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Analysis of the Management of Cereal Crop Residues on Farms to Optimise Cattle Feed in the Western Cotton Growing Zone of Burkina Faso

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Abstract

Crop residues are insufficiently valorised by farmers in western Burkina Faso, while cattle face a shortage of forage. The aim of this study was to analyse the management of cereal crop residues in cotton-cereal farming to optimise their use as feed for draught cattle. A sample of 72 cotton farmers was selected from nine villages in the study area by the stratification method and interviewed using a semi-structured questionnaire. The quantities of cereal crop residue biomass collected by farmers were assessed directly in the field. The results showed that maize and sorghum stalks were predominantly used in cattle feed (86.1 and 90.3%), composting (50 and 44.4%), and mulching (26.9 and 25%), respectively. The average quantities of cereal crop residues stored were 0.83, 0.16, and 1.19 tonnes of dry matter (tDM) for crop farmers, livestock breeders, and agro-pastoralists, respectively, with respective fodder balances of -3.99, -29.05, and -16.99 Tropical Cattle Units (TCU) for the use of cattle, or -0.88, -0.38, and -1.81 TCU for the use of draught cattle during the lean season. Concentrated feed use was 0.20, 0.05, and 0.21 kg/cattle/day; respectively. The main factors influencing the quantities of cereal residues stored on the farms were the size of the cultivated areas and the farmers' capacity for transportation. Provision of transport equipment and storage infrastructure would therefore appear to be a solution that could improve the level of fodder residue storage, particularly for draught oxen.

Keywords: cereals, cattle, forage balance, animal load, cotton-growing area

1. Introduction

Mixed farming–livestock production systems are predominant on cotton farms in western Burkina Faso (Vall et al., 2006; Belem et al., 2023). In this production strategy, the role of animals, particularly draught cattle, is crucial. They are a source of energy that significantly improves labour productivity and is also a determining factor in the production of organic manure (Berger, 1996; Havard, 1997; Dugué & Dongmo-Ngoutsop, 2004). In the current context of high climate variability (Sieza et al., 2019), animal power makes a major contribution to the success of cultural operations (ploughing, sowing). According to Mengusti et al. (2015), the absence of draught animals on farms entails the risk of delayed sowing.

Unfortunately, livestock production on cotton farms still faces some challenges, the most important of which is the quantitative and qualitative availability of fodder at all times of the year (Belem et al., 2023). Draught cattle are the most vulnerable because they always start the rainy season feeble and this affects their efficiency in cultivation operations (Vall & Abakar 2002).

However, given the extent of the agricultural area in the cotton zone, the resulting crop residues represent an important alternative source of fodder. Their use in animal feed is economically advantageous for farms (Lawal et al., 2017; Seglah et al., 2019). However, as legumes are poorly represented in crop rotation, their tops are less available than cereal residues (Guenot & Huchet-Bourdon, 2014). Domestic ruminants can achieve relatively good zootechnical performance when legumes are moderately incorporated into the feed ration along with cereal residues (Diogo et al., 2018; Tensaba et al., 2021). However, when cereal residues are the only source of fodder available on the farm, their importance lies in the simple fact that they allow the animals to subsist during the critical period (Agromisa, 2015).

Despite all these advantages, this food resource for animals is poorly managed by producers (Sempore et al., 2013; Bénagabou et al., 2017). According to Andrieu et al. (2015), approximately 80% of cereal stalks are abandoned and used directly in the fields by farmers. Therefore, this study aims to investigate the current management of this resource to identify ways of improving its use in livestock feed, particularly for draught cattle on cotton farms in western Burkina Faso.

2. Materials and Methods

2.1 Study Sites

The study was conducted in the western cotton-growing zone of Burkina Faso in five sites in Mouhoun province and four sites in Tuy province (Figure 1). Administratively, these provinces are part of the Boucle du Mouhoun and Hauts-Bassins regions, respectively. These villages were chosen on the basis of the dominance of cotton in the production systems. Both provinces are located in the Sudanian zone. According to data from the provincial agriculture extension offices, rainfall in the Tuy and Mouhoun provinces in 2020 was 831.2 and 774.4 mm, respectively. The number of rainy days over the same period was 48 and 56, respectively.

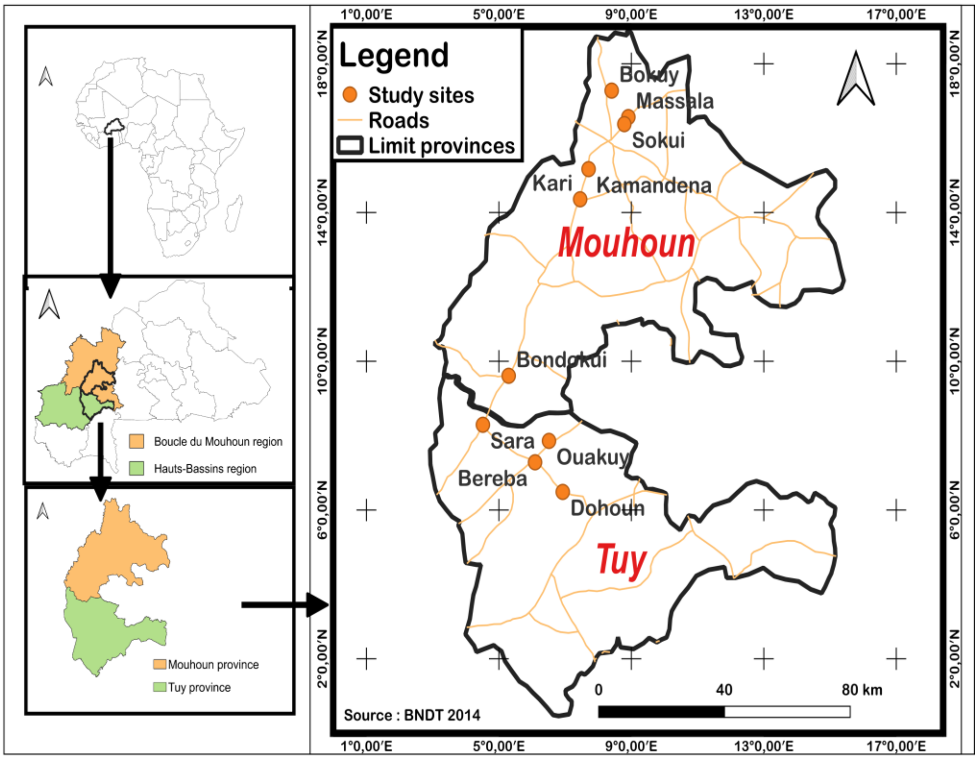


Figure 1. Map of the study sites

2.2 Sampling of Producers

In this study, the stratification method was used based on a recent typology of cotton producers established according to the functional and structural criteria of the farm (Firdion, 2012; Belem et al., 2023). This typology broadly defines three groups of producers: (i) crop farmers (81%; 6.7 ha and 3.6 cattle on average), (ii) livestock breeders (2%; 3.1 ha and 32 cattle on average), and (iii) agro-pastoralists (17%; 17.8 ha and 16.1 cattle on average). Thus, reasoned and almost proportional choices in each category of producers (or stratum) resulted in eight producers in each of the nine study sites. A total of 72 producers were sampled including, 52 crop farmers, 3 livestock breeders, and 17 agro-pastoralists.

2.3 Collection of Survey Data

Using the KoboToolbox platform, a questionnaire was designed and tested in a neutral environment, focussing mainly on aspects of agro-pastoral production and related crop residue management (crops produced, harvesting schedule, size of cattle herd, use of crop residues, etc.). Tablets were then administered individually to the 72 producers sampled in the form of semi-structured interviews. The digital data collected were stored directly on the platform and exported at the end of the surveys to an Excel spreadsheet for statistical analysis. In addition, regular field visits were made to compare the data collected with the realities on the ground and to collect additional data either by observation or by interviewing members of the household.

2.4 Estimation of the Quantity of Stored Cereal Crop Residues

Cereal harvest residue stocks are in small batches/bales that are almost homogeneous among producers. To assess these stocks, samples of 10–20 batches of stalks were weighed beforehand at each grower's premises, by type of cereal, using a precision balance to obtain an average weight. The total number of batches was then obtained by direct counting. The total weight of the stock was obtained by multiplying the number of batches of cereal stalks by their average weight.

2.5 Estimation of Stock Feed Balance

The fodder balance was estimated (equation 2) by comparing the animal load of the stock (equation 1) of cereal crop residues with the animal load of the entire cattle herd and the draught cattle herd for 90 days corresponding to the lean season in the study area (March, April, and May) (FAO, 2020; Djohy et al., 2023). Cattle were chosen because they are mostly fed with cereal residues, and draught cattle were chosen because of their importance in the resilience of cotton farms. In the calculations, one bovine animal was considered a tropical cattle unit (TCU) (Gomgnimbou et al., 2014).

$$\textbf{Stock animal load (SAL) (TCU)} = \frac{\text{Quantity of stock (kgDM)}}{\text{DDM}((\text{kgDM/TCU})/\text{Day}) * \text{PU}(\text{Day})} \qquad \textbf{(Equation 1)}$$

Stock feed balance (TCU) = **SAL** (TCU) - **FAL** (TCU) **(Equation 2)**

DDM = daily dry matter requirement for a TCU = 6.25; **PU** = stock utilisation period or lean period = 90 days (March, April, and May); **FAL** = farm animal load.

2.6 Data Analysis

Statistical analyses were performed using R 4.1.3 software. Analyses of variance were performed, and means were compared using Tukey's test with a threshold of 5%. To understand the factors influencing the quantities of cereal crop residue stock and the use of concentrated feed on cotton farms, we performed a principal component analysis (PCA) with six variables (quantity of stock, total annual quantity of concentrated feed used, number of animal-drawn carts, number of motorised vehicles (motor tricycles), number of draught cattle and total cereal area sown). Results are expressed as mean ± standard deviation.

3. Results

3.1 Use of Harvest Residues the from Main Crops

Table 1 shows the main uses of crop residues from cotton farms in the study area. The practises identified were feeding livestock, composting, mulching to cover the soil, burning in the fields, and use as household fuel. These practises and their importance varied according to the farming type and harvested residue.

For livestock feed, maize and sorghum harvest residues were used most by crop farmers, with frequencies of 80.8% and 88.5%, respectively. Livestock breeders were more likely to use maize harvest residue (100%). For agro-pastoralists, the use of harvest residues as fodder was the most diversified. Apart from cowpea haulms and rice straw to a lesser extent, the frequency of use of other residues ranged from 52.9% to 100%. Furthermore, field observations revealed that stocks of cereal residues were used by progressive distribution in bulk without any prior processing (chopping, treatment with urea, etc.).

Composting with crop residues was the most common practice among agro-pastoralists, with relative frequencies of up to 76.5% for maize and sorghum crop residues. These agro-pastoralists also practiced the most mulching, particularly with maize harvest residue (41.2%).

Finally, the use of residues as fuel or for burning was marginal in all types of cotton farms, with percentages generally below 10% and often zero.

Table 1. Frequency of use of different types of crop residue on cotton farms

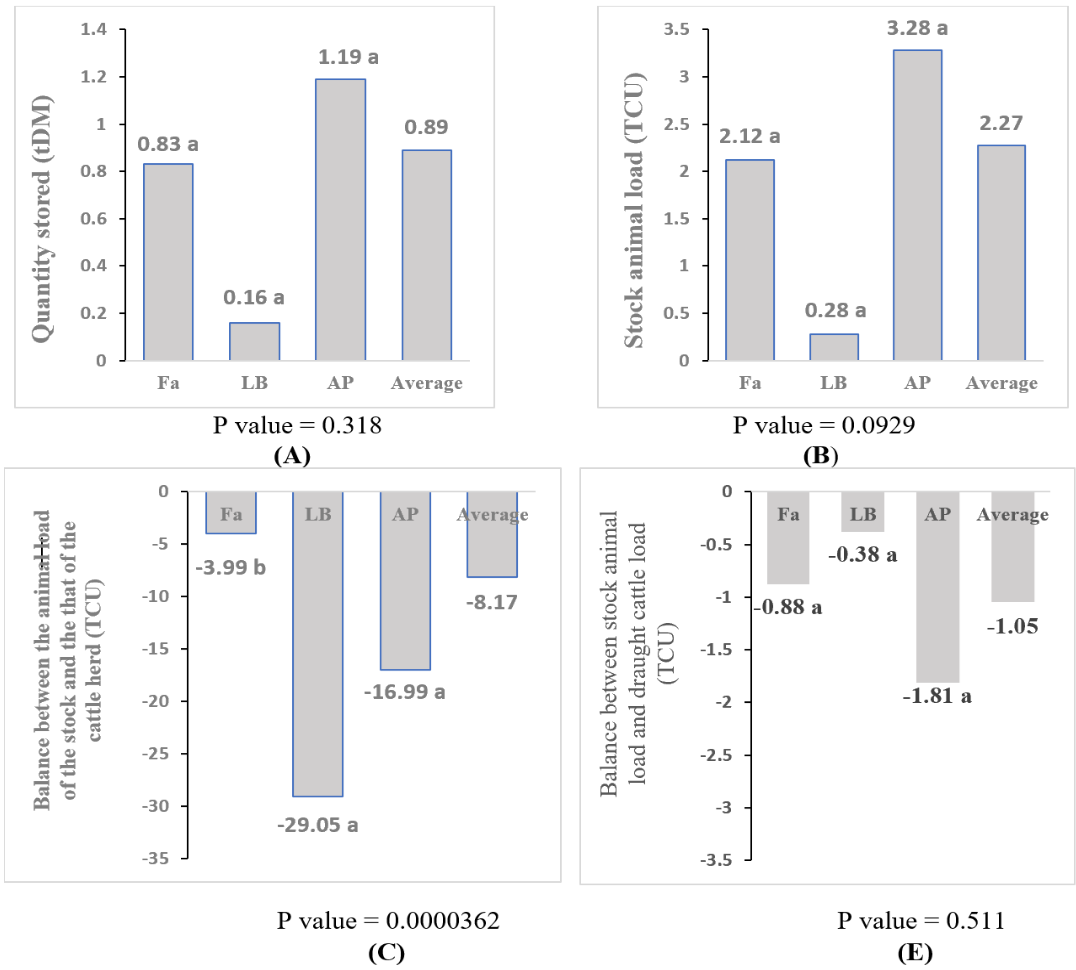
Use of CR/Types of CR		Maize harvest residues;	Millet harvest residues	Sorghum harvest residues	Rice harvest residues	Peanut harvest residues	Cowpea harvest residues
Livestock feed (Relative frequency in %)	Fa	80.8	44.2	88.5	7.7	48.1	19.2
	LB	100.0	33.3	66.7	0.0	33.3	0.0
	AP	100.0	52.9	100.0	35.3	82.4	11.8
	Average	**86.1**	**45.8**	**90.3**	**13.9**	**55.6**	**16.7**
Composting (Relative frequency in %)	Fa	42.3	25.0	36.5	0.0	5.8	0.0
	LB	33.3	0.0	0.0	0.0	0.0	0.0
	AP	76.5	35.3	76.5	17.6	17.6	0.0
	Average	**50.0**	**26.4**	**44.4**	**4.2**	**8.3**	**0.0**
Mulching (Relative frequency in %)	Fa	13.5	9.6	17.3	0.0	0.0	0.0
	LB	0.0	0.0	0.0	0.0	0.0	0.0
	AP	41.2	23.5	23.5	0.0	0.0	0.0
	Average	**26.9**	**17.3**	**25.0**	**0.0**	**0.0**	**0.0**
Fuel (Relative frequency in %)	Fa	7.7	7.7	7.7	0.0	0.0	0.0
	LB	0.0	0.0	0.0	0.0	0.0	0.0
	AP	5.9	5.9	5.9	0.0	0.0	0.0
	Average	**6.9**	**6.9**	**6.9**	**0.0**	**0.0**	**0.0**
Burns (Relative frequency in %)	Fa	1.9	9.6	0.0	0.0	0.0	0.0
	LB	0.0	0.0	0.0	0.0	0.0	0.0
	AP	0.0	0.0	0.0	0.0	0.0	0.0
	Average	**1.4**	**6.9**	**0.0**	**0.0**	**0.0**	**0.0**

Legend: Fa= Crop farmers; LB = livestock breeders; AP = agro-pastoralists; CR = crop residue

3.2 Fodder Balances for Cereal Crop Residue Stocks

The quantities of cereal crop residues collected and stored by farmers and fodder balances during the lean season (March, April, and May) of the total cattle herd and draught cattle are illustrated in Figure 2.

These results show that the largest stockpiles (1.19 tDM) were produced by agro-pastoralists, although there was no significant difference between the type of farming. The same applies to the animal costs corresponding to these stocks. The fodder balance established with the farm's total cattle herd was negative for all farm types, but crop farmers' balance (-3.99 TCU) was nevertheless significantly higher than the others. For draught cattle only, the fodder balance also remained negative for all farm types.



For each figure, A, B, C and D, the averages assigned the same letter are not significantly different at the 5% level.

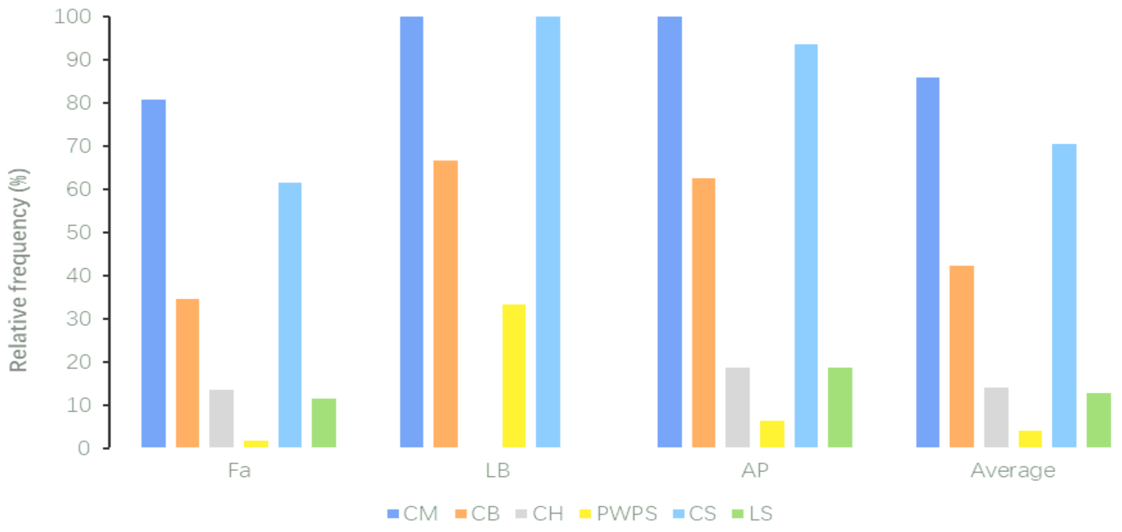
Legend: Fa= Crop farmers; LB = livestock breeders; AP = agro-pastoralists;

Figure 2. Quantities of cereal crop residues in storage (A), animal load in storage (B), balance between the animal load in storage and load on the cattle herd (C), and balance between animal load in storage and load on the farm's draught cattle

3.3 Level of Use of Feed Concentrates

Figure 3 shows the frequency of the use of concentrated feeds on cotton farms. Several concentrated feeds were used by the farmers, the most dominant of which were cottonseed cake (85.9%) and cooking salt (80.4%). These were followed by cereal bran (42.3%), which was most commonly used by agro-pastoralists and livestock breeders.

The average quantities of concentrated feed used by producers (Table 2) were significantly higher among agro-pastoralists. However, given the size of their cattle herds, these quantities remained low (0.21 kg/cattle/day). This indicator was also virtually the same for crop farmers and livestock breeders. It also appeared that for all types of farmers, cotton cake was the most commonly used concentrated feed for ruminants (71.4% on average).



Legend: CM = cottonseed meal; CB = cereal brans; CH = Cottonseed hulls; PWPS = Pods of woody plant species; CS = cooking salt (NaCl); LS = lick stone

Figure 3. Level of use (relative frequency of use by households) of concentrated feed on cotton farms

Table 2. Feed concentrates acquired from cotton farms

Settings	Fa	LB	AP	Average	P Value
**Quantity of food concentrates (Kg/an/farm)	349 ± 344[b]	268 ± 102[ab]	1 061±1 294[a]	505 ± 733	0.00177
**Quantity of food concentrates (kg/ cattle/day/farm)	0.20 ± 0,21[a]	0.05 ± 0,04[a]	0.21 ± 0,20[a]	0.20 ± 0,20	0.456
Share of cottonseed meal (%/farm)	72.0 ± 31,9[a]	79.1 ± 19,4[a]	68.3 ± 23,8[a]	71.4 ±29,3	0.816

Legend: ** = cottonseed meal + cereal bran + cottonseed hulls + Pods of woody species; On the same line, the averages affected by the same are significantly different

3.4 Analysis of Factors Influencing the Storage of Cereal Stalks and the Acquisition of Concentrated Feed

The PCA design succeeded in capturing 57.25% of the total inertia information, of which 38.46% was attributed to the first dimension. The correlation coefficients between the variables studied and each of the two dimensions are summarised in Table 3. Figure 4 explicitly illustrates the contribution of each variable to the formation of the two dimensions of the plan, as well as the inter-variable correlations, by presenting the spatial distribution of the individuals.

Examination of the results reveals that all variables contributed positively to the formation of the first dimension of the factorial plan. Regarding the second dimension, the "QCS-stored" and "N-Cart" variables had a negative and positive influence on its formation, respectively, indicating a negative correlation between these two variables. However, a positive correlation was observed between the “QCS-stored” and “NM-Cart variables”. This correlation suggests that the large quantities of cereal stalks stored per household were more closely associated with motorised transport equipment, particularly motorbikes.

Furthermore, analysis of the distribution of individuals in the factorial plane reveals that the owners of motorised transport equipment mainly belong to cluster 3, which groups together the agro-pastoralists, who are characterised as being big producers but few. On the other hand, crop farmers (small/medium producers), who are the most numerous and predominate in cluster 2, are the most likely to own animal-drawn carts, which have a lower transport capacity than motorised tricycles. Therefore, it appears that transport capacity influences the quantities of cereal harvest residues stored on cotton farms.

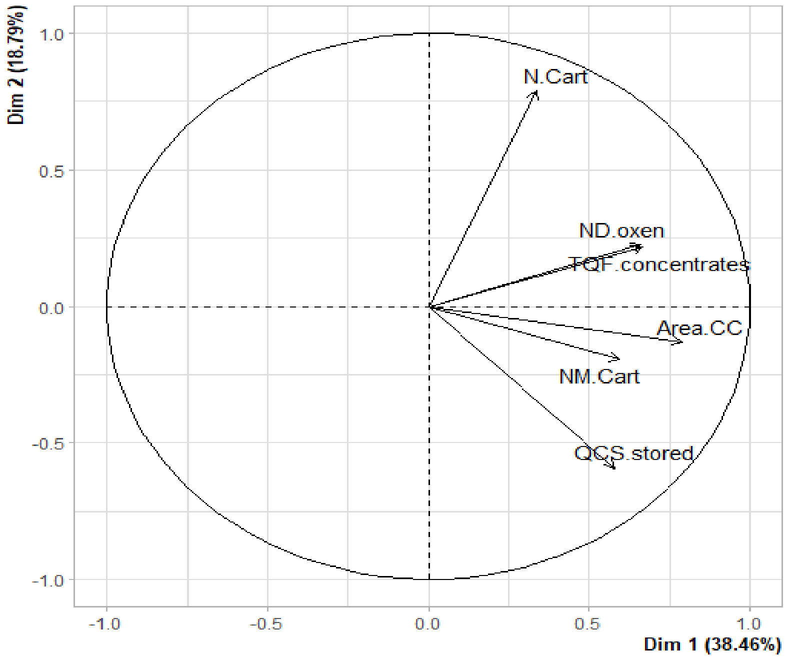
In addition, analysis of the correlation circle revealed a significant positive correlation between the variables “QCS-stored” and “Area-CC”, as well as between “Area-CC” and “NM-Cart”. This suggests that in addition to the capacity of the means of transport, the size of the cultivated land also influences the volume of stocks carried by growers.

Finally, the correlation circle reveals a strong correlation between the variables “ND-Oxen” and “TQFconcentrates”, indicating a significant influence of the number of draught cattle on the quantities of concentrated feed purchased by producers. Agro-pastoralists in cluster 3 make the largest purchases of concentrates.

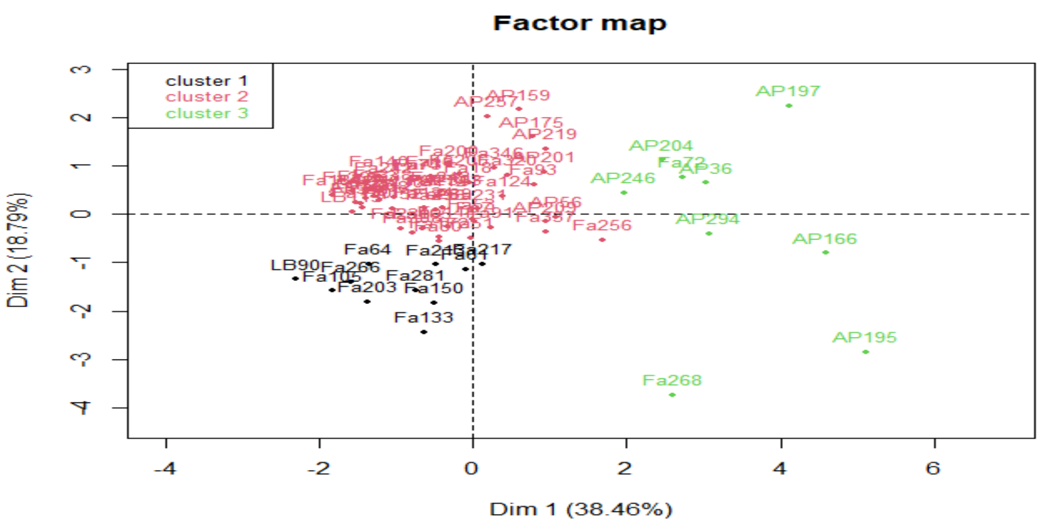
Table 3. Correlations between variables in the first two dimensions of the factorial design

Variables	First dimension		Second dimension	
	Correlation	P Value	Correlation	P Value
Area-CC	0.7888560	1.8952 e-16	-	-
TQFconcentrates	0.6645174	1.9568 e-10	-	-
ND-oxen	0.6629961	2.2251 e-10	-	-
NM-Cart	0.5939195	3.8142 e-08	-	-
QCS-stored	0.5803601	9.1225 e-08	-0.5917611	4393 e-08
N-Cart	0.3381179	3.6738 e-03	0.7901994	1.553 e-16

Legend: Number of draft oxen = ND-oxen; Quantity of cereal stalks stored =QCS-stored; Number of carts = N-Cart; Number of motorised carts (tricycle) = NM-Cart; Area of cultivated cereals = Area-CC; Total quantity of food concentrates = TQFconcentrates;



(A)



(B)

Figure 4. Variables correlation circles (A) and Cotton farmers distribution in the factorial map Dim1 et Dim2 (B)

4. Discussion

Crop residues from cotton farms are used in various ways, which vary according to the type of crop residue and the category of cotton farm. Indeed, these crop residues are mainly mobilised for livestock feed, composting and, to a lesser extent, mulching, as mentioned by

Sanon et al. (2014) , Dagbenonbakin et al. (2013) and, Djenontin et al. (2012). Sorghum and maize crop residues are mainly used, given that these crops are widely grown on most cotton farms. According to Guenot and Huchet-Bourdon, (2014), the predominance of maize is mainly explained by the economic factors inherent in cotton cultivation. As far as sorghum is concerned, apart from considerations related to family food, the choice of this crop by a higher number of producers is also explained by the production of fodder using harvest residues, particularly during the dry season.

Agro-pastoralists, who are the biggest producers with the greatest need for soil fertility, practise composting and mulching the most. Their greater resources, in terms of both farm equipment and labour, are a major asset in implementing these activities. They are also the main beneficiaries of capacity building in this area (Belem et al., 2023).

From the point of view of livestock feed, note that cereal crop residues, despite their low nutritional value compared with legumes tops (Gnanda et al., 2015; Kiema et al., 2012), are an important source of fodder for farms facing fodder shortages in the dry season (Agromisa (2015). However, most of the maize residues are used by livestock breeders for direct grazing, which is not very effective in terms of coping with the fodder shortage, which lasts for almost three months in this cotton-growing area. This may be because maize harvests (Vall et al., 2006) are early and the storage infrastructure (open sheds) is virtually inadequate to cope with bad weather. This situation confirms the comments made by Andrieu et al. (2015), who stated that up to 80% of cereal residues are left in the fields at Koumbia in the province of Tuy. However, a large proportion of sorghum harvests are carried out almost after the rains have stopped (Vall et al., 2006). Because the agricultural calendar is less rigid, farmers can collect a proportion of these residues for storage.

Our results in forage management of crop residues are partially congruent with those of Diogo et al. (2018), who also found that maize and sorghum harvest residues were used for direct grazing in northern Benin. However, in their study, legume stalks (groundnuts, cowpeas) and rice straws were the most commonly used as animal feed, which differs from our study area, except in the case of agro-pastoralists, who have a fairly diversified use of crop residues because of the diversification of their production.

This difference could be explained by the relative availability of various types of harvest residues, given that crop production on cotton farms is dominated by cotton and maize (Guenot and Huchet-Bourdon, 2014 ; Traoré et al., 2015). However, our results are consistent with those of Kiema et al. (2012) in the Sahel region of Burkina Faso, where cereal crop residues, representing up to 72.6% of the total fodder stock on farms (compared with only 12.8% for legumes tops), dominate the livestock feeding strategy during the dry season.

Our results also showed that the storage capacity of cereal stalks is limited and insufficient to cover the needs of the cattle herd during periods of food shortage. The fodder balance of stocks was negative for all producers, both for draught cattle and for the farm’s total cattle herd. However, livestock breeders and, to a lesser extent, agro-pastoralists were the most deficient in terms of cereal crop residue stocks. They generally opt for grazing residues in the fields because most of their herd is subject to mobility (Belem et al., 2023).

In addition to harvest calendar constraints, the CPA study identified transportation capacities and the size of the land sown with cereals as factors influencing the volume of residue stock carried by producers. Motorised vehicles (motor tricycles, tractors), which are faster and offer much greater transport capacity than animal-drawn carts, are increasingly being used, particularly by agro-pastoralists, to transport crop residues. This could be because stored cereal stalks generally come from bush fields, which are relatively far from storage sites. Harvests in the huts are generally early, and the resulting crop residues are not protected from bad weather when stored. Improving the quality of fodder storage infrastructure is therefore a major challenge for improving the fodder value of harvest residues on cotton farms.

However, our findings show that cereal crop residues are distributed in bulk on the ground without any prior treatment (use of urea, salt, chopping, etc.), which would limit ingestion capacity. They are often combined with other feeds (oilseed cake, cereal bran, etc.), preferably for draught cattle (Vall and Abakar 2002), but the quantities remain relatively low (0.2 kg/cattle/day). Therefore, a nearly balanced ration based on cereal stalks should be achieved, depending on the production objectives. In the context of cotton farms with a predominance of draught cattle in the system, a maintenance ration based on cereal harvest residues for this category of animal would make a substantial contribution to strengthening the integration of agriculture and livestock farming in terms of both labour performance and organic manure production (Ba et al., 2015).

5. Conclusion

This study analysed the current use of harvest residues on cotton farms in western Burkina Faso. It showed that crop residues are put to various uses, which vary according to the type of residue and the type of cotton farm. These uses are still dominated by livestock feed, particularly maize and sorghum harvest residues. Much of the maize residue is used for direct grazing in the fields after harvest because most of this crop is harvested at a time when the last rains of the season pose a threat to conservation. As for legume haulms, their low level of use, particularly among livestock breeders, is considered to be due to their poor availability on cotton farms. Agro-pastoralists had a nearly diversified use of crop residues as fodder because of the diversification of their crop production.

The quantities of stored cereal crops were insufficient for all types of producers to cover the fodder shortage period, which lasts for at least 90 days in the area. In addition to the constraints of the agricultural calendar, which were not conducive to early storage (inadequate storage infrastructure), the capacity of the means of transport and the size of the area sown were the factors that most influenced the volume of cereal crop residue stored on each farm. Stored harvest stocks are generally fed to animals without any prior processing. Concentrated feed is often used to supplement this roughage, but in very limited quantities.

To optimise the fodder use of cereal residue stocks, it would be necessary to use rations based on these cereal stalks, particularly for draught cattle in the dry season. Based on the findings of this study, the following suggestions can be made:

- Construction of storage barns for collected and processed residues;

- Cattle, especially draught oxen, are fed almost balanced rations based on these stocks;
- An in-depth study on the use of legumes tops on cotton farms.

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Authors contributions

All authors participated in the design of the research protocol and data collection. Belem Adama processed and analysed the data and wrote the first draft of the manuscript. Ouédraogo-Koné Salifou, Bazoumana Koulibaly and Traoré Mamadou provided guidance and read and corrected the manuscript. Traoré Dramane took part in the writing.

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Competing interests

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Informed consent

Obtained.

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The Publication Ethics Committee of the Macrothink Institute.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

References

Agromisa. (2015). *Les résidus de cultures pour l'alimentation animale. En particulier à l'étable.* Adri Vink. https://cgspace.cgiar.org/bitstream/handle/10568/90001/1880_PDF.pdf?sequence=3

Andrieu, N., Vayssières, J., Corbeels, M., Blanchard, M., Vall, E., & Tittonell, P. (2015). From farm scale synergies to village scale trade-offs: Cereal crop residues use in an agro-pastoral system of the Sudanian zone of Burkina Faso. *Agricultural Systems*, *134*, 84-96. doi.org/10.1016/j.agsy.2014.08.012.

Ba, A., Dembele, B., Coulibaly, D., & Kanadjigui, Y. (2015). Utilisation des fourrages de céréales-mucuna dans l'alimentation des bœufs de trait (Sud Mali). *IRD Éditions*, 329-336. https://books.openedition.org/irdeditions/36574?lang=fr#:~:text=Conclusion,434%20g%2Fj %20en%202017

Belem, A., Ouédraogo-Koné, S., Koulibaly, B., Traoré, M., Traoré, D., Coulibaly, K., & Nacro, H. B. (2023). Diagnostic des pratiques d'intégration agriculture-élevage et des contraintes associées dans les exploitations cotonnières à l'ouest du Burkina Faso. *Revue Africaine de Santé et de Production Animale*, *2*, 90-103. https://www.eismv.org

Bénagabou, O. I., Blanchard, M., Bougouma Y.V., Vayssières J., Vigne M., Vall E., Lecomte, P., & Nacro H. B. (2017). L'intégration agriculture-élevage améliore-t-elle l'efficience, le recyclage et l'autonomie énergétique brute des exploitations familiales mixtes au Burkina Faso? *Revue d'élevage et de médecine vétérinaire des pays tropicaux, 70*(2), 31-41. https://doi.org/10.19182/remvt.31479

Berger, M. (1996). L'amélioration de la fumure organique en Afrique soudano-sahélienne. *Agriculture et développement, numéro hors-série 1996.* https://agritrop.cirad.fr/388228/1/document_388228.pdf

Dagbenonbakin, G. D., Djenontin, A. J., Ahoyo Adjovi, Igue, M., & Mensah, G. A. (2013). Production et Utilisation de Compost et Gestion des Résidus de Récolte. Fiche technique. *Institut National des Recherches Agricoles du Bénin. Dépôt légal N°6529 du 18/01/2013, 1er trimestre 2013, Bibliothèque Nationale (BN) du Bénin*, p. 10. file:///C:/Users/BELEM/Downloads/ft_n_04_dagb_nonbakin_et_al_compost.pdf

Diogo, R. V. C., Adedigba, S., Djedje, M., & Dossa, L. H. (2018). Gestion et contribution des résidus de récolte à la réduction du déficit alimentaire des élevages traditionnels de petits ruminants dans la zone soudanienne du Nord Bénin. *Ann. UP, Série Sci. Nat. Agron.*, *8*(1), 1-12.

Djenontin, A. J., Dagbenonbakin, G., Igue, A. M., Azontonde, H. A., & Mensah, G. A. (2012). Gestion de la matière organique du sol : Valorisation des résidus de récolte par l'enfouissement au Nord du Bénin. Fiche technique. *Institut National Des Recherches Agricoles du Benin (INRAB). Dépôt légal N° 5569 du 09/01/2012, 1er trimestre 2012, Bibliothèque Nationale (BN) du Bénin*. p. 8.

Djohy, G. L., Sounon Bouko, B., Djohy, G., Dossou, P. J., & Yabi, J. A. (2023). Contribution des résidus de culture à la réduction du déficit alimentaire des troupeaux de ruminants dans l'Ouémé Supérieur au Bénin. *Cahiers Agricultures*, *32*(13), 1-11. https://doi.org/10.1051/cagri/2023007

Dugué, P., & Dongmo-Ngoutsop. A. L. (2004). Traction animale et association agriculture élevage dans les savanes d'Afrique de l'Ouest et du Centre. D'un modèle techniciste à une démarche d'intégration raisonnée à différentes échelles. *Revue d'élevage et de médecine vétérinaire des pays tropicaux*, *57*(3-4), 157-165. https://doi.org/10.19182/remvt.9886

FAO. (2020). Estimation des bilans fourragers dans la région du Sahel d'Afrique de l'Ouest et Centrale. Production et santé animales – Directives no 22. Rome. *Organisation des Nations Unies pour l'alimentation et l'agriculture*, p. 50. https://doi.org/doi.org/10.4060/ca9111fr

Firdion, J.-M. (2012). Construire un échantillon. *Presses Universitaires de France*. p. 69. https://doi.org/10.3917/puf.paug.2012.01.0069

Gnanda, I. B., Bougouma-Yameogo, V. M., Wereme/N'diaye, A., Ouedraogo, T., Kabore, A., Lodoun, B., & Sinon, B. (2015). L'embouche bovine dans les élevages du Plateau Central du Burkina Faso : Résultats économiques d'une démarche de validation d'un référentiel technico-économique sur la spéculation. *International Journal of Biological and Chemical Sciences*, *9*(6). https://doi.org/10.4314/ijbcs.v9i6.11.

Gomgnimbou, A. P. K., Nacro, H. B., Sanon, O. H., Sieza, I., Kiendrebeogo, T., Sedogo, M. P., & Martinez, J. (2014). La gestion des déjections animales dans la zone périurbaine de Bobo- Dioulasso (Burkina Faso) : Structure des élevages, perception de leur impact environnemental et sanitaire, perspectives. *Cahiers Agricultures*, *23*(6), 393-402. https://doi.org/10.1684/agr.2014.0724

Guenot, A., & Huchet-Bourdon, M. (2014). Rôle du coton sur la filière maïs au Burkina Faso. *Économie rurale*, *341*, 107-119. https://doi.org/10.4000/economierurale.4353

Havard, M. (1997). La traction animale dans les pays francophones d 'AfriqueSub Saharienne. Effectifs et marches. *Séminaire CTA (Centre Technique de Coopération Agricole et Rurale), Ouagadougou, Burkina-Faso « Intégration de la mécanisation dans les stratégies pour une agriculture durable »*. p. 15.

Kiema, A., Sawadogo, I., Ouedraogo, T., & Nianogo, A. (2012). Stratégies d'exploitation du fourrage par les éleveurs de la zone sahélienne du Burkina Faso. *International Journal of Biological and Chemical Sciences*, *6*(4), 1492-1505. https://doi.org/10.4314/ijbcs.v6i4.8

Lawal, A. A. M., Chaibou, M., Garba, M. M., Mani, M., & Gouro, A.S. (2017). Gestion et utilisation des résidus de cultures pour l'alimentation animale en milieu urbain et périurbain : Cas de la communauté urbaine de Niamey. *Journal of Applied Biosciences, 115*, 11423-11433. https://dx.doi.org/10.4314/jab/v115i1.2

Mengusti, A., Kassa, B., Seifu, E., & Ponniah, A. (2015). Contraints of the linkage between maize livestock sub-systems ethiopian agriculture. *Journal of Agricultural Extension and Rural Development*, *1*, 8-15. https://doi.org/DOI: 10.5897/JAERD13.0537

Sanon, H., Savadogo, M., Tamboura, H., & Ba, K. (2014). Caractérisation des systèmes de production et des ressources fourragères dans un terroir test de la zone soudanienne du Burkina Faso. *VertigO - la revue électronique en sciences de l'environnement*, *14*(2), 1-15. https://id.erudit.org/iderudit/1034700ar

Seglah, P. A., Wang, Y., Wang, H., & Bi, Y. (2019). Estimation and Efficient Utilization of StrawResources in Ghana. *Sustainability IMS Mag,11, 4172,* 1-25. https://doi.org/doi:10.3390/su11154172

Sempore, A., Andrieu, N., Le Gal, P.-Y., Nacro, H. B., & Sedogo, M. P. (2013). Quelles stratégies pour améliorer l'intégration agriculture-élevage dans des exploitations de savane ouest-africaine ? Approches par simulation avec les producteurs. *AGRAR-2013: 1st conference of African research on agriculture, food, and nutrition. Yamoussoukro, Côte d'Ivoire, June 4-6, 2013*, 349-363. https://agritrop.cirad.fr/578120/1/ANDRIEU%20p.349.pdf

Sieza, Y., Gomgnimbou, A. P. K., Serme, I., & Belem, A. (2019). Etude de la variabilité climatique sur la dynamique d'occupation et d'utilisation des terres à des fins agro-pastorales dans la zone sud-soudanienne du Burkina Faso. *International Journal of Biological and Chemical Sciences*, *13*(4), 1980-1994. https://doi.org/10.4314/ijbcs.v13i4.6

Tensaba, R. S., Kiema, A., Gnanda, B. I., N'diaye, A. W., Zongo, M., & Tiema, A. K. P. (2021). Effet de l'utilisation de rations améliorées sur la rentabilité zoo-économique de l'embouche ovine paysanne en région Centre-Nord du Burkina Faso. *International Journal of Biological and Chemical Sciences*, *15*(6), 2327-2336. https://dx.doi.org/10.4314/ijbcs.v15i6.7

Traoré, A., Traoré, K., Traoré, O., Bado, B. V., Nacro, B. H., & Sedogo, M. P. (2015). Caractérisation des systèmes de production à base de riz pluvial strict dans les exploitations agricoles de la zone Sud-soudanienne du Burkina Faso. *International Journal of Biological and Chemical Sciences*, *9*(6), 2685-2697.https://doi.org/10.4314/ijbcs.v9i6.14

Vall, E., & Abakar, O. (2002). Ajuster l'alimentation du bovin de trait au cours de l'année, selon l'intensité du travail. *Fiche technique. Conception Cirad-Tera - Cathy Rollin.* https://agritrop.cirad.fr/514397/1/document_514397.pdf

Vall, E., Diallo, M., Blanchard, M., César, J., & Poccard Chapuis, R. (2006). Situation et dynamique agropastorale des villages de Koumbia et Waly (Burkina Faso) : Diversité et pratiques. *Centre International de Recherche-Développement sur l'Elevage en Zone Subhumide* (Burkina Faso). https://agritrop.cirad.fr/555185/1/document_555185.pdf