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Complementation Test of Draft Oxen in Dry Season with Harvest Residues in the Cotton Zone in Northwestern Benin

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Authors' contributions

This work was carried out in collaboration among all authors. Author SK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BMB and SD managed the analyses of the study. Author BS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study was to conduct a dietary supplementation test on draft cattle in the dry season using the crop residue reserves that had been built up. The experimental design used was a split-plot with soil type as the large area factor and feed complementation as the small area factor. The soil type modalities were clay soils, gravelly soils, sandy soils and sandy-clay soils. The modalities of the feed complementation factor consisted of cattle from the control lot (R0) that received no complement and the second lot (Rc) that received the complement. The data collected were related to the weight of the animals, the duration of ploughing and the investment costs of the rationing trials. The Analysis of Variance (ANOVA) generalized linear mixed model was used to analyze the

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data. The results showed that the supplemented draught cattle lost less weight than the control lot. The supplemented steers finished ploughing 1/4 hectare on average 30 minutes compared to the non-supplemented steers. The profitability study of the complemented units resulted in a 25% gain in ploughing time under the conditions of cotton farms in northern Benin. The practice of building up crop residue reserves during the dry season offers several opportunities to address the current challenges of climate change.

Keywords: Draft oxen; crop residue reserves; profitability; North Benin.

1. INTRODUCTION

Climate-smart agriculture is a winning solution to meet the challenge of food insecurity and the fight against desertification in the Sahel and West Africa [1]. The practices / technologies of Intelligent Agriculture facing the climate (CSA) in animal production mainly aims to improve breeding systems, reproduction techniques and animal feeding by valuing the by-products of plant production without compromising the environment. In this agricultural sub-sector, pastoral and agro-pastoral producers resort to the mobility of livestock to wetter areas, in search of pasture and water during the dry season [2]. Kate et al. [3] identified six major strategies for adapting to climate change in livestock in North Benin: transhumance, increasing the use of crop residues, medical prophylaxis, strengthening the management committees of transhumance corridors, creation of water dams and installation of fodder reserves, introduction of new breeds and improvement of livestock performance through genetic selection. Indeed, the constitution of fodder reserves is a practice that existed in Benin, but which has developed more following current climatic constraints. Agro-breeders store haulms of crops after harvest or fodder harvested for the occasion in sheds or on the roofs of houses. These are the tops of sorghum, cowpea and groundnuts [4]. These stored crop tops are used to feed draft animals in the dry season. They are sprinkled with salt to stimulate the appetite of the animals. The collection and storage of crop residues by agro-pastoralists is a growing practice in West Africa [5-7].

The adoption of animal traction has often provided the opportunity and the means for an intensification of cultivation practices and a rapid expansion of cultivated areas [8, 9]. A supplement of 2.5 to 5 kg of cowpea haulms allows the draft oxen during the last three months of the dry season to work in one hour 1737 m² against 1498 m2 for the unsupported draft oxen [10]. Studies carried out both in the sub-region and in southern Africa have shown that it is the live weight and not the body condition that mainly determines the working capacity of draft oxen [11,12]. The practice of building up fodder reserves for the dry season offers several opportunities to face the current challenges of climate change. However, various other questions still need to be clarified such as the profitability of the technology (benefit / cost analysis) as well as the adaptability of this technology to current production systems. The general objective of this study was to conduct a trial of food rationing of draft oxen in the dry season from crop residues. Specifically, this involves: (i) evaluating the performance of supplemented draft oxen during field work, (ii) determining the profitability of supplementation, (iii) evaluating the adaptability of this technology to production systems current and (iv) proposing scenarios for improving the adoption of fodder reserves.

2. MATERIALS AND METHODS

2.1 Description of Study Area

This study was carried out in the agro-pastoral zone of cotton production in the commune of Banikoara. It is located in the North-West of the Department of Alibori, between 2º05 'and 2º46' of East longitude and between 11º02 'and 11º34' of North latitude and covers an area of 4397.2 km² of which approximately 49% is cultivable land. and 50% of protected areas (W du Niger National Park and the Atacora hunting zone). It is bounded to the north by the commune of Karimama, to the south by the communes of Kérou and Gogounou, to the east by the commune of Kandi and to the west by Burkina-Faso (Fig. 1).

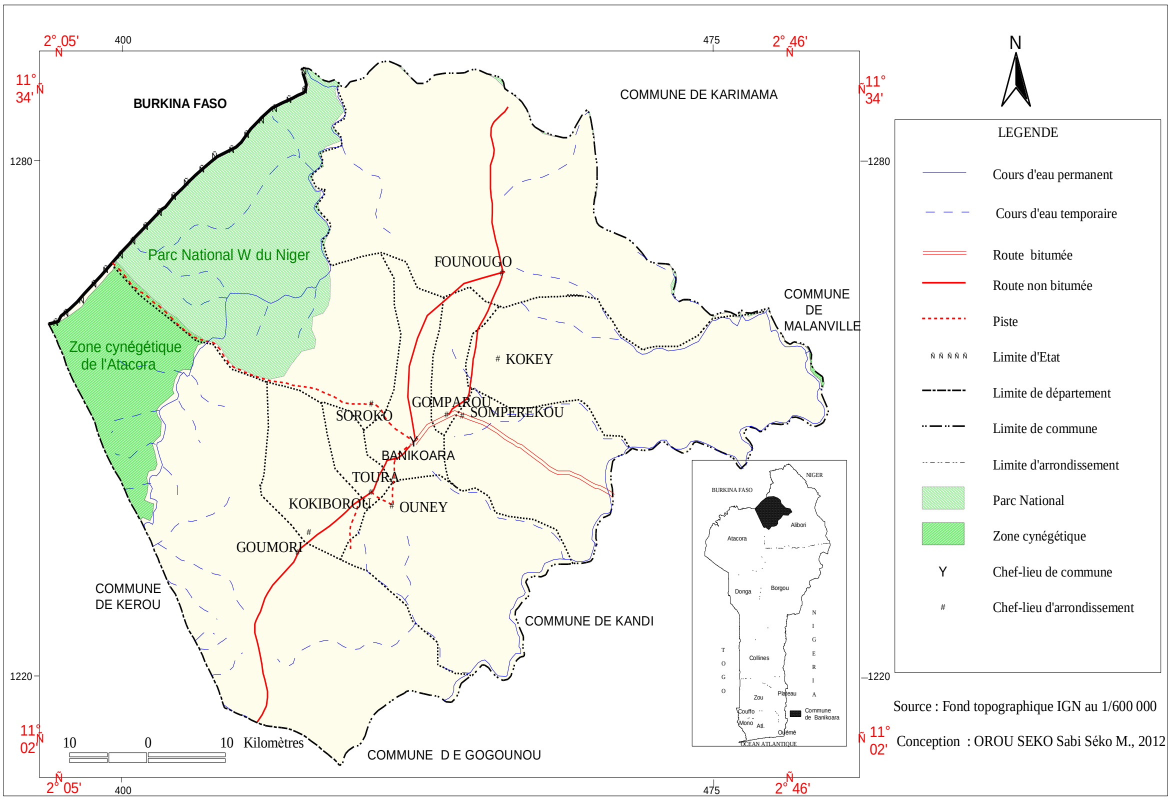

Fig. 1. Geographic and administrative location of Banikoara district

2.2 Experiment Design

A total of 40 oxen were divided into two lots, 20 per lot. All the animals used in this study were half-breeds from the cross between Zebu and Borgou. The animals were aged between 4 and 7 years with an average age of 5 years 5 months. The average weight of the subjects at the start of the experiment was 202.6 Kg and 206.90 Kg respectively for the control batch and the supplemented batch without there being any significant difference. The subjects of the different batches were dewormed, treated and vaccinated against common diseases in the region before the start of the experiment. The ingredients used in the formulation of the complementary ration consisted of rice straw, peanut haulm and cottonseed. The straws were collected at the end of the harvest and at the start of the dry season (December to January). However, the tops were collected between October and December. The cotton seeds come from the Banikoara cotton ginning factory. These different food reserves collected by the producer were stored on a watchtower and were used for the food supplementation test for draft oxen. Cottonseeds and mineral supplements used in the feeding test have been contributed by research.

2.3 Methods

2.3.1 Description of the technology

Crop residues and agro-industrial by-products are the staple food for livestock in the dry season. Agro-pastoralists have fodder reserves to maintain draft oxen. Indeed, these agro-pastoralists bring back to their habitat almost all the cereal straw and legume tops of their farm. Their draft oxen are kept in a pen and tied to a stake and fed at the trough throughout the lean season. This practice reflects a certain rationality of agro-pastoralists and adaptation to climate change. The food ration based on residues (cereal straw and peanut tops) and cotton seeds available in the medium added to the lick stone, must cover the nutrient requirements of the draft oxen.

2.3.2 Formulation of the supplementation ration

The matrix method was used for the formulation of the daily rations. It makes it possible to find the solution leading to cover several needs with more than two ingredients [13,14]. The energy, nitrogen, mineral and vitamin requirements used in this study are those described by Lhoste et al. [15] for draft oxen (Tables 1 and 2).

The proposed complementary ration is made up of 4 kg of straw; 1 kg of legume tops and 1 kg of cotton seeds during the dry season. The duration of the experiment is three months with two months in the dry season (March-April) and one month at the start of wintering (May). The complementary ration, the composition of which is presented in Table 3, is distributed to the animals each day. A mineral supplement in the form of a lick stone was also distributed to the animals.

The quantity of water consumed by the subjects during the experimental period is that recommended by Lhoste et al. 16] (Table 4).

During the work period, the animals were watered three (03) times a day, i.e. at noon, during the break and during hot hours. The recommended values for the bulkiness coefficient (CE) of adult animals for maintenance are between 2 and 2.3.

2.3.3 Experiment design

Four types of soil were considered in this experiment for plowing. These are clay soils, gravelly soils, sandy soils and sandy clay soils. Each category of soil selected received two different lots of 20 oxen each for plowing. The first batch, the control (R0), is made up of animals which did not receive any complement during the experiment. The second batch includes the subjects supplemented (Rc) with a ration formulated with rice straw, legume tops (peanuts) and cotton seeds. Within each batch, the pair of oxen constitute the observation unit and receive treatment. The number of repetitions per treatment is 10. The plowing time was calculated for each pair of oxen over an area of 0.25 ha. The forty (40) oxen were chosen at random from the herds of the commune of Banikoara. The experiment was conducted for three months spread over two seasons. The factors of the test are: ration and type of soil.

Table 1.Energy and nitrogen requirements for a draft beef weighing 250Kg

	UFL/j	MAD/(g/j)
Dry season (light work intensity) and time per day 4 h	3.5	242.5
Beginning of wintering (hard work intensity and time per day, 6h)	4.55	341.5

Source : Lhoste et al. [15], Lhoste et al. [16]

Table 2. Mineral and vitamin requirements

Mineral element requirements (g / kg) DM distributed				Vitamin requirements ui/j/100kg) PV		
Draft oxen	Ca	P	Na	Vitamin A	Vitamin D	Vitamin E
	3	2	3	20.000	400	120

Source : Lhoste et al. [15] Lhoste et al.[16]

Table 3. Composition of the complementary food ration

Ingredients	Dry season	Beginning of rainy season
Straws (Kg)	4	5
Tops (Kg)	1	2
Cotton seed (Kg)	1	1
Total (Kg)	6	8

Table 4. Amount of water consumed (l / 100 kg PV) depending on the season of the working season

Amount of DM consumed (kg / 100 kg bw)	Labour	Dry season		Rainy season	
		Humid	Hot	Humid	Hot
< 1.5	Low	4 à 6	6 à 8	2 à 4	3 à 5
> 2.5	High	7 à 10	10 à 14	4 à 8	5 à 10

Lhoste et al. [16]

2.3.4 Data collection

The data collected relates to the performance of the animals during the work, the profitability of the coupling unit and the adaptability of the technology. In terms of performance, the plowing time and the thoracic perimeter were measured. The thoracic perimeter was measured using the 2m Combi-Rondo tape measure with an accuracy of 1mm. The estimation of the weight of the animals is made from the thoracic perimeter. The regression used is that of CREVAT adapted by Simoens and Housou-ve, [17] to Borgou cattle then by Kate (2001) [12] applied to mestizos from the ZébuxBorgou cross: PV = 2.65 PT- 196.22.

Regarding the profitability of the coupling unit, the data collected related to the investment costs (fixed costs and variable costs). The variable costs are costs related to food (cereal straw, peanut haulm and cotton seeds), veterinary care (prophylaxis, surveillance and veterinary costs), operations (collection and transport of fodder, distribution of food). The fixed costs relate to the depreciation costs of the draft oxen, the plow and its accessories and infrastructure, including hangars and watchtowers. The formula used to determine the profit of the coupling units is that used by the Center d'Agro-Entreprise au Mali to calculate the profitability of a dairy farm within the framework of the Sustainable Economic Growth project financed by USAID [18].

$$\mathrm{SR} = \frac{\text{Fix cost}}{\text{Plowing price per ha} - \text{Unit variable fee}}$$

The bioeconomic hypothesis formulated is that of a coupling unit with a plowing capacity of 11.17 ha on average after the rationing test. NB: 11.17 ha is the average size of a farm in the commune of Banikoara [19]. As for the adaptability of the technology, the data collected concerns the availability of resources by period; the resource requirements per period and the application constraints of the technology. They were collected through a focus group.

2.3.5 Statistical analysis

The data collected was entered into the Microsoft Office 2013 Excel spreadsheet to constitute the database. To test the link between plowing time and animal weight we used a Pearson correlation test. The data matrix constituted in line by the pairs of oxen and in column by the factors and the variables namely: the time of plowing, the ration, the month and the type of soil was constituted and informed. An analysis of variance based on a mixed generalized linear model was used to test first the effect of ration and month on the live weight of animals and then secondly the effect of ration and type. of soil on the time of plowing oxen. The "lm" function of the "stat" package [20] was used for this purpose. All these analyzes were carried out with the R3.5.1 software [20].

3. RESULTS

3.1 Assessment of the Physical State of Pairs of Pairs of Characters

The results of the linear fixed-effect model showed that ration, month and their interaction had no impact on the mean bodyweight of pairs of oxen during the experimental period (Table 5). However, throughout the duration of the experiment, the average live weight of the animals supplemented (Rc) based on straw, haulms and cotton seeds was higher than those which did not receive any supplement (R0) during the test without the difference being significant (Table 6). In March, the values taken by the live weight were 202.50 kg and 206.90 kg respectively for the control batch and the supplemented batch. At the end of the test (June), the average live weight of the subjects of the control batch was 189.60 kg against 203.10 kg for the supplemented batch. Whether it was the control or the supplemented batch, all subjects had lost weight by the end of the experimental period. However, the supplemented subjects lost less weight (3.80 kg) compared to those of the control group (13 kg).

Table 5. Result of mixed effect linear model

	Df	F value	P
Ration	1	3,11	0,084
Month	2	0,91	0,409
Ration:Month	2	0,30	0,742
Residus	54		

3.2 Effect of Complementation and Soil Type on Draft Oxen Plowing Time

The results of the linear fixed-effect model (Table 7) showed that complementation had a highly significant effect on plowing time. However, the type of soil had no effect on the duration of plowing. The same is true for the interaction between ration and soil type.

Draft oxen that received supplementation took significantly less time ($p<0.05$) to plow the same area as those that received no supplementation (Fig. 2). Thus, the average plowing time was 171.70min for the control batch against 137.90min for the supplemented batch, ie a difference of 33.80min. However, from one soil type to another (Fig. 3), the average plowing time seems to be better on gravelly soils (151min) compared to other soil types (152.40; 152.50 and 157min respectively for sandy-clay soils, clayey and sandy) without there being any significant difference.

Table 6. Evolution of the physical condition of pairs of draft oxen

	R0	Rc
March	202.60±7.50	206.90±8.50
April	198.10±7.48	213.60±8.70
June	189.60±6.70	203.10±7.10

3.3 Profitability of Coupling Units

The fixed costs for the coupling unit represented around 35% of the total cost of the investments against 65% for the variable costs (Table 8).

On the basis of these costs, the break-even point which reflects the number of hectares that must be plowed to cover the investment costs (fixed costs + variable costs) was 6.8 ha. The cost / benefit analysis was used to determine the profitability and efficiency of a coupling unit. In fact, the relative impact of costs on the profit margin of the rental of plowing per hectare is as follows: depreciation of the pair of oxen (10%); amortization of the plow + accessories (14%); depreciation of infrastructure, particularly watchtowers and hangars (3%); food (25%); operations (12%); veterinary care (11%) and profit margin (25%).

Table 7. Results of analysis of variance

	Df	F value	P
Ration	1	101.91	0.001
Soil type	3	0.29	0.830
Ration:soil type	3	1.60	0.241
Residus	12		

3.4 Adaptability of Technology

The stocktaking meeting allowed the producers to review the results of the technology and give the assessments as shown in Table 9. The main constraints that could hinder the adoption of this technology were: the low availability of legume tops in dry season, the lack of labor and means of transport and the low palatability of the tops in the rainy season. The approaches to solutions to these constraints were respectively increasing the proportion of pulses within farms, granting seasonal credits to farmers and treating residues with urea to increase their palatability.

Table 8. Fixed costs and variable costs

Costs	FCFA/year	FCFA/trimester
Fixed costs		
Amortization of the pair of draft oxen over 5 years	72.000	18000
Amortization of the plow + accessories	100.840	25210
Depreciation of infrastructure (hangar / watchtower)	20.000	5000
Total fixed costs	192.840	48210
Variable costs		
Food	181.720	45430
Operations	85.360	21340
Maintenance (veterinary care)	81.600	20400
Total variable costs	348.680	87170

Table 9. Summary of the verbatim of the focus groups on the forms of adaptation

1	Limited quantity of legume tops in the dry season	Increase the proportion of legumes on farms
2	Lack of labor and possession of a means of transporting fodder	Granting of seasonal credit to farmers
3	From the first rains, the tops are no longer palatable by the animals	Urea treatment of crop residues to improve palatability.

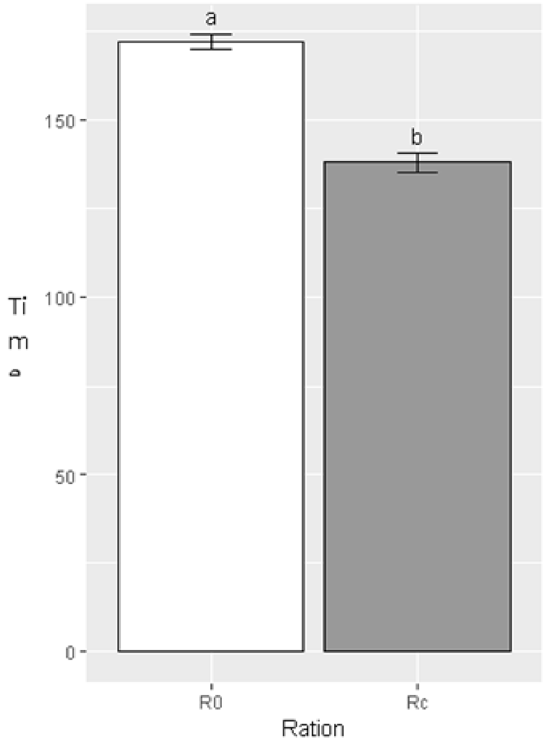

Fig. 2. Average plowing time of draft oxen according to treatment

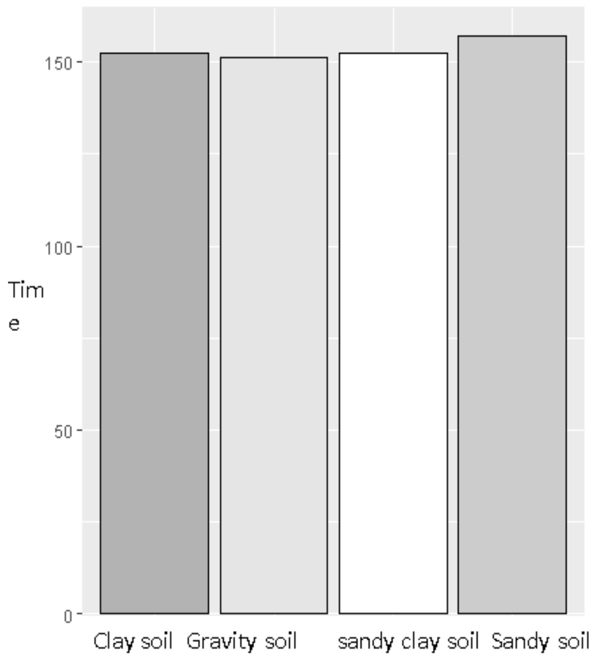

Fig. 3. Average plowing time of draft oxen according to soil type

4. DISCUSSION

The unsupplemented draft oxen lost weight throughout the trial. The same is true for those from the batch who received supplement even if their weight improved in the second month. The improvement in the weight of supplemented subjects is probably explained by the supplement which was distributed to them. The weight loss recorded at the end of the test for these subjects would be related to the physical activity exercised during the plowing. The age of the oxen did not influence the performance of the draft oxen. These performances were impacted only by the treatment. The supplement distribution probably explains the improvement in plowing time in the supplemented lot. The intensification of agriculture and the maintenance of the production potential of the farm land leads to an increased availability of crop residues. The scarcity of fodder in pasture areas during the dry season has encouraged the use of crop residues for feeding cattle herds. Very early on, more adequate management of these residues proved necessary with the increase in herd numbers, in particular those of farmers. Each farm keeps harvest residues from its crops for its herd at least for a certain period. Thus the herd of the farm grazes the fields from the harvest and fodder reserves are built up for the hot dry season. This management guarantees the agro-pastoralist the maintenance of the basic metabolism of draft oxen and the performance of field work at the start of the rainy season in the Sudano-Sahelian region [21]. The integration of fodder production into the cropping system also makes it possible to build up fodder reserves for draft oxen and dairy cows. This reserve supplements the stock of harvest residues and gives the animals a greater capacity for supplementation [22]. The management of forage resources has made it possible to improve the performance of draft oxen. In fact, draft oxen supplemented with cereal straw, legume tops and cottonseed finish ridging a quarter of a hectare on average 30 minutes before those which are supplemented in the traditional way [23]. Similar results were obtained with a supplementation of 2.5 to 5 kg of cowpea haulm distributed to the draft oxen during the last three months of the dry season when the supplemented draft oxen plowed in one hour 1737 m^2 against 1498 m^2. for unsupplemented draft oxen [10].

In the present study, supplementation of draft oxen reduced feed costs by approximately 25% of production costs without compromising the amount of the ration given. In principle, the producer can increase his profit margin by around 25% to 30%. This knowledge of the costs of the coupling unit and the establishment of a cost monitoring system should therefore make it possible to know at which link the loads must be reduced in order to increase profit [24]. This information can help him to better produce and market his plowing services at a competitive and profitableprice.

For this reason, he must know his charges related to the hiring of plowing of one hectare. Once he knows these production costs, he should reduce the variable costs which have a greater impact on his profit margin.

5. CONCLUSION

The practice of building up fodder reserves for the dry season offers several opportunities to face the current challenges of climate change. Started in March 2019, the draft oxen rationing test in the dry season at the Kokey RD site ended in June 2019. On the evaluation of the trials carried out, it appears that the draft oxen having received food supplementation at based on cereal straw, legume tops and cottonseed ends up ridging a quarter of a hectare on average 30 minutes before those which are supplemented in the traditional way. The profitability study reports a profit margin of (25%) on the plowing service of one hectare under the conditions of cotton farms in North Benin. All in all, the practice of building up fodder reserves for the dry season offers several opportunities to face the current challenges of climate change. But certain constraints, in particular the availability of labor and the possession of a means of transporting the stock of fodder from the fields to the stalls, may limit the adoption of this practice. Additional measures will have to be initiated to maintain the complementation dynamics of the oxen milked in the dry season.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. AGRHYMET. Climate-smart agriculture, a winning solution to meet the challenge of food insecurity and the fight against desertification in the Sahel and West Africa: Note to decision-makers, Communication Unit of the AGRHYMET, Niamey. 2015;9.
2. ECOWAS. Intervention framework for the development of climate-smart agriculture in the process of implementing the west African regional agricultural policy

(ECOWAP / CAADP), Report of the Forum of High Level of Smart Agriculture Actors facing the Climate in West Africa.Bamako. 2015;15-18:68.

3. Kate S. Effects of climate change on agriculture and adaptation measures in agro-pastoral cotton production zones in the commune of Banikoara (Benin). Doctoral thesis in Planning and Management of Natural Resources. University of Abomey-Calavi, Benin, 2015; 299.
4. Dimon R. Adaptation to climate change: Perceptions, local knowledge and adaptation strategies developed by producers in the communes of Kandi and Banikoara in northern Benin. Agricultural engineer thesis. UAC / FSA. 2008;130.
5. Jabbar MA. Evolving crop-Livestock Farming systems in the Humid Zone of West Africa: Potential and research needs. In journal for farming systems Research-Extension. 1994;4(3):47-60.
6. Picard J. Peasant spaces and practices: livestock-agriculture relationships in two cotton terroirs in North Cameroon. In Dugué P. (eds.). Fertility and agriculture – livestock relations in savannah zones. Proceedings of the workshop on biomass flows and fertility management at the terroir level. Cirad. 1998, Montpellier, France; 2000.
7. Djenontin J, Amidou M, Wennink B. Cattle breeding in North Benin. Mode of management of the land's pastoral resources. Technical report RD / BORGOU / CRAN / INRAB. 2000;48.
8. Peltre-Wurtz J, Steck B. Influence of a development society on the peasant environment. Cotton and horse-drawn cultivation in the Bagoe region (Ivory Coast, Abidjan), ORSTOM. 1979;428.
9. Bigot Y. Horse-drawn cultivation and its limits in the evolution of production systems in the savannah zones of Côte d'Ivoire, Abidjan, CIRDES, cahier n°30; 1981.
10. ILCA. Improving livestock production in Africa. Evolution of ILCA'S program 1974 - 1994. Addis Ababa, Ethiopia. 1994;233.
11. Pearson RA, Valle A. Performance and management of draft animals in sub-Saharan Africa: a review. In Revue Elev. Med. Vet. Country Too. 1998;51(2):155-163.
12. Kate S. Implementation of an agriculture-livestock integration process in the village of Kokey, Banikoara sub-prefecture. End-of-cycle dissertation for the University of Technology CPU / UNB. 2001;65.
13. Afolayan MO, Afolayan M. Nigeria oriented poultry feed formulation software requirements. Journal of Applied Sciences Research. 2008;4(11):1596-1602.
14. Roush WB. Using the matrix algebra capabilities of the TI59 calculator for teaching ration formulation. Poultry Science. 1982;61:2153-2156.
DOI: 10.3382 / ps.0612153.
15. Lhoste PH, Thierry G, Huguenin J. Animal traction and agricultural development in hot regions. Volume 3. Animals. Montpellier, France, CIRAD-IEMVT. 1990; 240.
16. Lhoste PH, Havard M, Vall E.Animal traction. Quæ, CTA, Presses agronomique de Gembloux.2010;224.
ISBN: 978-92-9081-459-7
17. Symoens C, Housou-Vê G. Baryometric measurements in Borgou cattle in North-East Benin. Elev review. Med. Vet. Country Too. 1991;44(4):487-490.
18. CAE. Manual of good feeding practices for livestock and poultry. USAID Sustainable Economic Growth Project. 2000;54.
19. INSAE (National Institute for Statistics and Economic Analysis). Fourth General Population and Housing Census (RGPH-4). Final results: General characteristics of the population. Cotonou, Benin. 2015;404.
20. R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria;2018.
Available:https://www.R-project.org/.
21. Breman H, Diara I. Livestock supplementation in the Sudano-Sahelian zone: a necessity in the dry season. PSS Guide N ° 3 IER / DS / MDRE. 1998;85.
22. Brah N, Houndonougbo MH, Issa S. Steps and methods of poultry feed formulation: A bibliographical synthesis. Int. J. Biol. Chem. Sci. 2015;9(6):2924-2931.
23. Hiernaux P, William J, Fernandes R, Riviera S, Schlech T. The roles of livestock in the intensification of agricultural production methods in the Sahel, Socio-economic and Technical Option;1993.
24. Kate S, Houndonougbo PV, Tougan UP, Tchobo A, Gounou N, Ogodja OJ, Tinté B, Ogouwale E, et al. Impact of climate change on cattle production and adaptation in the municipality of Banikoara

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