in a dynamic of promotion of AE in Burkina Faso. The overall objective of this study is to develop cropping systems that enable sustainable production of grain sorghum and cowpea in terms of quantity and quality, while preserving the foundations of agricultural production in the context of agroecological transitions in Burkina Faso.

MATERIALS AND METHODS

Study site: The study was conducted under rainfall conditions in 2024 and 2025 at the Saria Environmental and Agricultural Research Station (Figure 1) of the Institute of Environmental and Agricultural Researches (INERA). The site is located in the province of Boulkiemde (12°16' N lat; 2°09' W long). It benefits from a Sudano-Sahelian climate type, characterized by a long dry season extending from November to April and a short growing season from May to October. The soils at Saria are ferric lixisols (FAO, 2015) or the subgroup of hardened leached tropical ferruginous soils of sandy-loam texture with 76% sand, 16% silt, 8% clay, and a pH ranging from 5.65 to 5.73. The vegetation is of the sudanian type and is characterized by the presence of savanna annual grass with trees and shrubs (Fontes and Guinko, 1995; Koumbem, 2023). Rainfall in 2024 was 910.6 mm with 74 days of rain, and in 2025 it was 821.5 mm with 71 days of rain.

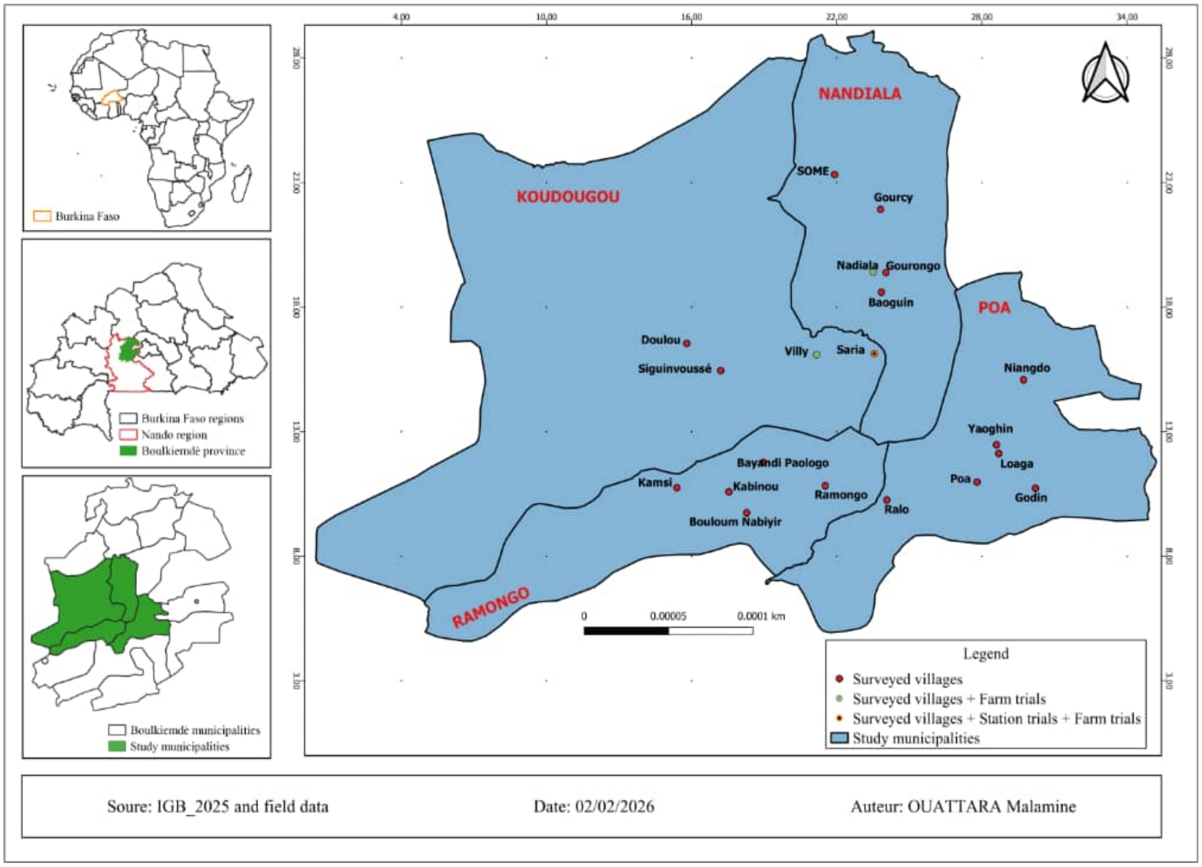


Figure 1 : Map of the study area

Plant Materials: The plant material used in the study consisted of grain sorghum and cowpea. For grain sorghum, a local variety obtained from farmers in the village of Saria and an improved variety from INERA called Kapelga were used. For cowpea, a local variety obtained in the village of Saria and an improved variety from INERA called Komcalle were used. The Kapelga variety of grain sorghum has a semi-maturity cycle of 90 to 100 days and a potential yield of 2.8 t ha^{-1} in the station and 1.2 t ha^{-1} in the farmers' field. The Komcalle variety of cowpea has a semi-maturity cycle of 60 days, a potential yield of 1.5 t ha^{-1} in the station and 0.75 t ha^{-1} in the farmers' field. The local varieties of grain sorghum and cowpea have semi-maturity cycles of 120 and 90 days, respectively.

Pesticides: The plant protection products used to control cowpea insect attacks are: Top Lamda 25 EC, which is a pyrethroid chemical insecticide, and neem oil (an organic product).

Fertilizers: The fertilizers used are compost as organic fertilizer and NPK (14N-23P-14K-6S-1B) as mineral fertilizer.

Methods

Experimental setup: The experimental design is a completely randomized block factorial design. The factors taken into account are (i) cropping system, (ii) crop variety, (iii) fertilization and (iv) pest control type. Fourteen (14) total treatments were used in the study (Table 1). The size of the elementary plot is 24 m^2 (6 m long and 4 m wide).

Table 1 : Treatments applied in the plots, 2024 and 2025, Saria, Burkina Faso.

T1: Local grain sorghum + 2.5 t ha^{-1} of compost year^{-1}
T2: Local cowpea + 2.5 t ha^{-1} of compost year $^{-1}$
T3: Local grain sorghum + 2.5 t ha^{-1} of compost year $^{-1}$ + 50 kg ha^{-1} of NPK
T4: Improved grain sorghum + 2.5 t ha^{-1} of compost year $^{-1}$ + 50 kg ha^{-1} of NPK
T5: Local cowpea + 2.5 t ha^{-1} of compost year $^{-1}$ + 50 kg ha^{-1} of NPK + Organic pest control
T6: Local cowpea + 2.5 t ha^{-1} of compost year $^{-1}$ + 50 kg ha^{-1} of NPK + Chemical pest control
T7: Improved cowpea + 2.5 t ha^{-1} of compost year $^{-1}$ + 50 kg ha^{-1} of NPK + Organic pest control
T8: Improved cowpea + 2.5 t ha^{-1} of compost year $^{-1}$ + 50 kg ha^{-1} of NPK + Chemical pest control
T9: Local grain sorghum + Local cowpea + 2.5 t ha^{-1} of compost year $^{-1}$
T10: Improved grain sorghum + improved cowpea + 2.5 t ha^{-1} of compost year $^{-1}$
T11: Local grain sorghum + local cowpea + 2.5 t ha^{-1} of compost year $^{-1}$ + 50 kg ha^{-1} of NPK + biological control
T12: Local grain sorghum + Local cowpea + 2.5 t ha^{-1} of compost year $^{-1}$ + 50 kg ha^{-1} of NPK + Chemical pest control
T13: Improved grain sorghum + improved cowpea + 2.5 t ha^{-1} of compost year $^{-1}$ + 50 kg ha^{-1} of NPK + biological pest control
T14: Improved grain sorghum + improved cowpea + 2.5 t ha^{-1} of compost year $^{-1}$ + 50 kg ha^{-1} of NPK + chemical pest control.

Conducting the trial

Soil preparation and planting: Tractor ploughing was carried out on June 29, 2024, and July 5, 2025. Compost was spread and covered on July 6, 2024, and July 5, 2025, in the elementary plots at a rate of 2,500 kg ha^{-1}. Grain sorghum and cowpea were planted on the same day in alternating rows. In sole grain sorghum or cowpea plots, the spacing was 80 cm between rows and 40 cm within hills. In intercropped cops, the spacing was 40 cm between a row of grain sorghum and a row of cowpea and 40 cm between hills.

Weed and pest controls: Two plants per hill were thinned after emergence. A low dose of NPK was applied 14 days after planting (DAS) using the microdose technique, i.e., 1.5 g per hill in plots to receive mineral fertilizer. Three weedings were carried out to control weeds. To control cowpea pests, pest controls were carried out using Top Lamda 25 EC and neem oil depending on the basic plots, when flower buds appeared and pods formed, at a dose of one liter per hectare for each product.

Data collection: The data collected included parameters such as yield components of grain sorghum and cowpea. Grain sorghum and cowpea were harvested at physiological maturity of the grains. The yield parameters were used to determine crop yields by treatment. The average grain and stover yields per hectare for grain sorghum and cowpea per treatment were determined by calculating the ratio between the weight of the production of each plot and its area.

Data analysis: A Microsoft Excel spreadsheet was used to record the collected data. Statistical analysis of the collected data was performed using SAS/STAT® software. Effects at a probability threshold ≤ 0.05 were declared significant.

RESULTS

Effects of the cropping system on grain sorghum and cowpea yields: Analysis of variance showed that the cropping system had a significant effect on grain (P = 0.0006) and stover (P = 0.0079) yields of grain sorghum, as well as on grain yield of cowpea (P = 0.0002). Sole grain sorghum production significantly increased grain yield (56.99%) and stover yield (49.26%) compared to the combination (Figure 2a). Similarly, sole cowpea production significantly increased cowpea grain yield (52.36%) and stover yield (41.76%) compared to the combination (Figure 2b).

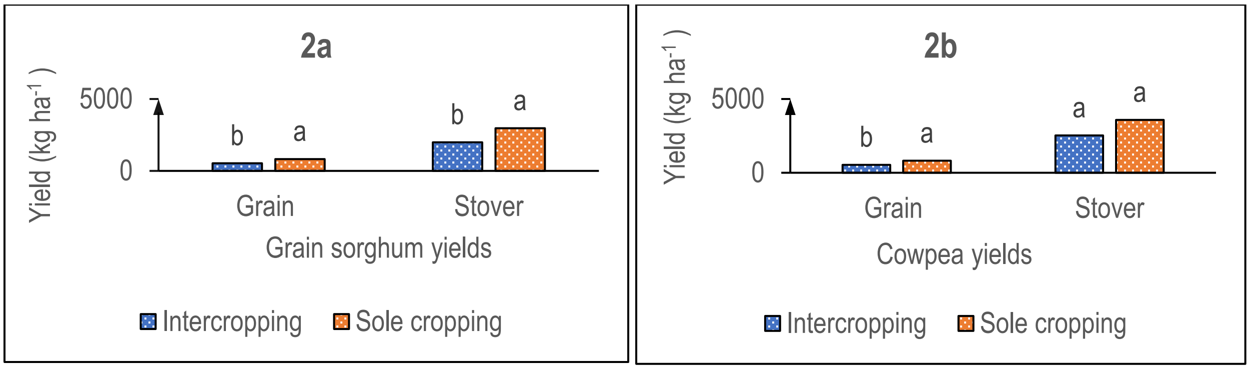


Figure2 : Effects of cropping system on grain sorghum and cowpea yields

Effects of grain variety on grain sorghum and cowpea yields: The analysis of variance showed a significant effect of the cowpea grain variety on grain yields (P = 0.0056) and stover yields (P < 0.0001). Compared to the local variety, the improved cowpea grain variety resulted in a 36.78% increase in grain yield (Figure 3). However, the local cowpea variety significantly increased cowpea stover yield by 317.27% compared to the improved variety. Analysis of variance showed no significant effect of grain sorghum grain variety on yields.

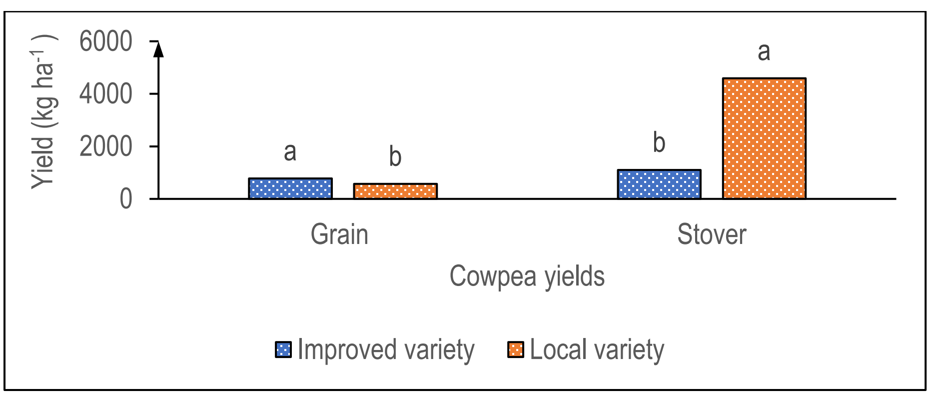
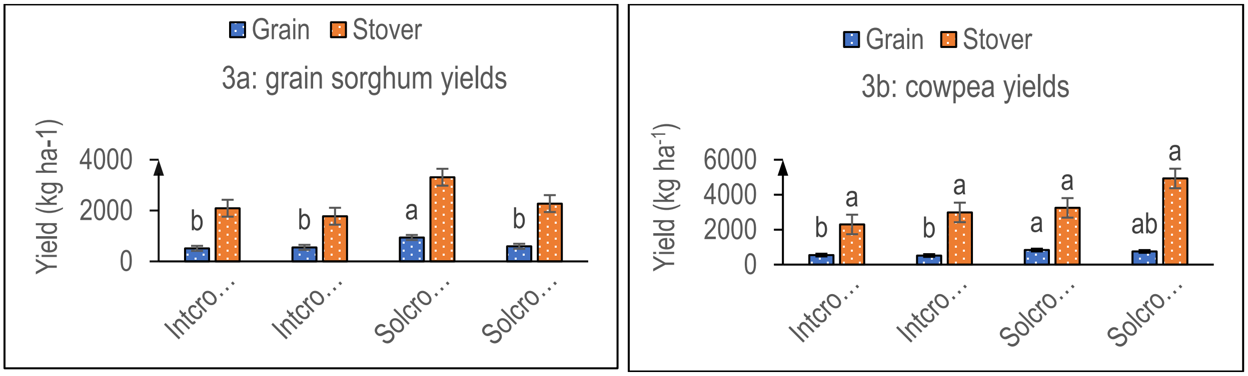


Figure3 : Effects of grain variety type on cowpea yields

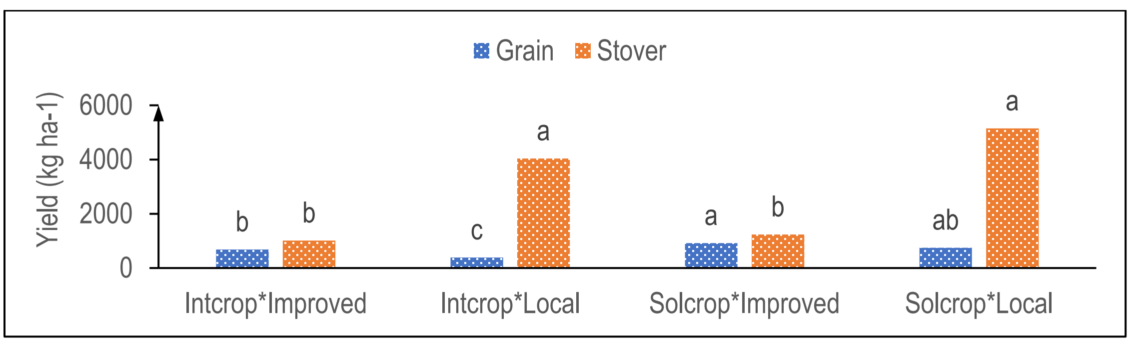
Interactive effects of the cropping system and mineral fertilization using microdosing technique of NPK on grain sorghum and cowpea yields. : Analysis of variance showed an interactive effect of the combination of cropping system and mineral fertilization with NPK (50 kg ha^{-1}) on grain sorghum grain yield (P = 0.0289) and cowpea grain yield (P = 0.0024). Sole grain sorghum production with microdose mineral fertilization significantly increased grain sorghum grain yields from 346.88 kg to 428.6 kg (Figure 4a) and cowpea grain yields from 80.4 kg to 314.44 kg (Figure 4b) compared to sole production without fertilization and intercropping with or without mineral fertilization.



Legend: Intcrop = Intercropping; Solcrop = Sole cropping; MF= mineral fertilization; WMF= without mineral fertilization (control)

Figure 4 : Interactive effects of cropping system and mineral fertilization using microdosing technique of NPK on grain sorghum grain yield

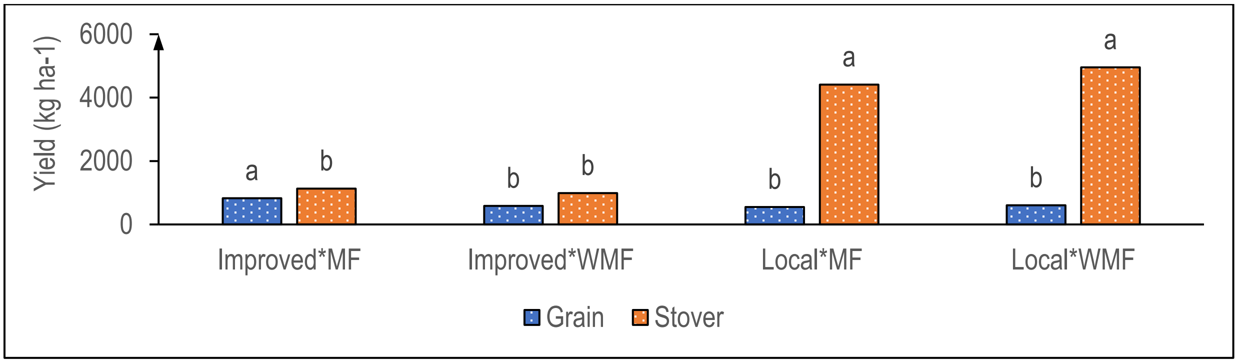
Interactive effects of cropping system and grain variety on grain sorghum and cowpea yields: Analysis of variance showed an interactive effect of cropping system and grain variety on cowpea grain ($P < 0.0001$) and stover ($P < 0.0001$) yields but showed no significant effect on grain sorghum yields. The improved cowpea variety in sole cropping significantly increased cowpea grain yield by 22.65% compared to the local cowpea variety in sole cropping. For cowpea stover yield, results indicated a significant increase for local cowpea stover yields by 299.69% to 316.51% compared to the improved variety (Figure 5).



Legend: Intcrop = Intercropping; Solcrop = Sole cropping

Figure 5 : Interactive effects of cropping system and grain variety on cowpea grain and stover yields

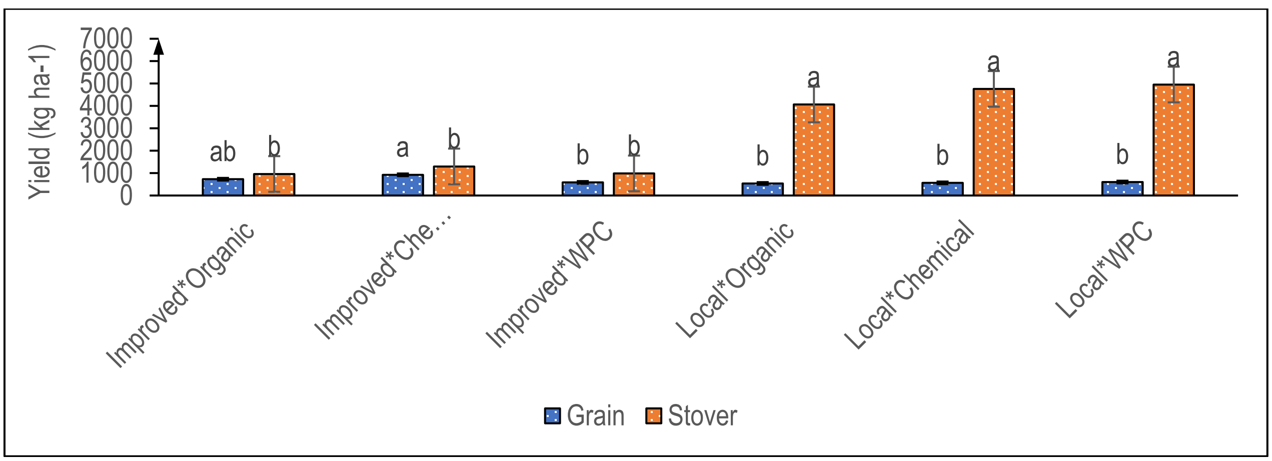
Interactive effects of grain variety and mineral fertilization on grain sorghum and cowpea yields: The improved cowpea variety with mineral fertilization applied using the microdosing technique significantly increased cowpea grain yield by 41.18% compared to the improved variety without mineral fertilization and by 37.13% to 49.68% compared to the local variety with or without microdose mineral fertilization. On the other hand, the local cowpea variety with or without mineral fertilization significantly increased cowpea stover yield by 290.65% to 402.52% compared to the improved variety with or without mineral fertilization (Figure 6).



Legend: MF = mineral fertilization; WMF = without mineral fertilization

Figure 6 : Interactive effects of grain variety and microdose mineral fertilization on cowpea grain and stover yield

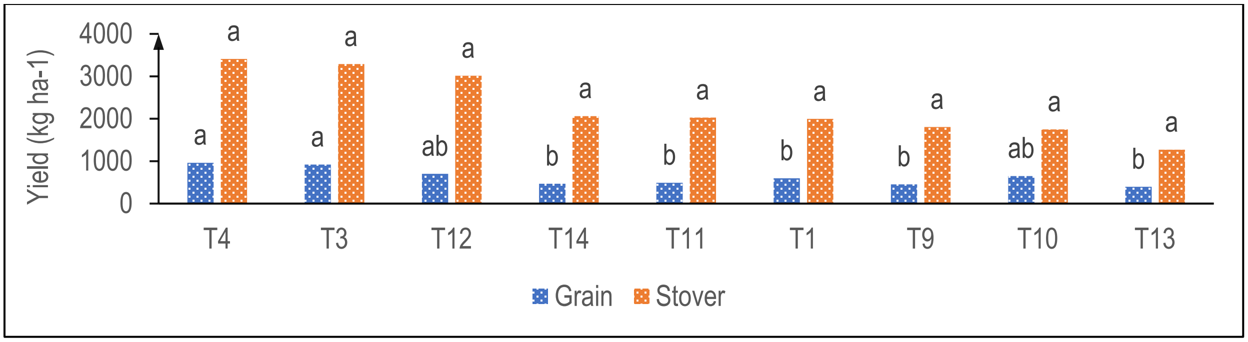
Interactive effects of grain variety and pest control on grain sorghum and cowpea yields: Analysis of variance showed an interactive effect of crop variety and pest control type on cowpea grain ($P < 0.0201$) and stover yields ($P < 0.0001$) but showed no significant effect on grain sorghum yields. The improved cowpea variety with chemical or biological treatment significantly increased cowpea grain yield by 24.33% to 58.03% compared to the improved variety without pest control and by 35.09% to 71.71% compared to the local variety with or without pest control. However, the local variety with or without pest control significantly increased the cowpea stover yield by 324.64% compared to the improved variety (Figure 7).



Legend: WPC= without pest control application.

Figure7 : Interactive effects of grain variety and pest control on cowpea grain and stover yield

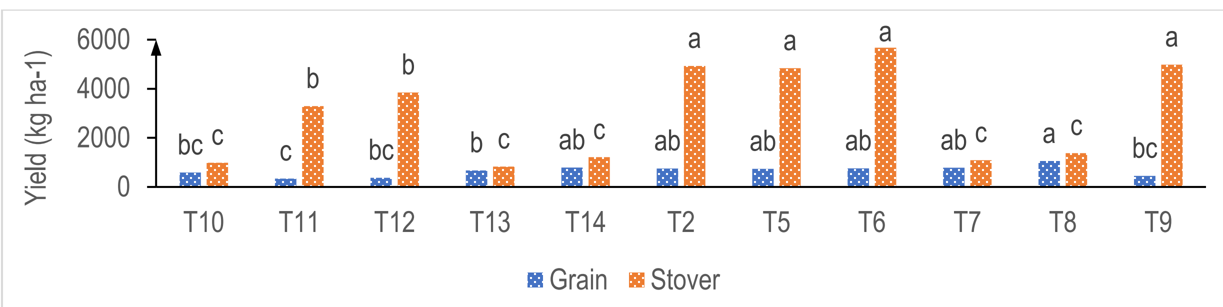
Effects of treatments on grain and stover yields of grain sorghum: The analysis of variance showed a significant effect of the combination of all four factors in the study on grain sorghum grain yield ($P = 0.0049$). The highest grain and stover yields were obtained with treatment T4 (963.13 kg ha^{-1} and 3,410.29 kg ha^{-1} for grain and stover, respectively) and treatment T3 (918.78 kg ha^{-1} and 3,287.25 kg ha^{-1} for grain and stover, respectively), see Figure 8.



Legend: T1 = local grain sorghum; T3 = local grain sorghum + mineral fertilization; T4 = improved grain sorghum + mineral fertilization; T9 = local grain sorghum + local cowpea; T10 = improved grain sorghum + improved cowpea; T11 = local grain sorghum + local cowpea + mineral fertilization + biological pest control; T12 = local grain sorghum + local cowpea + mineral fertilization + chemical pest control; T13 = improved grain sorghum + improved cowpea + mineral fertilization + biological pest control; T14 = improved grain sorghum + improved cowpea + mineral fertilization + chemical pest control.

Figure8 : Effects of treatments on grain and stover yields of grain sorghum

Effects of treatments on cowpea grain and stover yields: The combination of factors tested in this study had a significant effect on cowpea grain ($P = 0.0016$) and stover ($P < 0.0001$) yields. The highest grain yield of 1057.05 kg ha^{-1} was obtained with treatment T8 and the lowest of 338.8 kg ha^{-1} with treatment T11. The highest stover yield of 5672.73 kg ha^{-1} was obtained with treatment T6 and the lowest of 831.25 kg ha^{-1} with treatment T13 (Figure 9).



Legend: T2 = local cowpea; T5 = local cowpea + mineral fertilization + biological pest control; T6 = local cowpea + mineral fertilization + chemical pest control; T7 = improved cowpea + mineral fertilization + biological pest control; T8 = improved cowpea + mineral fertilization + chemical pest control; T9 = local grain sorghum + local cowpea; T10 = improved grain sorghum + improved cowpea; T11 = local grain sorghum + local cowpea + mineral fertilization pest control; T12 = local grain sorghum + local cowpea + mineral fertilization + chemical pest control; T13 = improved grain sorghum + improved cowpea + mineral fertilization + pest control treatment; T14 = improved grain sorghum + improved cowpea + mineral fertilization + chemical pest control.

Figure 9 : Effects of treatments on cowpea grain and stover yields

DISCUSSION

The results of the study showed that intercropping grain sorghum and cowpea with leads to low yields of grain sorghum grain and stover, as well as cowpea grain. Previous authors have demonstrated the effect of intercropping that reduces yields compared to sole crops (Zongo *et al.,* 2021; Obulbiga *et al.,* 2022; Toe, 2022; Traore, 2022; Raboin *et al.,* 2023). The improved cowpea variety, which is Komcallé has favored substantial cowpea grain yield compared to the local variety. This result is consistent with the findings of the study by Raboin *et al.* (2024), conducted in the Sudano-Sahelian zone of Burkina Faso, which showed that the improved Komcallé variety significantly increased cowpea grain yield compared to the local “pisnou” variety. Similarly, Aly *et al*. (2017) and Oumarou *et al.* (2017) showed that improved cowpea varieties increase cowpea grain yields compared to local varieties. On the other hand, results have shown a significant increase in cowpea stover yields in plots planted with a local variety compared to those planted with the improved variety (Komcallé). This result is in contrast with those of Raboin et al. (2024), who found no significant difference between the improved Komcallé variety and the local "pisnou" variety. The interaction between sole grain sorghum with NPK application significantly increased grain yields for grain sorghum compared to sole cropping without fertilization and the grain sorghum and cowpea intercropped with or without mineral fertilization. This shows a significant effect of mineral fertilization on grain sorghum in sole production. The results from study conducted by Sissoko *et al.* (2019) indicated higher grain sorghum yields with mineral fertilizer applied using microdosing technique than with traditional farming practices. Results have also shown a significant effect of chemical pest control with the improved variety or sole cowpea cropping compared to biological pest control. Biological pest control also had a significant effect compared to untreated plots. This demonstrates the advantage of using neem oil for cowpea treatment. To this end, Akoudjin *et al.* (2023) reported that the use of neem leave aqueous solution as an alternative control strategy to synthetic pesticides against cowpea insects should be encouraged in farmers’ communities.

CONCLUSION AND APPLICATION OF RESULTS

The objective of this study was to evaluate the effects of agroecological cropping systems on sorghum and cowpea yields. The results demonstrated that certain agroecological transition systems could be promoted in Burkina Faso for the sustainable production of sorghum and cowpea. Based on these results, the following systems can be recommended to farmers: to achieve high grain sorghum yields, growing of sole cropping with microdose mineral fertilization is recommended regardless of the sorghum variety; to achieve high grain yields of cowpea, growing of improved varieties in sole cropping with microdose mineral fertilization and chemical or biological control of pests is recommended; to achieve high stover yields of cowpea, the use of improved varieties in sole cropping with microdose mineral fertilization and chemical or biological control of pests is recommended; to achieve higher total yields of grain sorghum and cowpeas, intercropping grain sorghum and cowpeas with microdose mineral fertilization is recommended.

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