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Adaptability and Phenotypic Description of Introduced Sorghum (*Sorghum bicolor* L.) Varieties in the North-West Region of Cameroon

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Abstract

Sorghum is a versatile and resilient crop that's been cultivated for thousands of years. It is known for its ability to thrive in hot, dry conditions and withstand periods of drought, making it an important food source in many parts of the world. The objective of this study was to evaluate the adaptability and phenotypic description of introduced sorghum varieties in the North West region of Cameroon. The experiment was conducted in 2024 at the experimental farm of the University of Bamenda and was laid down in a Randomized Complete Block Design (RCBD) with four replications. The treatments were five introduced varieties from Mali and two varieties collected from the Northern region of Cameroon. The descriptive analysis revealed the morphological variation among the varieties on the stem, leaves and panicles of the plant. The analysis of growth and yield parameters revealed significant variation among the traits estimated. The highest emergence percentage was (96.62%) recorded by Wassanio, highest plant height (185.7 cm) recorded by Doussousouma-Nio, highest number of leaves (14) given by White sorghum, highest leaves length (95.37 cm) obtained by white sorghum, highest number of tillers (0.625) expressed by Grinkan, highest plant circumference (9.65) given by white sorghum. Additionally, the top 3 high-yielding introduced sorghum varieties were Tiandougou Coura (10.35 t/ha), Wassanio (9.9 t/ha) and Doussousouma-Nio (8.4 t/ha). These introduced varieties could be recommended for multi trials evaluation and release process in the North West Region of the

country. Whereas, the white sorghum collected from the Northern region of the country was not adapted to the North West region.

Keywords

Sorghum, Varieties, Descriptive, Adaptability, Growth and Yield

1. Introduction

Sorghum is a virtuous grain with the scientific name *Sorghum bicolor*. It is a species of monocotyledonous plant in the Poaceae family like wheat, rice or millet. Sorghum (*Sorghum bicolor* L. (Moench)) is the fifth most important staple food crop after rice, wheat, maize, and barley [1]. It is a C4 carbon cycle plant with high photosynthetic efficiency and productivity [2]. This crop originated and was domesticated in sub-Saharan Africa and spread to India, Kenya, Nigeria and China. In sub-Saharan Africa, several closely-related wild species of sorghum are found [3] [4]. Recent studies reported that the earliest evidence of domestication can be found in eastern Sudan around the fourth Millennium BC [5]. This crop is widely cultivated in more than 100 countries around the world [6]. The drought tolerance [7] of sorghum and its ability to withstand more heat and an array of other biotic and abiotic stresses than maize has made it one of the main security food crops that have wide adaptation in the most marginalized regions of the world [8] [9]. Sorghum is the main cereal grown in the North and Far North regions of Cameroon. It is cultivated on 70% of the total land and accounts for nearly 80% of the total volume of cereal production. It is a multipurpose crop cultivated across the globe as a source of grain, sweet stem, animal feed, pasturage, fodder, fiber, broomcorn, fuel, bioethanol, alcoholic beverages, and building materials [10]. The grain Sorghum is used to make semi leavened bread, fermented and none fermented porridges, cakes as well as brewing traditional and modern beers in Kenya and other African Countries [10]. It is the champion of photosynthesis, resistant to drought, causing its different varieties to complete their cycle in less than three months, enabling several harvests per year and causing it to easily adapt to adverse environmental conditions. Sorghum yields considerably higher biomass production with less use of fertilizers and irrigations [11]. Sorghum flour is used in the production of breads, gluten-free food [12] and derived products. Sorghum is also combined with maize to make an African traditional opaque beer "Amgba" mainly considered as food than beverage by Gbaya peoples in Adamaoua region of Cameroon [13]. Sorghum variety (sweet sorghum) is cultivated for juice production from the stalk (can be chewed like sugar cane) and the value-added products like syrup and ethanol (fuel) [14]. In animal feed (forage sorghum), the seeds are particularly appreciated by poultry, cattle, goats, etc.

With the rising prevalence of celiac disease and the need for gluten-free grains, sorghum is a naturally gluten-free grain which presents a safe and nutritious

alternative to other cereals containing gluten like wheat. It becomes useful in various food products, providing essential nutrients without triggering adverse reactions in individuals with gluten-related disorders [15]. Its ability to withstand harsh climatic conditions makes it a vital crop to fight against hunger and malnutrition, thereby contributing to agricultural sustainability and food security in vulnerable regions [16]. Moreover, with the increase in the scarcity and prices of baking flour in Cameroon, Sorghum production can be encouraged to increase the locally made flour and reduce over dependence on imported flour.

Sorghum has the efficiency advantage of doing well particularly in hot and dry environments [17]. The production of sorghum in the North West region is scarce whereas it could valuably substitute maize or wheat in that area. The aim of this research was to evaluate the adaptability and phenotypic description of introduced sorghum varieties in the North-West agro-ecological climate.

2. Materials and Methods

2.1. Site Description

This research was carried out from March to July 2024, at the school experimental farm of the University of Bamenda, Bambili, Tubah sub-division, Mezam division of the North West Region of Cameroon (**Figure 1**). It is located, bordered

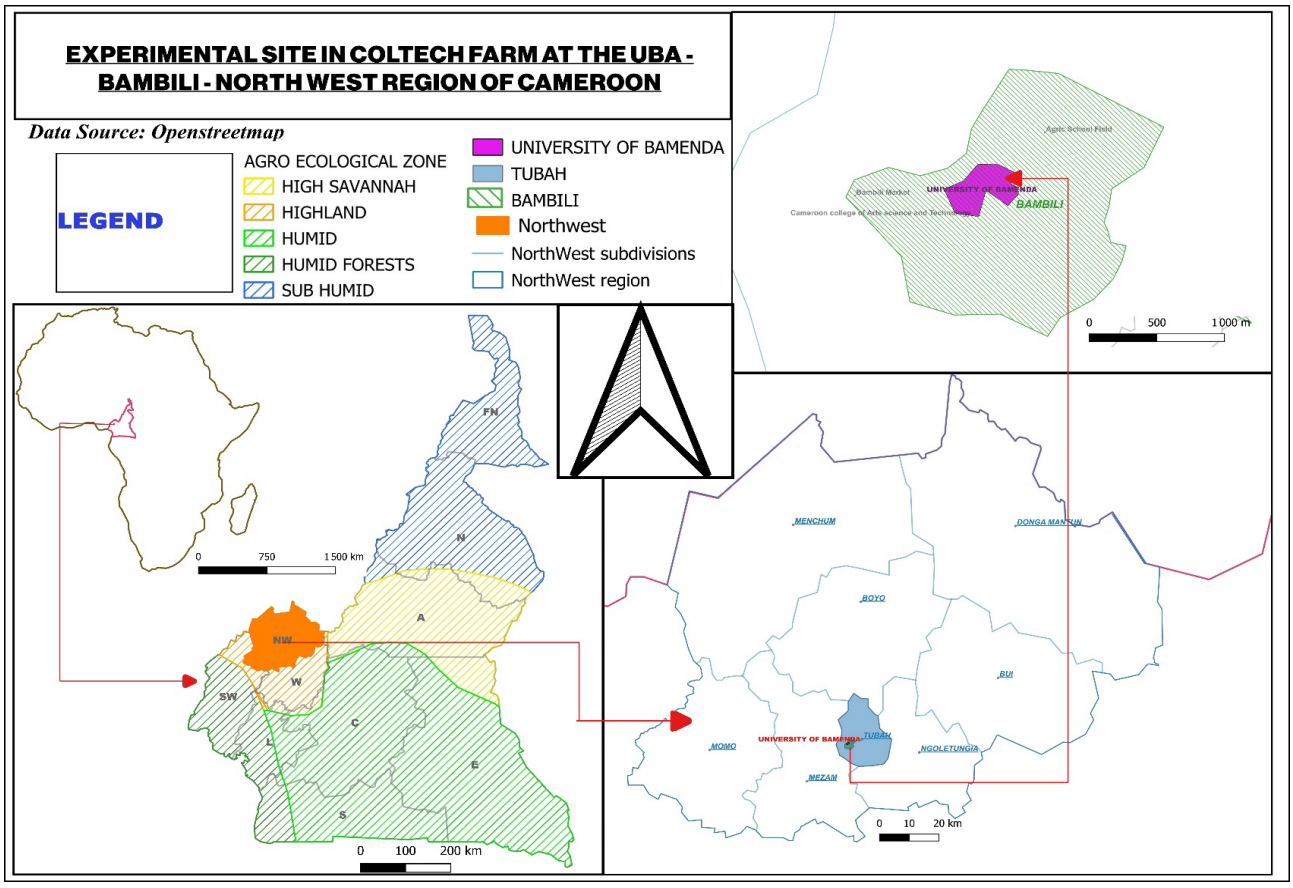


Figure 1. Site description in Bamenda.

to the North by Belo in Boyo Division, to the North West by Bafut, and to the west by Nkwen in Bamenda III sub division [18]. This experimental site has a geographical coordinate of 5˚59'0" North, 10˚15'0" East, with an altitude of 1558 m above sea level [19].

2.2. Research Treatments

The research treatments were characterized by the five different sorghum varieties collected (Wassonio Sorghum, Dougouyiriwa stage 3, Grinkan, Tiandougou Coura and Doussousouma-Nio) collected from the Sorghum Program of Sokoto Regional Agricultural Research Center of the Institute of Rural Economy (Institut d'Economie Rurale (IER)) at Bamako Mali and 2 varieties (red and white sorghum) from the Northern region of Cameroon.

2.3. Experimental Design and Planting

The experiment was laid out in a Randomized complete block design with four replicates, each block separated from other by a path of 1 m. Each replicate had 7 experimental units, making a total of 28 experimental units. Each experimental unit measured 1 by 1.5 m and separated with a path of 0.5 m. The field had a spacing of 1 m with the enclosure or border bed, making a total surface area of 116 m^2.

Manure application and planting was done on the 2nd of March 2024. Firstly, nine planting holes where open per experimental unit and 125 grams of manure was applied per hill, then mixed thoroughly with the soil, after which the seeds of sorghum were planted in the hills. 10 seeds were sawn per hill in order to have the required plant stands per hill per experimental unit. Sorghum was planted 50 cm between plants and 75 cm within rows, giving a planting density of 30,000 to 60,000 plants/ha. Planting was done in three lines per variety, per experimental unit making a total of nine plants per experimental unit. Thinning was done three weeks after planting allowing two best healthy plants per whole. A total of 18 plants per experimental unit were maintained.

2.4. Field Maintenance

The first spraying was done 6 days after planting, with the use of insecticides, to kill insects that were cutting off the plants after germination. The plant was also sprayed at an interval of two weeks after complete germination against stem borers and leaf miners which were attacking the plants. The first manual weeding was done four weeks after germination. Hilling was done by scraping up the soil around the base of every plant to form a small mound using a hoe. Weeding continued every after two weeks till the plants attained maturity. Fertilizer application was done 6 weeks after germination with NPK (20-10-10) being used. It was applied in a quantity of 5 grams per plant, giving a total of 3 kg of fertilizer applied in the field.

3. Data Description and Collection

Data collection was done based on the emergence percentage, vegetative parameters,

yield parameters, grain yield, moisture content and plant descriptive data.

3.1. Emergence Percentage

Plant emergence was recorded from the 6th to the 12th day after planting (DAP). The number of plants that emerge were counted and recorded per treatment, per replicate. And the emergence rate of the different varieties was estimated using the formula below:

$$Emergence\ rate = \frac{\text{Number of emerged seedlings}}{\text{Total number of seeds planted}} * 100$$

3.2. Vegetative Parameters

The growth rate of the sorghum plants was determined using the vegetative growth parameters such as plant height, number of leaves, leave length, number of tillers and plant circumference. Two plants were randomly selected on which data was collected on. Data collection started four weeks after emergence (WAE) and was continuously collected after every two weeks.

3.2.1. Plant Height (PH)

Two plants were selected randomly per treatment for the collection of plant height, which started 4 weeks after emergence. An average of the two plants was calculated and recorded as plant height for each treatment. This plant height in centimeter was measured from ground level to the top of the spike.

3.2.2. Number of Leaves

The leaves of the two randomly selected plants were counted and an average obtain. This process started 4 weeks after emergence (WAE) and continued till the appearance of the flag leave.

3.2.3. Leave Length

Leaves length was measured using a measuring tape from the pointy part at one of the leave to the point where the leaf joins the stalk at the other end, on the two plants selected.

3.2.4. Number of Tillers

The number of tillers was recorded from 4 weeks after emergence (WAE). The tillers were counted after every two weeks.

3.2.5. Plant Circumference

The diameter of two randomly selected plants was measured using a tape and recorded in centimeters. The average was then obtained from the two plants.

3.3. Yield Parameters

The yield of the various sorghum varieties was recorded on: panicle length, panicle circumference, number of panicle branches, moisture content and the grain yield.

3.3.1. Panicle Length and Circumference

The panicle length was determined by measuring the height of the panicle from the base to the top of the panicle to the top and its circumference was measured round the panicle using a measuring tape and measurements recorded in centimeters (cm).

3.3.2. Number of Panicle Branches

Two plant panicles were taken from each treatment to count the number of branches per panicle, the average of the two plant panicles were calculated and recorded as the number of branches of panicles per treatment.

3.4. Grain Yield

The sun-dried panicles were then threshed after drying, winnowed and weighed using an electronic scale to obtain grain weight per experimental unit. Grain yield were estimated in kg/ha using the following formula [20].

$$\text{Grain yield}\left(\frac{\text{kg}}{\text{ha}}\right)=\frac{\text{Total grain weight}\left(\text{kg}\right)}{\text{Size of the area}\left(\text{m}^2\right)}*10,000\ \text{m}^2$$

3.5. Moisture Content

The moisture content of the different sorghum varieties was also collected immediately after threshing and was measured in percentage.

3.6. Descriptor Data

The descriptor data of sorghum included: the plant color, Leaf midrib color, the waxy bloom, inflorescence compactness and shape, glume color, grain covering, Awns, Grain color, Grain plumpness and Grain form. The description of the plant takes into account the various parts as indicated in **Figure 2** below.

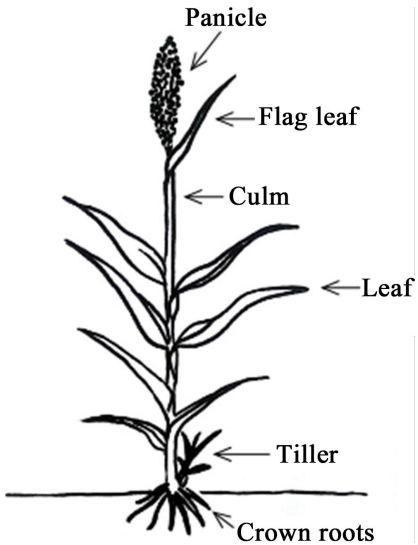


Figure 2. Diagram depicting the different parts of sorghum plant (https://www.ogtr.gov.au/sites/default/files/files/2021-07/the_biology_of_sorghum.pdf).

3.6.1. Plant Color

The plant color was determined at maturity stage. And was either pigmented (grey-brown or brown) and Tan (greyed-yellow group) in color per variety.

3.6.2. Leaf Midrib Color

The leaf midrib color was also determined per variety and was white, dull green, yellow, brown, or purple.

3.6.3. Waxy Bloom

In sorghum plants, the waxy bloom can be slightly present, medium, mostly bloomy or completely bloomy. This data was collected by observation.

3.6.4. Inflorescence Compactness and Shape

The inflorescence compactness and shapes were determined by simple observation of the panicles. Each variety had its own shape and was recorded as: semi-loose drooping primary branches, semi loose erect primary branches, semi compact elliptic, broom corn and compact elliptic.

3.6.5. Glume Color

The glume color at maturity was determined per variety to either be red, white, or sienna (yellow) in color.

3.6.6. Grain Covering

The amount of grain covered by glumes per variety was also recorded. The coverings were determined to be 25% grain covered, 50% grain covered, and 75% grain covered.

3.6.7. Awns

The present or absent of awns was determine by observation per variety. Some varieties were aweless while others waned.

3.6.8. Grain Color

The grain color was determined per variety, and they were either white or red in color.

3.6.9. Grain Plumpness

Grain plumpness refers to the level in which the grains are filled. This was determined per variety and recoded to either be dimple or plump.

3.6.10. Number of Grain Per Glume

The grain form was recorded to either be twin or single in a glume per variety cultivated.

3.7. Data Analysis

The analysis of variance (ANOVA) was conducted on the emergence percentage, plant height, number of leaves, leaves length, number of tillers, plant circumference, the flowering date, the length and circumference of panicle, and number of

branches per panicle using Origin Pro software (version 9.8). The mean data of various treatments was separated using Turkey LSD test.

4. Results and Discussion

4.1. Mean Square of Growth and Yield Parameters Estimated

Highly significant differences ($P \leq 0.001$) were observed among varieties for all the parameters estimated as well as among data collection period chosen (Table 1). The interaction variety x data collection period was significant for the estimated traits except for number of tillers. The tested varieties also expressed highly significant differences ($P \leq 0.001$) for the yield traits collected (Table 2).

Table 1. Mean square value of different parameters estimated.

SV	Df	Emergence rate	Plant height	Number of leaves	Leaf length	Number of tillers	Plant circumference
Replicate	3	14.71 NS	549.07 NS	3.63 NS	195.53 NS	1.10***	1.42 NS
Varieties	6	724.26***	3519.07***	21.32***	720.26***	0.88***	49.30***
Collection period	2	5190.32***	104,621.9***	40.68***	4827.81***	0.52***	12.86***
Interaction	24	10,332.89***	715.44**	6.28***	311.15***	0.10 NS	3.49***
Error	105	48.86	237.65	0.79	41.25	0.75	0.56

Where, *** = significant different at P (<0.001); NS = non-significant at 5% probability level; SV = source of variation; DF = degrees of freedom.

Table 2. Mean square of yield parameters estimated.

SV	Df	Flowering date	Panicle height	Number of branches	Panicle circumference
Replicate	3	0.019 NS	0.60 NS	183.97***	16.39***
Varieties	6	5.34***	1221.90***	2611.72***	281.46***
Error	105	0.24	6.93	10.48	3.08

Where, *** = significant different at P (<0.001); NS = non-significant at 5% probability level; SV = source of variation; DF = degrees of freedom.

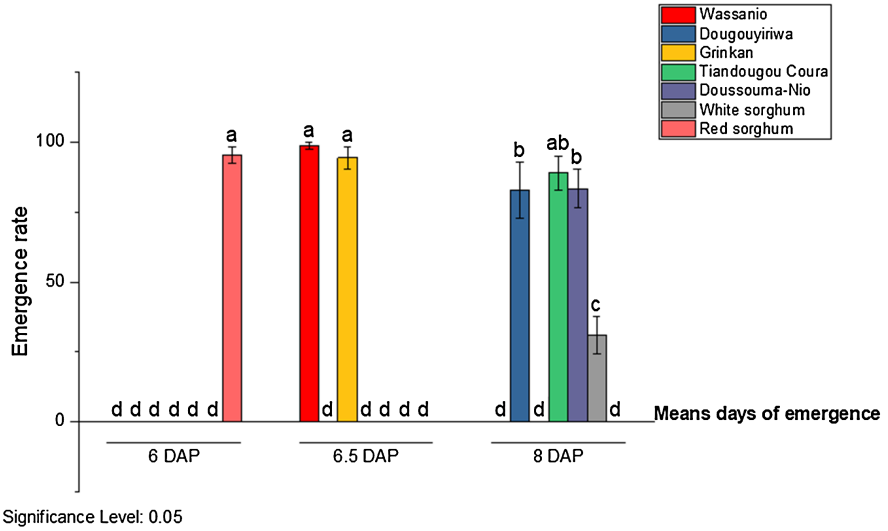
4.2. Growth Performance of the Tested Sorghum Varieties

Red sorghum was the first to emerge 6 days after planting (DAP), followed by Grinkan at 7 days after planting (Figure 3). Tiandougou Coura showed the highest emergence performance 8 days after planting.

4.3. Performance of Other Growth Parameters

The highest plant height was recorded by Doussousouma-Nio (185.75 cm) and White sorghum (180.87 cm) at 12 week after planting (WAP) followed by Wassanio (178.43 cm), while the lowest was recorded by Grinkan (133.93 cm) (Table 3). The highest number of leaves (14) was recorded by White sorghum (T6) at 12 WAP and the lowest was recorded by Grinkan (6 leaves). The highest (95.37 cm) and the

lowest (53.83 cm) leaf length at 12 WAP were recorded by White sorghum (T6) and Dougouyiriwa (T2) respectively. The plant circumference ranged from 4.81 to 9.65 cm at 12 WAP for Dougouyiriwa and White sorghum respectively (Table 3).



Footnote: Means in same treatment followed by the same letter are not significantly different from each other at 5% level of significance. T1 = Wassanio, T2 = Dougouyiriwa, T3 = Grinkan, T4 = Tiandougou Coura, T5 = Doussousouma-Nio, T6 = White sorghum and T7 = Red sorghum

Figure 3. Emergence rate.

Table 3. Mean growth parameters.

Treatments	Parameters			
	Plant height (12 WAP) in centimeters	Number of leaves	Leaves length in centimeters	Plant circumferences in centimeters
Wassanio (T1)	178.43^{ab}	8^{sdefg}	64.81^{bcde}	5.3^{b}
Dougouyiriwa (T2)	170.37^{abc}	8^{bcdefg}	53.43^{defg}	4.81^{bc}
Grinkan (T3)	133.93^{cde}	7^{efgh}	63.83^{cde}	5.26^{b}
Tiandougou Coura (T4)	167.75^{abc}	9^{bcdf}	73.75^{bc}	5.23^{b}
Doussousouma-Nio (T5)	185.75^{a}	8^{cdefgh}	66.93^{bcd}	4.93^{bc}
White sorghum (T6)	180.87^{a}	14^{a}	95.37^{a}	9.65^{a}
Red sorghum (T7)	155.5^{abcd}	8^{cdefgh}	60.45^{cde}	4.97^{c}

4.4. Performance of Related Yield Traits

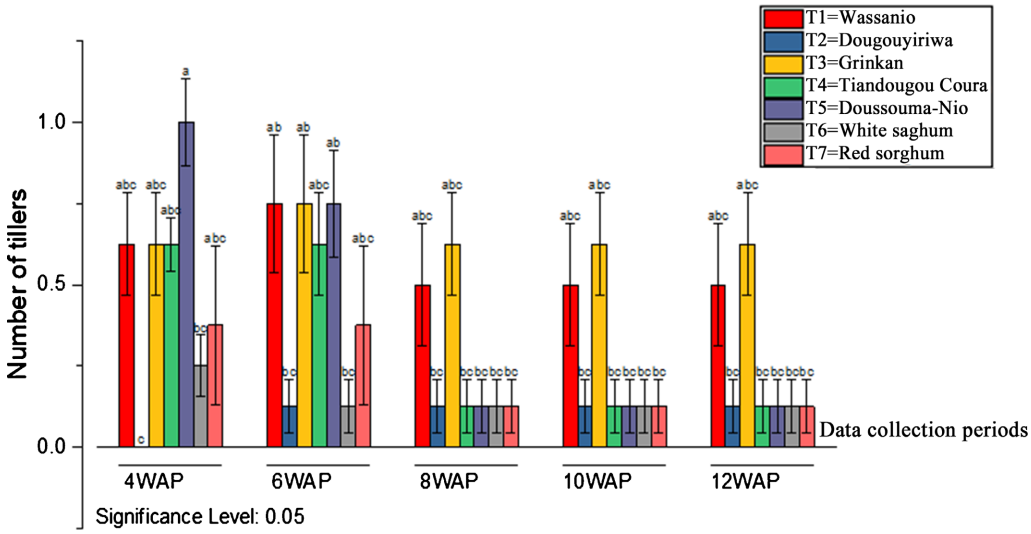
4.4.1. Number of Tillers

The number of tillers was collected in 5 different periods and ranged from 0 to 1 at 4, 10 and 12 WAP respectively (Figure 4). The highest number of tillers (1) was recorded by Dousousouma-Nio (T5) at 4 WAP while the lowest 0 was recorded by Tiandougou Coura (T4), Dousousouma-Nio (T5), White sorghum (T6) and

Red sorghum (T7).

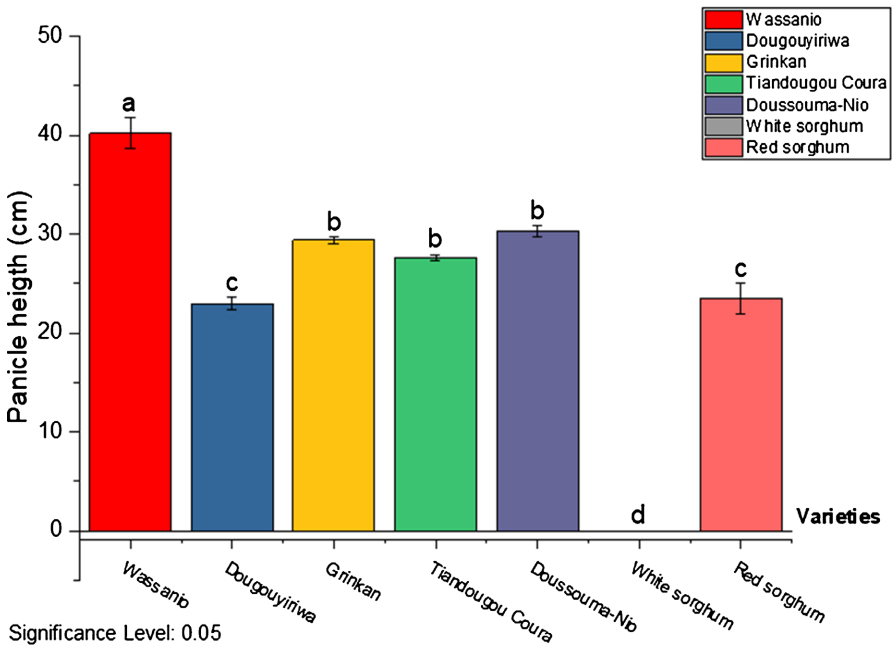
4.4.2. Panicle Height

The highest (40.18 cm) and lowest (0 cm) panicle height was recorded by Wassainio and White sorghum variety (Figure 5). The highest panicle height (40.18 cm) was recorded by Wassainio followed by 30.31 and 29.37 cm on Doussousouma-Nio and



Footnote: Footnote: Means in same treatment followed by the same letter are not significantly different from each other at 5% level of significance. T1 = Wassanio, T2 = Dougouyiriwa, T3 = Grinkan, T4 = Tiandougou Coura, T5 = Doussousouma-Nio, T6 = White sorghum and T7 = Red sorghum.

Figure 4. Number of tillers.



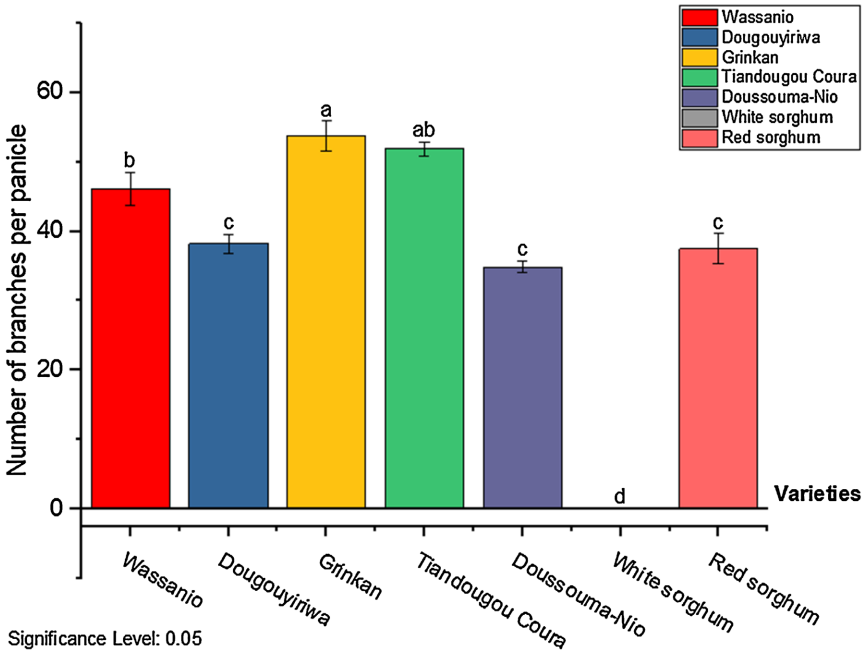
Footnote: Means in same treatment followed by the same letter are not significantly different from each other at 5% level of significance.

Figure 5. Panicle height.

Grinkan variety respectively. The order in the panicle height of these sorghum varieties is as follows: Wassanio, Doussousouma-Nio, Grinkan, Tiandougou Coura, Red sorghum, Dougouyiriwa, and white sorghum with 40.18, 30.31, 29.37, 27.62, 23.43, 22.93 and 0 cm respectively.

4.4.3. Number of Branches per Panicle

The highest (53.75) and lowest (0) number of branches per panicle was recorded by Grinkan and White sorghum varieties (Figure 6). The highest number of branches per panicle (53.75) was recorded by Grinkan followed by 51.87 (Tiandougou Coura) and 46.12 (Wassanio) respectively. The order in the number of branches per panicle of these sorghum varieties is as follows: Grinkan, Tiangougou Coura, Wassanio, Dougouyiriwa, Doussousouma-Nio, Red sorghum, and white sorghum with 53.75, 51.87, 46.12, 38.25, 34.87, 37.5 and 0 respectively.



Footnote: Means in same treatment followed by the same letter are not significantly different from each other at 5% level of significance.

Figure 6. Number of branches per panicle.

4.4.4. Panicle Circumference

The highest (18 cm) and lowest (0 cm) panicle circumference was recorded by Red sorghum and White sorghum varieties (Figure 7). The highest panicle circumference (18 cm) was recorded by red sorghum followed by 16.68 cm and 14.75 cm for Tiandougou Coura and Doussousouma-Nio varieties respectively.

4.5. Yield Performance of the Tested Sorghum Varieties

The highest (86.25 g or 10.35 t/ha) and lowest (0 g or 0 t/ha) grain yield was recorded by Tiandougou Coura (T4) and White sorghum (T6) varieties (Figure 8(a) and

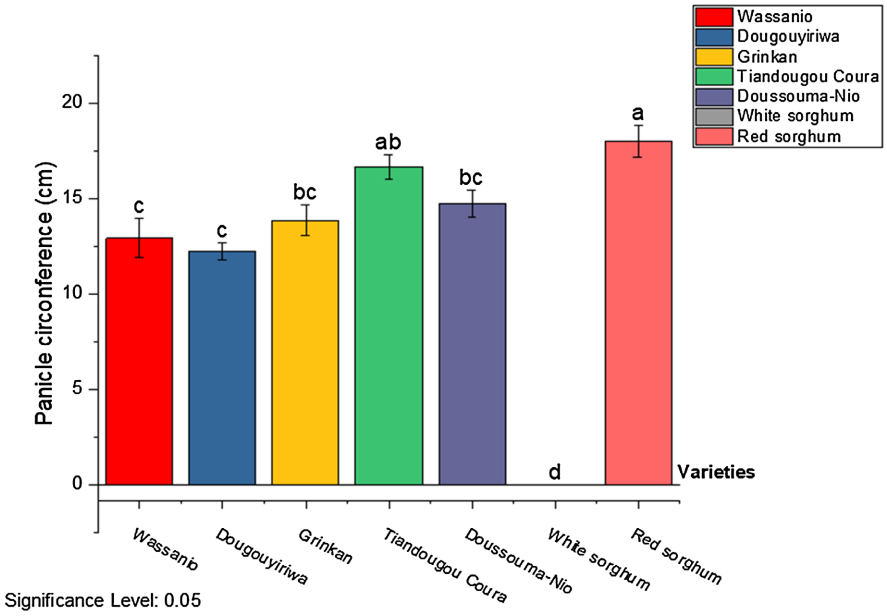
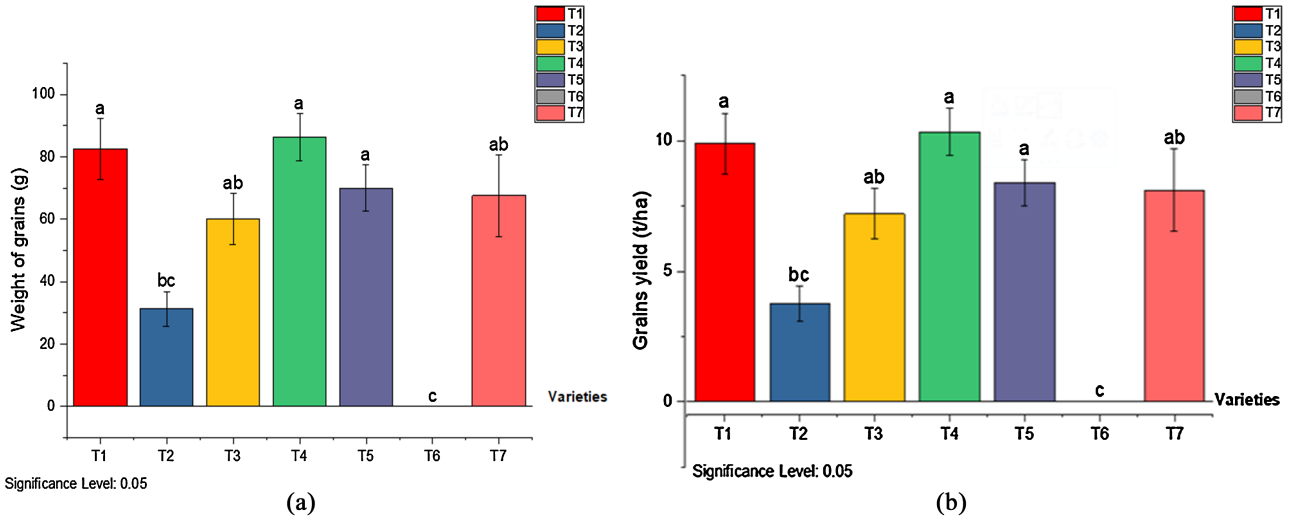


Figure 7. Panicle circumference.



Footnote: Means in same treatment followed by the same letter are significantly different from each other at 5% level of significance.

Figure 8. Weight of sorghum grains.

Figure 8(b)). The order in the grain yield of these sorghum varieties is as follows: Tiandougou Coura (T4), Wassanio (T1), Doussousouma-Nio (T5), Red sorghum (T7), Grinkan (T3), Dougouyiriwa (T2) and White sorghum (T6) with 86.25, 82.5, 70, 67.5, 60, 31.25 and 0g respectively or 10.35, 9.9, 8.4, 8.1, 7.2, 3.75 and 0 t/ha respectively.

Based on the grain yield of the sorghum varieties, the top five varieties were T4, T1, T5, T7 and T3 (Table 4).

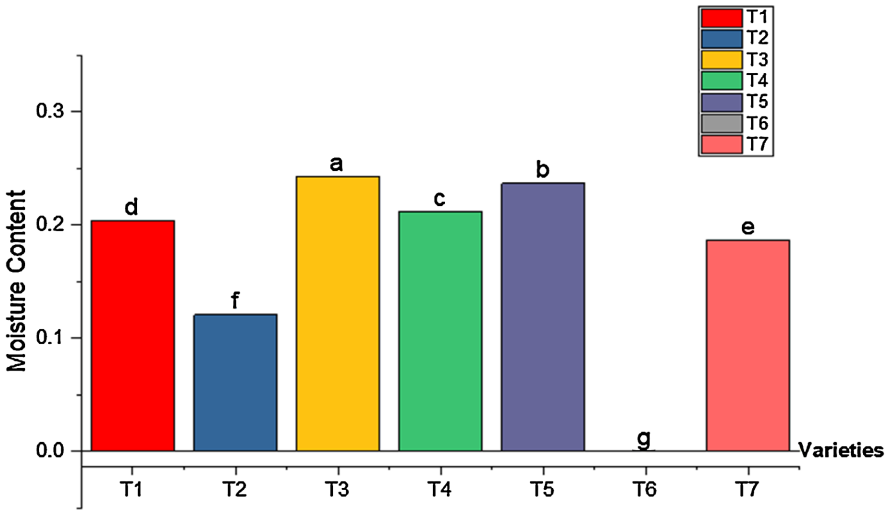
4.6. Moisture Content Results of the Introduced Sorghum Varieties

The highest (0.243) and lowest (0) moisture content was recorded by Grinkan

(T3) and White sorghum (T6) varieties (Figure 9). The order in the moisture content of these sorghum varieties is as follows: Grinkan (T3) Doussousouma-Nio (T5), Tiandougou Coura (T4), Wassanio (T1), Red sorghum (T7), White sorghum (T6) with 0.243, 0.243, 0.237, 0.212, 0.204, 0.187 and 0 respectively.

Table 4. Ranking of the varieties based on the yield.

Varieties	Yield (t/ha)	% increase over check	Ranking of introduced sorghum varieties
Tiandougou Coura (T4)	10.35	28	1
Wassanio (T1)	9.9	22	2
Doussousouma-Nio (T5)	8.4	4	3
Red sorghum (T7)	8.1	0	/
Grinkan (T3)	7.2	−11	4
Dougouyiriwa (T2)	3.75	−54	5
White sorghum (T6)	0 (no grain)	/	/



Footnote: Means in same treatment followed by the same letter are significantly different from each other at 5% level of significance.

Figure 9. Moisture content results of the introduced sorghum varieties.

4.7. Morphological Description of the Tested Sorghum Varieties

4.7.1. Wassanio Variety

At maturity, the plant color remains green with the leaf midrib whitish in color (Figure 10). There is a lack of waxy bloom. The inflorescence compactness and shape of the panicle is semi-loose drooping primary branches. The glumes of the panicles are red in color with the presence of awns. The color of the grain is white, with a grain covering of about 75%. The grains form in single, with a plumpness grain type.

Figure 10. Wassanio Sorghum.

4.7.2. Dougouyiriwa Stage 3 Sorghum Variety

The plant has a green color, with leaf midrib having a dull green (**Figure 11**). There is absence of waxy blooms. The inflorescence compactness and shape of the panicle, is semi-loose erect primary branches. The glumes of the panicles are white in color, with the absence of awns. It has a white grain color, with covering of about 25%. The grain has single form with a plumpness shape.

Figure 11. Dougouyiriwa stage 3 sorghum variety.

4.7.3. Grinkan Variety

The plant color remains green, with the leaf midrib dull green (**Figure 12**). There is an absence of waxy blooms. The inflorescence compactness and shape of the panicle, is semi-loose drooping primary branches. The glumes of the panicles are sienna (yellow) in color with the absence of awns. The grains are white, with a grain covering of about 75%. It has single form grains, with a dimple shape.

4.7.4. Tiandougou—Coura Variety

The plant has a green color, with the leaf midrib dull green (**Figure 13**). There is absence of waxy blooms. The inflorescence is semi-compact and elleptic in shape. The glumes of the panicles are red with the absence of awns. The grains are white,

with a grain covering of about 75% and it has single form, with a dimple shape.

4.7.5. Doussousouma—Nio Variety

It has plant color yellowish, with leaf midrib dull green (Figure 14). There is an absence of waxy bloom. The inflorescence is semi-compact with elliptic shape of the panicle. The glumes of the panicles are sienna (yellow) in color, with the absence of awns. The grains are white in color, with grain covering of about 50%. It has single form grains, with a dimple shape.

Figure 12. Grinkan variety.

Figure 13. Tiandougou—Coura variety.

Figure 14. Doussousouma—Nio variety.

4.7.6. White Sorghum

The plant color is green, with white midrib color (Figure 15). The panicle has the

broom corn shape.

Figure 15. Sorghum white.

4.7.7. Red Sorghum

At maturity, the plant color turns brown with the leaf midrib brown as well (**Figure 16**). There is absence of waxy bloom. The inflorescence is compact elliptic in shape for the panicle. The glumes of the panicles are red in color with the absence of awns. The grains are red with grain covering of about 25%. It has single form grains with plumpness grain type.

Figure 16. Red sorghum.

5. Discussion

Significant differences were observed between the tested varieties and the various periods of data collection for all the parameters estimated. The differences could be explained by the fact that each of the tested varieties has a specific genetic makeup. In addition, the various periods of data collection chosen were appropriate and effective. Dilnesaw *et al.*, [21] found significant differences of their sorghum varieties at emergency.

In the current study, the growth parameters varied from one variety to another. Doussousouma-Nio expressed the highest plant height (185.75 cm) followed by Wassanio (180.87 cm). Similar results were obtained by Musa *et al.* [22] who found plant height ranged from 179.7 - 246.1 cm when evaluating various varieties of sorghum in Sokoto Sudan Savanna of Nigeria.

White sorghum gave the highest number of leaves, the highest leaf length and the highest plant circumference (9.65 cm). But, it failed to produce viable grain. Kumar *et al.* [23] reported that plants are not just passive living beings that exist in nature, but they are complex and highly adaptable species which react sensitively to the environmental forces/stimuli with movement, morphological changes and through the communication of volatile molecules. The failure of White sorghum to produce grain could be the resulting effects of a given stress condition in the tested environment, insuring its unadaptability to that environment. Therefore, White sorghum was considered not to be adapted to the North West region of the country.

The highest number of tillers (1) was recorded by Dousousouma-Nio at 4 WAP while the lowest 0 was recorded by Tiandougou Coura, Dousousouma-Nio, White sorghum and Red sorghum. Kumar *et al.* [24] attributed the differences obtained on the tillering parameter of the introduced sorghum seed varieties to the genetic factors, and the environmental conditions affecting the production of tillers in sorghum plant.

The results on yield parameters (flowering date, panicle height, number of panicle branches and panicle circumference) presented highly significant differences among the tested varieties. This result was in agreement with the findings of Musa *et al.* [22] who obtained the number of days to heading ranges from (73.00 - 90.00 days) and was earlier (73.00 days) in Janjari variety followed by Yartawa and Jardawa (82.00 - 83.33 days).

The grain yield varied from 0 (White sorghum) to 10.35 t/ha (Tiandougou Coura). The top 3 high-yielding introduced sorghum varieties were Tiandougou Coura (10.35 t/ha), Wassanio (9.9 t/ha) and Doussousoumia-Nio (8.4 t/ha). The Red sorghum (8.1 t/ha) which is a locally grown sorghum in the Northern region of the country, was found to be adapted to the North West region as compare to the White sorghum which was not. Dembele *et al.* [25] recommended in their study that the sorghum variety (Fadda) being a guinea-type hybrid variety could be recommended to the farmers for grain and fodder production because of its better adaptation in the Sudano-Sahelian zone of Mali.

6. Conclusion

The test for adaptability and description of introduced Sorghum (*Sorghum bicolor* L.) varieties in the North-West agro-ecological climate presented significant differences among the tested varieties for all the growth and yield parameters. Each mature sorghum variety has a particular morphology of the plant. From the emergence rate, the best sorghum varieties recorded were Wassanio (T1) with 96.62% at 6.5 DAP followed by red sorghum (T7) and Grinkan (T3) with the emergence percentage of 95.36% and 93.44 % at 6 and 6.5 DAP respectively. Also, based on growth parameter (plant height), the best sorghum variety recorded was: Doussousouma-Nio (T5) with height 185.75 cm, followed by White sorghum (T6), Wassanio (T1), and Dougouyiriwa (T2) with 180.87 cm, 178.43 cm and

170.37 cm respectively. The top 3 high-yielding introduced sorghum varieties were Tiandougou Coura (10.35 t/ha), Wassanio (9.9 t/ha) and Doussousoumia-Nio (8.4 t/ha). Therefore, these introduced sorghum varieties are recommended for multi-test environments to follow the release process in the North West Region of Cameroon. In addition, White sorghum was not adapted to the tested environment but, red sorghum can be produced in large scale in the North West region of the country.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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