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Farmers' perception of sorghum - cowpea production under cropping systems, water and organo-mineral fertilizer management in the Centre-West Region of Burkina Faso

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Keywords

Consent to adopt, household farm, cropping system, tillage.

Abstract

Land degradation associated with soil moisture and fertility stresses and declining agricultural productivity are negatively impacting crop production in the sudano-sahelian agroecological zone of West Africa, particularly in the Centre-West Region of Burkina Faso. In this part of the country, sorghum-cowpea intercropping is one of the major cropping systems. The objective of this study was to assess farmers' perception of sorghum and cowpea production in intercrop system under tillage methods and organo-mineral fertilizers and their consent to adopt technologies from research in the Centre-West Region of Burkina Faso. To achieve such objective, a survey involving 82 sorghum-cowpea producers selected from three (03) villages was realized using a semi-structured questionnaire. Sixty-three (63%) of the interviewed farmers consented to adopt any production practice that combined tillage and cropping system with fertilization which will help them achieve their production objectives. Results also indicated that socio-economic characteristics such as gender, membership of a farmer organization, training on microdose application, availability of agricultural equipment, livestock and availability of cultivable land are the major factors influencing the farmers' consent to adopt technologies. Results from this survey could guide agricultural policy-makers when designing good production practices to promote the dissemination of technologies and their adoption by farmers.

1. Introduction

Burkina Faso is an agricultural country whose economy is based on agriculture (INSD, 2022). However, like other countries in the world, Burkina Faso is facing many constraints such as precariousness of the agroecosystem. Indeed, the soils in the country are naturally poor in organic matter, particularly in essential nutrients including nitrogen and phosphorus (Pallo et al., 2009; Bationo *et al.*, 2011; CILSS, 2012). The situation is accentuated by soil degradation due to the continued exploitation of natural resources, land pressure, climate change and sometimes non-adapted farming practices which negatively affect soil fertility (Koulibaly *et al.*, 2016; Ouédraogo and Thiombiano, 2017). In addition, the displacement of rural populations due to the insecurity in the country is negatively affecting the agricultural sector. In fact, farmers are quitting their native villages with arable land for more secured areas but with insufficient and poor lands, leading to land pressure in the host areas. Furthermore, the irregularity and poor distribution of rainfall negatively affect crop productivity (Ouédraogo *et al.*, 2020). As a result, populations are unable to achieve food security (FAO, 2017).

The Sudano-sahelian zone of Burkina Faso is facing this precarious situation linked to the decline in soil fertility, low or irregular rainfall and demographic pressure on arable land (Kohio *et al.*, 2017). Sorghum-cowpea intercropping is one of the major cropping systems in the Sudano-sahelian agroecology of Burkina Faso, but this cropping system has recently succumbed to declining soil productivity, largely attributed to soil moisture and fertility stresses.

Convincing agronomic practices including water and soil conservation techniques, tillage, organic and mineral fertilization to improve crop productivity have been developed and recommended to farmers (Bado, 2002; Somé *et al.*, 2015; Halidou, 2017; Palé *et al.*, 2021; Zongo *et al.*, 2021; Koumbem *et al.*, 2023). Previous works showed the contribution of combined tillage, fertilization and cereal-legume system to improving crop yields (sorghum, millet, corn and cowpea). In the Sudano-sahelian zone of Burkina Faso for example, Palé *et al.* (2021) reported the beneficial effect of ploughing in increasing pearl millet yields from 266 to 635 kg $ha^{-1}$for grains and 381 to 601kg ha^{-1} for stover. Ouédraogo *et al.* (2020) showed in a study conducted in a farmer environment, that a technological package composed of stone lines, zaï and NPK + urea generated additional yields in sorghum grains ranging from 5.66% to 44.45% in 2018 and from 25.15% to 53.80% in 2019 compared to farmer practice. Furthermore, Zongo *et al.* (2021), reported a significant increase of +10 to 58% in total grain yields of sorghum and cowpea compared to sole sorghum and high efficiency of nutrient acquisition by sorghum associated with cowpea. But it is clear that these technological packages introduced in the farmers' areas are little or not used by farmers, thus limiting adoption. This low adoption of technological packages could be related to the fact that farmers' perception of new technologies are poorly investigated and understood.

Thus, the question of how farmers (first users of improved farming techniques) perceive these new technologies merits an investigation.

Through a survey, the present study attempts (1) to learn and capitalize the farmers' perception of the use of cropping systems with different soil amendments under different water management methods in sorghum-cowpea fields and (2) to evaluate their consent to reproduce those technologies in the Centre-West Region of Burkina Faso.

2. Methodological Approach

2.1 Study site

The survey was realized in three villages surrounding the Saria Environmental and Agricultural Research Station. The Saria Environmental and Agricultural Research Station (12° 16' N lat; 2° 09' W long) in the province of Boulkiemdé is located 80 km West of Ouagadougou, the capital of Burkina Faso. The three villages covered were Nandiala, Saria (research station location site) and Villy with a mean distance of six (06) km from the research station (Figure 1).

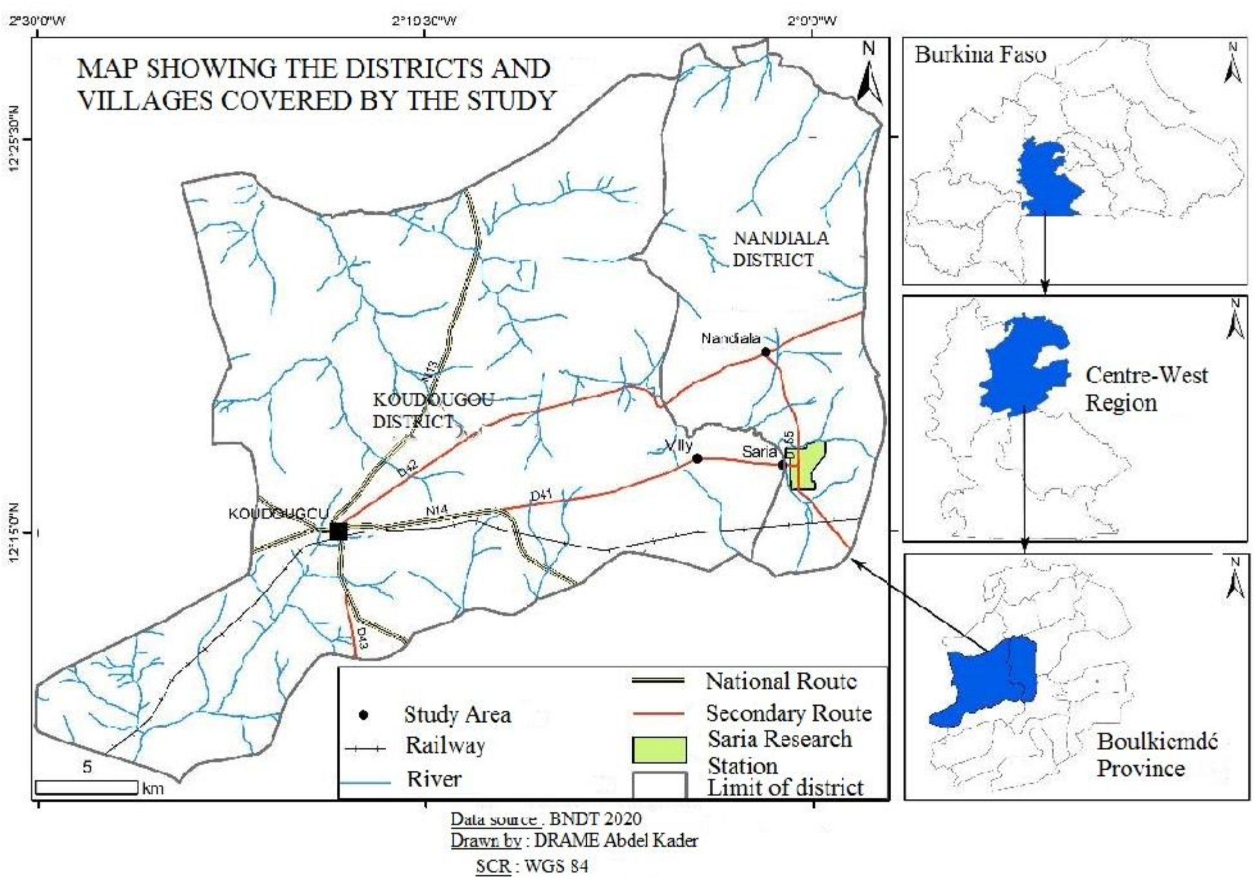

Figure 1. Villages covered by the study

The area is located in the sudano-sahelian climatic zone, characterized by a short rainy season from May to October and a dry season from November to April (Figure 2).

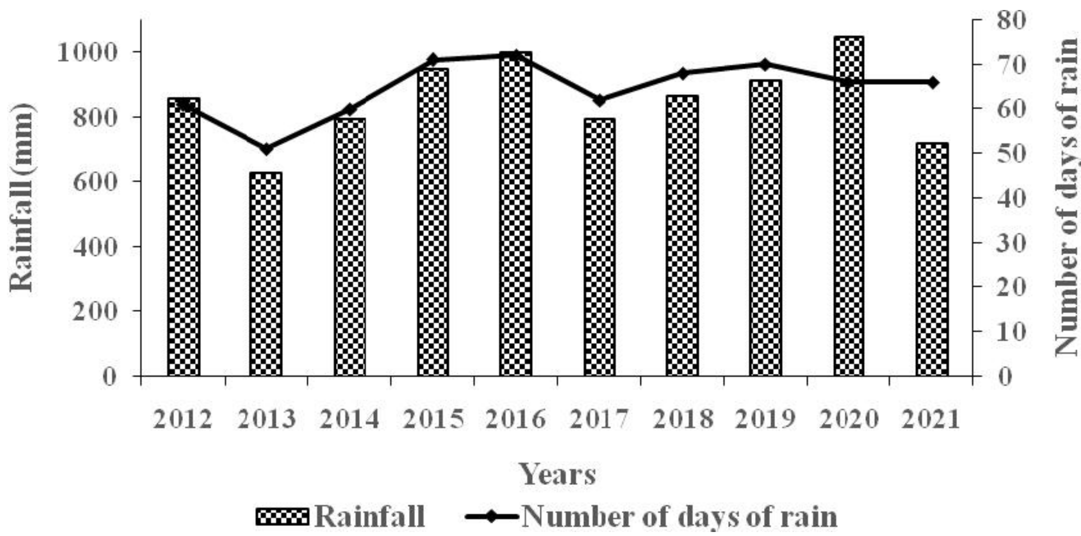

Figure 2. Annual rainfall and number of days of rain recorded for the past ten years (2012-2021) in the study area

2.2 Sampling of interviewed farmers

The approach of this study consisted of carrying out a survey involving farmers who participated in field days organized in on-farm experiments conducted by their fellowships. These fellowships had prior participated in on-station experiment field day organized the first year (2020) of the experiment. During this on-station experiment field day, participating farmers were invited to score each technology (treatment) combining tillage method and cropping system with soil amendment (organic and/or mineral fertilization). These scores were used to rank the treatments and thereafter eight of them were experimented in farmers' fields in 2021. The interviewed farmers in this study were prior invited to participate in field days organized in these on-farm experiments in 2021. Three villages where on-farm-experiments were conducted were then involved in the study. For a total of 90 farmers (30 per village) initially expected as the sample size for the study, only 82 farmers total including male and female for the three villages participated in the survey.

2.3 Data Collection

Data were collected through a survey questionnaire directly administrated to individual farmer in all three villages covered by the study. The unit of observation was each household and the respondent was the farmer (male or female), responsible or involved in decisions to be taken regarding farm management. Information collected from the direct interview was completed by direct observations in the field. The evaluated parameters focused on the socio-economic characteristics of farmers, the agronomic and socio-economic interests of legume-cereal intercropping systems, the difficulties in managing intercropped plots, the consent of the farmer to adopt new technologies and the explanatory factors of the adoption.

2.4 Data analyzes

Data processing was performed using Sphinx software. Descriptive statistics (means, standard deviations, proportions) were generated by the same software. The processed data from Sphinx software were exported to a Microsoft Excel spreadsheet and then analyzed with the SPSS Statistics software version 20. The procedure consisted of putting into perspective the relationships between the different variables using descriptive statistics and independence Chi-square test at the 5% threshold. This procedure aimed to pull out the determining factors of perception and consent to adopt the most profitable technologies.

3. Results

3.1 Sociodemographic and economic characteristics of farmers

The results from the survey indicated that more than half (51.20%) of the farmers interviewed were women compared to 48.80% for men (Table 1).

Table 1. Socio-demographic characteristics of farmers, Nandiala, Saria and Villy, Burkina Faso

Social characteristics		% of respondents
Gender	Female	51.20
	Male	48.80
Age (years)	Less than 39	35.40
	40 to 59	54.90
	more than 60	09.70
Schooling	Not Schooled	78.00
	Schooled	22.00
Main activity	Agriculture	100
Nature of family labor	Household workers	98.80
	Rental	57.30
	Mutual Assistance	40.20
Household size (number of individuals)		9.68
Average number of household workers		5.14
Average size of cultivable land (ha)		04
Availability of cultivable land (ha)	< 6	80.50
	6 - 12	9.80
	12 - 18	4.90
	18 - 24	1.20
	24 - 30	2.40
	> 30	1.20
Number of plows	0	64.60
	1	29.30
	2	6.10
Number of riggers	0	91.40
	1	8.60
Number of Manga hoes/weeders (0 to 2)	0	70.40
	1	28.40
	2	1.20
Average number of poultry		10.20
Average number of sheep		3.77
Average number of goats		4.12
Average number of draft animals		0.18
Average number of beef cattle		0.52

Source: Data from survey conducted by Mahamoudou KOUMBEM in 2022

The average age of the interviewed farmers was 44 years. Educated farmers represented less than a quarter of interviewed farmers in this investigation. The labor used is mainly composed of household active members. Agriculture appeared to be the main activity for the respondents. The average household size is around 10 individuals with five (05) active members in average. In terms of arable land availability, more than 80% of respondents possessed less than 6 ha. The average cultivable and available land per farmer was approximately 4 ha.

Regarding farm equipment, the survey revealed that none of the interviewed farmer owned a tractor. The number of farmers who possessed plows were estimated 35.4%. In these 35.4%, 29.10% were owners of one plow and only 6.10% owned two plows. Results indicated that only 8.60% of the respondents had a rigger. Concerning the manga hoes/weeders (animal drawn hoes used for scarifying and weeding), the survey revealed that 70.40% of farmers did not have these tools and the rest few respondents had one or two.

In terms of livestock availability, the survey indicated that the average number of draft animals per farmer was 0.52 and that for beef cattle was 0.18. The average number for both sheep and goats possessed by the respondents was between 3 and 4.12. Results from the survey revealed an average number of ten heads per farmer for all poultry.

Nearly 83% of respondents practice the cereal-legume intercropping system (Table 2). The type of crop association practiced is mainly mixed pocket planting (cited by 76.80%).

Table 2. Economic characteristics of farms, Nandiala, Saria and Villy, Burkina Faso

Economic characteristics of farms		% of respondents
Food self-sufficiency	No	95.10
	Yes	4.10
Causes of production deficit	Low soil fertility	78.00
	Land degradation	56.10
	Low arable soil availability	41.50
	Drought	79.30
	Flooding	8.50
	Insect damages on crops	17.10
	Low labor	26.80
	Lack of knowledge on innovative technologies	14.60
Practice of cereal-legume intercropping system	No	17.10
	Yes	82.90
Method of cereal-legume intercropping	Same hill	76.80
	Alternated hills	9.80
	Alternated rows	1.20

Source: Data from survey conducted by Mahamoudou KOUMBEM in 2022

Regarding the level of production, the study indicated that less than 5% of interviewed farmers had declared sufficient their food production during the rainy season 2021-2022 to cover the family's food requirements. The deficits in food production were mainly associated with soil degradation and low soil fertility, drought and insufficient cultivable land.

3.2 Farmers' perception of the performance of innovative technologies and their consent to adopt those technologies

Results showed that farmers had a good appreciation of innovative technologies (Table 3).

Table 3. Farmers' perception and motivations for different innovative technologies,Nandiala Saria and Villy, Burkina Faso

Perceptions and motivations for technologies		% of respondents
Overall perception of technologies	Bad	0.00
	Medium	14.60
	Good	40.20
	Excellent	45.10
Could the scaling-up of these technologies lead to the self-food security achievement?	No	0.00
	Yes	100.00
Are you willing to adopt these innovative technologies ?	No	36.60
	Yes	63.40
Why do you want to adopt these technologies?	Improvement of crop productivity	61.00
	Improvement of soil fertility	20.70
	Reduction of risks of production failures due to climatic shocks	30.50
	Balanced diet	54.90
	Other reasons	2.40

Source: Data from survey conducted by Mahamoudou KOUMBEM in 2022

In fact, 45.10% of farmers believed that these technologies were excellent in terms of improving agricultural productivity and achieving food self-sufficiency. Also, 40.20% of farmers affirmed that the technologies were suitable for meeting their production objectives. Specifically, more than 60% of respondents believed that these technologies could improve crop productivity. In addition, more than 30% believed that adoption of these technologies could contribute to reducing the risks of production failures and coping with rainfall variability. Furthermore, more than 54% affirmed that these new introduced technologies by researchers which combine cereals and legumes are a good way in diet balance assurance. All respondents believed that the scaling-up of these innovative technologies could contribute to the achievement of food self-sufficiency. Nearly two thirds (63%) of interviewed farmers have agreed that adoption of innovative technologies could result in household's agricultural productivity improvement, food security achievement and food nutritional quality improvement. Among the eight technologies tested in the farmers' environment, five of them were found to be the most efficient and profitable according to the respondents (Table 4).

Table 4. Farmers' perception of the performance of innovative technologies and their consent to the adoption of promising technologies, Nandiala, Saria and Villy. Burkina Faso

Tested technologies	Perception on performance	Consent to adoption	Amount consented (CFA ha^{-1})
	----------------%--------------		
TM1-CS2-SA3	0.00	0.00	-
TM1-CS4-SA4	4.90	3.70	55000 ± 35000
TM2-CS1-SA3	41.50	24.40	75000 ± 34641
TM2-CS4-SA4	53.70	41.50	72058 ± 44689
TM3-CS1-SA4	97.60	59.80	68469 ± 42158
TM3-CS3-SA4	96.30	61.00	70300 ± 42166
TM3-CS4-SA4	91.50	54.90	71333 ± 42885
TM4-CS4-SA4	13.40	8.50	75714 ± 62678

Source: Data from survey conducted by Mahamoudou KOUMBEM in 2022

Farmers' perception indicated that among the five technologies considered as best performing three of them were outstanding. These three technologies included TS3-SC1-AS4 (tied-ridging + cropping system alternating two lines of sorghum with two lines of semi-erect cowpea + compost + NPK + urea), TS3-SC3-AS4 (tied - ridging + cropping system alternating one line of sorghum with one line of semi-erect cowpea + compost + NPK + urea) and TS3-SC4-AS4 (tied-riding + cropping system alternating one line of sorghum with one line of creeping cowpea + compost + NPK + urea). In fact, more than 91% of farmers declared that these technologies had higher agronomic and economic values. Furthermore, 54 to 61% of farmers affirmed their willingness to adopt these last three technologies. The survey revealed that farmers consented to pay 68,000 to 71,333 CFA per hectare for the implementation of TS3-SC1-AS4, TS3-SC3-AS4 and TS3-SC4-AS4 technologies. Furthermore, 24 to 41.50% of farmers have agreed to adopt the TS2-SC4-AS4 (ploughing + cropping system alternating one line of sorghum with one line of creeping cowpea + compost + NPK + urea) and TS2-SC1-AS3 (ploughing + cropping system alternating two lines of sorghum with two lines of semi-erect cowpea + NPK + urea) technologies. However, these two technologies (TS2-SC4-AS4 and TS2-SC1-AS3) are relatively more expensive according to farmers who estimated that they could invest 72,000 to 75,000 CFA per hectare to implement them.

3.3 Explanatory factors of farmer's consent to adopt efficient technologies

The chi-square independence test at the 5% critical probability showed that the gender issue ($P = 0.002$), the proximity of the field to the house ($P < 0.001$), the fact of being a member of farmer group ($P = 0.024$), the availability of labor ($P = 0.03$), the fact of being trained in microdose technology ($P = 0.036$), the livestock size (in terms of number of heads)($P = 0.008$), the labor size ($P = 0.01$), the ownership of draft animals ($P = 0.05$), the size of available cultivable land (0.027) and the farmer's total agricultural production ($P = 0.031$) appeared to be the factors which significantly influenced the decision of the farmer regarding his consent to adopt or not the promising technologies (Table 5).

Table 5. Qualitative variables influencing farmers' consent to adopt technologies, Nandiala, Saria and Villy, Burkina Faso

Economic characteristics		Consent to adopt the technologies (%) No	Yes	Significance of the Khi-2 test at $p \leq 0.05$
Gender	Female	52.4	47.6	
	Male	20.0	80.0	0.002*
Schooling	Not schooled	34.4	65.6	
	Schooled	44.4	55.6	0.433
Literacy	Not literate	39.3	60.7	
	Literate	30.8	69.2	0.456
Vegetable production	No	40.8	59.2	
	Yes	30.3	69.7	0.232
Job except from farming	No	43.8	56.2	
	Yes	32.0	68.0	0.281
Proximity of the field to the house	Home field	13.9	86.1	
	Bush field	54.3	45.7	< 0.001*
Food self-sufficiency	No	35.9	64.1	
	Yes	50.0	50.0	0.568
Practice of cereal-legume intercropping system	No	50.0	50.0	
	Yes	33.8	66.2	0.252
Difficulty to store sorghum	No	33.3	66.7	
	Yes	50.0	50.0	0.214
Difficulty to store cowpea	No	34.2	65.8	
	Yes	55.6	44.4	0.210
Links with a financing institution	No	38.7	61.3	
	Yes	14.3	85.7	0.200
Belonging to a farmer organization	No	40.5	59.5	
	Yes	0.0	100.0	0.024*
Household workers	Not sufficient	45.9	54.1	
	Sufficient	9.5	90.5	0.030*
Training in microdose technique	No	40.0	60.0	
	Yes	0.0	100.0	0.036*
Training in tillage methods	No	37.8	62.2	
	Yes	25.0	75.0	0.474
Training in compost production	No	36.4	63.6	
	Yes	40.0	60.0	0.870
Training in intercropping system management	No	38.0	62.0	
	Yes	0.0	100.0	0.180

Source: Data from survey conducted by Mahamoudou KOUMBEM in 2022; * significant at $p \leq 0.05$

The results showed that male farmers were more willing to adopt efficient technologies to achieve their objectives than female farmers. In fact, more than 80% of men showed great desire to adopt technologies, while less than 50% of women were willing to adopt. Also, the survey results indicated that farmers who have their fields located far from their houses (bush fields) were more hesitant about adopting new brought technologies. Indeed, 86.1% of farmers who have home fields agreed to adopt the technologies compared to 45.7% of bush field owners. Furthermore, being membership in a professional farmers' organization, particularly an agricultural group, positively influenced farmer's consent to adopt technologies. All farmers who were members of an agricultural group consented to the adoption of promising technologies. Conversely, less than 60% of farmers who were not members of such organization were willing to adopt the technologies. The results revealed that the household labor size significantly influenced the farmer’s willingness to adopt technologies. All farmers who had more than 16 active individuals consented to adopt the new technologies proposed by researchers.

In addition, farmers who declared that their household active members were able to carry out all the agricultural activities of the household were more willing to adopt new introduced technologies. Results also showed that training in microdose technique is a good practice and way to enhance farmer’s knowledge and thus increase his willingness to adopt efficient technologies compared to those who did not have an opportunity to be trained in this fertilization technique. The chi-square test indicated independence of farmers' consent with the fact that they were trained or not in the practice of cereal-legume intercropping system ($P > 0.05$) and tillage methods ($P > 0. 05$). On the other hand, this test showed that the size of livestock possessed by the farmer was an explanatory factor of his willingness to adopt efficient technologies. In fact, farmers whose livestock size ranged between 21 and 80 heads largely agreed to adopt technologies (Table 6).

However, farmers who possessed fairly large livestock size (more than 121 heads) were not willing to adopt the technologies. Furthermore, the possession of draft animals for ploughing, seeding and ridging was a factor that positively influenced the consent of farmers to adopt or not the new technologies. The majority of interviewed farmers who had more than two draft animals were more willing to adopt technologies than those whose number of draft animals did not exceed one. However, farmers whose household sizes are in between 11 and 15 active members were not consenting to adopt the new technologies. The results also indicated that the cultivable land size owned by the farmer was also an explanatory factor of the farmer’s willingness to adopt efficient technologies. In fact, farmers who possessed more than two hectares of arable land were more willing to adopt new technologies compared to those with small and limited land size. Also, all interviewed farmers who possessed more than seven hectares had agreed to adopt the promising technologies.

Table 6. Quantitative variables influencing farmers' consent to adopt technologies, Nandiala, Saria and Villy, Burkina Faso

Socio-economic characteristics		Consent to adopt the technologies (%) No	Consent to adopt the technologies (%) Yes	Significance of the Khi-2 test at p ≤ 0.05
Cattle availability (number of heads)	0 to 20	47.2	52.8	0.008*
	21 to 40	7.1	92.9	
	41 to 60	0.0	100.0	
	61 to 80	42.9	57.1	
	≥ 121	100.0	0.0	
Household size	1 to 5	54.5	45.5	0.308
	6 to 10	36.1	63.9	
	11 to 15	28.6	71.4	
	16 to 20	25.0	75.0	
	21 to 25	0.0	100.0	
	26 to 30	0.0	100.0	
	31 to 35	0.0	100.0	
Number of household workers	1 to 5	47.4	52.6	0.011*
	6 to 10	10.5	89.5	
	11 to 15	100.0	0.0	
	16 to 20	0.0	100.0	
	21 to 25	0.0	100.0	
Experience in agriculture (number of years)	1 to 10	48.0	52.0	0.532
	11 to 20	31.2	68.8	
	21 to 30	38.5	61.5	
	31 to 40	20.0	80.0	
	41 to 50	50.0	50.0	
Availability of agricultural equipment	0 to 2	45.6	54.4	0.068
	3 to 4	13.3	86.7	
	5 to 6	25.0	75.0	
	7 to 8	0.0	100.0	
Draft animals	≤ 1	41.2	58.8	0.050*
	≥ 2	14.3	85.7	
Availability of cultivable land (ha)	0.5 to 1	46.4	53.6	0.027*
	1.25 to 2	56.5	43.5	
	2.25 to 4	21.4	78.6	
	4.25 to 7	25.0	75.0	
	7.25 to 9	0.0	100.0	
	9.25 to 12	0.0	100.0	
	12.25 to 36	0.0	100.0	
Total food production (kg)	≤ 500	50.0	50.0	0.031*
	1,000	30.8	69.2	
	1,001 to 2,000	7.1	92.9	
	2,001 to 3,000	50.0	50.0	

Source: Data from survey conducted by Mahamoudou KOUMBEM in 2022; * significant at p ≤ 0.05

4. Discussion

4.1 Farmers' perception of the performance of innovative technologies and their consent to adopt those technologies

The implemented technologies are well perceived by the interviewed farmers as good agricultural practices that contribute to improving soil fertility and crop productivity. In addition, farmers pointed out the benefit effect obtained from the legume-cereal association that allows harvest of different crops and therefore food diversification and balance in the household. This performance of the new introduced technologies largely and positively perceived by farmers could be explained by the fact that tillage methods and cropping systems with soil amendments constitute a good agricultural practice to improvement of soil and crop productivities. Indeed, this practice would have improved the soil physical properties due to ploughing and tied-ridging compared to minimum tillage which did not create great changes to the crop profile (Mando *et al.*, 2005). Also, the addition of organic fertilizers would have increased the level of soil fertility through the improvement of its physical, chemical and biological properties (Guébré *et al.*, 2020) and uptake of nutrients provided through mineral fertilization (Tolesa *et al.*, 2022). This combined effect of fertilizers would have had a positive impact on crop production. Furthermore, as mentioned by Sawadogo *et al.* (2022), crop association is a practice that allows greater land use efficiency with agroecological benefits while reducing production risks and constraints (Raseduzzaman and Jensen, 2017), thus confirming the assertions of farmers who mentioned that the brought technologies by researchers make it possible to limit the risk of production failures related to climatic damage. The diversification of food sources in the household mentioned by farmers to appreciate the technologies also confirms previous results reported by Sawadogo*et al.*(2022) who stated that in Burkina Faso, agricultural households cultivate legumes in association with cereals for food supplementation as well as for income to face other household's needs.

4.2 Amounts of money that farmers could spend for the implementation and adoption of new brought technologies

The amounts of money that farmers were willing to spend for the implementation of new brought technologies on a land size of one hectare vary from one technology to another. This could be explained by the different performances observed by the farmer for each of the technologies. Sigué *et al.*(2019) reported that such decision is based on the result of the economic evaluation (cost-benefit) that the farmer has made. The result of such economic evaluation constitutes one of the factors that drives the farmer's decision when it comes to decide on the amount of funds to allocate to the implementation and adoption of the new technologies introduced by researchers. Thus, the volume of money to invest would be higher if the profitability of the technology is perceived to be very interesting. Except for technology TS2-SC1-AS3, the amount of money that farmers agreed to spend per hactare for the implementation of each technology could not cover the input costs for none of the respective technologies, due to the farmers' low financial capacities. Indeed, the interviewed farmers depend mainly on agricultural income, but according from them, their production does not cover the household food requirements until harvests from the following season. However, farmers who practiced the TS2-SC1-AS3 technology declared that the amounts of money to cover the inputs costs could be afforded by farmers since no compost (which generates an additional fertilization cost) was required for this technology. Furthermore, given the fact that farmers are convinced of the economic performance of technologies, improving the accessibility to agricultural credit by strengthening financing structures would enhance the availability of funds to farmers for purchasing inputs. These remarkable observations were previously reported by Adjiba *et al.* (2021) who reported that access to credit positively influences the adoption of innovative technologies that would lead to sustainable land management. Rabe *et al.* (2017) also indicated that the access to financing institutions by farmers significantly influences the use of fertilizers that improves sustainable soil fertility management techniques.

4.3 Explanatory factors of farmers' consent to adopt innovative technologies

As reported by Roussy *et al.* (2015), this study showed that farmers' perception of technologies and their willingness to adopt them were influenced by the socio-economic characteristics of the agricultural activity. Results indicated that men were more willing to adopt technologies than women, a fact that could be explained by the status of men being mostly the heads of households and therefore having the responsibility to provide his household members with all their primary needs. Thus, as men have to overcome the agro climatic constraints (soil degradation, climatic hazards, cultivable land reduction, etc.) affecting productions, they are ready to adopt more resilient practices. Furthermore, land ownership could explain the fact that men are more willing to adopt new technologies than women. In general, women do not have enough arable land compared to men. In fact, the heads of households (men) give a small size of land to women to cultivate on their exclusively own management. This remark is supported by the results from the present investigation that showed that farmers who possessed larger cultivable lands were more positive in adopting innovative technologies. Likewise, these observations are consistent with those previously reported by Labiyi *et al.* (2018) who mentioned the unavailability of arable land to explain the poor economic performance of women working in agriculture. Furthermore, Vissoh *et al.* (2023) confirmed this idea, stating that men have all control of the household production factors while women only have access to these factors, a fact that explains why women are often provided with the most degraded land. Furthermore, these results corroborate those of Rabe *et al.* (2017) who reported in Niger that the adoption rates of agricultural techniques including cowpea planting populations, application of mineral and organic fertilizers were higher in male fields than in female.

The proximity of the field to the house had a significant and positive influence on farmers' willingness to adopt technologies. This result is similar to that of Etsay *et al.* (2019) and could be explained by the fact that implementing these technologies on home fields would reduce the labor need for the transportation of manure to bush fields. Indeed, the implementation of technologies implies, for example, the availability of compost, which is generally produced close to houses. Adjiba *et al.* (2021) reported the particular attention that plots located close to houses benefit from farmers regarding soil fertility management, thus encouraging farmers to invest in sustainable management technologies for these home fields.

A positive and significant impact on the willingness of interviewed farmers to adopt technologies had been recorded from those farmers belonging to a farmer organization (group). This result was confirmed through the responses recorded from certain farmers who stated that farmer groups favor sharing experiences with other members. Likewise, Vissoh *et al.* (2023) noted that membership in a professional agricultural organization constitutes a good factor driving agricultural activities while facilitating farmers' access to agricultural and extension services (inputs, credits, trainings, …). Yong-Ngondjeb *et al.*(2014) and Traoré *et al.* (2019) also reported that local farmer organizations positively influenced farmers' consent and therefore promoted technology adoption through the sharing of information and experience within the groups.

The availability of workers in the household significantly influenced the farmer's willingness to adopt the innovative technologies. Farmers who have sufficient workers are more empowered to adopt technologies. This could be related to the fact that in almost all households, the family workers constitute the main labor source. This result corroborates those of Nigussie *et al.* (2017) who showed that the availability of workers in a household was an important factor that largely influenced the adoption of sustainable land management technologies. However, Yabi *et al.*

(2016) found the larger sizes of the household workers to negatively influence the adoption of the crop association. Therefore, they concluded that the higher the number of farm workers, the less receptive are the households to implement an innovative production practice.

Contrary to training in tillage and crop association which did not have a significant influence on farmers' consent to adopt technologies, training in microdose had a significant and positive effect on farmers' consent to adoption. Farmers who had benefited from microdose training agreed to adopt the new introduced technologies. Tillage and crop associations are agricultural practices well-known in the study villages. Compared to the microdose technique which is newly-disseminated technique, these two technologies could not be as attractive as microdose fertilization technique (an integral part of the technologies tested) which strengthens farmers' capacity for larger use of technologies. Trainings received in the use of improved cowpea varieties (Barry; 2016) and in new soil fertility management (Pouya *et al.*, 2020) were also shown to be factors that positively influenced the decision of farmers to adopt improved cowpea varieties and better soil fertility management.

Results from the investigation showed the size of livestock (number of heads) to be a factor that influenced farmer's consent to adopt or not the innovative technologies. MRAH (2017) revealed the contribution of livestock in the household to the development of agricultural sector by providing organic manure to farmers for the enhancement of crop productivity and draft animals for farm activities. Thus, farmers who possess livestock would increase their capacity to apply technologies that require the use of manure for soil fertility improvement and animal traction for tillage, which would encourage them to adopt the technologies. Furthermore, Adjiba *et al.* (2021) reported that livestock constitutes source of incomes to use in agriculture in rural areas, thus favoring financial investments in sustainable land management technologies. However, the study showed that farmers who possessed livestock with more than 120 heads did not consent to adopt the technologies brought by researchers. This could be explained by the fact that when the household's incomes resulted from non-agricultural activities became higher than agriculture-based incomes, then competition between agricultural and non-agricultural activities for labor would take place (Rodríguez-Entrena and Arriaza, 2013). At this time, the farmer would be more interested investing for the non-agriculture activities than implementing new agricultural technologies.

Unlike the declaration of Sigué *et al.* (2018) indicating a negative significant effect of field size on the adoption of microdose technology, the results from the present investigation revealed that the availability and size of cultivable land constituted a factor that significantly and positively influenced the farmer's consent to adopt new technologies. For Sigué *et al.*, the increase in the farm size devoted to agricultural activities constituted for farmers additional investment costs for the acquisition of fertilizers in microdose technique. However, it should be noted that Sigué *et al.* (2018) based their investigation on the size of the farm which is different from the total and available cultivable land owned by the farmers. In the present study, it can be drawn from results that the more sufficient and cultivable land the farmer possesses, the greater his consent to adopt technologies would be. This situation is closely related to the low availability of cultivable land which is more and more becoming a veritable limiting factor for crop production. Indeed, insufficient cultivable land for the majority of farmers is due to population growth and continuous soil degradation, while the possession of big land by the household appears to be a very determinant factor that motivates the adoption of technologies that require sufficient production area. Agricultural production being the main source of interviewed farmers' incomes used to finance activities, there is no doubt that the level of the total household agricultural production has a significant influence on the farmer's willingness to adopt technologies. This would explain why farmers who have small quantities of agricultural productions are less willing to adopt technologies than those who are in a medium situation with insufficient agricultural productions. This result is supported by previous researchers who emphasized that agricultural incomes play a key role in the adoption of innovative technologies (Sigué *et al.*, 2018; Gao *et al.*, 2018) and constituted the primary factor which stimulated the farmer's decision to adopt microdose technology (Sigué *et al.*, 2018). On the other hand, the households who were already food self-sufficient because they have enough food were less willing to adopt innovative technologies.

5. Conclusion

This study conducted through a survey in the Centre-West Region of Burkina Faso in 2021 aimed to assess farmers' perception of sorghum - cowpea production under different tillage methods and cropping systems with soil amendments and their consents to adopt the introduced technologies in their own environment. Results from the investigation showed that nearly two thirds (63%) of the interviewed farmers were willing to adopt these innovative agricultural technologies brought to them by researchers for the quantitative and qualitative improvement of sorghum and cowpea in a sorghum-cowpea system. Regarding both the farmers' perception of innovative technologies and consents to adopt those technologies, the survey indicated that the socio-economic characteristics of the household influenced perceptions and consents. Thus, factors such as gender, membership in a farmers' organization, training on microdose technique, availability of labor, possession of livestock and availability of cultivable land all have a significant influence on the farmer's consent to adopt technologies. Based on these results, one appropriate recommendation to address to the agricultural policy-makers would be to take into account these socio-economic determinants when making decisions regarding research and development actions in order to promote the appropriation of new agricultural technologies by farmers and to ensure sustainability of their production systems.

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