International Scholars Journals

International Journal of Agroforestry and Silviculture ISSN: 2375-1096 Vol. 11 (7), pp. 001-009, July, 2023. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Identifying the factors influencing Anacardium Occidentale L. (cashew) survival at juvenile stage for the resilient and productive cashew-based agroforestry systems in Burkina Faso (West Africa)

Saye Traoré[1], Thomas Lamizana[2] and Ayub Djibo[3]

[1]Institut de l'Environnement et de Recherches Agricoles (INERA), station de recherches environnementales et agricoles de Farako-Bâ, 01 BP 910, Bobo-Dioulasso, Burkina Faso
[2]Projet d'Appui au Développement de l'Anacarde dans le bassin de la Comoé pour la Réduction des Emissions dues à la Déforestation et la Dégradation des forêts (PADA-REDD+), 01 BP 337, Bobo-Dioulasso, Burkina Faso
[3]Université Joseph Ki-Zerbo, Ecole doctorale sciences et techniques, 03 BP 7021, Ouagadougou 03, Burkina Faso.

Accepted 28 March, 2023

Abstract

The cashew seedlings survival after planting is a major factor affecting the productivity of the cashew-based agroforestry systems. This research investigated the factors influencing the cashew seedlings survival at juvenile stage for the resilient and productive cashew-based agroforestry systems in Burkina Faso. Different cashew seedlings clones were planted in three field experiment plots in the south west region. The living, dead, stressed percentages and numbers of seedlings were evaluated after 15 months to assess the survival. The seedlings survival was sensitive to the rainfall, temperature and soil conditions and under the genetics factors control. The application of the good sylvicultural practices would improve the seedlings survival. The cashew adaptation to the rainfall, temperature and soil conditions was under the genetics factors control. The farmers training and awareness increase about the good sylvicultural practices and the intensification of the research for selecting and promoting the cashew clones that are adapted to the rainfall, temperature and soil conditions of the different regions of the cashew production could improve the seedlings survival contributing to the productive and resilient cashew-based agroforestry systems. Further research to investigate the cashew nuts production and quality of the clones is required to recommend the performant clones.

Keywords: improvement, genetics, ecophysiology, soil, climate.

INTRODUCTION

The cashew-based agroforestry systems are increasing in the agricultural production systems in Burkina Faso (Somé, 2014 ; Belem, 2017) due to the social and economic benefits provided by the cashew nuts for the farmers (Nugawela et al., 2006 ; Marlos et al., 2007 ; Sarah, 2014 ; Sali et al., 2020). The cashew nut is the 3rd agricultural product of exportation after the cotton and the sesame in Burkina Faso (DGPER, 2015). Several initiatives to establish the cashew-based agroforestry systems were implemented by the government of Burkina Faso and its partners including the free distribution of improved cashew seeds, grafted cashew seedlings and the farmers trainings related to the good sylvicultural practices of cashew production.

Despite these investments, it was reported a low density of the cashew trees in the cashew-based agroforestry systems in Burkina Faso (Ricau, 2013). The low cashew seedlings survival after planting was reported to be the major cause of this low density of the cashew trees and it reduces the productivity and the production of the cashew-based agroforestry systems (Leibowitz, 2012 ; Lara et al., 2014 ; Adu-Gyamfi et al., 2019). In fact, determining the causes of the low cashew seedlings survival after planting are crucial to improve the cashew-based agroforestry systems productivity and production. The literature review did not show such research studies carried out in Burkina Faso. Then, the objective of this research was to investigate the factors affecting the survival of different cashew seedlings clones at juvenile stage after planting for recommendations to improve the cashew seedlings survival after planting and contribute to the productive and resilient cashew-based agroforestry systems.

MATERIAL AND METHODS

Sites description

The experiment was conducted in the south west region of Burkina Faso in the field experiment plots established at three different sites including Dano, Diébougou and Kampti. The rainfall, temperature and soil characteristics of these three sites were those observed in the south west region. The south west region is a major region of the cashew production with about 884 farmers, 2663 ha under conventional cashew production and with a productivity of about 379 t/ha (UNPA, 2014). The south west region is located between 10°67' and 12°11' latitude north and 2°84' and 5°49' longitude west. The average annual temperature of the south west region is between 21 °C and 32 °C and the average annual rainfall is between 900 mm and 1200 mm (Belem, 2017). The soils of the south west region are tropical eutrophic brown on clay material, ferralitic medium desaturated on sandy-clay material and mineral hydromorphic (Belem, 2017). The geographical coordinates of the field experiment plots at Dano, Diébougou and Kampti were respectively WGS 1984 UTM Zone 30 N with (X 490034, Y 1230437), WGS 1984 UTM Zone 30 N with (X 474543, Y 1205593) and WGS 1984 UTM Zone 30 N with (X 443571, Y 1132195). The cashew seedlings clones used for the experiments were produced with the grafts collected from the elite cashew trees at the south west and the centre west regions of Burkina Faso. The average annual rainfall of the centre west region is between 600 mm and 900 mm and the average annual temperature is 37 °C (Asimi, 2009). The soils of the centre west region are tropical ferruginous, tropical eutrophic brown with low leaching and hydromorphic with low humus content (Asimi, 2009). The centre west region is located at 11° 45′ nord and 2° 15′ ouest. The clones produced with the polyclonal seeds from the northern Ghana were used in the experiments. The average annual rainfall of the northern Ghana is 49,53 mm and the average annual temperature is 28, 87 °C (Friesen, 2002). The soils of the northern Ghana are sandy with low clay and nutrients contents (Friesen, 2002). The northern Ghana is located at longitude -0.9056623 and latitude 9.5439269.

Plant material

The cashew seedlings clones used in the experiments were produced with 08 cashew grafts collected from the elite cashew trees in the centre west and the south west regions of Burkina Faso and with 01 plolyclonal seeds from the northern Ghana. The cashew rootstocks used for the grafting were provided by the Burkina Faso national centre in charge of forest seeds production. The elite cashew trees from which the grafts were collected were those with the best dendrometric, health and production performance and they were identified from the best cashew plantations jointly with the farmers. The cashew seedlings clones produced were maintained in nursery and planted in the field experiments plots 02 months later. The number of cashew seedlings for each clones planted in the field experiment plots at Kampti, Dano and Diebougou are presented in the Table 1. The clones Ouéssa, Nicéo, Diakadougou and Diébougou were produced with the grafts collected from the elite cashew trees in the south west region. The cashew clones Cassou, Fido, Kayero and Sapouy were produced with the grafts collected from the elite cashew trees in the centre west region. The cashew clones Ghana were produced with the polyclonal seeds from the northern Ghana. There was not an application of the best sylvicultural practices in the field experiments plots. The difference between the number of the cashew seedlings for the different clones used in the field experiment plots was explained by the success of the grafting and the number of the grafts collected from the elite cashew trees.

Experimental design and data collection

The field experiments plots established at each site had the size 100 m X 100 m and they were selected in relation with the farmers. The field experiment plots were secured. The distance between the cashew seedlings clones planted in the field experiment plots were 06 m between the seed holes and 06 m between the planting lines. The cashew seedlings clones were planted randomly on September 2019. For evaluating the survival of the cashew seedlings clones, the parameters measured were the number of living, stressed and dead cashew seedlings for each clone 15 months later, allowing to take into account 01 dry and 01 rainy season. The numbers obtained were then used to calculate the percentages. The survival of the cashew

Table 1. Distribution of the cashew seedlings number for each clone planted in the field experiments of Dano, Diébougou and Kampti.

Clones	Dano	Diébougou	Kampti
Polyclonal seeds from Ghana	69	51	67
Diakadougou	46	89	69
Nicéo	43	49	50
Ouéssa	40	54	59
Cassou	39	0	0
Fido	24	0	0
Diébougou	9	21	16
Kayero	11	0	0
Sapouy	4	0	0
Total	285	264	261

Table 1. Results of the ANOVA test of the effects of the clones and sites on the living, dead and stressed cashew seedlings numbers .

Tests	**Parameters**	**DDL**	**Sum of squares**	**Mean of squares**	**F**	**Pr > F**
	Living seedlings	4	1969,733	492,433	3,969	**0,035**
Clones effect	Dead seedlings	4	621,733	155,433	2,272	0,133
	Stressed seedlings	4	15,067	3,767	1,153	0,387
	Living seedlings	2	19,600	9,800	0,037	0,964
Sites effect	Dead seedlings	2	154,133	77,067	0,803	0,471
	Stressed seedlings	2	17,733	8,867	3,547	0,062

Significant = P < 0.05 very significant = P < 0.01 highly significant = P < 0.001

seedlings clones was high when the percentages or the numbers of the dead and stressed cashew seedlings were low and the percentages or the numbers of the living cashew seedlings were high.

Statistical analysis

The ANOVA test was used to test the effects of the sites and clones on the living, dead and stressed cashew seedlings numbers using the software XLSTAT. When the differences among the means were significant with ANOVA, they were separated by the test of Student-Newman Keuils at 5%. The Microsoft Excel software was used to assess the difference of the living, dead and stressed cashew seedlings percentages between the clones at each site and between the sites for each clone due to the fact that the cashew seedlings clones produced with the grafts collected from the elite cashew trees in the centre west region were planted only at the field experiment plots of Dano due to the insufficiency of the grafts collected.

RESULTS

Evaluation of the effects of the clones and sites on the living, dead and stressed cashew seedlings numbers

The results of the ANOVA showed a significant effect of the clones on the living cashew seedlings number (Table 1). The number of the living cashew seedlings was higher for the clone Diakadougou (Figure 1). The results of the ANOVA did not reveal a significant effect of the clones on the dead and stressed cashew seedlings numbers (Table 1). The results of the ANOVA did not show a significant effect of the sites on the living, dead and stressed cashew seedlings numbers (Table 1). In general, the survival of the cashew seedlings at juvenile stage was better for the clone Diakadougou.

Evaluation of the living, dead and stressed cashew seedlings percentages between the clones at Dano

The living cashew seedlings percentage was higher than the dead percentage for the clones Diakadougou, Nicéo, Ouéssa, Diébougou, Ghana and these clones did not show the stressed cashew seedlings (Figure 2). The dead cashew seedlings percentage for the clones Cassou, Fido, Kayero and Sapouy was important and close to the living cashew seedlings percentage (Figure 2). The highest stressed cashew seedlings percentage was observed for the clone Fido (Figure 2). The highest living cashew seedlings percentage was observed for the clone Ghana (Figure 2). The highest dead cashew seedlings percentage was observed for the clone Cassou (Figure 2). The cashew seedlings survival at juvenile stage was better for the clones Diakadougou, Nicéo, Ouéssa, Diébougou and Ghana at Dano.

Evaluation of the living, dead and stressed cashew seedlings percentages between the clones at Diébougou

The living cashew seedlings percentage was higher than the dead and stressed percentages for the clones Diakadougou, Nicéo, Ouéssa, Diébougou and Ghana (Figure 3). The highest percentage of the stressed cashew seedlings was observed for the clones Diakadougou and Ghana (Figure 3). The highest living cashew seedlings percentage was observed for the clones Diakadougou and Ouéssa (Figure 3). The highest dead cashew seedlings percentage was observed for the clones Diakadougou, Nicéo and Ghana (Figure 3). The cashew seedlings survival at juvenile stage was better for the clone Ouéssa at Diébougou.

Evaluation of the living, dead and stressed cashew seedlings percentages between the clones at Kampti

The living cashew seedlings percentage was higher than the dead and stressed percentages for the clones Diakadougou, Nicéo, Ouéssa and Diébougou (Figure 4). The dead cashew seedlings percentage was higher than the living and stressed percentages for the clone Ghana (Figure 4). The highest dead cashew seedlings percentage was observed for the clone Ghana (Figure 4). The highest living cashew seedlings percentage was observed for the clones Diakadougou, Nicéo and Ouéssa (Figure 4). The highest stressed cashew seedlings percentage was observed for the clones Ouéssa and Diakadougou (Figure 4). The cashew seedlings survival at juvenile stage was better for the clone Nicéo at Kampti.

Evaluation of the living, dead and stressed cashew seedlings percentages between the sites for each clone

For the clone Ghana the highest percentage of the dead cashew seedlings was observed at Kampti (Figure 5a), the highest percentage of the living cashew seedlings was observed at Dano (Figure 5b) and the highest percentage of the stressed cashew seedlings was observed at Diébougou and Kampti (Figure 5c). For the clone Nicéo the highest dead cashew seedlings percentage was observed at Diébougou (Figure 5a), the highest living cashew seedlings percentage was observed at Kampti (Figure 5b) and the highest stressed cashew seedlings percentage was observed at Kampti and Diébougou (Figure 5c). For the clone Diakadougou the highest dead cashew seedlings percentage was observed at Diébougou (Figure 5a), the highest living cashew seedlings percentage was observed at Diébougou and Kampti (Figure 5b) and the highest stressed cashew seedlings percentage was observed at Diébougou and Kampti (Figure 5c). For the clone Ouéssa the highest dead cashew seedlings percentage was observed at Kampti (Figure 5a), the highest living cashew seedlings percentage was observed at Kampti and Diébougou (Figure 5b) and the highest stressed cashew seedlings percentage was observed at Kampti (Figure 5c). For the clone Diébougou the highest dead cashew seedlings percentage was observed at Diébougou (Figure 5a), the highest living cashew seedlings percentage was observed at Diébougou and Kampti (Figure 5b) and this clone did not show the stressed cashew seedlings (Figure 5c). The cashew seedlings survival at juvenile stage for the clone Ghana was better at Dano compared to the others sites. The cashew seedlings

Figure 1. Variation of the living cashew seedlings number according to the clones.

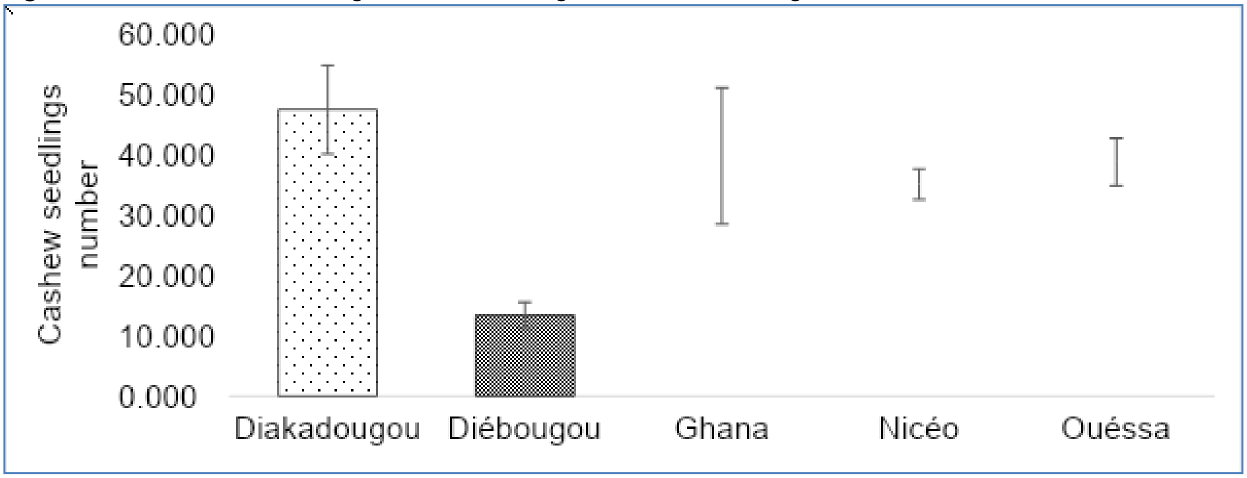
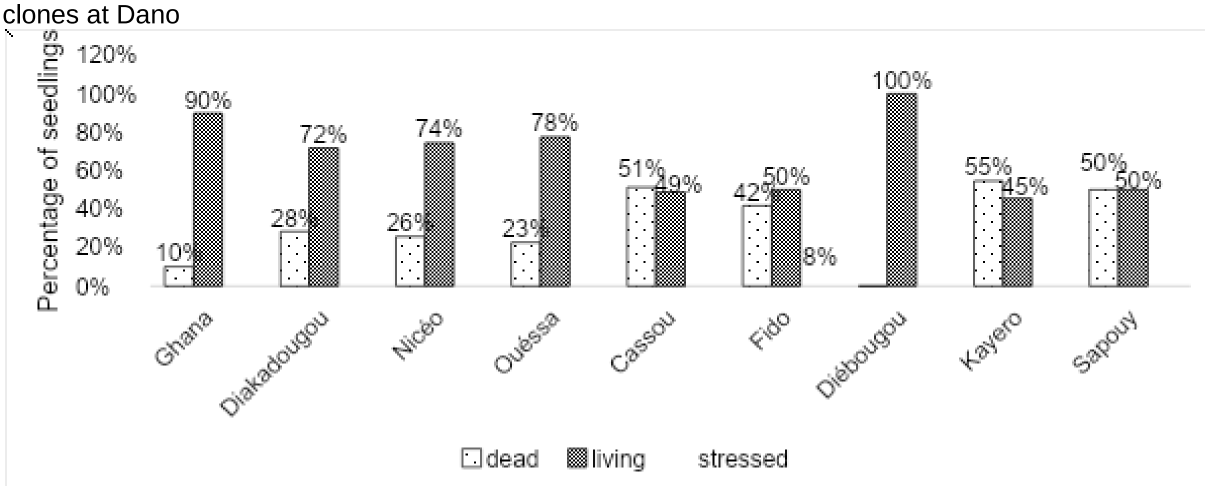


Figure 2. Variation of the living, dead and stressed cashew seedlings percentages according to the clones at Dano



survival at juvenile stage for the clone Nicéo was better at Dano compared to the others sites. The cashew seedlings survival at juvenile stage for the clone Diakadougou was better at Dano compared to the others sites. The cashew seedlings survival at juvenile stage for the clone Ouéssa was better at Dano and Diébougou compared to Kampti. The cashew seedlings survival at juvenile stage for the clone Diébougou was better at Dano and Kampti compared to Diébougou.

DISCUSSION

The cashew is characterised by a high phenotypic and genotypic variability (Olubode et al., 2018) and this could explain the difference of the seedlings survival performance between the clones with the higher seedlings survival observed for the clone Diakadougou compared to the others clones. In fact, the cashew seedlings survival is under the control of the genetics factors and this implies that the survival can be considered as an important criterion to take into account in the selection of resilient cashew varieties for increasing the production (Adu-Gyamfi et al., 2021). However, research studies reported that the cashew survival was weakly influenced by the genetics factors (Adu-Gyamfi et al., 2019). The clone Diakadougou showing the better seedlings survival performance should be monitored over the years in measuring the nuts production and their characteristics as these parameters were reported to be under the genetic control (Archak et al., 2003 ; Cavalcanti et al., 2007 ; Adu-Gyamfi et al., 2020) and are of high importance in the international cashew market (Adu-Gyamfi et al., 2022). The effect of the sites on the seedlings survival

Figure 3. Variation of the living, dead and stressed cashew seedlings percentages according to the clones at Diébougou.

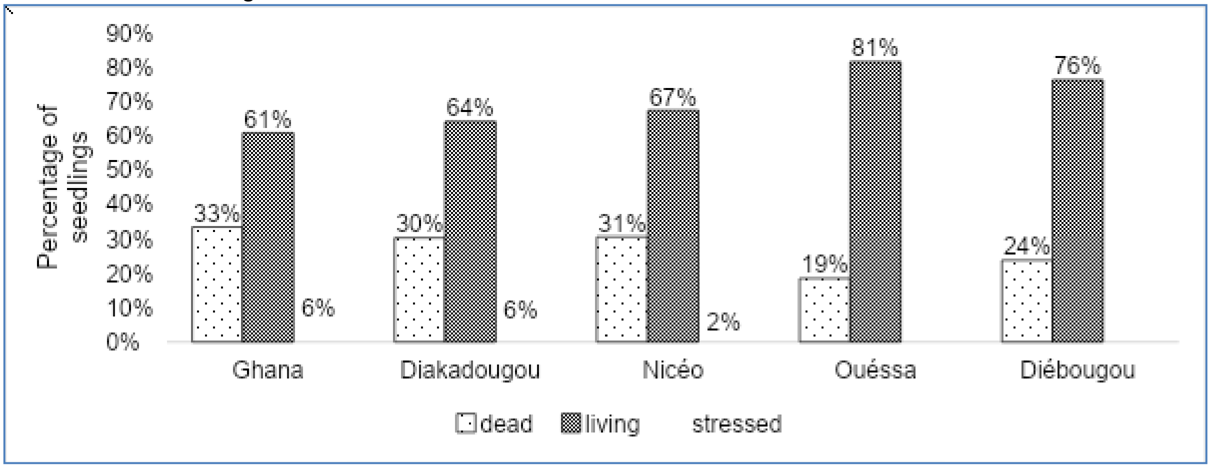
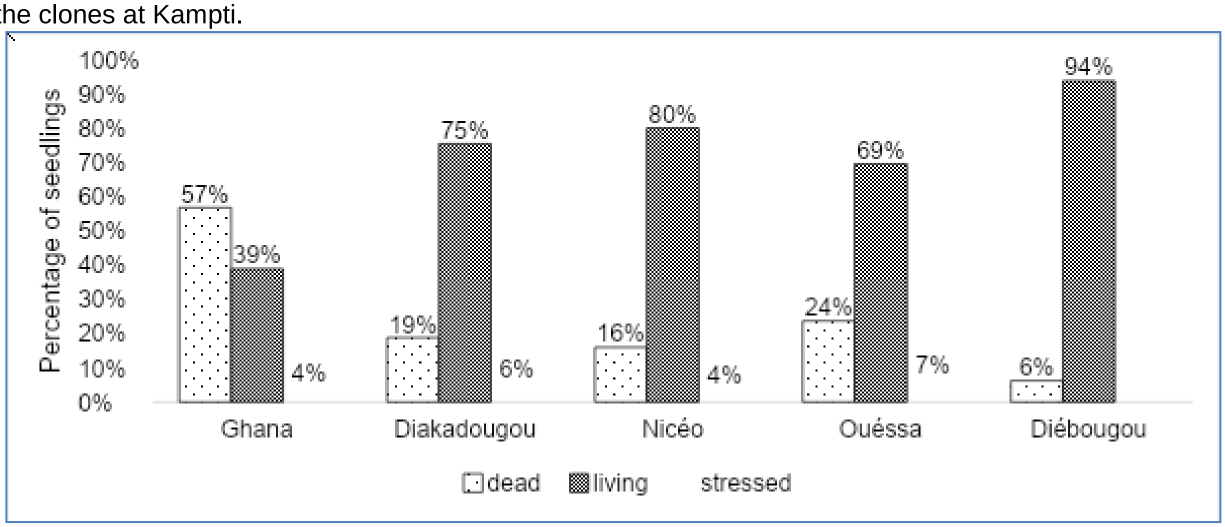
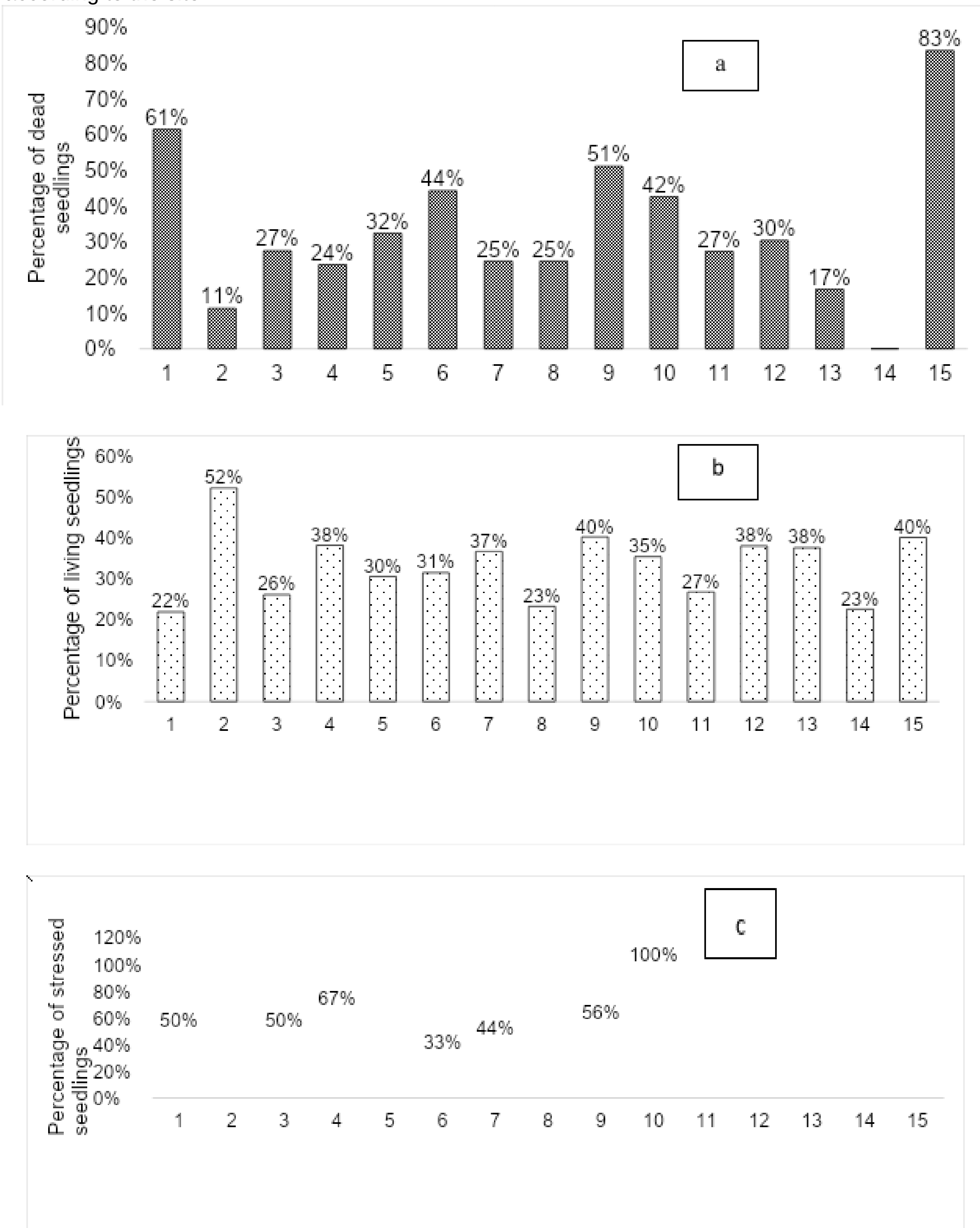


Figure 4. Variation of the living, dead and stressed cashew seedlings percentages according to the clones at Kampti.



was not significant suggesting that the rainfall, temperature and soil conditions were not significantly different between the 03 field experiment plots established in the south west region. The results showed at the field experiment plot of Dano that the clones from the south west region had the higher seedlings survival compared to the clones from the centre west region with a different rainfall, temperature and soil conditions. In fact, the cashew tree is sensitive to the rainfall, temperature and soil conditions corroborating several authors (Mbow et al., 2009 ; Bambara et al., 2013 ; Balogoun et al.2016 ; Bello et al., 2017 ; Djighaly et al. 2021 ; Grüter et al., 2022). However, several others authors reported that the cashew trees are drought tolerant and have the ability to grow under harsh environments (Bezerra et al., 2008 ;Capelari et al., 2021). This study showed that the cashew tree adaptation to the rainfall, temperature and soil conditions is under the influence of the genetics factors due to the fact that the clones from the south west region had a greater ability to adapt to the rainfall, temperature and soil conditions of the south west region compared to the clones from the centre west region at Dano, to the best seedlings survival performance observed for different clone at the different experiment plots and to the ability of the clones from the polyclonal seeds from the northern Ghana to grow at the south west region rainfall, temperature and soil conditions. Indeed, several authors reported the influence of the genetics factors in the adaptation of the cashew trees to the environment (Adu-Gyamfi et al., 2019 ; Ndiaye, 2019 ; Adu-Gyamfi et al., 2021 ; Djighaly et al., 2021;

Figure 5. Percentage of the: **a** dead cashew seedlings for each clone according to the site; **b** living cashew seedlings for each clone according to site the **c** stressed cashew seedlings for each clone according to the site.



Grüter et al., 2022). It is therefore relevant to intensify the research for identifying the cashew clones that are adapted to the rainfall, temperature and soil conditions of the different region of the cashew production. The seedlings survival of a large number of the clones from the south west region and from the polyclonal seeds from Ghana performed better at the experiment plot of Dano. This could probably be explained by the application of the good sylvicultural practices of the cashew production. Boyce (2010) and Lara et al. (2014) reported that the seedlings survival after planting for achieving the expected benefits of the planting operations was improved with the application of the good sylvicultural practices. Lara et al. (2014) also reported that intensified communication related to the application of the good sylvicultural practices improved the seedlings survival after planting.

CONCLUSION

This research evaluated the cashew seedlings survival performance for different clones at juvenile stage. The seedlings survival was sensitive to the rainfall, temperature and soil conditions and it was under the influence of the genetics factors. The application of the good sylvicultural practices of the cashew production would improve the seedlings survival. The cashew adaptation to the rainfall, temperature and soil conditions was under the influence of the genetics factors. The farmers training, the awareness increase about the good sylvicultural practices of the cashew production and the intensification of the research for selecting and promoting the cashew clones that are adapted to the rainfall, temperature and soil conditions of the different regions of the cashew production could improve the seedlings survival after planting and contribute to the productive and resilient cashew-based agroforestry systems. Further research to investigate the cashew nuts production and nuts quality of the clones that showed a good seedlings survival performance at the different experiment plots is required before to make a recommendations of the performant clones to promote for each site.

ACKNOWLEDGMENTS

We would like to thank the « Projet d'Appui au Développement de l'Anacarde dans le bassin de la Comoé pour la Réduction des Emissions dues à la Déforestation et la Dégradation des forêts (PADA-REDD+) » for funding this research activity. We would also like to thank the experts involved in the implementation of the PADA-REDD+ project for their valuable contributions in the data collection of this research activity.

REFERENCES

Adu-Gyamfi PKK, Barnnor M, Akpertey A, Padi F (2022). Genetic Variability and Combining Abilities for Earliness to Nut Yield and Nut Weight in Selected Cashew *(Anacardium Occidentale* L.) Clones. Int. J. Fruit Sci. 22 (1) : 539-550.

Adu-Gyamfi PKK, Akpertey A, Barnnor M, Ofori A, Padi F (2020). Genotypic characterization of cashew (*Anacardium occidentale* L.) clones using agro-morphological traits. Plant-Environ. Interactions 1 (3) : 196-206.

Adu-Gyamfi PKK, Barnor M, Akpertey A, Dadzie AM, Anyomi E, Osei-Akoto S, Padi F (2021). Broadening the Gene Pool of Cashew (Anacardium occidentale) for Survival and Precocity. Agric. Res.10 : 613 - 625.

Adu-Gyamfi PKK, Dadzie MA, Barnor M, Akpertey A, Alfred Arthur A, Osei-Akoto S, Ofori A, Padi F (2019). Genetic variability and trait association studies in cashew *(Anacardium occidentale* L.). Sci. Hortic 255 : 108-114.

Archak S, Gaikwad A, Gautam D, Rao EV, Swamy KR, Karihaloo J (2003). Comparative assessment of DNA fingerprinting techniques (RAPD, ISSR and AFLP) for genetic analysis of cashew (Anacardium occidentale L.) accessions of India. Genome 46 : 362–369.

Asimi S (2009). Influence des modes de gestion de la fertilité des sols sur l'activité microbienne dans un système de cultures de longue durée au Burkina Faso. Thèse de doctorat d'état ès-sciences naturelles, université polytechnique de Bobo Dioulasso.

Balogoun I, Ahoton EL, Saïdou A, Bello OD, Ezin V et al (2016). Effect of Climatic Factors on Cashew (*Anacardium occidentale* L.) Productivity in Benin (West Africa). J. Earth Sci. Clim. Chang. 7 (1) : 1-11.

Bambara D, Bilgo A, Hien E, Masse D, Thiombiano A, Hien V (2013). Perceptions paysannes des changements climatiques et leurs conséquences socio environnementales à Tougou et Donsin. Climats sahéliens et sahélo-soudanien du Burkina Faso. Bull. Rech. Agron. Bénin 74(1) : 8-16.

Belem BCD (2017). Analyse des déterminants de l'adoption des bonnes pratiques de production de l'anacarde au Burkina Faso. Mémoire, Université de Laval.

Bello DO, Ahoton IE, Saidou A, Akponikpè IPB, Ezin VA, Balogoun I, Aho N (2017). Climate change and cashew (*Anacardium occidentale* L.) productivity in Benin (west africa) : perceptions and endogenous measures of adaptation. Int. J. Biol. Chem. Sci. 11(3) : 924-946.

Bezerra MA, Claudivan FL, Filho EG, Carlos EBA, José TP (2008). Physiology of cashew plants grown under adverse conditions. Braz. J. Plant Physiol. 19(4) : 449-461.

Boyce S (2010). It takes a stewardship village : Effect of volunteer tree stewardship on urban street tree mortality rates. Cities and the Environment 3.

Capelari ÉF, Dos Anjos L, Rodrigues NF, Sousa RMJ, Silvera JAG, Margis R (2021). Transcriptional profiling and physiological responses reveal new insights into drought tolerance in a semiarid adapted species, *Anacardium occidentale.* Plant. Biol. 23(6): 1074-1085.

Cavalcanti JJV, de Resende MDV, Crisóstomo JR, de Paiva J (2007). Genetic control of quantitative traits and hybrid breeding strategies for cashew improvement. Crop. Breed. Appl. Biotechnol. 7: 186–195.

DGPER (2015). Brève présentation de la filière anacarde. Ouagadougou, DGPER, Burkina Faso.

Djighaly PI, Ndiaye S, Dieme JS, Dieng F, Gueye M, Zazou AZ, et al. (2021). Comparative study of drought stress tolerance of four provenances of *Anacardium Occidentale* L. grown under semi controlled conditions. Int. J. Agric. Environ. Bio-Res. 06 (03) : 245-256.

Friesen J (2002). Spatio-temporal Rainfall Patterns in Northern Ghana. Diploma thesis, 81p.

Grüter R, Trachsel T, Laube P, Jaisli I (2022). Expected global suitability of coffee, cashew and avocado due to climate change. PLoS One 17(1) : 1-24.

Lara A, Romana B, John J, Battles A, Joe R, Bridea Mc (2014). Determinants of establishment survival for residential trees in Sacramento County, CA. Landsc. Urban Plan. 129 : 22–31.

Leibowitz R (2012). Urban tree growth and longevity: An international meeting and research symposium white paper. Arboric. Urban For. 38 (5) : 237–24.

Marlos BA, Claudivan F, lacerda DE, Enéas gomes F, Carlos de abreu B, José Prisco T (2007). Physiology of cashew plants grown under adverse conditions. Brazilian J. of Plant Physiol. 19 (4) : 449-461.

Mbow AFB, Diop SS, Tounkara A, Gueye B, Seck ML (2009). Changements climatiques : entre résilience et résistance. Agridape 24(4) : 4-5.

Ndiaye S (2019). New Techniques and Research To Improve and Enhance Production in the Sahel Region (grafting, polyclonal seeds, etc.). Forum sur le Cajou Sahélien (FOCAS), Bamako, Mali.

Nugawela P, Baldé A, Poublanc C (2006). La chaîne de valeurs anacarde au Sénégal, analyse et cadre stratégique d'initiatives pour la croissance de la filière. Programme USAID/ croissance économique.

Olubode OO, Joseph-Adekunle TT, Hammed LA, Olaiya AO (2018). Evaluation of production practices and yield enhancing techniques on productivity of cashew (*Anacardium occidentale* L.). Fruits 73(2) : 75–100.

Ricau P (2013). Connaître et comprendre le marché international de l'anacarde.

Sali B, Madou C, Nome A, Kuate J (2020). Caractérisation socio-économique des grands bassins de productions d'anacardiers (*Anacardium occidentale*) et étude comportementale de leur peuplement dans le Cameroun septentrional. Int. J. Biol. Chem. Sci. 14(6) : 2094-2111.

Sarah A (2014). Systèmes d'innovation et territoires : un jeu d'interactions ; les exemples de l'anarcade et du jatropha dans le sud-ouest du Burkina Faso. Thèse de doctorat Université Panthéon-Sorbonne - Paris I.

Somé LFMC (2014). Analyse socioéconomique des systèmes de production d'anacarde au Burkina Faso : cas des régions des Cascades et des Hauts-Bassins. Mémoire Institut du développement rural, Université de Bobo-Dioulasso.

UNPA/BF (2014). Base de données des producteurs/trices affilié(e)s pour les années 2011 à 2013.