Original Research Article

Effect of Mixed Bovine and Ovine Stabling on Soil Properties and on Growth and Yield of Okra (*Abelmoschus esculentus* L. Moench.) in the Sudano-Sahelian zone of Burkina Faso

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ABSTRACT

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| In Burkina Faso, okra is one of the most important vegetable crops. Low soil fertility is one of the major constraints to okra production. The objective of this study was to evaluate the effect of mixed bovine and ovine stabling on soil properties and on growth and yield of okra in Sudano-Sahelian zone. The study was conducted during the 2023-2024 agricultural season. The experiment design used is a Randomized Complete Block Design with two treatments (with and without stabling) and four replications. The data collected are plant height, collar diameter, number of leaves, number of flowers, soil temperature and soil pH.  Results of the study showed that the stabling treatment (PR) recorded the highest pH (6.27), the highest fruit weight (137.62 g plant-1) and the best fruit yield (2.75 t ha⁻¹), i.e. a yield gain of 17.62% compared to the control (TA). These results highlight that mixed cattle and sheep stabling, a source of organic matter, improves the soil and okra productivity. Thus, the practice of stabling could be an alternative to restore the soil and boost okra production in the Sudano-Sahelian zone of Burkina Faso. |

*Keywords: stabling, okra, bovine manure, Boudtenga, soil restoration, Burkina Faso.*

1. INTRODUCTION

Burkina Faso's economy is based on the agricultural sector. It contributes 16.3% to GDP formation (INSD, 2024). Market gardening is practiced by a small proportion of households (11.9%) and rural households practice much more than urban households (INSD, 2023). Indeed, 12.6% of households in rural areas practice market gardening compared to 7.2% of households in cities. Okra production is an important part of production with 23632 tons in 2023 (FAOSTAT, 2025) and the 6th place after eggplant in rural areas. Okra (*Abelmoschus esculentus* L.) is a fruit vegetable belonging to Malvaceae family, cultivated for its fruits and leaves in Burkina Faso. Okra is a high-value crop because it is a source of nutrients important to human health, such as vitamins, potassium, calcium, carbohydrates, dietary fiber, and unsaturated fatty acids such as linolenic and oleic acids (Durazzo et al., 2018; Hasan et al., 2025) and is commonly used in different industrial sectors. The fruits, seeds, and leaves of okra have applications due to their composition and properties. This is because the seeds are rich in α-tocopherol and have high levels of minerals, including calcium, potassium, copper, iron, phosphorus, magnesium, zinc and manganese (Dantas et al., 2021). Despite these performances, okra production faces constraints including water insufficiency and low soil fertility. Water, land degradation and low natural soil fertility had been identified as major constraints to agricultural production in sub-Saharan Africa. This situation is explained by erratic rainfall, water erosion and anthropogenic pressure. In Burkina Faso, irrigation systems have been set up with the aim of contributing to better water management. In addition, many works have indicated that organic amendments increase porosity, improve structure and structural stability, improve water retention capacity, mineralization of soil mineral elements (N'Dayegamiye et al., 2005; Mukalay et al., 2008; Diakité et al., 2020). Thus, based on the potential of okra in this context of precarious rainfall associated with the continuous degradation of the soil, it is therefore essential to consider an improvement in okra yields. It should consider the restoration of soil capital and smart water management. The present work aims to assess the influence of animal stabling on the soil and the productivity of okra.

2. material and methods

**Study site**

The study was conducted on the Henri Christiane farm. This farm is located in the village of Boudtenga, about 35 km east of Ouagadougou, between the parallels of 12.48639° and 12°29' 11'' north latitude and the meridians -1.26583° and 1°16'57'' west longitude. Its altitude is 320 m. It is part of the department of Saaba, province of Kadiogo and is located in the North Sudanese phytogeographical domain (Guinko, 1984).

**Plant material**

Okra (*Abelmoschus esculentus* L.) is the plant material used in our study. It is the hybrid variety Rokia F1 with a seed-to-maturity cycle of 40 days.

**Experimental design and agronomic management**

The experimental device used is a Randomized Complete Block Design with two treatments and four replications. The factor studied is the application of organic manure at two levels of variation: with and without penning of animals. The total surface area of the system is 211.2 m2 and consists of elementary plots with an area equal to 42.24 m2. The dimension between the elementary plots was 0.5 m. The parking lot left animal faeces on site. The trial was set up after ploughing using a motorized machine. Sowing was carried out on moist soil at the rate of one seed per pocket. Three weedings were carried out 14 days after sowing, 22 days and 36 days followed by ridging at 57 days.

**Collected parameters**

To assess okra productivity and soil fertility dynamics, the following data were collected: plant height, crown diameter, number of leaves, number of flowers, soil temperature, and soil pH.

* ***The height of the plants*:** this was measured using a tape measure.
* ***The number of leaves*:** it was evaluated by counting the number of leaves produced per plant as they appeared.
* ***The number of flowers*:** it was evaluated by counting the number of flowers produced per plant as they appeared.
* ***The number of fruits*:** this was obtained by counting the number of viable fruits per plant.
* ***The diameter at the collar of the plants*:** it was measured using a digital caliper.
* ***The pH and temperature of the soil*:** these were taken using an electronic pH meter with a probe (Soil tester).

**Data processing and statistical analysis**

The different means and standard deviations are calculated using the EXCEL version 2019 software and the analysis of variance (ANOVA) is performed using the analysis software R. recommend version (3.5.2). The significant differences between the means were highlighted using the Student-Newman-Keuls (SNK) test at the 5% probability threshold.

3. results and discussion

**3.1. Results**

**3.1.1. Effects of treatments on plants height, number of leaves, number of flowers, number of fruits, diameter at the collar and temperature of soil**

The analysis results showed that the treatments had no significant effect on height (P=0.0547), collar diameter (P=0.0522), number of leaves (P=0.811), number of flowers (P= 0.134), and number of fruits (P= 0.477). Also, there was no statistically significant difference between the effects of the treatments on soil temperature (table below).

Table 1. Plant growth parameters and soil temperature under treatments

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Treatment | Height (cm) | Diametter at collar (mm) | Number of leaves per plant | Temperature (℃) | Number of flowers per plant | Number of fruits per plant |
| TA | 46.08±2.12a | 14.50±1.43a | 33.64±2.62a | 30.56±0.48a | 1.82±0.58a | 4.18±0.77a |
| PR | 41.58±1.89a | 11.90±1.61a | 34.41±2.28a | 30.65±0.31a | 1.25±0.29a | 4.56±0.63a |
| P-Value | 0.0547 | 0.0522 | 0.811 | 0.409 | 0.134 | 0.477 |

TA: Control; PR: Mixed bovine and ovine stabling. Means with the same letters were not significantly different at p ≤0.05

**3.1.2. Effects of treatments on soil pH**

Analysis of the results revealed that the pH of the soils studied ranged from 5.96±0.24 to 6.27±0.15. The soil under the PR treatment was less acidic than that under the TA treatment (P=0.0162). The application of animal manure led to a significant increase in soil pH from 5.96 (TA) to 6.27 (PR).

Figure 1: Effects of treatments on soil pH

**PR:** stabling and **TA:** Absolute control.

**3.1.3. Effects of treatments on okra fruit yield**

The results obtained for okra fruit yield show a statistically significant difference (P = 0.00419). Treatments have an influence on fruit productivity. The highest weights were recorded in okra in plots under penning. Okra cultivation has better performance on the ground under the pen. The penning has led to an increase in the weight of the fruit by 17.62% compared to the TA.

Figure 2: Effects of treatments on okra yield

**3.1.4. Relationship between pH, temperature and plant parameters**

Figure 3 shows the interactions between pH and the parameters of the plants studied. Principal component analysis (PCA) revealed that pH and temperature are positively correlated with the number of leaves, flowers and fruits and yield. Also, the number of leaves, flowers and fruits are positively correlated with diameter and height. However, a negative relationship was observed between pH, temperature, and yield with diameter and height.

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Figure 3: Principal Component Analyses (PCAs) between pH, temperature and agronomic parameters of okra.

**3.2. Discussion**

**3.2.1. Effects of treatments on soil pH**

The pH of the soil under mixed animals waste is less acidic than that of the control soil. The stabling of the animals led to an increase in the pH units of the soil and therefore reduced the acidity of the soil. The mixture of cattle and sheep manure exerted a significant influence on soil chemistry. These results are in line with those obtained by Naramabuye & Haynes, (2006) who found that the pH of the soil treated with cattle manure was higher than the control soil. Also, similar results were found by Cairo-Cairo et al., (2023) and Citak & Sonmez, (2011) which have shown that manure increases the pH of the soil. Also Ano & Ubochi, (2007) had reported a steady increase in soil pH following the application of cow manure. The increase in pH recorded is attributable to the organic matter content. The penning of animals is a source of organic matter. The corrective effect of soil pH by organic matter had been widely demonstrated (Hien, 2004; Koull, 2007; Adamou et al., 2009). In addition, the increase in pH can be attributed to calcium carbonate and bicarbonate in manure (Whalen et al., 2000; Eghball et al., 1996). The addition of cations such as Ca and Mg (L'Herroux et al., 1997) and the presence of organic anions in manure can neutralize H+ ions (Butterly et al., 2013). Other authors had found that sheep manure significantly reduced soil acidification and increased soil pH (De Souza et al., 2023; Traoré et al., 2021). Thus, animal excrement from penning could be an alternative for regulating the pH of the soil.

**3.2.2. Effects of treatments on okra fruit weight and yield**

The analysis of variance shows that the treatments significantly influenced the fresh weight of okra. Animal stabling recorded the highest number of fruits per plant and the highest fruit weight. The heaviest fruits were observed in the plots under stabling. Indeed, the mixture of bovine and sheep manure made it possible to note a 17.62% gain in fruit weight compared to the control. Our results corroborate those of Moyin-Jesu, (2007) which had shown that the application of 6 t ha-1 of plant residues increased okra fruit yield. Also Abdou et al., (2022) found that cattle manure allowed for higher weights of okra fruit than the absolute control. This influence on the weight of the fruit is explained by the addition of excrement from the penning (Ncuuri et al., 2023). Adding compost to the soil led to improve soil health and okra growth ( Nengi-Benwari & Abah, 2025). These droppings increase the organic matter content (Adekiya et al., 2020) and improves soil pH. Yet, organic matter has multiple benefits due to the balanced supply of nutrients, including micronutrients, increased availability of soil nutrients due to increased soil microbial activity, decomposition of harmful elements, improvements in soil structure and root development, and increased availability of soil water (Han et al., 2016). Furthermore Maheshbabu et al., (2008) had indicated that the addition of manure helped boost crop yields. Also, the analysis of the main component showed a strong and positive correlation between pH and fruit weight. Indeed, the more the pH value tends towards neutrality, the more heavy fruits are formed. Thus, this improvement in pH promotes the assimilation of nutrients by the plants (Genot et al., 2009) of okra. This improvement in pH also leads to an improvement in nitrogen and carbon content. Indeed, authors had mentioned a very positive correlation between the increase in the pH value and the increase in the carbon and mineralizable nitrogen content of the soil (Andersson et al., 2000; Curtin et al., 1998; Neina, 2019). The weight of okra fruit under the penning is high compared to the control. This increase in weight is explained by the improvement in pH due to the dissolution of organic matter resulting from the decomposition of bovine and sheep manure. The consequence of dissolved organic matter is the increase in mineralizable C and N and stimulates phosphorus uptake. Thus nitrogen is used by the plant to strengthen fruiting and fresh weight (Yang et al., 2023) as it is essential for the growth and development of fruit trees and is therefore a key factor in determining productivity (Zhao et al., 2008). Moreover, phosphorus fertilization significantly improves vegetative growth parameters and yield performance of okra (Hasan et al., 2025) and farmyard manure increased okra yields by more than 50% (Thakur, 2025). In addition, an analysis of the carbon and nitrogen and assimilable phosphorus contents should be carried out to confirm this dependence. Mixing cattle and sheep manure is an alternative to regulate pH and increase soil organic matter content for increased okra productivity in Burkina Faso.

4. Conclusion

The study consisted of evaluating the influence of mixed cattle and sheep pens on the soil and okra productivity in the Sudanian zone of Burkina Faso. The results revealed that penning positively affects soil chemistry (P=0.0162) and okra yield (P = 0.00419). The highest pH values and fruit weight are recorded under the mixed cattle and sheep penning treatment. Thus, these results highlight that it is possible to improve okra productivity through the practice of penning. Therefore, the adoption of penning could be a good alternative to restore soils, improve the availability of organic matter and increase okra productivity in the Sudano-Sahelian zone of Burkina Faso.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

Disclaimer (Artificial intelligence)

Option 1:

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 the writing or editing of this manuscript.

References

Abdou, R., Halilou, A. I., Zango, O., Agbo So, T. K., Yahaya, M. I., & Bakasso, Y. (2022). Effect of Fertilizers on the Productivity of Three Varieties of Okra (Abelmoschus esculentus L. Moench.) in the Zinder Region (Niger). International Journal of Biological and Chemical Sciences, 16(1), 378–389. https://doi.org/10.4314/ijbcs.v16i1.32

Adamou, I., Chimene, A. F., Robert, N., & Mama, N. (2009). Impact of Organic Matter Management on the Mineral Status of Soils and Crops in the Sudano-Guinean Savannahs of Ngaoundéré, Cameroon. In African Savannahs in Development: Innovating to Last (p. 10). CIRAD.

Adekiya, A. O., Ejue, W. S., Olayanju, A., Dunsin, O., Aboyeji, C. M., Aremu, C., Adegbite, K., & Akinpelu, O. (2020). Different organic manure sources and NPK fertilizer on soil chemical properties, growth, yield and quality of okra. Scientific Reports, 10(1), 16083. <https://doi.org/10.1038/s41598-020-73291-x>

A.O., Nengi-Benwari, and Abah, B. M. 2025. “Impact of Compost Levels on Soil Properties and Growth Performance of Okra”. Asian Journal of Research in Crop Science 10 (1):150-61. <https://doi.org/10.9734/ajrcs/2025/v10i1340>

Andersson, S., Nilsson, S. I., & Saetre, P. (2000). Leaching of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) in mor humus as affected by temperature and pH. Soil Biology and Biochemistry, 32(1), 1–10. https://doi.org/10.1016/S0038-0717(99)00103-0

Ano, A. O., & Ubochi, C. I. (2007). Neutralization of soil acidity by animal manure: Mechanism of reaction. African Journal of Biotechnology, 6(4), 364–368.

Butterly, C. R., Baldock, J. A., & Tang, C. (2013). The contribution of crop residues to changes in soil pH under field conditions. Plant and Soil, 366(1–2), 185–198. https://doi.org/10.1007/s11104-012-1422-1

Cairo-Cairo, P., Diaz-Martin, B., Machado-de-Armas, J., & Rodriguez-Lopez, O. (2023). Effects of poultry manure on structure and some indicators of fertility in tropical soils. Archives of Agronomy and Soil Science, 69(13), 2692–2702. https://doi.org/10.1080/03650340.2023.2171020

Citak, S., & Sonmez, S. (2011). Effects of chemical fertilizer and different organic manure application on soil pH, EC and organic matter content. J. Food Agriculture. Environ, 9(3), 739–741.

Curtin, D., Campbell, C.A., & Jalil, A. (1998). Effects of acidity on mineralization: pH-dependence of organic matter mineralization in weakly acidic soils. Soil Biology and Biochemistry, 30(1), 57–64. https://doi.org/10.1016/S0038-0717(97)00094-1

Dantas, T. L., Alonso Buriti, F. C., & Florentino, E. R. (2021). Okra (Abelmoschus esculentus L.) as a Potential Functional Food Source of Mucilage and Bioactive Compounds with Technological Applications and Health Benefits. Plants, 10(8), 1683. https://doi.org/10.3390/plants10081683

De Souza, A. A. B., Ramos Da Silva, W., Nascimento, C. W. A. D., Da Silva, Y. J. A. B., & Biondi, C. M. (2023). Residual effects of alkalized sewage sludge application on soil quality and sugarcane yield. Archives of Agronomy and Soil Science, 69(10), 1705–1717. https://doi.org/10.1080/03650340.2022.2106369

Diakité, B., Dalanda Diallo, M., Goalbaye, T., Diédhiou, S., Diallo, A., Talla, R., Diop, A., & Guissé, A. (2020). Effect of applying different doses of organic fertilizers on the growth and yield of tomato (Solanum lycopersicum L.) under semi-controlled conditions. Journal of Animal & Plant Sciences, 44.1, 7553–7566. https://doi.org/10.35759/JAnmPlSci.v44-1.2

Durazzo, A., Lucarini, M., Novellino, E., Souto, E. B., Daliu, P., & Santini, A. (2018). Abelmoschus esculentus (L.): Bioactive Components’ Beneficial Properties—Focused on Antidiabetic Role—For Sustainable Health Applications. Molecules, 24(1), 38. https://doi.org/10.3390/molecules24010038

Eghball, B., Binford, G. D., & Baltensperger, D. D. (1996). Phosphorus Movement and Adsorption in a Soil Receiving Long‐Term Manure and Fertilizer Application. Journal of Environmental Quality, 25(6), 1339–1343. https://doi.org/10.2134/jeq1996.00472425002500060024x

FAOSTAT. (2025). Data Mining. <https://www.fao.org/faostat/fr/#data/QCL>

Genot, V., Colinet, G., Brahy, V., & Bock, L. (2009). The Fertility Status of Agricultural and Forest Lands in the Walloon Region (adapted from Chapter 4—Soil 1 of “The State of the Walloon Environment 2006–2007”). Biotechnology, Agronomy, Society and Environment, 13.

Guinko, S. (1984). Vegetation of Upper Volta [PhD Thesis]. University of Bordeaux III, France.

Han, S. H., An, J. Y., Hwang, J., Kim, S. B., & Park, B. B. (2016). The Effects of Organic Manure and Chemical Fertilizer on the Growth and Nutrient Concentrations of Yellow Poplar (Liriodendron tulipifera Lin.) in a Nursery System. Forest Science and Technology, 12(3), 137–143. https://doi.org/10.1080/21580103.2015.1135827

Hasan, Md. R., Hossain, Md. E., Bhadra, A. K., Chowdhury, B., Haque, Md. M., Bonna, R., Nahar, L., & Islam, F. (2025). Phosphorus Application Improved Growth and Yield of Okra (Abelmoschus esculentus L.) during the Kharif Season in Bangladesh. International Journal of Plant & Soil Science, 37(8), 194–204. https://doi.org/10.9734/ijpss/2025/v37i85621

Hien, E. (2004). Carbon Dynamics in a Ferric Acrisol of West-Central Burkina Faso: Influence of Cultivation Practices on the Stock and Quality of Organic Matter. Montpellier.

INSD. (2023). In-depth Analysis of the Characteristics of Agricultural Households in Burkina Faso (p. 128) [Technical]. National Institute of Statistics and Demography.

INSD. (2024). National Accounts for 2023 (p. 11) [Technical]. Ministry of Economy, Finance and Forecasting.

Koull, N. (2007). Effect of Organic Matter on the Physical and Chemical Properties of Sandy Soils in the Ouargla Region. Master's Degree, Kasdi Merbah University, Ouargla.

L’Herroux, L., Roux, S. L., Appriou, P., & Martinez, J. (1997). Behavior of metals following intensive pig slurry applications to a natural field treatment process in Brittany (France). Environmental Pollution, 97(1–2), 119–130. https://doi.org/10.1016/S0269-7491(97)00072-9

Maheshbabu, H. M., Hunje, R. H. R., Patil, N. K. B., & Babalad, H. B. (2008). Effect of organic manures on plant growth, seed yield and quality of soybean. Karnataka Journal of Agricultural Sciences, 21(2), 219–221.

Moyin-Jesu, E. I. (2007). Use of plant residues for improving soil fertility, pod nutrients, root growth and pod weight of okra (Abelmoschus esculentum L). Bioresource Technology, 98(11), 2057–2064. https://doi.org/10.1016/j.biortech.2006.03.007

Mukalay, M. J., Shutcha, M. N., Tshomba, K. J., Mulowayi, K., Kamb, C. F., & Ngongo, L. M. (2008). Causes of high plant heterogeneity in a maize field under the pedoclimatic conditions of Lubumbashi. Presses Universitaires de Lubumbashi, Annales Faculté Des Sciences Agronomiques, 1(1), 4–11.

Naramabuye, F.-X., & Haynes, R. (2006). Short-term effects of three animal manures on soil pH and Al solubility. Australian Journal of Soil Research, 44. https://doi.org/10.1071/SR05062

Ncuuri, K. D., Kingori, G. G., & Mahugu, M. M. (2023). Effect of Source and Rate of Livestock Manure on Yield, Quality and Net Economic Benefit of Okra (Abelmoschus esculentus (L.) Moench.). Journal of Experimental Agriculture International, 45(7), 119–131. https://doi.org/10.9734/jeai/2023/v45i72141

N’Dayegamiye, A., Drapeau, A., & Laverdière, M. R. (2005). Effects of Household Residues Compost Additions on Crop Yields and Selected Soil Properties. Agrosolutions, 16(2), 57–71.

Neina, D. (2019). The Role of Soil pH in Plant Nutrition and Soil Remediation. Applied and Environmental Soil Science, 2019, 1–9. https://doi.org/10.1155/2019/5794869

Thakur, M. (2025). Response of Organic and Natural Farming Management Practices on Productivity and Profitability of Okra [Abelmoschus esculentus (L.) Moench]. International Journal of Plant & Soil Science, 37(8), 473–481. https://doi.org/10.9734/ijpss/2025/v37i85648

Traoré, S., Ouédraogo, P., Bayen, P., Bationo, B. A., Lee, N., Lorenz, N., & Dick, R. P. (2021). Effect of livestock manure on soil microbial and nutrient dynamics in zaï cropping systems of the Sahel. Land Degradation & Development, 32(11), 3248–3258. https://doi.org/10.1002/ldr.3979

Whalen, J.K., Chang, C., Clayton, G.W., & Carefoot, J.P. (2000). Cattle Manure Amendments Can Increase the pH of Acid Soils. Soil Science Society of America Journal, 64(3), 962–966. https://doi.org/10.2136/sssaj2000.643962x

Yang, Y., Huang, Z., Wu, Y., Wu, W., Lyu, L., & Li, W. (2023). Effects of nitrogen application level on the physiological characteristics, yield and fruit quality of blackberry. Scientia Horticulturae, 313, 111915. https://doi.org/10.1016/j.scienta.2023.111915

Zhao, D., Kane, M., Borders, B., & Harrison, M. (2008). Pine growth response to different site-preparation methods with or without post-plant herbaceous weed control on North Florida’s Lower Coastal Plain. Forest Ecology and Management, 255(7), 2512–2523. https://doi.org/10.1016/j.foreco.2008.01.011.