International Journal of Research Studies in Agricultural Sciences (IJRSAS)
Volume 9, Issue 11, 2023, PP 1-6
ISSN No. (Online) 2454–6224
DOI: http://dx.doi.org/10.20431/2454-6224.0911001
www.arcjournals.org

Influence of Cropping Systems on Sorghum Yield in Southern Chad

Agoubli ISSINE[1*], HaraTOUKOU[2], A. GODS WILL Azinwie[3], Hassan MANSOUR[1]

[1]*Faculty of Agronomic Sciences and Environment, University of Sarh, Chad*

[2]*Faculty of Science, University of Dschang, Cameroun*

[3]*Faculty of Science, University of Buea, Cameroun*

Corresponding Authors:** ***Agoubli ISSINE, *Faculty of Agronomic Sciences and Environment, University of Sarh, Chad*

Abstract: *A study carried out in southern Chad aimed to determine the influence of cropping systems on the yield of Sorghum (Sorghum bicolore (L.) Moench). Five villages were chosen in the Mayo-Lémié department for this study. In each chosen village, three soil samples were collected including one from a field operated for one to two consecutive years (A), a sample from a field exploited between three to four years (B) then a sample from a field exploited for at least five years (C). A total of fifteen samples were collected and the yields on each sampled plot were taken. The study shows that sorghum is produced without rotation and without restitution of nutrients; yields decrease with the duration of exploitation in all five villages. To improve the situation it would be advisable to use mineral fertilizer in combination with organic fertilizer.*

Keywords: *Chad, Sorghum, yield, Mayo-Lémié.*

1. Introduction

Sorghum (Sorghum bicolore (L.) Moench) is the fifth most cultivated and consumed cereal in the world after corn, rice, wheat and barley (Doggett, 1988, FAO, 2004). In Africa, it occupies second place after maize (Benoit et Samba, 2008). The main sorghum growing areas are in warm regions such as Asia, Africa and America (Hien, 2004). In most developing countries where it is mainly used as human food, extensive management methods are still practiced, with few inputs and without crop succession (Issiné *et al.*, 2022). These practices contribute to the degradation of the quality of arable land (Issiné *et al.*, 2022). Indeed, land degradation constitutes a serious problem in most developing countries and especially in sub-Saharan Africa(Gunamantha et *al.*, 2021). In Chad, sorghum is one of the main food crops (Nekouam, 1993). For several decades, the monoculture of this species has represented the dominant system; an intensification of production systems becomes essential by adopting new technologies such as the use of early varieties, crop rotations, the practice of agroecology and crop diversification. These strategies fit perfectly into the integrated management of soil fertility and could help protect producers against climate risks, reduce nutrient losses and improve food security (Kaho, 2011). The application of organic matter and small doses of mineral fertilizer are agricultural practices that can boost yields in the face of climate effects (Gunamantha et *al.*, 2021). Low soil fertility and unsuitable agricultural practices are aggravating factors. It is with the aim of identifying the main factors which influence sorghum yields that this study was carried out.

2. Materials and Methods

2.1. Presentation of the Study Area

The study area is located in South-Western Chad, in the middle of the Sudano-Sahelian environment. It extends from 10°31′ to 11°06′ North and 15°00′ to16°30′ East (figure 1). The climate is characterized by a long dry season from October to May and a short rainy season, from June to September. The mean annual rainfall is about 652 mm, and the average temperature is 28°C.

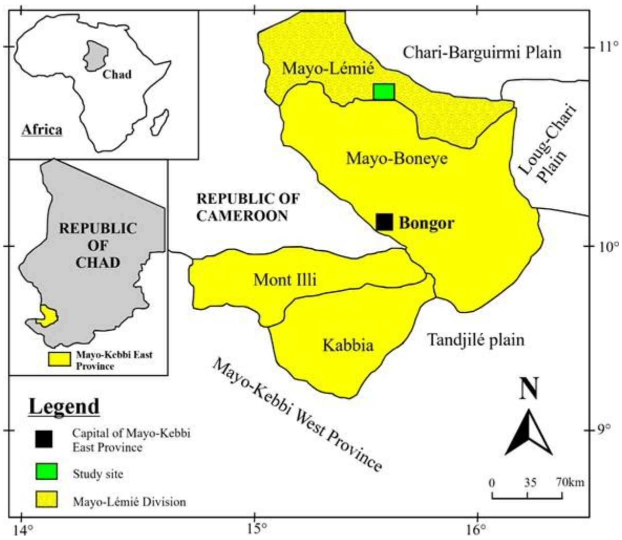

Figure1. *Location of the study area*

2.2. Methods

Sorghum producers were surveyed in 05 villages (Table 1) of Mayo-Lémié in order to assess their social and economic conditions; in each of the 05 villages, 20 producers were surveyed and soil samples were taken for physicochemical analyses. In each chosen village, three soil samples were taken, including a sample taken from a field exploited successively no more than two years after fallowing (A); a sample from a field operated between three to four consecutive years after fallow (B) and a sample taken from a field operated at least five years after fallow (C). A total of 15 soil samples were collected and sent to the laboratory to determine fertility parameters (pH, CEC, total nitrogen, phosphorus, calcium, potassium, etc.).

Table1. *Villages surveyed and sampled*

Village name	Latitude	Longitude	Altitude
Gongrongo	10° 52’ 757’’N	15° 32'651’’E	314 m
Mogrom	11° 07’ 556’’N	15° 24’ 004’’E	308 m
Midjoué	10° 54’ 449’’N	15’ 35’ 090‘’E	316 m
Béré	10° 46’ 502’’N	15° 48’ 644‘’E	313 m
Guelendeng	10° 54’ 601 ‘’N	15’ 33’ 903 ‘’E	312m

3. Results

3.1 Cultivation techniques

The investigation showed that in most cases, the field is plowed with a plow before sowing. The preparation of the soil and the mechanical maintenance of the fields by harness cultivation are well integrated into the technical itineraries of the farmers; direct sowing without plowing is only applied in 37% of cases (figure 2).

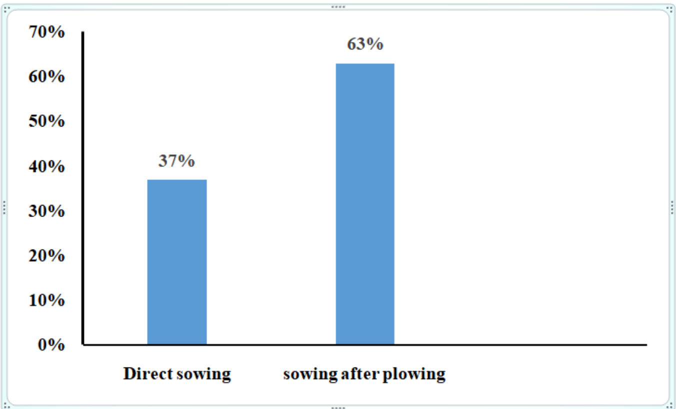

Figure2. *Main sowing methods*

3.2. Association and crop succession

The production strategies of farmers in Mayo-Lemié do not vary from one year to the next. Sorghum occupies the largest agricultural areas. Year after year, sorghum is grown on the same plots, often in pure culture. We can regularly observe sorghum grown in association with okra, sorrel or cucumbers. The crop association in this case only concerns secondary crops associated with sorghum which always remains the main one.

3.3 Yields at the different sites

In the five villages, yields are highest in fields exploited for at most two years (site A) followed by fields exploited between three and four years then finally by those exploited for more than five years (figure 3). In Gongrongo, in site A, the yield is 900 kg/ha; it decreases by 33% in site B and by 50% in site C. On the other hand in Mogrom, the yield is 600 kg/ha in sites A and B; it decreases by 50% in site C. In Midjoué, the yield decreases by 43.74% in site B and by 62.5% in site C; in Béré, it decreases by 33% and 50% respectively in site B and C; finally, in Guelendeng, the reduction in yield is 50% in the two sites (site B and C). In all five villages sampled, yields decline with the duration of exploitation.

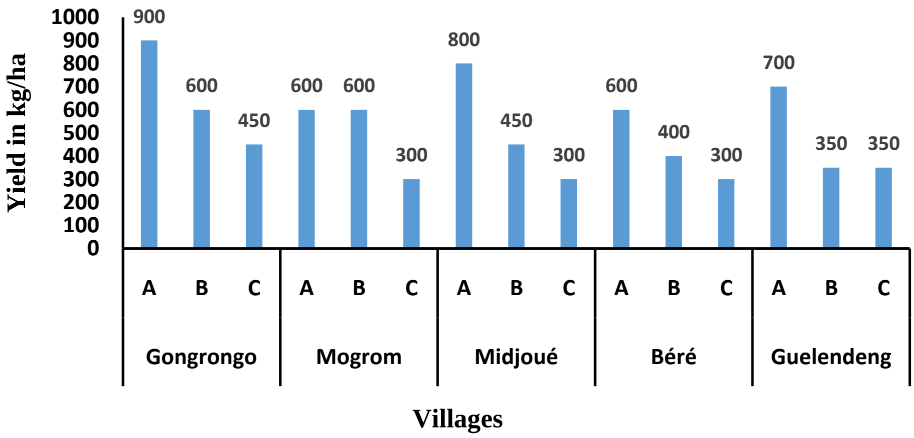

Figure3. *Yields obtained in the different sites*

3.4 physicochemical properties

Generally speaking, the soil samples analyzed consist of high levels of sand followed by silt and then clay. Nitrogen contents vary from 0.35 to 0.8% in the different samples. The organic matter contents vary from 0.76 to 3.97%. pHs vary from slightly acidic to acidic. The contents of exchangeable cations are low. CECs vary from low to moderate (12.4 - 45.6 meq/100 g of soil). Potassium instead of decreasing with the duration of exploitation rather increases in Gongrongo and Mogrom; Likewise, magnesium and calcium levels increase in Guelendeng in site C. However, the levels of the latter remain below standards. The reduction in nutrients in the different sites is not proportional to the reduction in yields. Table 2 presents all the characteristics of the soils studied.

4. Discussion

4.1 Cultivation techniques

Fields plowed before sowing give a better yield than those which have not been plowed. These results confirm the work of (Issiné, 2015)who showed that the yield gain obtained through plowing amounts to an average of 30% compared to traditional preparation. Increasing the density to 25,000,000 pockets per hectare (spacing of 0.8 m x 0.5 m) increasesthe yield as shown by Payne (1997). Whatever the level of education or social situation of the producer, the production techniques are the same; it does not evolve with culture and ecology; this situation is likely to cause the rapid destruction of natural resources as noted by Honvou et *al.* (2022). Land preparation always begins with burning cut shrubs and crop residues; this affects the level of organic matter and destroys the soil structure, which has negative effects on water infiltration and soil fertility in the long term. By burning the soil, the ashes release nutritional substances which are directly usable by the plants, the first harvest following the burning is generally good, after a few seasons, there is a negative effect of the burning on the level of the nutritional substances and on the soil fertility. During burning, a large quantity of nitrogen and sulfur are released which are no longer available to plants (Tsozué et *al.*, 2014). After burning, all the nutrients stored in the vegetation end up in the soil solution, but cannot be fully used right away. The often violent rains that fall in the form of thunderstorms carry with them large quantities of these elements such as nitrogen and others. On the other hand, phosphorus, in mineral form, attaches to soil particles and is no longer available to plants, so yields drop.

4.2 Association and crop succession

The positive effect of rotation on yields has been attributed to nitrogen from legumes in the rotation (Boubié, 2002). However, other researchers have attributed the positive effects of rotation to improved biological and physical properties of the soil and the ability of some legumes to make the highly insoluble phosphorus bound to calcium soluble through exudates from their roots(Boubié, 2002).

4.3 Yields at the different sites

The results obtained are consistent with those obtained by Issiné (2023) who state that today, land degradation has become a global ecological problem that affects arable land around the world ; Taylor *et al.* (2017)add that land degradation in sub-Saharan Africa is increasing sharply and constitutes a serious threat to the agricultural sector. Many authors (Bruinsma, 2017 ; Altieri, 2018),think that apart from monoculture, crops under plant cover, additions of organic matter to the soil and agroecology can be used to improve soil fertility. Crops under plant cover have the advantage of increasing the quantity of organic matter and stopping soil erosion (Yemefack et *al.*, 2004). For Issiné (2023), monoculture is one of the causes of the decline in agricultural productivity; thus, for several authors, fallows can be mentioned to compensate for production which is only decreasing because they promote the production of organic matter which has the advantage of increasing the level of soil fertility on the one hand and to limit its erosion on the other hand.

4.4 physicochemical properties

The low levels of organic matter can be attributed to the continuous cultivation of fields and the burning of crop residues as mentioned by Tsozué et *al.*(2020); this result can also be the result of rapid mineralization of biomass under the effect of climatic, chemical and physical factors of the soil (Basga et *al.*, 2018). Indeed, pH is a key element of the chemical composition of the soil and determines the availability of nutrients for plants and soil microorganisms. Low base saturation is correlated with Ph ; its control is necessary to obtain a higher level of fertility in sustainable agriculture. Base saturation and CEC have low values. The very low levels of nitrogen, phosphorus and other nutrients can be explained by the low level of organic matter (Valery et Pansu, 2022).It should also be added that the type of vegetation and the competition between agriculture and livestock accentuate the deficiency in nutrients (Tsozué et *al.*, 2015). The CEC values obtained correspond to type 2:1 minerals which are often encountered in environments with low rainfall where leaching is not very advanced (Valery et Pansu, 2022). The low potassium content can also be attributed to the sandy texture because a soil low in clay and silt has a reduced capacity to retain potassium. In semi-arid regions of Africa, soil phosphorus deficiency is considered one of the major biophysical constraints to agricultural production (Hubert et Schaub 2011). Organic matter and organic carbon decrease with the duration of operation as listed by (Hubert et Schaub 2011). The increase in the levels of potassium, magnesium and calcium in certain sites is contrary to the results obtained by Issiné (2015); but, it is reminiscent of the work of Yerima et Van ranst (2005) talking about wind inputs and the continuous burning of field residues which release the ashes thus increasing their contents. However, if wind inputs are not taken into account, the situation confirms the work carried out by. Issiné (2015) for whom, in a field where sorghum is cultivated in pure culture, the yields drop without the nutrient elements of the soil varying. considerably. Likewise, in a crop succession, sorghum has a depressing effect on the crops that follow it and this effect is also observed on itself (Deshmukh, 2012). Therefore, sorghum would benefit better if it is cultivated after legumes which can increase the mineral nitrogen of the soil and this leads to an increase in yields of 60 to 300% compared to monoculture (Boubié, 2002).The drop in yield would not only be due to a mineral deficiency due to exports but Yerima et Van Ranst (2005) assumes that phenol acids contained in sorghum roots would be the cause of phytotoxicity. The increase in the levels of potassium, magnesium and calcium in certain sites is contrary to the results obtained by Altieri (2018),but, it is reminiscent of the work of Yerima et van Ranst (2005) talking about wind inputs and the continuous burning of field residues which release the ashes thus increasing their contents. However, if wind inputs are not taken into account, the situation confirms the work carried out by Issiné (2023) for whom, in a field where sorghum is cultivated in pure culture, the yields drop without the nutrient elements of the soil varying. considerably. Likewise, in a crop succession, sorghum has a depressing effect on the crops that follow it and this effect is also observed on itself (Kaho, 2011). Therefore, sorghum would benefit better if it is cultivated after legumes which can increase the mineral nitrogen of the soil and this leads to an increase in yields of 60 to 300% compared to monoculture (Gustavo, 2022).The drop in yield would not only be due to a mineral deficiency due to exports but Honvou *et al*. (2022),assumes that phenol acids contained in sorghum roots would be the cause of phytotoxicity. However, whatever the nature of the phytotoxic substances responsible, it is clear that the resulting allelopathy process can be eliminated by inoculation of the soil with a fungus or bacteria, which implies that these substances are biodegradable. Compost and manure can degrade this substance which inhibits the growth of sorghum. Therefore, the use of organic matter is very important because in addition to this role mentioned above, it makes it possible to strengthen the retention and infiltration capacity of the soil in water, air and even in nutrient elements in reducing its erodibility and increasing potential productivity.

5. Conclusion

At the end of this study, it appears that sorghum is cultivated without restitution of exported elements or rotation. After a few consecutive years of plowing, a drop in productivity is observed. This drop in productivity is due to the phenomenon of allelopathy which appears following the secretion by the sorghum roots of a substance which immobilizes soil nutrients making them unavailable to the plants after several consecutive years of use. The low productivity of sorghum in the area can be attributed to poor field management, lack of information and inappropriate prices of agricultural inputs. The use of organic matter is well indicated to improve the situation but given its quantity which would not be sufficient for sustained agriculture, mineral fertilizer is needed in combination with organic fertilizer. For this, the training of producers in mastering crop rotation and technical itineraries as well as the manufacture of compost is desirable. It is also necessary to slightly raise the pH of the soil by adding CaCO3 which could also raise the calcium level. The search for exact doses of fertilizer to optimize yields could constitute other areas of research. At the end of this study, it appears that sorghum is cultivated without restitution of exported elements or rotation. After a few consecutive years of plowing, a drop in productivity is observed. This drop in productivity is due to the phenomenon of allelopathy which appears following the secretion by the sorghum roots of a substance which immobilizes soil nutrients making them unavailable to the plants after several consecutive years of use. The low productivity of sorghum in the area can be attributed to poor field management, lack of information and inappropriate prices of agricultural inputs. The use of organic matter is well indicated to improve the situation but given its quantity which would not be sufficient for sustained agriculture, mineral fertilizer is needed in combination with organic fertilizer. For this, the training of producers in mastering crop rotation and technical itineraries as well as the manufacture of compost is desirable. It is also necessary to slightly raise the pH of the soil by adding $CaCO_3$ which could also raise the calcium level. The search for exact doses of fertilizer to optimize yields could constitute other areas of research.

References

[1] Altieri M A, 2018. Agroecology: the science of sustainable agriculture. CRC Press. 2nd Edition.

[2] Basga S D, Temga JP, Tsozué D, Danbé D, Nguetnkam J P,2018. Morphological, mineralogical and geochemical features of topomorphic vertisols used for sorghum production in North Cameroon, Eurasian Journal of Soil Science, Vol 7 : 346-354.

[3] Benoit C, SambaT,2008.Le potentiel de rendement du mil et du sorgho en Afrique de l'Ouest. Projet mil et sorgho. Rapport.

[4] Boubié V B,2002.Rôle des légumineuses sur la fertilité des sols ferrugineux tropicaux des zones guinéenne et soudanienne du Burkina Faso. Thèse de Doctorat Ph D, université Laval Quebec.

[5] Bruinsma J, 2017.World agriculture: towards 2015/2030: an FAO study: Routledge.

[6] Deshmukh K K, 2012. Evaluation of soil fertility status from Sangamner area, Ahmednagar district, Maharashtra, India. Rasayan Journal of Chemistry Vol 5 : 398-406.
[7] Doggett H,1988.Sorghum.2nd Ed. Harlow (England). Longman Group UK Limited. 64p.
[8] Food and Agriculture Organization (FAO), 2004.Evaluation des importations et aides alimentaires par rapport à l'appui au développement de l'agriculture : évidence par l'étude de cas. République du Tchad.
[9] Food and Agriculture Organization (FAO),2012.Assessment of Needs Due to Floods in the Tandjile, Mayo-Kebbi East, Mayo Kebbi West, Food and Agriculture Organization,Rome, Italy.
[10] Gunamantha M, Sudiana I K, Sastrawidana D K, Suryaputra I N G A, Oviantari M V, (2021).The evaluation of soil fertility status of open space in campus area and their suitability for tropical fruits production. Journal of Soil Science and Environmental Management. 12(2) 78-85.
[11] Gustavo B M, 2022. L'agriculture productiviste à l´agriculture multifonctionnelle dans le système agraire du cacao et le paiement pour services environnementaux. Université Paris-Nanterre; Laboratoire Dynamiques Sociales et Recomposition des Espaces (LADYSS); Programa CAPES-Print (Brésil).
[12] Hien E,2004.Dynamique du carbone dans un acrisol ferrique du Centre-Ouest du Burkina : influence des pratiques culturales sur le stock et la qualité de la matière organique. Thèse de doctorat, École Nationale Supérieure Agronomique de Montpellier (France).
[13] Honvou S H S, Aboh A B, Tèka O, Sèwadé C, Gandonou B C, Oumorou M, Sinsin B, 2022. Utilisation et modélisation de la dynamique de l'occupation du sol des parcours des transhumants dans la Basse et Moyenne Vallée de l'Ouémé (Bénin). Sciences and Technologies for Sustainable Agriculture. Vol. 2(1) 18-29.
[14] Hubert G, Schaub C,2011.La fertilisants des sols. L'importance de la matière organique. Chambre d'Agriculture, Bas- Rhin. Service Environnement-Innovation.
[15] Issiné A,2015.Facteurs socio-économiques et biophysiques influençant les rendements du sorgho (*Sorghum bicolore (L.) Moench*) dans le Mayo-Lemié au Sud-Ouest du Tchad. Mémoire Master. Université de Dschang, Cameroun.
[16] Issiné A, Tsozué D, Nzeukou N A, Fouateu Yongue R, Kagonbé BP,2022.Soil Characteristics and Pedoclimatic Evaluation of Rainfed *Sorghum* (*Sorghum bicolor* (L.) Moench) in the Mayo-Lemié Division, South-Western Chad. Applied and Environmental Soil Science, vol. 2022 pp 1-12.
[17] Issiné A,2023.Genèse, classification et aptitudes culturales des sols du Mayo-Lemié au Sud-Ouest du Tchad. Thèse PHD, Université de Maroua, Cameroun.
[18] Kaho F, Yemefack M, Feujio-Teguefouet P, Tchantchaouang J,2011.Effet combiné des feuilles de Tithonia diversifolia et des engrais inorganiques sur les rendements du maïs et les propriétés d'un sol ferralitique au Centre Cameroun. Tropicultura.
[19] Nekouam N,1993.Situation de la recherche sur le striga au Tchad.Lagoke STO., van der Straten LE, Mboob SS, eds, Integrated Management of Striga for the African Farmer. Harare:PASCON General Workshop.
[20] Payne W A, 1997.Managing yield and water use of pearl millet in the sahel. Agron. J. 89:481-490.
[21] Taylor P D, Fahrig L, Henin K, Merriam G, 2017. Connectivity is a vital element of landscape structure, 68 571-572.
[22] Tsozué D, Haiwe B R, Nghonda J P,2014.Local initiatives ofland rehabilitation in the sudano-sahelian region: case ofhard´e soils in the far north region of Cameroon.OpenJournal of Soil Science, vol. 4, pp. 6-15.
[23] Tsozué D, Nghonda J P,Mekem D L,2015.Impact of landmanagement system on crop yields and soil fertility inCameroon," *Solid Earth Discussions*, vol. 6, pp. 1087-1101.
[24] Tsozué D, Nafissa B, Basga S D, Balna J,2020.Soil change inarenosols under long term cultivation in the sudano-sahelianzone of Cameroon," Geoderma Regional, vol. 23.
[25] Valery A, Pansu M, 2022.Dynamique des matières organiques des sols, modèles proposés et relations modèles-organismes - Étude et Gestion des Sols, Vol 29 : 169-184.
[26] Yemefack M, Nounamo L, Njomgang R, Bilong P, 2004. Influence des pratiques agricoles sur la teneur en argile et autres proprieties agronomiques d'un sol ferralitique du sud Cameroun. Tropicultura, 22 (1) 3-10.
[27] Yerima B PK, Van Ranst E, 2005. Introduction to soil science: Soils of the tropics Trafford Publishing, 6E-2333 Government St, Victoria, BC Canada.

Citation: *Agoubli ISSINE, et.al., (2023). " Influence of Cropping Systems on Sorghum Yield in Southern Chad" International Journal of Research Studies in Agricultural Sciences (IJRSAS), 9(11), pp. 1-6 DOI: http://dx.doi.org/10.20431/2454-6224.0911001*