British Journal of Applied Science & Technology
16(1): 1-11, 2016, Article no.BJAST.25509
ISSN: 2231-0843, NLM ID: 101664541

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Use of No-till System on Straw by Cotton Producers in Cameroon

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2016/25509
Editor(s):
(1) Manjinder Singh, Department of Biological and Agricultural Engineering, University of Georgia, Georgia, USA.
Reviewers:
(1) Kebeney Syphyline, University of Eldoret, Kenya.
(2) Anonymous, University of Leicester, England.
(3) José Luiz Rodrigues Torres, Federal Institute the Minas Triangle, Uberaba, Brazil.
Complete Peer review History: http://sciencedomain.org/review-history/14434

Original Research Article

Received 7th March 2016
Accepted 19th April 2016
Published 3rd May 2016

ABSTRACT

Field surveys using questionnaires administered among cotton producers semi-openly were done in three cotton zone of Cameroon, Laïndé Massa in the North, Kilwo in the Far North and Tapi in the Adamaoua regions. The objective of this study was to evaluate the degree of appropriation of direct-seeding mulch-based cropping (DMC) systems, identify the problems that influence this appropriation and the consequences of no-appropriation in the cotton zone of Cameroon. The result showed that producers of the study sites were facing several difficulties which impeded the appropriation of DMC systems. These difficulties were landownership issues, financial difficulties resulting in significant financial means necessary for the implementation of DMC systems, the decrease in a radical way of subsidies from the ESA (Eau-Sol-Arbre) project, the difficulty in repayment of loans contracted during agricultural campaigns at the SODECOTON and high land rental costs. The consequences of no-appropriation of DMC systems were the continuous degradation of agricultural soils and decline in soil fertility, due to the acceleration of water and wind erosion, the clean of fields by fire and the practice of inappropriate farming techniques. The model of

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diffusion of DMC systems in family agriculture proposed by the ESA project cannot be generalized and applied to different contexts and must take in different causes of its no-appropriation identified here for its adoption.

Keywords: Appropriation; producer; direct-seeding mulch-based cropping system; cotton zone; Cameroon.

1. INTRODUCTION

Sub-Saharan Africa over the past two decades has been facing several problems including soil degradation [1,2]. It is one of the biggest environmental problems affecting millions of people living in this region, especially those living in rural areas [3]. About 5 to 7 million hectares of arable land are lost every year because of runoff and erosion [4]. In addition, soils are particularly threatened in the current context of high population growth and increased pressure on resources prevailing in the concerned regions [5]. The cotton zone of Cameroon is also confronted with this phenomenon of land degradation. The process, maintained by climate variability and high pressure on land, is at the base of the appearance and extension of bare and crusted spaces, unable to sustain agricultural and pastoral activities [6,7]. Faced with these environmental issues, it is urgent to realize and change behaviour and aggressive practices on the environment, particularly in agriculture [6-8]. To meet these challenges, new agricultural techniques have been developed, notably the Conservation Agriculture (CA) that favour the preservation of the productive capacity of the soil while seeking to enhance yields and/or producers' incomes [9-11]. It is in this context that direct-seeding mulch-based cropping (DMC) systems were introduced in the cotton zone of Cameroon since 2002 [12]. Experimentation of DMC systems have shown to be technically adapted to develop an innovative and sustainable agriculture [13-15]. It helps to improve soil organic matter (SOM) content, better management of weed, soil water and reducing erosion without compromising food grains production [7,16,17]. However, it is noted that despite the benefits both from agronomic and environmental view points, and efforts made for its dissemination by the Cotton Development Company of Cameroon (SODECOTON) through the ESA (Eau-Sol-Arbre) project of the Ministry of Agriculture and Rural Development for 4 years, the delay in DMC system to settle in the cotton zone and its appropriation is still limited [18].

Since the DMC systems have been introduce in Cameroon, no study has been done to appreciate the degree of their appropriation. Though, several studies related to the adoption of DMC have been done in the world. Factors such as limited access to land, weak land tenure arrangements, limited technical knowledge, limited support from extension agencies, poor access to inputs and markets, and smallholders' need for immediate returns to investment are considered as key constraints preventing the adoption of CA [19]. More generally, factors influencing farmers' decision-making are local land degradation and production costs issues, involvement of local elites, markets for secondary crops [20]. In Vietnam, small region were reluctant to adopt DMC due to the extra labor and input required to implement these techniques during the first years, which hampers their economic performance [21].

The objective of this study is to evaluate the degree of appropriation of DMC systems by local producers, identify the problems that influence this appropriation and the consequences of no-appropriation in the cotton zone of Cameroon.

2. MATERIALS AND METHODS

2.1 Study Sites

The cotton zone of Cameroon covered three administrative regions namely North, Far North and part of the Adamawa whose regional capitals are respectively Garoua, Maroua and Ngaoundere (Fig. 1). Three study sites corresponding to the ESA Project village tests were chosen, including Laïndé Massa in the North, Kilwo in the Far North and Tapi in the Adamaoua (Fig. 1).

Laïndé Massa site is located in the North region (8°13'0'N; 13°25'60"E). It has a Sudanese climate type, characterized by five to six months of rainy season, with a total rainfall ranging from 800 to 1000 mm, an average temperature and evapotranspiration of 28°C and 168 mm/month

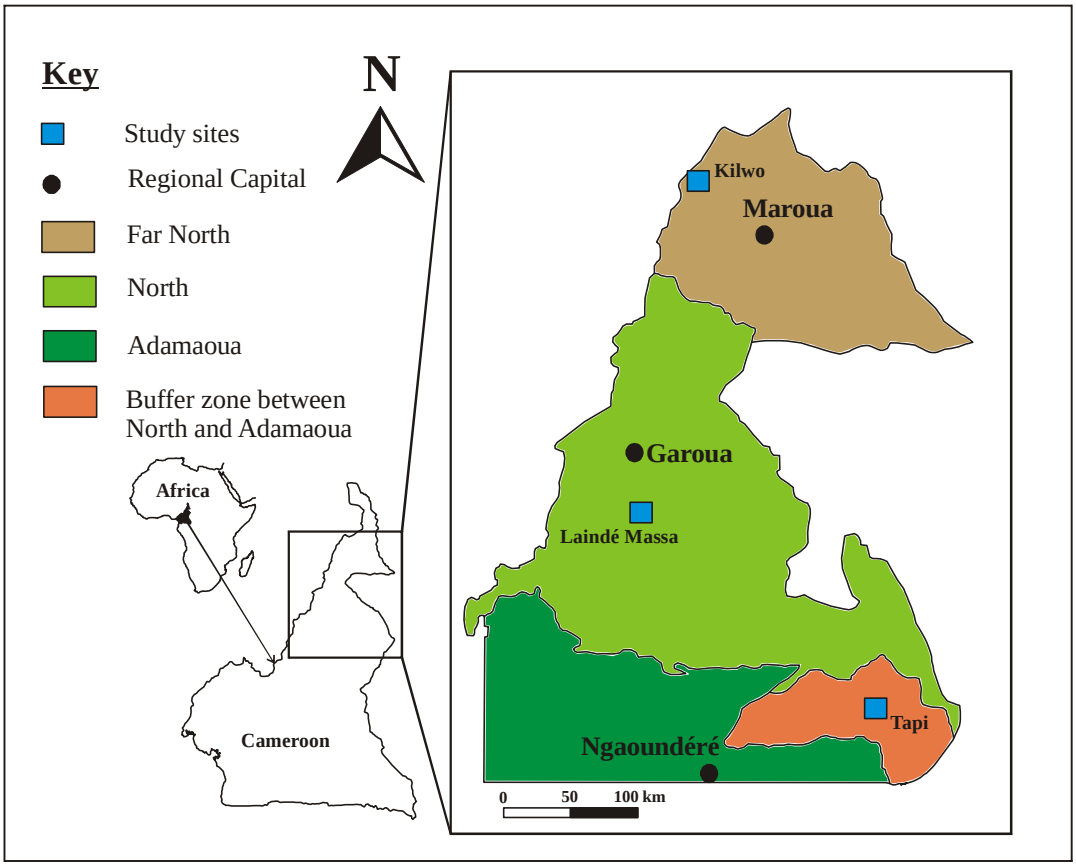

Fig. 1. Location of the study sites
(Source: SODECOTON archives, 2014)

respectively and an annual insolation of about 2800 hours [22]. The pedological cover is mainly constituted of vertisols and ferruginous tropical soils [23]. The vegetation is a sudanese savannah [24] with here and there a clear appearance, degraded around villages [25].

Kilwo site is located in the Far North region of Cameroon (10°39'N; 13°59'E). It has a sudano-sahelian climate, characterized by a rainy season of four months with a total rainfall of about 700 to 850 mm, an average temperature and evapotranspiration of 28°C and 173 mm/month respectively, and an annual insolation of 2800 hours [22]. Soils are mainly vertisols, ferruginous tropical soils and lithosols [23]. The vegetation is a savannah [24].

Tapi site is a buffer zone between the North and the Adamawa regions (7°22'11"N; 14°31'47"E). It is then under the influence of two types of climates which are sudanese climate of the northern part and the mountain climate of Adamawa plateau. The rainy season has more than six months with a total rainfall of 1250 to 1500 mm/year, an average temperature and evapotranspiration of 25°C and 144 mm/month respectively and an annual insolation of 2500 hours [22]. Soil types include red ferrallitic soils sometimes indurated on the interfluves and hydomorphic soils along rivers [26]. The vegetation is a woody Sudanese savannah with here and there a clear appearance forest [24].

2.2 Data Collection and Analysis

Field works consisted firstly to evaluate the number of producer in each site. There were a total of 285 in the three study sites, 100 in Laindé Massa, 96 in Kilvo and 89 in Tapi. Of these 285 growers, 267 were interviewed, 93 in Laindé Massa, 90 in Kilvo and 84 in Tapi (Table 1). The approaches used were mainly based on field surveys. These surveys were done in the local language (Fulfulde) during one month. A pre-testing of questionnaires for validation was done.

In each site, questionnaires were administered semi-openly. Questions were closed for quantified information and open for information requiring an understanding of the logic and reasoning of the producer. They focused mainly on the functioning of DMC systems, methods of dissemination of DMC systems, issues that limit appropriation of DMC systems and the consequences of no-appropriation of this system on the environment. After data collection, Microsoft Excel and SPSS software were used to type and analyze data. All the respondents participated in each questionnaire. In the counting phase, responses were classified and corresponding percentages were calculated, based on the number of respondents. In this study, statistical analyses were about descriptive statistics, focused on frequency and mean essentially.

Table 1. Representation of producers in the study sites

Study sites	Number of producers	Number of producers surveyed
Kilwo	96	90
Laindé Massa	100	93
Tapi	89	84
Total	285	267

3. RESULTS

3.1 Factors Limiting Appropriation of DMC Systems in the Study Sites

The appropriation of DMC techniques in the cotton zone of Cameroon is confronted with several problems. These problems are amongst other things land ownership, financial, socio-cultural and problems related to the support of the ESA project.

3.1.1 Land ownership

Land ownership constraints experienced in the study sites are presented in Table 2. The survey results showed that in Kilwo and Laindé Massa, 78% and 64% of respondents respectively were not landowners. On the contrary, in Tapi, 58% of the respondents were landowners. The percentage decreased with latitude from Kilvo to Tapi. When a producer is not a landowner, he is afraid of losing a parcel on which he gave his energy and time to rehabilitate, since DMC need high investment. Globally, land ownership is an important constraint that greatly influences the appropriation of DMC systems. Landowners represent only 39% in the cotton zone of Cameroon.

Table 2. Repartition of producers according to land ownership in the study sites

Study sites	Non owners	Owners
Kilwo	78%	22%
Laindé Massa	64%	36%
Tapi	42%	58%
Mean	61%	39%

3.1.2 Financial constraints

Financial constraints experienced in the study sites are presented in Table 3. The results show that in Kilwo and Laindé Massa sites, 96% and 78% of respondents respectively, claimed that they needed substantial financial means for the implementation of the DMC system. In Tapi on contrary, this was affirmed only by 66%. In order to facilitate the implementation of the DMC system, the ESA project needed to concede some subsidies to producers. The radical decrease of these subsidies was one of the financial difficulties affecting the appropriation of DMC system. It was expressed by 79% of respondents in Kilwo, 75% in Laindé Massa and 52% in Tapi. Also, the difficulty in the reimbursement of credits (credits for plant protection products, fertilizer and cover plant seeds) contracted during agricultural campaign at the SODECOTON was one of the financial difficulties that affect the degree of appropriation of DMC systems in the cotton zone of Cameroon. It was more expressed in Kilwo and Laindé massa (83% and 80% respectively) than in Tapi (75%). The high cost of renting land was also one of the financial constraints evoked by producers. It was more pronounced in Kilwo and Laindé Massa sites (93% and 90% respectively) than in Tapi where only 45% of surveyed producers mentioned this issue as a main constraint. Globally, financial constraints in the implementation of the DMC system in cotton zone of Cameroon were due to financial means (80%), radical decrease of subsidies (69%), difficulty in the reimbursement of credits (79.33%) and the high land rental costs (76%).

3.1.3 Sociocultural constraints

Sociocultural constraints experienced in the study sites are presented in Table 4. Survey results indicated that the poor distribution of crop areas by local leaders was a major obstacle.

Traditional authority which was highly respected and highly feared by the population in these areas, had powers on all land and could allocate crop areas to whom he wants and recovered it when he wants. This issue was expressed by 85% of producers in Kilwo, 80% in Laindé Massa and 82% in Tapi. Conflicts between producers and breeders were one of the constraints that influence the degree of appropriation of DMC systems expressed in the study sites. This issue was more expressed in Tapi (84%) than in the other sites (69% in Kilwo and 75% in Laindé Massa). Practice of traditional techniques had also, an influence on the appropriation of DMC systems. These traditional techniques, although could not provide optimal yields, did not need much investigations for their implementation. The influence of this issue was expressed by 65% of producers in Kilwo, 70% in Laindé Massa and 78% in Tapi. The most important sociocultural constraint was the poor distribution of crop areas (82.33%). This issue was followed by conflicts between producers and breeders (76%) and the practice of traditional techniques (71%).

3.1.4 Influence of the technical support of the ESA project

Survey results relating to the support of the ESA project are presented in Table 5. They showed that the poor organization of technical monitoring greatly influenced the degree of the appropriation of DMC systems. It was more expressed in Laindé Massa site (75%) than in Kilwo (64%) and Tapi (63%). In addition, producers affirmed that there was a lack of awareness on the DMC systems. This issue was expressed by 48% in Laindé Massa, 43% in Kilwo and 40% in Tapi. Globally, the poor organization of technical monitoring and the lack of awareness on the DMC systems were respectively expressed by 67% and 44% of producers in the cotton zone of Cameroon.

3.2 Consequences of No-appropriation of the DMC system on the Environment

Concerning the environmental consequences of no-appropriation of the DMC system, famers perceived on the basis of their local knowledge the continued degradation of agricultural soils and decline in soil fertility. This was due to three issues namely acceleration of water and wind erosion processes, cleaning of fields by fire and inappropriate farming techniques (Table 6). The acceleration of water and wind erosion processes was more expressed by producers in Tapi (82%) and Kilwo (77%) than in Laindé Massa (65%). The cleaning of fields by fire was expressed in the same order as the acceleration of water and wind erosion processes. This issue was highly expressed in Tapi (90%) and Kilwo (88%) than in Laindé Massa (76%). Practice of inappropriate farming techniques on the contrary was weakly expressed globally than the two other issues. It was more expressed in Laindé Massa (56%) than in the two other sites (42% in Tapi and 38% in Kilwo).

Table 3. Influence of financial issues on DMC systems ownership in the study sites

Study sites	Important financial means for DMC systems implementation	Radical decrease of subsidies	Difficulty in loans repayment	High rental cost
Kilwo	96%	79%	83%	93%
Laindé Massa	78%	75%	80%	90%
Tapi	66%	52%	75%	45%
Mean	80%	69%	79,33%	76%

Table 4. Influence of socio-cultural issues on DMC systems ownership in the study sites.

Study sites	Poor distribution of crop areas by local leaders	Conflicts between producers and breeders	Ancient agricultural techniques
Kilwo	85%	69%	65%
Laindé Massa	80%	75%	70%
Tapi	82%	84%	78%
Mean	82,33%	76%	71%

Table 5. Influence of the technical support of the ESA project issues on DMC systems ownership in the study sites

Study sites	Lack of awareness about the DMC systems	Poor organization of the technical monitoring
Laindé Massa	48%	75%
Kilwo	43%	64%
Tapi	40%	63%
Mean	44%	67%

Table 6. Consequences of non ownership of the DMC system on the environment

Study site	Acceleration of water and wind erosion processes	Cleaning of fields by fire	Inappropriate farming techniques
Laindé Massa	65%	76%	56%
Kilwo	77%	88%	38%
Tapi	82%	90%	42%
Mean	75%	85%	45%

Ultimately, the cleaning of fields by fire was the main cause of land degradation in the cotton zone of Cameroon. It was expressed by 85% producers. It was followed by the acceleration of water and wind erosion processes (75%) and more weakly by the practice of inappropriate farming techniques (45%).

4. DISCUSSION

The results revealed that landownership, financial constraints, sociocultural constraints and influence of the technical support of the ESA project were issues that influenced the degree of appropriation of DMC techniques in the cotton zone of Cameroon.

Landownership influence was felt by the fact that many producers are not owners of their plots. Indeed, the non-landowner was not certain that he could cultivate the land for several consecutive years. There was thus no motivation to invest time and money to improve fertility or limit erosion if he was not sure of getting a return on investment after several years [27]. This was in line with Giller et al. [28] who considered land security as favourable condition for the appropriation of DMC systems by small African producers. They rarely practiced DMCs on plots with high land insecurity [28]. According to Balarabe et al. [12], investments made during the period of implementation of DMC systems could only be recouped after a few years. It was therefore imprudent for producers to invest on land which did not belong to them and where they could abandon in a short term.

Public lands, community land and land cultivated through different modes of attribution (sharecropping or rental) were part of the land on which the appropriation of DMC systems is still rare or nonexistent [29]. In addition, rental agreement on some plots also limited investments since it was renewed over several years, or even every year [27]. However, in the Tapi site, almost all producers were owners of their plots. This was in line with Giller et al. [28] who clearly illustrates that in the southern part of the cotton zone, land pressure was not strong as in other territories of the cotton zone. In this area, it could still be found uncultivated land waiting to be cleared. Moreover, in this context of very strong land availability, DMC systems were of less interest than the very extensive systems based on slash and burn that did not require major investment, excepted in work before the rainy season [3]. However, it was important to note that these important uncultivated lands waiting to be cleared attract many people from other lands to migrate to this area. Land ownership thus greatly influenced the degree of DMC system appropriation according to our results, which were contrary to those of Knowler and Bradshaw [20], for who the factor "no owner" had no influence on the degree of the appropriation of DMC systems.

The significant financial means necessary for the implementation of DMCs had a strong influence on the degree of appropriation of DMC systems [30]. The use of chemical inputs (fertilizers, herbicides, insecticides, fungicides ...), the specific equipment (sprayers) and the seeds obliged producers to mobilize capital during the first years of the implementation of DMC systems [31]. However, their low investment capacities did not permit equipment access nor necessary

inputs [32]. According to Naudin and Balarabe [33], DMC systems required inputs sometimes of more important cost at the beginning, and so, could be a constraint to the appropriation of DMC systems. On one hand, producers living in conditions of relative precariousness remained wary about technical innovations. They were generally in risk minimization logic. It would therefore be futile to encourage them to adopt DMC systems as doubts persist about the technical and economic efficiency of these systems [34]. On the other hand, those with limited capital were usually compelled to think in short term, which probably constituted a brake to the adoption of DMC systems [28]. This was illustrated by the fact that some producers preferred burning plant residues plots. Indeed, the ash obtained interested them because it directly affected yields of the current agricultural campaign.

Access to credit was often considered as an alternative to the lack of capital [35]. Some producers had subsidies during the period of on-farm trials in order to facilitate the appropriation of DMC systems. These subsidies had decreased during the diffusion period that was the phase during which the project wanted to permit mass adoption of DMC system. This decrease was quickly felt by producers due to their precarious situation [36]. But, according to Seguy and Raunet [32], the influence of the decrease of subsidies from the ESA project was negligible, since producers must be able to manage themselves through the producer groups (PG) made available to them. As for the reimbursement of credits contracted during agricultural campaign at the SODECOTON, being a membership of PG was a condition for granting loans to producers. PG enabled them to better monitor and ensured the recovery of credits [37]. However, despite the credit system set up, it often happened that the producer could not respect their due. This might be due to lower agricultural yields and higher production costs during the implementation phase of DMC systems which might influence and weigh on their incomes. In addition, the decline in agricultural yields due to climatic hazards and operational failures of the other PG would not permit to them to respect their due [33]. According Giller et al. [38], the dysfunction of PG generally concern the late arrival of chemical inputs and processing equipment against weeds (sprays), which could delay the achievement of farm work and thus compromising crop yields. DMC systems required high use of fertilizers and pesticides to fit the needs of different plants and crop associations, limit nitrogen hungers, control weed growth when the labour was expensive and less available for weeding and seeds treatment [28]. The high land rental cost was just a consequence of land problem that is felt at the level of finance [32].

Socio-cultural issues also influenced the degree of appropriation of DMC systems. This influence was felt through poor distribution of crop areas by local leaders, conflicts between producers and breeders, and practice of traditional agricultural techniques. The traditional authority that was highly respected and highly feared by the population in these areas had power over all lands and therefore could allocate the agricultural spaces to who he wants and recovered it when he wants. These results corroborated with those of Chabierski et al. [39] in Madagascar. Moreover, interference between administrative authorities and customary land law on one hand and the modern state land laws on the other hand were complex, confusing and progressive; they created a space of "confusion management" favourable to opportunistic behaviours and rentiers, strongly influenced by local power relations and the politicization of the competition for land [40]. Deficiencies of grazing and bush fires limited the interest of DMC system and might discourage producers to sustain the DMC system. In such context, it was difficult to keep the mulch and this could lead to conflicts, particularly between producers and breeders, in line with Dongmo et al. [40] observations. There were sometimes very violent conflicts for biomass allocation after harvest if producers wanted to book some mulch for their cattle and for DMC system [41]. These conflicts were also due to a lack of regulation regarding the grazing of cattle in most villages where livestock was allowed to freely graze crop residues immediately after harvest season [42,43]. Better integration agriculture-livestock-natural spaces must be sought for fodder use of crop residues and vegetation cover [44]. Communities would then define the collective rules designed to protect the vegetation cover (wandering animals, bush fires). It was also to better manage the existing biomass and increase its production so that its use by the DMC system was not done in the detriment of livestock [45]. Producers of the study sites were still attached to ancient traditional techniques. According Raunet et al. [37], this attachment was explained by the fact that the majority of producers still did not master the DMC techniques due to their complexities.

This complexity was usually felt by the conduct of the cover crop, especially when there was a live cover. Managing a live cover in fact implies knowledge and the choice of appropriate herbicides according to the main crop in place, cover crop, weather conditions and potential weeds.

Technical support of the ESA project had a strong influence on the degree of appropriation of DMC systems [46,47]. This influence was felt through poor organization of the technical monitoring and lack of awareness about the DMC systems. Participatory intervention methods but in fact too planned, did not promote adequate implementation of advice actions beside producers. Consultation frameworks proposed at the end of diagnoses and support missions have remained at the stage of recommendations [40]. Moreover, it would also have been interesting to assess the functionality of the DMC system and the types of DMC system actually set up in the study site. The proper functioning of DMC systems and their integration in farms required good technical knowledge and involved a major transformation of agricultural practices and production systems [43,48]. Given the complexity of this innovation in technical and managerial terms, its diffusion must be accompanied by initial support and advice in duration. Surveys showed that many of them did not have enough information on the DMC systems. This lack of information was expressed at the farm level by hesitations or by the existence of many different producers' perceptions on this technical innovation. Regarding hesitation, it incited in most cases to continue the practice of conventional agriculture [49]. Only the relatively wealthy producers could invest in technical innovations relatively unknown because they had the capital and risk-taking capacity required [50]. Concerning the various perceptions on DMC systems, they resulted from the misunderstanding of this technical innovation, which might make producers reluctant [40].

5. CONCLUSION

Field investigations had shown that producers of the study sites were facing several difficulties which did not allow the easy appropriation of the DMC systems in the cotton zone of Cameroon. These difficulties were landownership issues, financial difficulties resulting in significant financial means necessary for the implementation of DMC systems, the decrease in a radical way of subsidies from the ESA project, the difficulty in repayment of loans contracted during agricultural campaigns at the SODECOTON and high land rental costs. In addition, socio-cultural constraints were felt through poor distribution of crop areas by local leaders, conflicts between producers and breeders and practice of ancient traditional agricultural techniques. Problems of support from the ESA project were felt through the poor organization of technical monitoring and lack of awareness on DMC systems. Consequences of no-appropriation of the DMC systems on the environment were continued degradation of agricultural soils and decline in soil fertility. They were due to the acceleration of water and wind erosion, the clean of fields by fire and the practice of inappropriate farming techniques. In this context, it was clear that the issue of appropriation of DMC systems remained a critical issue for sustainable management of soil resources in the cotton zone of Cameroon. The model of diffusion of DMC in family agriculture proposed by the ESA project could not be generalized and applied to different contexts and must take in different causes of its no-appropriation identified here for its adoption.

ACKNOWLEDGEMENTS

The authors wish to thank the SODECOTON authorities in Maroua who provided the internship. They are indebted to anonymous reviewers for their constructive remarks that substantially improved the quality of the paper.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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