ГЛАСНИК Српског географског друштва 104(1) 225-238
BULLETIN OF THE SERBIAN GEOGRAPHICAL SOCIETY 2024

Original scientific paper UDC 551.58:582.916.36(662.5)
https://doi.org/10.2298/GSGD2401225S

Received: January 06, 2024
Corrected: February 28, 2024
Accepted: March 13, 2024

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CLIMATE VARIABILITY AND SESAME PRODUCTION IN THE RURAL COMMUNITY OF BÉRÉGADOUGOU, BURKINA FASO

Abstract: In Burkina Faso, sesame (Sesamum indicum L.) is the second most important export crop after cotton. In the rural commune of Bérégadougou, it is the second most important cash crop after groundnuts. This oilseed is essentially a rainfed crop and is therefore largely dependent on rainfall. The aim of this article is to analyze sesame production in a context of climatic variability. To achieve this, the research methodology is based on a global geographical approach that integrates meteorological data (1991-2021), climatic parameters and fieldwork. The results show a rainfall pattern with a rainy season (May to October) and a dry season (November to April). Inter-annual rainfall trends over the analysis period show that rainfall is always above 500mm, whatever the year. Similarly, whatever the year, the average temperature is always above 27°C. These variations in rainfall and temperature have no impact on sesame production. Family farmers also gave 92% of their produce as evidence of their acceptance of climatic variability.

Key words: Burkina Faso, Bérégadougou commune, climate variability, sesame, farmers' perception

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Introduction

Africa appears to be the region where the greatest challenges remain in terms of the availability, development and distribution of water resources. Available water resources will diminish and drought will become more acute in mid-latitudes and semi-arid areas of low latitudes, exposing hundreds of millions of people to increased water stress (IPCC, 2007 cited by Karambiri, 2017) Agricultural activities in the aforementioned African countries are intimately linked to water and dependent on rainfall. It plays a key role in achieving food security, reducing poverty and improving the livelihoods of farming households. Indeed, the specific effects of climate change on agriculture in developing countries show that, overall, the situation in African countries will worsen and that areas that are marginal today could become hostile to agriculture tomorrow.

Climate is an essential determinant of farming. Cereal production depends on the length of the growing season, which varies between 70 and 90 days in semi-arid zones. Agricultural production and access to food will be severely affected, with serious consequences for food security (FAO, 2008 quoted by Ouédraogo, 2015). With the globalisation of trade and the need to respond to new challenges linked to climate change and the energy crisis, African agriculture is being called upon to produce new crops, whether perennial or annual, for food and/or energy (Audouin, 2014). Among these crops, sesame (Sesamum indicum) is increasingly taking pride of place on farms in some West African countries (Sanogo, 2017). Located in West Africa, Burkina Faso is a country where agriculture represents the main activity of rural populations.

Cash crops are dominated by cotton and sesame. Sesame production, Burkina Faso's second most important export crop after cotton, is part of the drive to diversify agricultural production and improve the living conditions of family farmers. Located in the west of Burkina Faso, in the Cascades region, the rural commune of Bérégadougou is no stranger to sesame production. Sesame is grown on family farms, with planted areas varying in size from 0.5 to 2 ha. It provides substantial income for producers in their quest to reduce poverty and achieve food security. Faced with climate variability, which causes losses on agricultural plots through lower yields and a drop in production, a question needs to be asked: is sesame production possible in a context of climate variability? To answer this question, the hypothesis to be examined is as follows: sesame production is possible in a context of climatic variability.

The aim of this study is to analyse sesame production in a context of climatic variability. In order to achieve the objective assigned to this research and to examine the hypothesis, a methodology was adopted for data collection. The framework of the study, the results and the discussion are set out below.

Scope of the study

Theoretical framework

From a theoretical point of view, this research forms part of the vast field of geography and rural development. It uses concepts from the fields of physical geography and natural resource management. A number of researchers and development practitioners have commented on the effects of climate variability or climate change on agricultural production. Without being exhaustive, the results of Ba and Sy (2016) show that the vegetation cover is unable to provide the biomass needed for livestock, while woody plants are suffering high mortality. At the same time, livestock farming is being jeopardised, with high mortality rates among sheep and cattle in particular. As a result, forage production is insufficient for local and transhumant livestock. This is a source of concern for local people, who collect dry straw from October onwards to store it at home and wait until fodder becomes scarce before feeding it to their small livestock. Similarly, Marc et al. (2020) state that the results of analyses carried out on data from surveys of farmers show an overall trend towards earlier sowing dates and, above all, earlier harvest dates for the crops studied (winter wheat and barley), resulting in shorter crop cycles for these crops. Zongo (2016) also points out that the instability of agricultural yields is essentially attributable to the spatio-temporal distribution of rainfall. The success of a crop year depends above all on the amount of rain that falls during the year, whether the rains start early or late, how they are distributed during the year and whether they end abruptly during the vegetative phase or are delayed until harvest time. Work on sesame has focused on agronomic aspects (Djigma, 1985; Schilling & Cartan, 1991; Ridha & Mohamed, 2013; Sanogo, 2017), nutritional aspects (Habibou, 2006; Hadizatou, 2012; Sanogo & Yanogo, 2016) and therapeutic aspects (Habibou, 2006; Hadizatou, 2012; Sanogo, 2017). Thus, the state of the art reveals that previous studies do not specifically address sesame production in a context of climatic variability in the rural commune of Bérégadougou. Hence the need for this research on climate variability and sesame production. This research seeks to analyse sesame production in a context of climatic variability. To achieve this, a systems approach is needed to study the interactions between climatic parameters, farmers' perceptions of climate variability and sesame production.

Geographical context

The rural commune of Bérégadougou is located in the Comoé province of the Cascades region, in western Burkina Faso. Its geographical coordinates are 10°46'0" north latitude and 4°45'0" west longitude. The commune covers an area of 265 km2, or 1.72% of the provincial territory. It is bordered to the west and north-west by the rural commune of Moussodougou, to the east by the rural commune of Tiéfora, to the north by the rural commune of Toussiana and to the south by the urban commune of Banfora (figure 1).

It has a population of 15,162, 51.80% of whom are women (RGPH, 2020). The commune is characterised by two main activities: agriculture and livestock farming. Sesame (Sesamum indicum L.) is one of the cash crops grown in Bérégadougou.

Methodological framework

The methodological approach adopted is based on quantitative and qualitative data derived from documentary analysis, interviews and questionnaire surveys. The documentary analysis consisted of analysing information on climate variability and sesame production in articles, dissertations, theses, books and reports consulted in ministries and development agencies, in university libraries, in research structures and on the Internet. The field surveys took place in January 2023. They were based on the commune's territorial organisation. Field surveys were conducted in five localities: Bérégadougou, Fabédougou, Malon, Takalédougou Kôkô and Séréfedougou (figure 1). These areas were selected on a reasoned basis. The farmers surveyed were selected on the basis of two criteria: they had to be the head of a sesame-farming household residing in the territory and they had to be at least 30 years old. It was necessary to select standard samples, with 25 heads of household surveyed per locality, regardless of the size of the target population in each locality (Table 1).

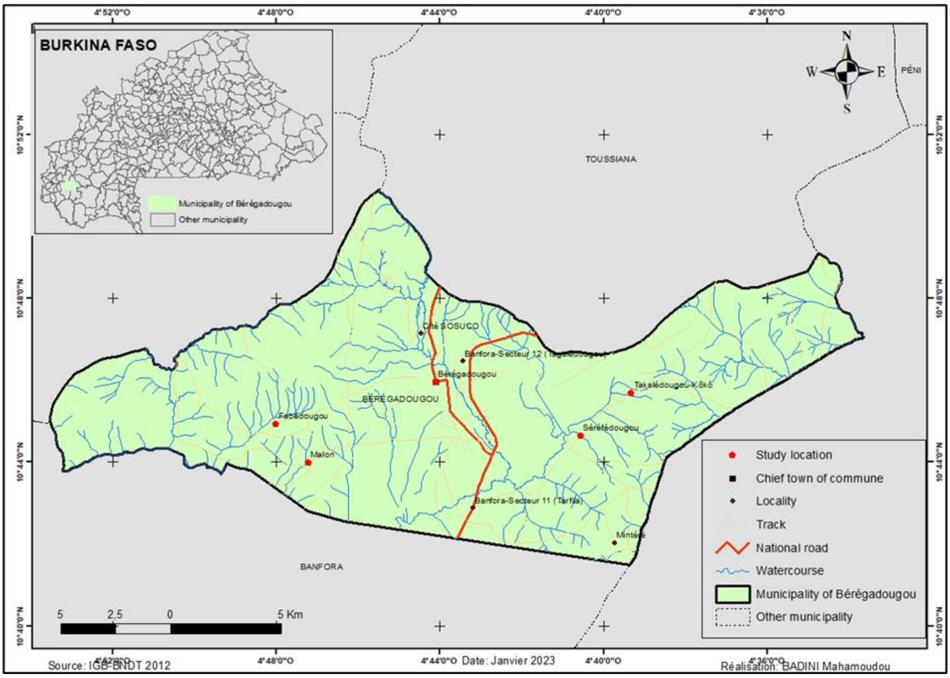

Fig. 1. Geographical location of the rural commune of Bérégadougou

Tab. 1. Breakdown of households by location surveyed

Localities	Number of population in 2016	Number of households	Sample retained	Corresponding rate (%)
Bérégadougou	12 212	2549	25	1
Fabédougou	875	183	25	14
Malon	192	40	25	62
Séréfedougou	977	204	25	11
Takalédougou Kôkô	908	187	25	12
Total/Average average	15 164	3163	125	4

Sources: INSD, 2022 and authors' calculations in 2023

In all, 125 heads of sesame-farming households were surveyed out of a target population of 3,163 households, at an overall sampling rate of 4%. The qualitative surveys were conducted with the heads of the decentralised government departments: the head of the agricultural technical support zone (ZATA) and the head of the livestock technical support zone (ZATE). In addition, rainfall, temperature, humidity and evaporation data from 1991 to 2022 from the Bérégadougou station were collected from ANAM. This station was chosen because it covers the study area. Similarly, the analysis of interannual rainfall variability was carried out using reduced standardised anomalies.

These anomalies were calculated using the formula for analysing the interannual variability of the following indices:

$$x_i' = \frac{x_i - \bar{x}}{\sigma(x)} \quad (1)$$

where:

x_i' = reduced centred anomaly for year i;

x_i = the value of the variable;

$\bar{x}$ = the mean of the series.

$\sigma(x)$ = the standard deviation of the series

Results

Scientific vision of climate variability

The rural commune of Bérégadougou belongs to the southern Sudanian climatic zone, marked by two seasons resulting from movements of the Inter-tropical Convergence. There is a dry season from November to April (figure 2).

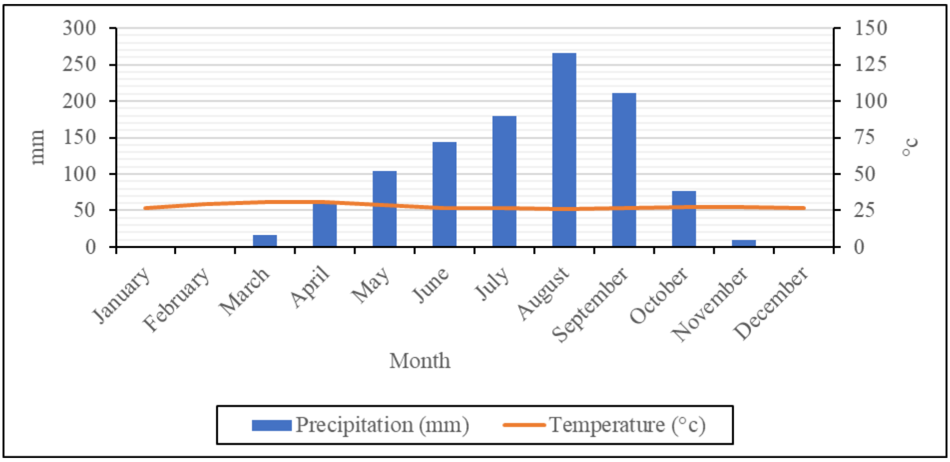

Fig. 2. Umbrothermal diagram for the municipality of Bérégadougou

This dry season is characterised by a cold period from November to mid-February and a hot, dry period from mid-February to mid-May. This is also the season when family sesame farmers engage in other non-agricultural activities. Thus, 57% engage in forestry and pastoral activities, 21% in handicrafts, 12% in trade, 7% leave for Bobo Dioulasso in search of temporary jobs, and 1.5% do not engage in any activity. The rainy season, from May to October, is the sesame production period. August is the stormiest month, with rainfall of over 250mm. These high rainfall levels can cause flooding on family farms and in homes. In addition, this period is marked by clearing work, setting fires after having piled up dead leaves from trees and plant debris on family sesame farms. After preparing the plots, the next stage is sowing, which lasts from the end of

June to mid-August. This stage is followed by crop maintenance (July, August and September). It ends with harvesting and post-harvest work (October to December).

Another feature of the rural commune of Bérégadougou is the high inter-annual variability in rainfall (figure 3).

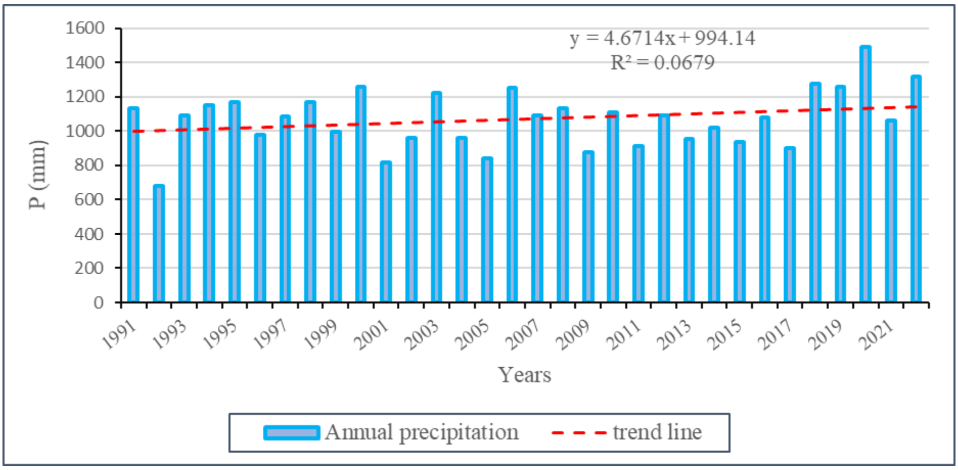

Fig. 3. Interannual rainfall trends

Analysis of Figure 4 calls for the following comments: (i) the crop years 1992, 1996, 1999, 2001, 2002, 2004, 2005, 2009, 2011, 2012, 2013, 2014, 2015, 2016, 2017 and 2021 are considered dry because the average rainfall is below 900 mm, which is the series average. Moreover, 1992 was the driest sesame season, with 683 mm of rainfall; (ii) the 2020 sesame season, with 1490.3 mm, was the wettest of all wet years, with average rainfall above 900 mm; (iii) whatever the year in the analysis series, rainfall was always above 680 mm. Water is an essential element in the growth of the sesame plant. Insufficient water would retard its growth during the various stages of its development.

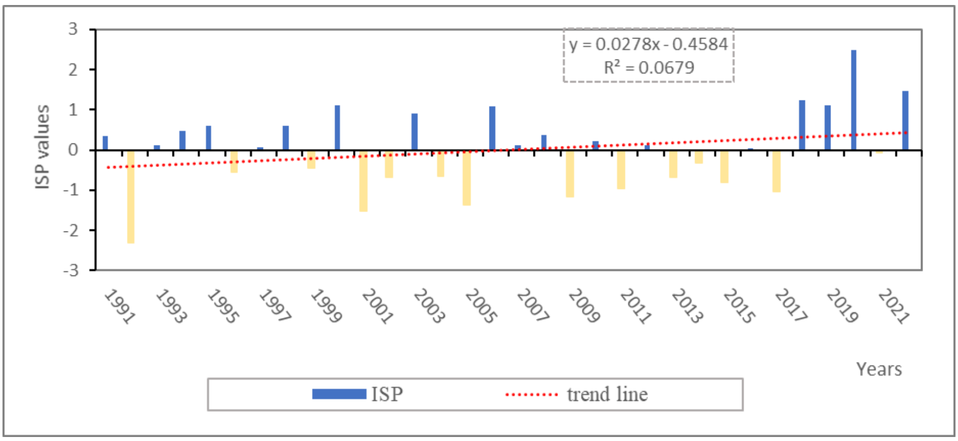

Fig. 4. Change in the standardised precipitation index

In addition, the Standardised Precipitation Index (SPI) can be used to quickly detect drought situations and assess their severity on sesame production. It is less complex than many other indices (the Palmer drought index, for example). The evolution of the standardised rainfall index (figure 4) for the rural commune of Bérégadougou leads to the following conclusions:

(i) the sesame crop years 1996, 1999, 2002, 2004, 2013, 2014 and 2015 are close to normal with SPI values between -0.99 and 0.99; (ii) the years 2001, 2005, 2009 and 2017 are moderately dry with SPI values between -1.0 and -1.49 while the years 2000, 2006, 2018, 2019 and 2021 are moderately wet with SPI values between 1.0 and 1.49 ; (iii) the 1992 sesame campaign is extremely dry with an SPI value between -2 and below while the 2020 year is extremely wet with an SPI value between 2 and above.

Analysis of changes in the standardised rainfall index over the series from 1991 to 2022, i.e. 30 years, has enabled a confident comparison to be made between past and current droughts in the geographical area of the rural commune of Bérégadougou, which is part of the southern Sudanian climate of the dry tropical zone. Whatever the year in the series, rainfall always exceeds 680mm. Nevertheless, the year 2020, which is considered to be extremely wet, could lead to flooding in sesame plots and in the concessions of family farmers.

Another feature of the rural commune of Bérégadougou is the high inter-annual variability of its mean annual temperatures (figure 5).

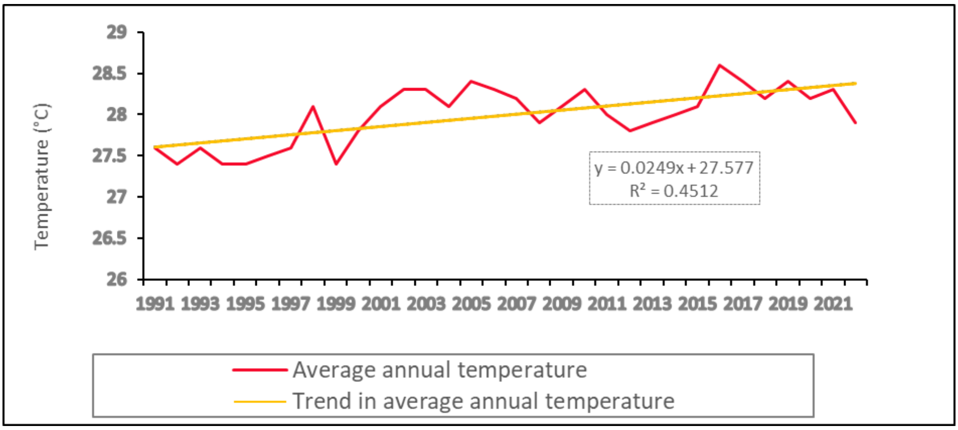

Fig. 5. Year-on-year change in mean annual temperatures

Figure 5 shows that the 1998, 2002, 2003, 2004, 2005, 2010 and 2016 sesame crop years recorded average annual temperatures above 28°C, while the other years had average temperatures between 27°C and 28°C. The hottest sesame crop year was 2017 at 28.5°C, while 1992 was the warmest at 27.38°C. Analysis of the series from 1991 to 2021 shows an increase in temperature of 1.2°C (0.025°C/year). This rise in temperature favours an increase in the rate of evapotranspiration in the study area, as shown in figure 6.

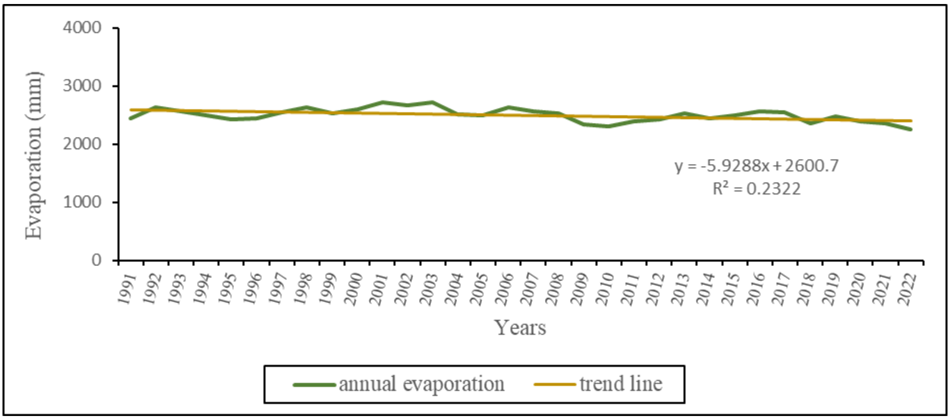

Fig. 6. Interannual trends in potential evaporation

Evapotranspiration is evaporation from the soil and transpiration by plants in general and sesame in particular. It is the quantity of water transferred from the soil to the atmosphere. It is fairly high in the rural commune of Bérégadougou, where it exceeds 2,000 mm in all years of the series of studies. Evapotranspiration regulates the vegetative cycle of the sesame plant and varies from year to year.

In addition to the high inter-annual variability of climatic parameters such as rainfall, temperature and evapotranspiration, relative humidity is also subject to variability, as shown in figure 7.

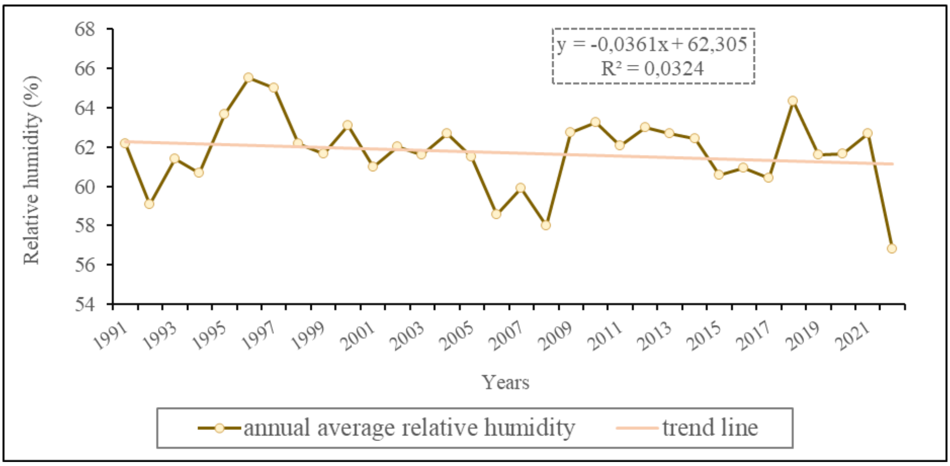

Fig. 7. Trends in average annual relative humidity

Relative humidity plays an important role in the growth of plants in general and sesame in particular. When humidity levels are too low (less than 35%), the growth of the sesame plant is often compromised, as it takes much longer to reach the desired size. As a result, the lower leaves fall off, growth is difficult and the overall quality of the plant is compromised. Analysis of the figure shows that the 1996 sesame season had the highest relative humidity (65.30%), while 2021 had the lowest (57%).

In short, the scientific analysis of climatic variability in the rural commune of Béré-gadougou shows variability in rainfall, temperature, potential evapotranspiration and relative humidity from one sesame crop year to the next over the thirty years of the analysis series.

Farmers' perceptions of climate variability on sesame production

Farmers' perceptions of the impact of climate variability on sesame production can be summed up as the great variability in rainfall from one year to the next, the increase in temperature, the appearance of violent winds, late onset of rainfall, disruption of the rainy season by dry spells, early cessation of rainfall, and the presence of flooding on family farms. Figure 8 shows the farmers' rationale for climate variability

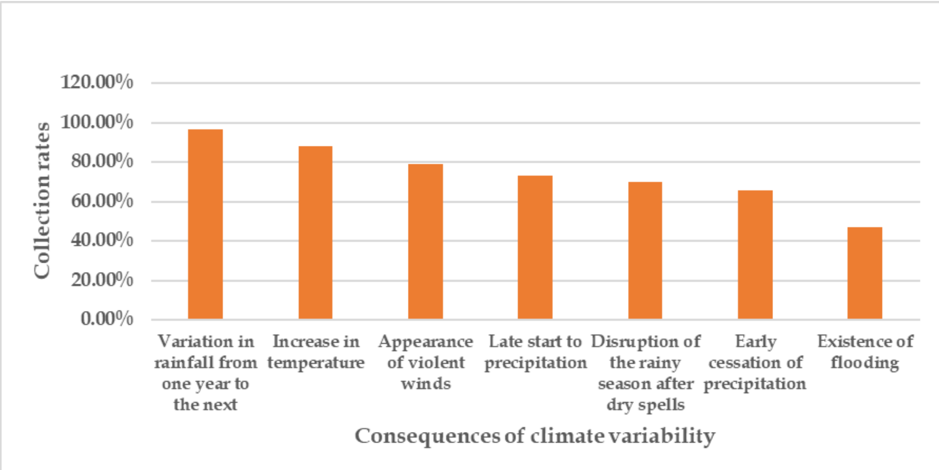

Fig. 8. Farmers' rationale for climate variability

Sesame farmers (96.70%) believe that the variation in rainfall from one year to the next is the main indicator of climatic variability, as water is the key element in agricultural production in general and sesame in particular. This rainfall variability is the cause of the late start (73% according to farmers) to the sesame season. As a result, sowing in mid-June was postponed until the end of June, a fortnight later than usual. Similarly, 70% of sesame growers attribute the disruption of the rainy season by dry spells to the variability of rainfall. Also, 65.87% of family sesame farmers think that the early cessation of rainfall is detrimental to the growth of the sesame plant. It disrupts the flowering and ripening of the sesame, often leading to water stress, which is a source of crop loss. Flooding on sesame farms was cited by 47% as a cause of production losses. For example, 8.6% of producers were unable to harvest their sesame crops when their plots were flooded in 2020.

Investigations revealed the occurrence of violent winds in the rural commune of Bérégadougou. Family sesame farmers (79.10) believe that strong winds at the end of the season disrupt harvests, leading to the loss of seeds through the bursting of bolls, with damage that can account for more than 25% of production.

Sesame production in a context of climatic variability

Sesame production, areas sown and yields are shown in figure 9.

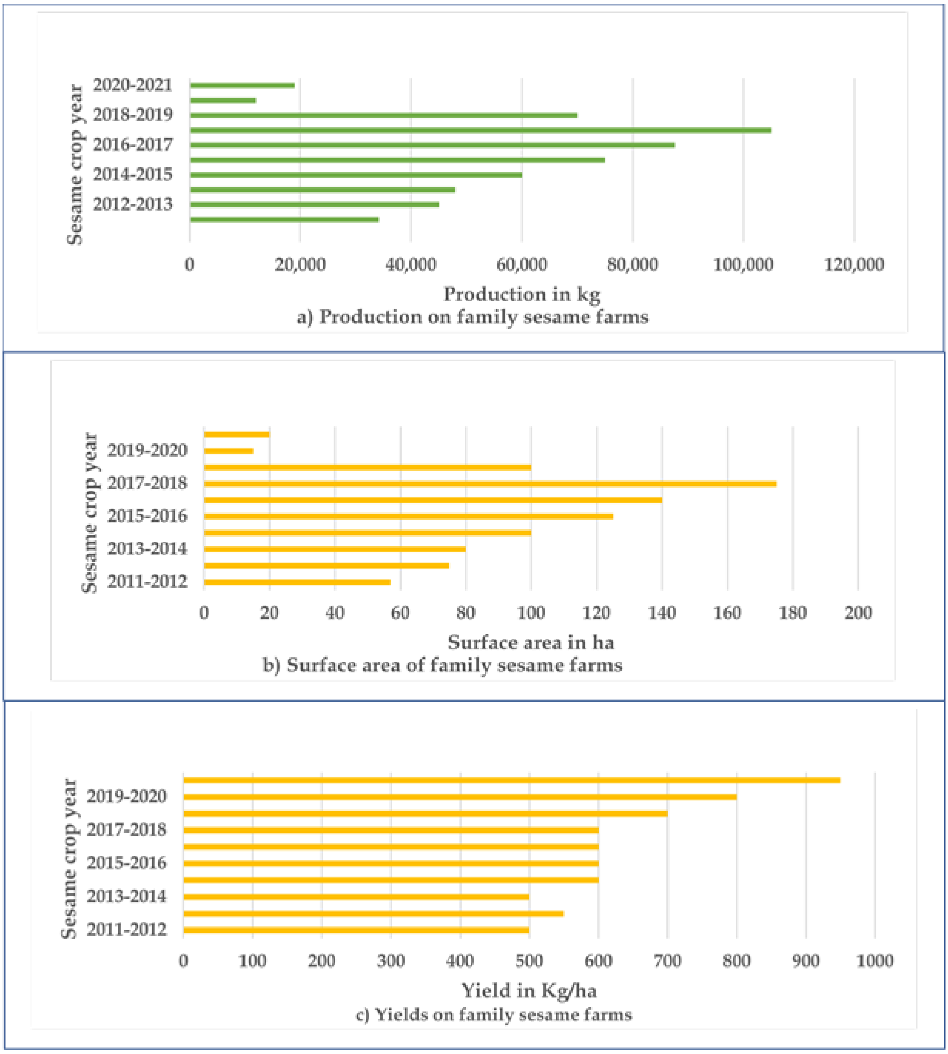

Fig. 9. Production, area and yield of sesame farms

Changes in sesame production in the rural commune of Bérégadougou are closely linked to changes in the area sown. As production increases, so does the area sown. For example, the 2018 sesame season, with 105,000 kg, saw high production on an area of 175 ha, which is the largest in the series of analyses. On the other hand, production yields during the same sesame season were 600 kg/ha, which is below (750 kg/ha) the varietal potential made possible by scientific research. As a result, production and the area sown will increase from 2011 to 2018, before declining until 2021. The majority of family sesame farmers (98%) say that the drop in production (120,000 kg) and area sown (15 ha) in 2020 was caused by the coronavirus pandemic. This period was marked by health restrictions, which led 67% of producers to stop producing sesame. Sesame yields in the plots are also rising steadily throughout the analysis period. From 2020 to 2021, yields exceeded the 750 kg/ha recommended by research. In other words, the increase in sesame yields is due, in the opinion of the producers (87%), to the mastery of technical production itineraries following the training campaigns provided by the agents of the Agricultural Technical Support Zone (ZATA) in the rural commune of Bérégadougou, and resilient strategies to mitigate the effects of climatic variability. The practice of crop rotation has been adopted by farmers. Crop rotation is a cultivation technique that consists of growing a succession of crops in a periodic cycle on a farm. It can be biennial or triennial. The sesame-corn rotation is practised by 87% of farmers, and the three-year sesame-corn-arachid rotation by 11%. Sesame growers also use crop combinations. Sesame and groundnuts (57%), sesame and millet (17%), sesame and sorghum (15%), sesame and beans (7%).

In short, the results obtained on the scientific view of climate variability through analysis of climatic parameters (rainfall, temperature, relative humidity, potential evapotranspiration), farmers' perception of climate variability on sesame production and sesame production in a context of climate variability, only have scientific relevance if they are compared with pre-existing authors.

Discussion

Climatic variability in the rural commune of Bérégadougou is marked by rainfall variability over the analysis series. It is marked by the alternation of 50% of deficit years, 43% of surplus years and 7% of average years. These results are shared by the work of Sanogo (2017) on sesame production in the province of Kossi, north-west Burkina. The author shows that rainfall is marked by alternating deficit and surplus years. Vodounou (2015) agrees, stating that meteorological conditions have a strong influence on agriculture in Benin, which is essentially rain-fed. All the variations observed in recent years have modified farming practices and led to the production systems seen today.

Analysis of rainfall has shown that, whatever the year, rainfall is always above 650 mm. This shows that rainfall conditions are good for sesame production, as the plant needs between 250 and 800 mm of water per year (Rhida and Mohamed, 2013). The commune of Bérégadougou is exposed to flooding, which affects production in the opinion of sesame farmers. Investigations by Nongana (1996) corroborate this result. The author shows that sesame is extremely sensitive to flooding and successive heavy rains which, at any time during the cycle, can greatly increase the incidence of fungal diseases.

An analysis of temperatures shows that the hottest sesame crop year was 2017, at 28.5°C, whereas 1992 was the warmest, at 27.38°C, resulting in an increase in temperature of 1.2°C (0.025°C/year). This increase in temperature favours a rise in the rate of evapotranspiration in the rural commune of Bérégadougou, which exceeds 2,000 mm whatever the year of the analysis series (1991-2022). Temperatures are always above 15°C in every year of the series. This plays an important role in the vegetative cycle of sesame, as "below 15°C (except for greenhouse crops), germination and development are slowed down. On the other hand, conditions are favourable at 25°C and above" (Sanogo, 2008). Analysis of relative humidity over the period 1991 to 2021 shows that the 1996 sesame season had the highest relative humidity (65.30%), while 2021 had the lowest (57%).

Regardless of the year, the relative humidity rate was always above 35%, attesting to good relative humidity conditions for sesame production.

The results obtained on farmers' perception of climatic variability on sesame production are marked by variations in rainfall from one year to the next (96.70%), increases in temperature (88.12%), violent winds (79.10%), late onset of rainfall (73%), disruption of the rainy season by dry spells (70%), early cessation of rainfall (65.87%) and flooding (47%).

These results are shared by the work of Romero et al (2011), who show that the increase in temperature, the very great variability in the frequency and intensity of rainfall/variable seasonality and the appearance of extreme climatic phenomena (increase in the frequency and intensity of droughts and floods) are the manifestations of climate change on agriculture in Burkina Faso. The work of Doukpolo (1994) concurs. The author states that an analysis of climate observations and projections shows a variability in rainfall, a rise in temperatures and an upsurge in extreme meteorological phenomena in this area, and that the impacts of climate change on agricultural production are already evident.

This climatic variability has prompted farmers in the rural commune of Bérégadougou to adopt resilient strategies to cope. They have adopted crop rotations, crop associations and the use of early varieties. These results are similar to the findings of Djessonou (2013), where, in response to extreme climatic events, farming communities in the commune of Za-Kpota, Benin, adopted crop rotation (95%), crop rotation (75%), chemical fertiliser (40%) and organic fertiliser (60%) as resilience strategies.

Conclusion

The aim of this study is to analyse sesame production in a context of climatic variability. Sesame production increased from 2011 to 2018, due in part to the mastery of production techniques and the application of cultivation methods such as crop rotation, crop association and the use of organic and chemical fertilisers. On the other hand, from 2019 to 2021, sesame production was decline, mainly due to the outbreak of coronavirus disease. Sesame yields in the rural commune of Bérégadougou have exceeded 750 kg/ha (recommended by research) since the 2019 season. The analysis of climatic parameters over the 1991-2021 series showed that sesame is a crop that is resilient to climatic variability. Rainfall, temperature, relative humidity and potential evapotranspiration conditions are favourable for growing sesame. In other words, sesame production is possible in a context of climatic variability in the study area.

Conflicts of Interest: The authors declare no conflict of interest.

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