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Research Article

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

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ABSTRACT

Cashew seedlings survival after planting is a major factor affecting cashew-based agroforestry systems productivity. This research investigated factors influencing cashew seedlings survival at juvenile stage for resilient and productive cashew-based agroforestry systems establishment in Burkina Faso. Different cashew seedlings clones were planted in three field experiment plots in south west region and the percentages of living, dead and stressed seedlings were evaluated after 15 months of experiment. Cashew seedlings clones survival was affected by rainfall, temperature and soil properties. The lack of sylvicultural practices application affected cashew seedlings clones survival. Cashew seedlings clones showed different adaptation potential to rainfall, temperature and soil parameters. Farmers training and raising their awareness on cashew sylvicultural practices and intensification research for selecting cashew clones adapted to different cashew production regions rainfall, temperature and soil parameters could contribute to improve cashew seedlings survival after planting for productive and resilient cashew based agroforestry systems.

Keywords: Improvement, Genetics, Eco physiology, Soil, Climate

INTRODUCTION

The cashew based agroforestry systems are increasing in the Burkina Faso agricultural systems due to the socioeconomic benefits provided by cashew trees for farmers [1]. The cashew value chains contribution in creating jobs and generating incomes for farmers in Burkina Faso is very important. The cashew nuts are the 3rd agricultural products exported after cotton and sesame in Burkina Faso [2].

Several initiatives to establish cashew based agroforestry systems were implemented by the government of Burkina Faso and its partners among whom free distribution of cashew improved seeds and grafted cashew seedlings as well as farmers training on best cashew sylvicultural practices, but we observed a low cashew seedlings survival after planting leading to low established cashew-based agroforestry systems productivity due to a weak cashew tree density on farms and few research addressed the causes of this issue. Several authors reported that information about seedlings early survival performance after planting and determining the causes affecting this are crucial to estimate projected benefits of tree planting operations [3]. Then, the objective of this research was to investigate the factors affecting the survival of 09 cashew seedlings clones at juvenile stage after planting for resilient and productive cashew-based agroforestry systems establishment.

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MATERIALS AND METHODS

Sites description

The experiments were conducted in field experiment plots in the south west region of Burkina Faso at three different sites including Dano, Diebougou and Kampti. The climate and soil characteristics at these three field experiment plots were those observed in the south west region. The south west region is a major region of cashew production with about 884 farmers, 2663 ha under cashew conventional production and with a productivity about 379 t/ha. The south west region is located between 10º67' and 12º11' latitude north and 2º 84' and 5º 49' longitude west. The average temperatures of the south west region are between 21 ºC and 32 ºC and the average annual rainfalls between 900 mm and 1200 mm [4]. The soils of the south west region are tropical eutrophic brown on clay material, ferralitic medium desaturated on sandy-clay material and mineral hydromorphic. The geographical coordinates of the field experiment plots at Dano, Diebougou 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 experiments were produced with grafts collected from cashew elite trees in south west and center west regions of Burkina Faso and with polyclonal seeds from northern Ghana. The average annual rainfalls of the center west region are between 600 mm and 900 mm and the average annual temperature is 37ºC. The soil of the center west region are tropical ferruginous soils, tropical eutrophic brown soils with low leaching and hydromorphic soils with low humus content. The center west region is located at 11º 45′ nord and 2º 15′ ouest. The clones produced with polyclonal seeds from northern Ghana were used for the experiments. The average annual rainfall of the northern Ghana is 49,53 mm and the average annual temperature is 28, 87 ºC [5].

The soil of the northern Ghana is sandy with low clay and nutrients contents. The northern Ghana is located at longitude -0.9056623 and latitude 9.5439269.

Plant material

The cashew seedlings clones used for the experiments were produced with 08 cashew grafts collected from cashew elite trees in the center west and south west regions of Burkina Faso and with 01 polyclonal seeds from northern Ghana. The cashew rootstocks used for grafting were provided by the Burkina Faso national center in charge of forest seeds production. The cashew elite trees from which they were collected the grafts were those with 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 Ouessa, Niceo, Diakadougou and Diebougou were produced with grafts collected from cashew elite trees in the south west region. The cashew clones Cassou, Fido, Kayero and Sapouy were produced with grafts collected from cashew elite trees in the center west region. The cashew clones Ghana were produced with polyclonal seeds from Ghana. There was not an application of best sylvicultural practices in the field experiments plots. The difference between the numbers of cashew seedlings for the different clones used in the field experiment plots was explained by the success of grafting and the number of grafts collected from the cashew elite trees.

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

Table 1. Distribution of the number of cashew seedlings for each clones planted in the wood yards of Dano, Diebougou and Kampti.

Experimental design and data collection

The field experiments plots used 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 cashew seedlings clones planted in the field experiments plots were 06 m between seed holes and 06 m between the planting lines. The cashew seedlings clones were planted randomly at each of the field experiment plots on September 2019. For evaluating the cashew seedlings clones survival at juvenile stage, the parameters measured were the number of living, stressed and dead cashew seedlings for each clone in the field experiment plots 15 months later, allowing taking into account 01 dry and 01 rainy season. The numbers obtained were then used to calculate the percentages for each clone. The cashew seedlings clone survival was high when the percentages of dead and stressed cashew seedlings were low and the percentage of living cashew seedlings were high.

Statistical analysis

The ANOVA test was used to test the effect of site and clones on living, dead and stressed cashew seedlings 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 cashew seedlings living, dead and stressed percentages between clones at each site and between sites for each clones due to the fact that the cashew seedlings clones produced with the grafts collected from elite trees in the centre west region were planted only in the field experiment plots of Dano due to the insufficiency of the grafts collected

RESULTS

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

The result of ANOVA test showed a significant effect of clones on living cashew seedlings. The living cashew seedlings were higher for the clone Diakadougou (Figure 1). The result of ANOVA test did not reveal a significant effect of clones on dead and stressed cashew seedlings. The result of ANOVA did not show a significant effect of the site on living, dead and stressed cashew seedlings. In general, the cashew seedlings survival at juvenile stage was better for the clone Diakadougou (Table 2).

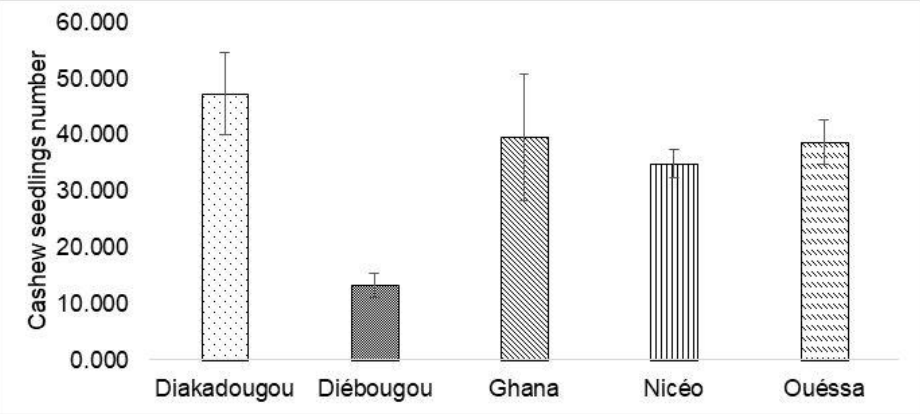

Figure 1. The clones effect on living cashew seedlings.

Tests	Parameters	DDL	Sum of squares	Mean of squares	F	Pr>F
Clones effect	Living seedlings	4	1,969, 733	492,433	3,969	0,035
	Dead seedlings	4	621,733	155,433	2,272	0,133
	Stressed seedlings	4	15,067	3,767	1,153	0,387
Site effect	Living seedlings	2	19,600	9,800	0,037	0,964
	Dead seedlings	2	154,133	77,067	0,803	0,471
	Stressed seedlings	2	17,733	8,867	3,547	0,062
Note: Significant: P<0.05; very significant: P<0.01; highly significant: P<0.001						

Table 2. Results of ANOVA test of clones and sites effects on living, dead and stressed cashew seedlings.

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

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

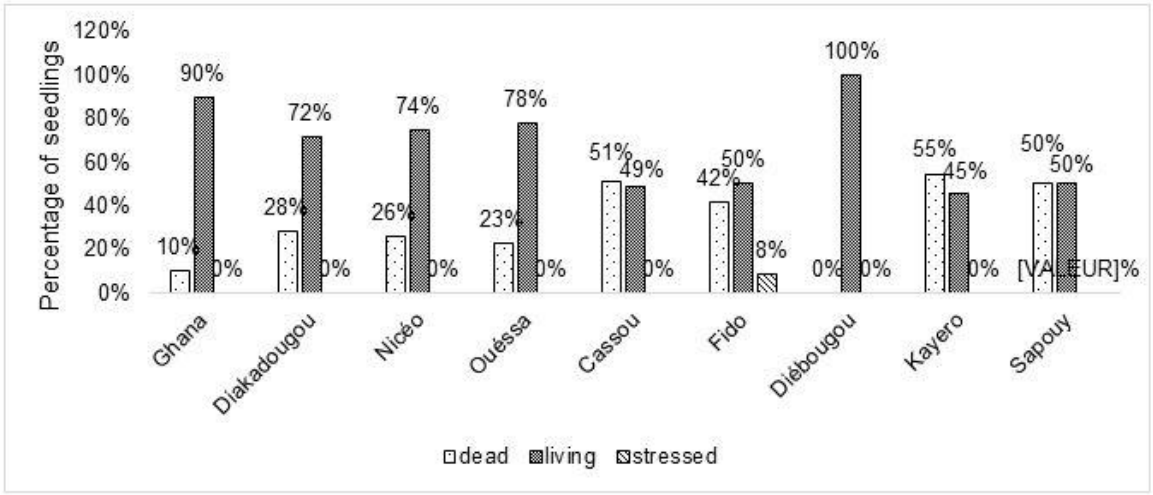

Figure 2. Percentages of living, dead and stressed cashew seedlings of the different clones at Dano.

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

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

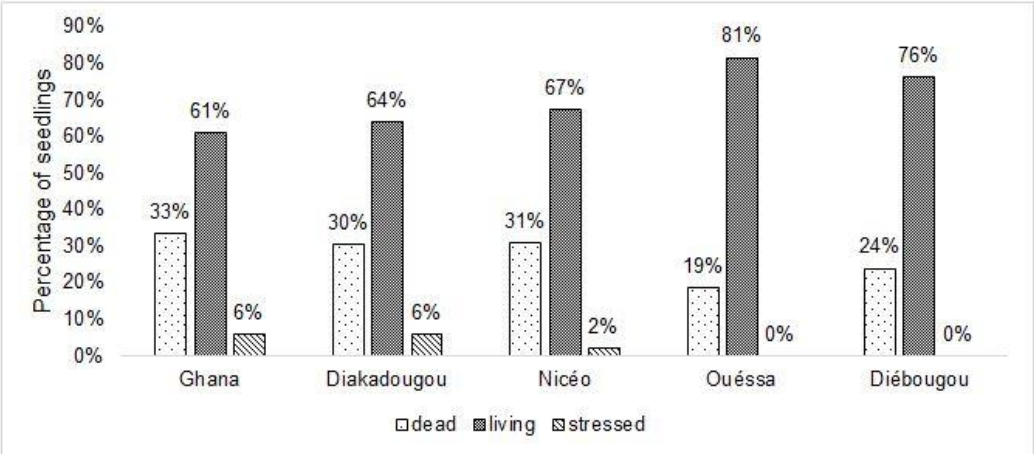

Figure 3. Percentages of living, dead and stressed cashew seedlings of the different clones at Diebougou

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

The percentage of living cashew seedlings was higher than dead and stressed percentages for the clones Diakadougou, Niceo, Ouessa and Diebougou. The percentage of dead cashew seedlings was higher than living and stressed percentages for the clone Ghana. The highest dead cashew seedlings percentage was observed for the clone Ghana. The highest living cashew seedlings percentage was observed for the clones Diakadougou, Niceo and Ouessa. The highest stressed cashew seedlings percentage was observed for the clones Ouessa and Diakadougou (Figure 4). The cashew seedlings survival at juvenile stage was better for the clone Niceo at Kampti [6].

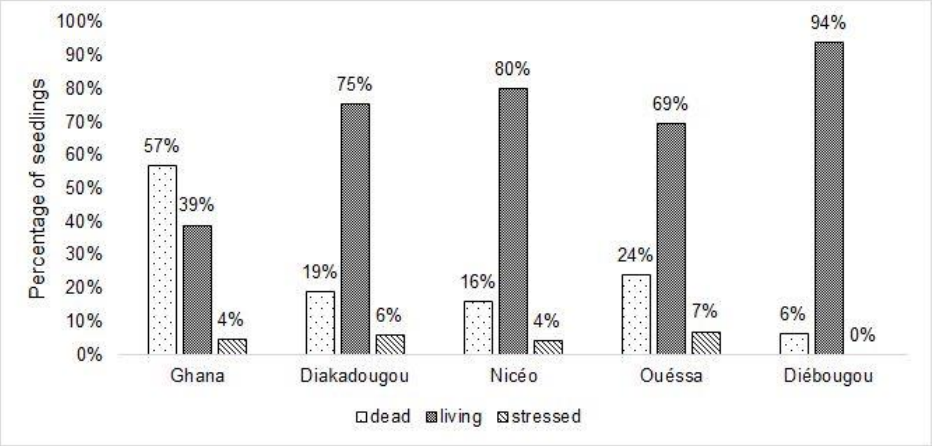

Figure 4. Percentages of living, dead and stressed cashew seedlings of different clones at Kampti.

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

For the clone Ghana the highest percentage of dead cashew seedlings was observed at Kampti, the highest percentage of living cashew seedlings was observed at Dano and the highest percentage of stressed cashew seedlings was observed at Diebougou and Kampti. For the clone Niceo the highest dead cashew seedlings percentage was observed at Diebougou, the highest living cashew seedlings percentage was observed at Kampti and the highest stressed cashew seedlings percentage was observed at Kampti and Diebougou. For the clone Diakadougou the highest dead cashew seedlings percentage was observed at Diebougou, the highest living cashew seedlings percentage was observed at Diebougou and Kampti and the highest stressed cashew seedlings percentage was observed at Diebougou and Kampti. For the clone Ouessa the highest dead cashew seedlings percentage was observed at Kampti, the highest living cashew seedlings percentage was observed at Kampti and Diebougou and the highest stressed cashew seedlings percentage was observed at Kampti. For the clone Diebougou the highest dead cashew seedlings percentage was observed at Diebougou (Figure 5A), the highest living cashew seedlings percentage was observed at Diebougou and Kampti and this clone did not show stressed cashew seedlings (Figure 5B and 5C). The cashew seedlings survival at juvenile stage for the clone Ghana was better at Dano compared to the others sites. The cashew seedlings survival at juvenile stage for the clone Niceo 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 Ouessa was better at Dano and Diebougou compared to Kampti. The cashew seedlings survival at juvenile stage for the clone Diebougou was better at Dano and Kampti compared to Diebougou [7].

Figure 5. Percentage of A) Dead cashew seedlings for each clone according to the site; B) Living cashew seedlings for each clone according to site; C) Stressed cashew seedlings for each clone according to the site.

DISCUSSION

The clone Diakadougou showed the better cashew seedlings survival at juvenile stage in general. This clone should be monitored over the years in measuring growth and cashew nuts production. The seedlings survival at juvenile stage did not change according to the site which means that the rainfall, temperature and soil parameters were not significantly different according to the field experiment plots in the south west region. The clones produced with the grafts collected from elite trees in the south west region showed higher seedlings survival at juvenile stage compared to the clones produced with the grafts collected from elite trees in the center west region at Dano field experiment plot, probably due to their ability to adapt rainfall, temperatures and soils parameters of the south west region with better growth. The literature review revealed that the rainfall, temperature and soil parameters of the center west and south region were different. The south west region is characterised by a rainfall between 900 mm to 1200 mm with brown eutrophic tropical soils on clay material, ferralitic soils moderately desaturated on sandy-clay material and hydromorphic mineral soils while the center west region is characterised by a rainfall between 600 mm to 900 mm with tropical ferruginous soils, tropical eutrophic brown soils with low leaching and hydromorphic soils with low humus content. The climate and soil properties are recognised to influence cashew productivity and growth. Balogoun, et al. in their research showed that the amount of rainfall, the number of days of rainfall and the agro climatic stresses are the main factors determining cashew production. Also, Balogoun, et al. and Bello, et al., reported that cashew trees are sensitive to the effects of climate change, particularly drought. Then, the longtime idea according to which the cashew trees are drought resistant due to the fact that they have been planted in marginal areas to combat desertification during several years should have to be reconsidred. It is therefore relevant to intensify research for identifying cashew clones adapted to the different ecological zone of production for appropriate management options to mitigate the effects of drought on cashew productivity as reported by Bello, et al.

The clones produced with the polyclonal seeds from northern Ghana showed different results regarding seedlings survival at juvenile stage depending on the field experiment sites showing a greater adaptation potential to different rainfall, temperature and soil parameters conditions of the polyclonal seeds due to the multiple and varied qualities that they deliver [8].

The clones produced with the grafts collected from elite trees in the south west region showed different seedlings survival performance at each of the site and according to the site probably due to the lack of good sylvicultural practices application. Boyce and Lara, et al., reported in their studies that seedlings survival after planting for achieving expected benefits of planting

operations was improved with the application of good sylvicultural practices. Lara, et al., also reported that intensified communication on the application of good sylvicultural practices improved seedlings survival after planting [9].

The clones produced with the grafts collected from elite trees in the south west region showed different performance of seedlings survival at juvenile stage according to the field experiment plots sites suggesting that each clone had different potential due to intrinsic characteristics to adapt to a specific rainfall, temperature and soil parameters conditions. These findings are in agreement with those of Diallo and Ginwal et al., who respectively showed that *Acacia senegal* and *Jatropha curcas* L. had significant differences between provenances of seeds in terms of seedling growth.

CONCLUSION

Evaluating cashew seedlings survival at juvenile stage of different clones showed that it was affected by rainfall, temperature and soil conditions as well as application of good sylvicultural practices. The research results also showed that the clones presented different seedlings survival performance at juvenile stage according to the site and at each site, suggesting different adaptation potential to rainfall, temperature and soil parameters for the clones. Farmers training and awareness on application of good sylvicultural practices and intensification research to identify clones adapted to rainfall, temperature and soil conditions of the different cashew production areas could contribute for productive and resilient cashew-based agroforestry systems establishment.

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