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Analyzing the relationship between technical recommendations of the cotton production in Burkina Faso.

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Abstract

Highlighting the relationships between the various recommended cotton farming techniques improves their adoption rate among cotton farmers in Burkina Faso. The aim of this study is to analyze the relationship between the Technical Recommendations for Cotton Production (TRCP) in Burkina Faso. It uses secondary data collected between 2021 and 2024 by the Cotton and Textile Fibers Program of the Institute of Environment and Agricultural Research (INERA) in Burkina Faso from 700 cotton farmers across the communes of Pâ, Solenzo, Djigouera, Soubakagnedougou, Toécé, Tenkodogo, and Diapangou. Principal Component Analysis (PCA) was used to identify the primary Technical Recommendations of the Cotton Production (TRCP) implemented by cotton farmers, while Pearson's correlation coefficient served as the analytical on the degree of relationship between the TRCP. Data processing was carried out using Stata 17. The results showed that the application of technical recommendations regarding the use herbicides before and after underground excursion seed cotton as the number of weeding operations accounts for 61% of all technical recommendations implemented by cotton farmers. Furthermore, the PCA results also showed that the TRCP associated with weeding frequency alone accounts for 56.35% of the explanatory power regarding the set of TRCP. However, the analysis of Pearson coefficients indicates a strong correlation (r = 0.725) only between the recommended number of weeding operations and the recommended herbicide usage. The study highlighted a significant relationship specifically concerning technical recommendations for weed management. It recommends that cotton companies step up efforts to raise awareness among cotton farmers regarding the implementation of RTCCs, particularly those related to the correct application rates of organic and mineral fertilizers.

Keywords : Relation, Technical recommendations, Cotton production, Burkina Faso

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Introduction

Globally Cotton is a substantial source of livelihood about one hundred million households in 75 countries [7]. In sub-Saharan Africa, it is product by around two million farmers [8]. In Burkina Faso, cotton the country's primary cash crop is grown about 243 681 farmers and supports the livelihoods of over four million people [12]. It contributes more than 4% to the national gross domestic product [23] and over 13% the national gross domestic agricultural product. Cotton accounts about 30% in crop rotation on farms; its residual effects benefit cereal crops (maize, sorghum, and millet) and legumes (groundnuts, cowpeas, and soybeans), thereby boosting food production and aiding soil fertility management in cotton-growing areas [13, 5]. Between 2004 and 2023, the Burkinabe government provided approximately 247 billion CFA francs in subsidies to the cotton sector. However, seed cotton yields are always struggle to exceed 900 kg/ha [10] Over the last decade, among the Regional Integrated Cotton Production Programme in Africa (RICPPA) countries, Burkina Faso has recorded the lowest yields, after Tchad and Togo. From 2014 to 2023, the average yield in Burkina Faso showed a productivity deficit of 138 kg/ha compared to Mali, and 228 kg/ha and 268 kg/ha compared to Côte d'Ivoire and Benin, respectively, resulting in lower competitiveness at the field level [15]. Nevertheless, inappropriate practices such as late sowing, under-application of mineral fertilizers, insufficiency use of organic manure, and poor weed and pest management can be identified as the primary causes of the decline of cotton production in Burkina Faso.

In the literature, many authors have studied the combined effect of several good agricultural practices on productivity. It is [20, 21, 4 et 16]. However, these authors relied on data from only a single agricultural season for their analyses. The use of panel data offers the advantage of accounting for unobserved heterogeneity among units or individuals. [22] used panel data to characterize the production systems of members of farmer organizations in northern Burkina Faso. However, the study's recommendations were largely geared toward producers whose primary objective is consumption of their agricultural output. In a different context where the production objective is the sale of agricultural products these recommendations would be biased. Indeed, profit-maximizing behavior in production decision-making is well-established in agricultural operations. It is therefore imperative to supplement the previous study. For this reason, the present study focuses on cotton farmers whose primary production objective is selling cotton to cotton companies. It uses panel data (2021–2024) to analyze the nature of the relationship between technical recommendations of the cotton production.

It assumes that technical recommendations for weed management are more strongly correlated with one another than those for soil fertility management. This hypothesis is confirmed if the

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correlation coefficients between technical recommendations for weeding and herbicide use before and after underground excursion seed cotton, are closer to 1 than the correlation coefficients between technical recommendations for NPKSB and organic fertilizer.

1. Methodology

1.1. Study area

This study was conducted in the three cotton-growing zones of Burkina Faso. The area of the cotton company SOFITEX is located in west of the Burkina Faso. It encompasses the administrative regions of Guiriko (Ex. Hauts-Bassins), Bankui (Ex. Boucle du Mouhoun), Tannounyan (Ex. Cascades), Djôro (Ex. South-West), and Nando (Ex. West-Center), and alone accounts for more than 80% of national seed cotton production, making it the country's primary cotton-growing zone. In terms of climate, the area exhibits a north–south gradient, ranging from a Sudan-Sahelian climate in the north to Sudanian and sub-Sudanian climates in the south. Average annual rainfall generally ranges between 600 and 1,200 mm, with values below 900 mm in the Sudan-Sahelian sectors and higher values in the Sudanian and sub-Sudanian zones [17] . The average annual temperature is approximately 27°C, with a mean temperature range of close to 5°C, while annual evaporation reaches about 2682 mm [17]. The climate is characterized by two distinct seasons a rainy season from June to September and a dry season from October to May conditions favorable for cotton production. Four sites were selected: Pâ (Houndé cotton-growing region), Solenzo (Solenzo cotton-growing region), Djigouera (N'Dorola cotton-growing region), and Soubakaniédougou (Banfora cotton-growing region).

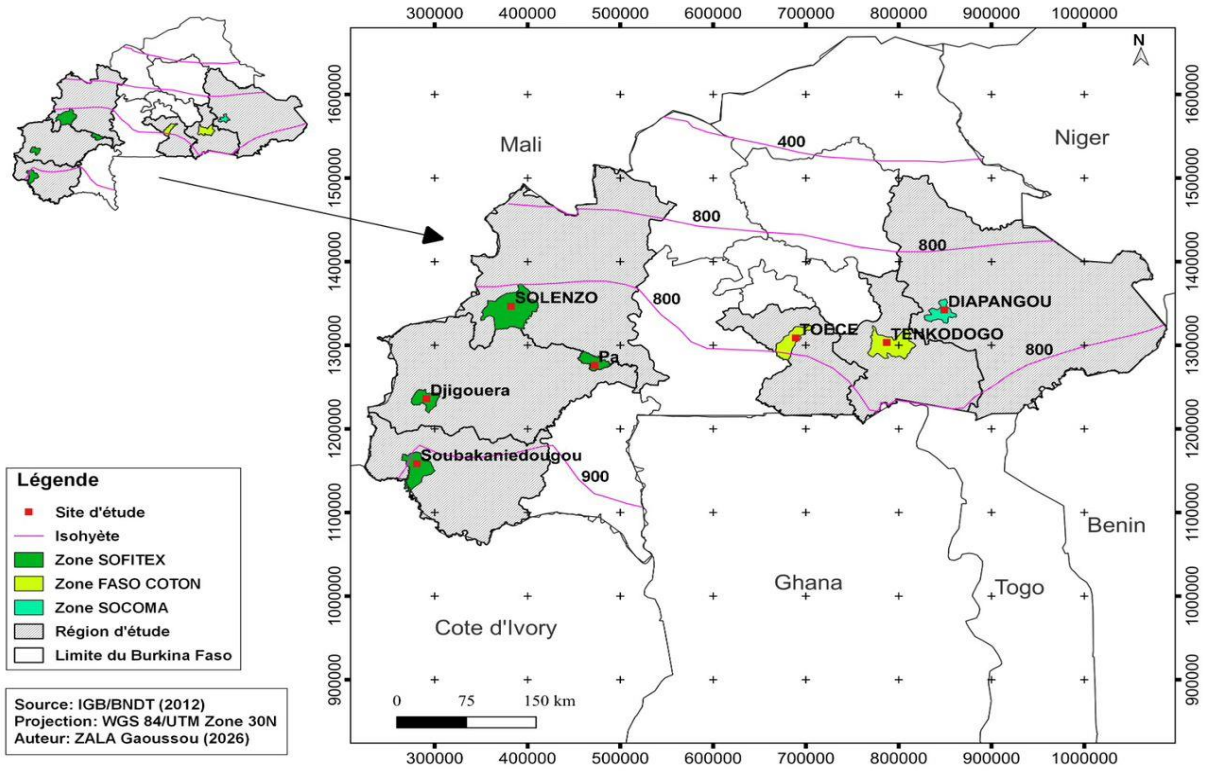
The area covered by the FASO COTON company is characterized by a dry, North-Sudanian continental climate, marked by the alternation of two sharply contrasting seasons. Average rainfall over the last ten years has ranged between 700 and 1000 mm. Due to security issues, this area accounts about 18% of the country's total cotton production. It is subdivided into three main production zones based on rainfall levels: a low-production zone with average rainfall of 900 mm (the Bazéga zone), and larger production zones with average rainfall of around 1000 mm (the Tenkodogo and Pô zones). Most municipality in this area experience two main seasons: a dry season from November to May including a cool period from November to February characterized by the Harmattan, a dry wind blowing from the Sahara and a wet or rainy season from May to October, marked by monsoon winds that bring rainfall. The average temperature is 32°C. The surveys covered the town of Toécé and Tenkodogo.

The SOCOMA zone currently accounts for only 2% of national production [14]. Rainfall ranges from 700 to 900 mm; it varies from year to year and is subject to unpredictability within any

given year. The climate is tropical, specifically of the Sudan-Sahelian type. In addition to terrorist acts, the area is characterized by other forms of insecurity, namely theft, the abduction or kidnapping of young girls, and accusations of witchcraft. The commune of Diapangou, comprising approximately 31 villages, was the primary commune studied in the country's Eastern zone.

The selection of these sites is based on their strategic importance to cotton production at the zonal, regional, and national levels, as well as their location along the country's north-south rainfall gradient, which allows for the observation of climate change impacts on various farming practices. Their climate is consistently characterized by two distinct seasons: a rainy season generally running from June to September and a dry season from October to May conditions that are favorable for cotton cultivation. Furthermore, the choice of these sites is significant because, between 2021 and 2024, they hosted cotton research activities featuring a permanent data collection system that involved various stakeholders across the cotton value chain.

Fig. 1: Location of study sites



Source : National Topographic Database of the Geographic Institute of Burkina. (2012) ; modified by student ZALA Gaoussou on March 12, 2026

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1.2. Sampling

The study utilized secondary data collected under the financing agreement support for cotton research 2021–2024 agreement. Accordingly, we describe the sampling method and the determination of the sample size. Between 2013 and 2021, there was an annual average of 243 681 cotton farmers engaged in cotton production, distributed across 9 402 Simplified Cooperative Society of Cotton Farmers (SCOOPS-PC) [12]. The sample size was estimated using the formula proposed by [18].

Eq : (1)

$$\mathbf{n} = \frac{tp^2p(1-p)\,N}{tp^2p(1-p)+(N-1)y^2}$$

n: represents the sample size ;

N : the actual size of the population

P : the expected population response proportion or actual proportion was set to 0.5 by default, allowing for the largest possible sample size.

tp : the 95%sampling confidence interval

y : the 5% sampling margin of error

$$\mathbf{n} = \frac{(1{,}96)^2 x 0{,}5 x (1-0{,}5) x\ 243\ 681}{(1.96)^2 x 0{,}5 x (1-0{,}5)+(\ 243\ 681\ -1) x\ (0{,}05)^2}$$

n = 664 cotton farmers

As any sample inevitably entails certain shortcomings (refusals to respond, illness, absence, unusable questionnaires), an additional thirty-six (36) producers were included to account for these contingencies. The final sample for the study thus comprises n = 700 cotton farmers. Data were collected from the same individuals over four (4) cotton seasons, spanning the 2021–2022 to the 2024–2025 seasons. Table 1 summarizes the sample distribution by production site.

The sites were selected based on a north–south gradient, ranging from the Sudan-Sahelian climate in the north to the Sudanian and sub-Sudanian climates in the south. In the SOFITEX zone, four sites were chosen: Pâ (Houndé cotton region), Solenzo (Solenzo cotton region), Djigouera (N'Dorola cotton region), and Soubakaniédougou (Banfora cotton region). The commune of Diapangou was selected within the SOCOMA company's zone. In the FASO COTON company's zone, the communes of Toécé and Tenkodogo were chosen.

A preliminary survey was first conducted across the various sites. The results showed that the cotton farmers in the seven sites were distributed as follows: 60% farmers less than 3 hectares,

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22% between 3 and 6 hectares, 12% between 6 and 9 hectares, and 6% farmers 10 hectares or more (Table 1). Consequently, the 700 cotton farmers were categorized according to these same land-area brackets to ensure the sample was representative of the total producer population in each site. Of the 700 producers, 412 produced less than 3 hectares of cotton, 162 farmers between 3 and 6 hectares, 84 farmers between 6 and 9 hectares, and 42 farmers 10 hectares or more.

To select the cotton farmers in each site, the "step" method was used. This involves determining a "step" based on the size of the parent population and the desired sample size [9]. It is calculated using the following formula:

$$Eq: pas = \frac{source\ population}{sample} \qquad (2)$$

Table 1: Number of cotton farmers surveyed by town and category of planted area

Cotton companies	Town	Surface area category				Total	Step
		]0;3[	[3;6[	[6;10[	[10;+∞[		
SOFITEX	Solenzo	46	29	38	23	136	3,3
	Pâ	85	15	0	0	100	11,2
	Djigouera	24	39	24	2	89	12,9
	Soubakagnedougou	33	35	17	15	100	18,1
FASO COTON	Toécé	73	2	0	0	75	4,2
	Tenkodogo	86	13	1	0	100	7,3
SOCOMA	Diapangou	98	2	0	0	100	2,6
	Total	445	135	80	40	700	7,7

Source: Cotton Program/INERA/plot monitoring 2021–2024

1.3. Baseline situation: Key technical recommendations for cotton production

The main technologies recommended for cotton production in Burkina Faso generally focus on: i) sowing management, ii) soil fertility management, iii) weed management, and iv) crop protection. The technical recommendations for cotton production are analyzed based on: i) the sowing period (between May 1 and June 30), ii) herbicide application (pre-emergence application on the day of or the day after sowing, or post-emergence application 15 to 20 days after sowing), iii) the number of weeding operations (at least two), iv) the application of organic manure, v) the application of chemical fertilizer (quantities of 150 kg/ha or more of NPKSB fertilizer 15 to 20 days after emergence, and 50 kg/ha of urea 40 days after emergence), and vi)

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the number of insecticide treatments (six or more treatments). These recommendations were established in Burkina Faso in a technical guide developed by [11].

The baseline situation established in this way makes it possible to determine the rate of application of technical recommendations for cotton production in the zones served by the three cotton companies. This rate corresponds to the adoption rate or degree of adoption of a technology. It is measured using the following formula:

Let Tj be the frequency (%) of cotton farmers applying technical recommendation j; t be the period; n be the number of cotton farmers following recommendation i; and N be the total number of cotton farmers surveyed.

Eq : $Tjt = \frac{njt}{Nt} \; x \; 100$ avec j = 1 ; …7 t = 1…4 (3) [2]

This yields:

- Frequency or rate (%) of farmers who sowed cotton during the recommended period (j=1);
- Frequency or rate (%) of farmers who applied pre-emergence herbicide (j=2);
- Frequency or rate (%) of farmers who applied post-emergence herbicide (j=3);
- Frequency or rate (%) of farmers who performed at least two weedings (j=4);
- Frequency or rate (%) of farmers who applied at least organic fertilizer (j=5);
- Frequency or rate of farmers who applied the recommended dose of NPKSB fertilizer (j=6);
- Frequency or rate (%) of farmers who carried out at least six insecticide treatments (j=7).

1.4. Tools for analyzing the relationships between technical recommendations for cotton production

To identify which technical recommendations for cotton production explain the extent to which cotton farmers applique the full set of recommendations, we employed Principal Component Analysis (PCA). The process involves, first, identifying the number of overall components retained by the software to explain the total variation across all variables (technical recommendations) included in the PCA. Next, we determine the number of components required to account for more than 50% of the total variation across the variables under consideration. Finally, the analysis concludes with a graphical representation to identify which recommendations are most strongly or weakly correlated.

Furthermore, to better illustrate the degree of correlation among the technical recommendations for cotton production, we will use a graph (specifically, a correlation circle) and the Pearson correlation coefficient. The circle will serve as a basis for analyzing the direction and

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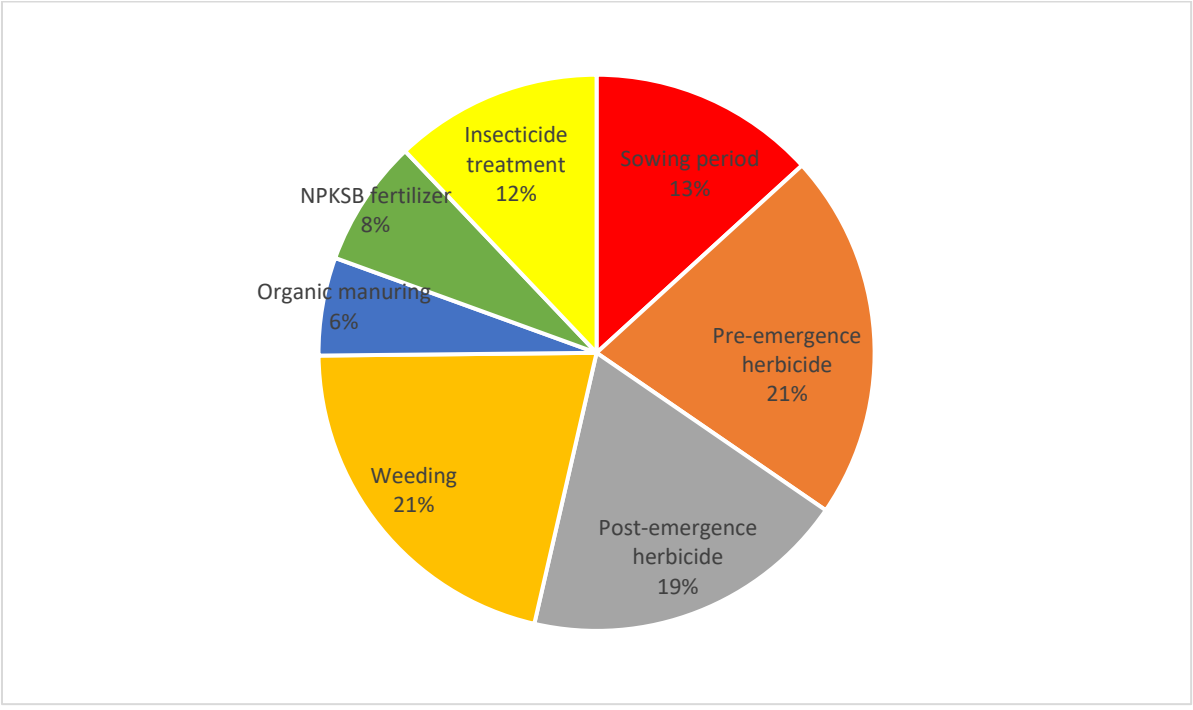
correlation of the various technical recommendations mentioned above. If two arrows are very close together, the angle separating them is close to 0°; since cos(0) = 1, their correlation coefficient is close to 1, indicating that the two technical recommendations are highly correlated. Conversely, if two arrows are orthogonal (perpendicular), the angle separating them is 90°. Similarly, a Pearson correlation coefficient close to 1 signifies that the two technical recommendations are highly correlated.

2. Results

2.1. Application rates for technical recommendations in cotton production

Figure 2 shows that three technical recommendations for cotton production account for more than half of all recommendations (61%). These are the application of a broad-spectrum pre-emergence herbicide, the performance of at least two weedings, and the application of a selective post-emergence herbicide. In other words, these are the technical recommendations most widely adopted by cotton farmers. Conversely, the application of NPKSB fertilizer and organic manure are the least applicated practices (8% and 6%, respectively).

Fig. 2: Application rates (%) of key technical recommendations for cotton production and typology of cotton growers



Source: Cotton Program/INERA/plot monitoring 2021–2024

2.2. Relationships between technical recommendations for cotton production

Table 3 shows that the first two components (Comp1 and Comp2) account for 50.10% of the total variation among the seven components considered in this PCA analysis. However, the technical recommendation regarding the number of weeding operations alone accounts for

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56.35% of the first component (Table 4). In contrast, for the second component, the application of organic fertilizer holds the greatest explanatory power 68.3% (Table 4).

Pairwise correlation coefficients between the various technical recommendations show positive values. This indicates that all the technical recommendations compared in pairs move in the same direction; in other words, if one increases, the other does as well (Table 5). However, Figure 3 reveals a strong correlation (r = 0.725) between the two technical recommendations most widely applicated by cotton farmers (weeding and pre-emergence herbicide application). Conversely, these two recommendations show a very weak correlation with the application of organic fertilizer. These relationships are explained by axes F1 and F2 (50.10%).

Table 3: Identification of the components explaining more than 50% of the total variation of all components considered in the PCA analysis.

Component	Eigenvalue	Difference	Proportion	Cumulative
*Comp1	2,355	1,202	0,336	0,336
Comp2	1,153	0,213	0,165	0,501
Comp3	0,939	0,085	0,134	0,635
Comp4	0,855	0,061	0,122	0,757
Comp5	0,794	0,142	0,113	0,871
Comp6	0,652	0,399	0,093	0,964
Comp7	0,252		0,036	1,000

Source: Cotton Program/INERA/plot monitoring 2021–2024

Table 4: Summary of technical recommendations with significant explanatory power regarding the full set of technical recommendations for cotton production.

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7	Unexplained
Type semis	0,2959	0,1816	-0,3666	0,7998	-0,3205	-0,0265	0,0432	0
Herbicide prélevée	0,5178	-0,2933	0,0308	-0,1004	0,1493	-0,4688	0,6267	0
Herbicide post-levée	0,4525	-0,0673	-0,1311	-0,1900	0,0126	0,8366	0,1935	0
Sarclage	0,5635	-0,2450	-0,0507	-0,1063	0,0879	-0,1837	-0,7531	0
Fumure organique	0,1174	0,6830	-0,3489	-0,1165	0,6121	-0,0991	0,0011	0
NPKSB	0,2443	0,5347	0,1509	-0,4135	-0,6609	-0,1534	0,0174	0
Nombre traitement insecticide	0,2205	0,2533	0,8369	0,3439	0,2358	0,1119	-0,0221	0

Source: Cotton Program/INERA/plot monitoring 2021–2024

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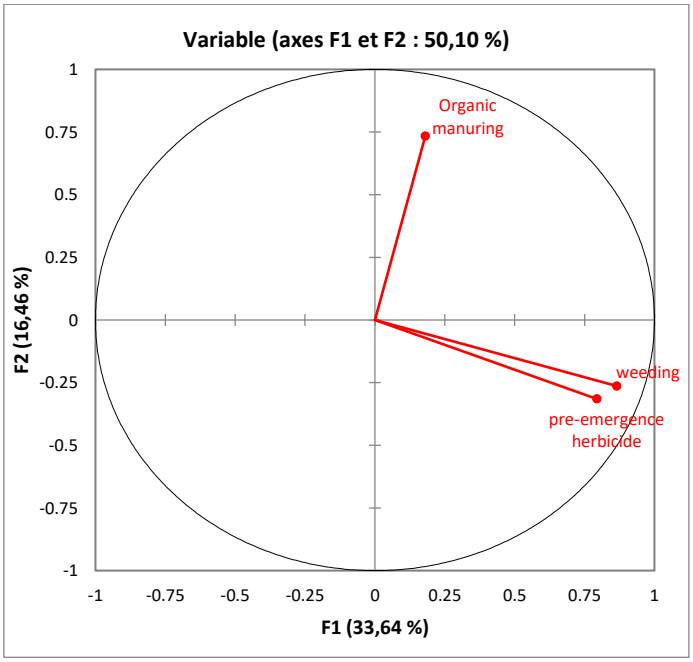
Table 5: Pearson correlation coefficient between technical recommendations for cotton cultivation

Recommandations	Type semis	Herbicide prélevée	Herbicide post-levée	Sarclage	Fumure organique
Type semis	NA	0,197	0,201	0,259	0,111
Herbicide prélevée	0,197	NA	0,363	0,725	0,0151
Herbicide post-levée	0,201	0,363	NA	0,507	0,0861
Sarclage	0,259	0,725	0,507	NA	0,0444
Fumure organique	0,111	0,0151	0,0861	0,0444	NA
NPKSB	0,118	0,128	0,178	0,172	0,169
Nombre traitement insecticide	0,0914	0,168	0,119	0,157	0,0591

Source: Cotton Program/INERA/plot monitoring 2021–2024

Fig. 3: Proportion of total variance among the various technical recommendations for cotton production explained by the axes



Source: Cotton Program/INERA/plot monitoring 2021–2024

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3. Discussion

This study has highlighted two main results, which will be discussed in this section. It analyzes the relationships between the technical recommendations for cotton production.

Data analysis revealed that herbicide use and weeding are the technical recommendations most frequently adopted by cotton growers. These practices show relatively high adoption rates compared to other technical recommendations for cotton production. Furthermore, PCA analysis indicated that the application of the mechanical weeding recommendation accounts for over 50% of the explanatory power regarding the set of technical recommendations for cotton farming. Additionally, there is a positive correlation between the weeding recommendation and herbicide application. Previous studies by [21] and [4] have shown that difficulties in managing weed infestation can lead to yield losses or even the abandonment of plots overrun by weeds. [3] and [20] demonstrated that cotton farmers in Burkina Faso currently combine various weeding methods: manual, mechanical, and chemical. In their study, these authors advocate combining all three control methods (chemical, mechanical, and manual) to better manage weed growth in cotton crops.

Furthermore, application rates for both organic manure and NPKSB mineral fertilizers fall well below technical recommendations. Such poor soil fertility management practices could lead to significant yield losses in cotton cultivation. Previous studies have demonstrated only positive effects of organic and mineral amendments on soil fertility. [1] showed that, among various types of inputs, only organic applications resulted in a significant improvement in organic matter content, cation exchange capacity (CEC), the sum of exchangeable bases, and soil pH in Burkina Faso. [19] consider that inappropriate practices such as failure to adhere to recommendations for organic and mineral replenishment and insufficient nutrient recycling via crop residues at the plot level are inadequate to address the scale of soil degradation. [2] also demonstrated that at least 70% of cotton farmers across Burkina Faso's three cotton-growing zones who followed both recommendations (regarding rates of organic manure and NPKSB mineral fertilizer) achieved cotton yields of at least 1 tonne per hectare.

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Conclusion

This study reveals that, among the technical recommendations for cotton production in Burkina Faso, weeding is the one most widely adopted by cotton farmers. Analysis of the relationships between the various recommendations showed a stronger link between the recommendation regarding the number of weeding operations and the use of pre-emergence herbicides compared to the other implemented recommendations. Thus, the hypothesis that technical recommendations for weed management are more strongly correlated with one another than those for soil fertility management is confirmed.

The study recommends an institutional overhaul of cotton production in Burkina Faso. To ensure sustainable and sustained cotton production in the country, it calls on cotton companies to explore new approaches to providing advisory support to cotton farmers.

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