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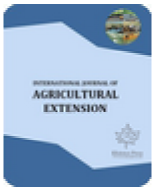

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EVALUATION OF EIGHT (08) SEEDING DENSITIES OF FIFTEEN (15) ACCESSIONS OF BAMBARA GROUNDNUT (*Vigna Subterranea* L. VERDCOURT) IN FAR NORTH-CAMEROON

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ABSTRACT

This study aims to identify between eight seeding densities based on fifteen accessions of Bambara groundnut to determine the best seeding densities in Far North Cameroon. The experimental design is a factorial block that includes eight seeding densities applied to fifteen accessions of Bambara groundnut, repeated four times. The treatments are combinations between accessions of Bambara groundnut and seeding densities. Total 480 experimental units were used for data collection. The trials were conducted successively over three years (2016, 2017, and 2018). The data collected were analyzed with Genstat Statistical Package, 12th edition software. The results show significant variations between the fifteen accessions of Bambara groundnut and within the eight seeding densities tested. High seeding densities (40x20cm; 40x25cm) made it possible to get better yields in terms of the average number of pods, and average weight of pods and seeds. For the average weight of seeds during the three years of cultivation: 26,66%; 40% and 53,33% accessions presented better yields at D1 (125 000 plants/ha); followed by D2 (100 000 plants/ha) which also presented during the three years of cultivation: 6,67%; 33,34% and 33,34% accessions with better yields in average seed weight. Thus, density 1 (125000 plants/ha) and density 2 (100000 plants/ha) corresponding respectively to spacings of 40cmx20cm and 40cmx25cm made it possible to group more accessions presenting better yields in terms of an average number of pods, the average weight of pods and seeds. Highly statistically significant interactions between seedling densities and accessions of Bambara groundnut are observed; suggesting that the performance of a density also depends on that of the accession.

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INTRODUCTION

In Cameroon, *Bambara groundnut* constitutes with soybean (*Glycine max*), peanut (*Arachis hypogea*), common bean (*Phaseolus vulgaris*) and cowpea (*Vigna* *unguiculata*) the main grain legumes cultivated and consumed due to their importance in the eating habits of populations (Kouebou et al., 2013). Its production increased from 19630 tons in 2006 to 27007 tons in 2013, which made Cameroon the fourth producer in the world after Nigeria (100000 tons), Burkina Faso (65000 tons) and Niger (30000 tons). Unfortunately, this production did not change considerably and remained at 27864 tons in 2016 (INS, 2017). The Far North ranks first nationally with production estimated at 17645 tons (INS, 2017). Yields are extremely low, of the order of less than 1 ton per hectare from 2001 to 2016 (Agri-Stat, 2010 and 2012; INS, 2015 and 2017) compared to peanuts, cowpeas, common beans and soyabean, which benefits from a package of technologies and several international collaborations. However, work is being carried out on Bambara groundnut but mainly focus on the nutritional qualities of the seeds and post-harvest technologies (Nyabyenda, 2005; Amarteifio et al., 2006; Kapso, 2009; Ngamchut et al., 2010; Alene et al., 2011; Ngamo et al., 2016). The few agronomic studies carried out focus on characterization, but remain limited to the determination of a few morphological and agronomic traits (Onwubiko et al., 2011; Berchie et al., 2012; Touré et al., 2012; Ndiang et al., 2012, 2014; Sobda et al., 2013; Yaya et al., 2013; Ameded, 2015; Amadou et al., 2015). Few studies on plant science are known at the limit of our knowledge. Several other studies are currently underway, including that relating to the research of seeding densities of some accessions of Bambara groundnut cultivated in the Far North of Cameroon. Indeed, the accessions of Bambara groundnut encountered in the Far North are cultivated without knowledge of the spacing between plants which until now remains scientifically unknown. Producers continue with their farming practices resulting in low yields that are mostly unpredictable (IRAD, 2013; INS, 2015; INS, 2017). Several studies in various places around the world have shown that the production of a crop can be improved by spacing between plants (Ghardi et Maamouri, 1994; M'hedhbi et al., 1994; Pageau, 1996; Adekpe et al., 2007; Kouassi and Zoro, 2010; Khodadadi and Nosrati, 2012); hence the interest we have in this study which aims to evaluate eight seeding densities applied on fifteen accessions of Bambara groundnut with a view to improving production techniques and increasing the yields of producers in the Far North Region of Cameroon.

METHODOLOGY

Study site

The study was carried out at the experimental farm of the Institute of Agricultural Research for Development (IRAD) of Maroua, more precisely at "Guiring" which is located in the Djarengol-Kodek, in the council of Maroua 3rd subdivision. The site has geographical coordinates: 14°36' East and 10°62' North, and an altitude of 383 m. It is located near the Maroua-Bogo axis, approximately 10 km from the city center. The location map of the study site is shown in Figure 1. The rainfall that prevailed during the three years of cultivation on this site (2016, 2017 and 2018) is also represented in Table 1.

Table 1. Rainfall record of the city of Maroua from 2016 to 2018.

Months	2016				2017				2018			
	1st decade	2nd decade	3th decade	Total/ month (mm)	1st decade	2nd decade	3th decade	Total/ month (mm)	1st decade	2nd decade	3th decade	Total/ month (mm)
April					7.7			7.7				
May	1.2	10,4	62,8	74,4	4,3	2,5	10,2	17	3,25	21,50	35,10	59,85
June		14,5	42,3	56,8	47,2	73	13,5	133,7	90,25	56,50	23,50	170,25
July	20.5	113	32,75	166,25	110,8	45,3	103,2	259,3	41	78	89	208
August	54	51,5	90	195,5	55,75	50,80	42,75	149,3	109	157,70	83,40	350,10
September	72.3	65,25	75	212,75	26	58,2	14	98,2	109	53	74	236
October		4		4	3,5			3,5	4	21,50	15,75	19,75
Cumulative				709.7				668.7				1043.95
Days				53				53				66

Source: DRADER-EN. 2016, 2017 and 2018

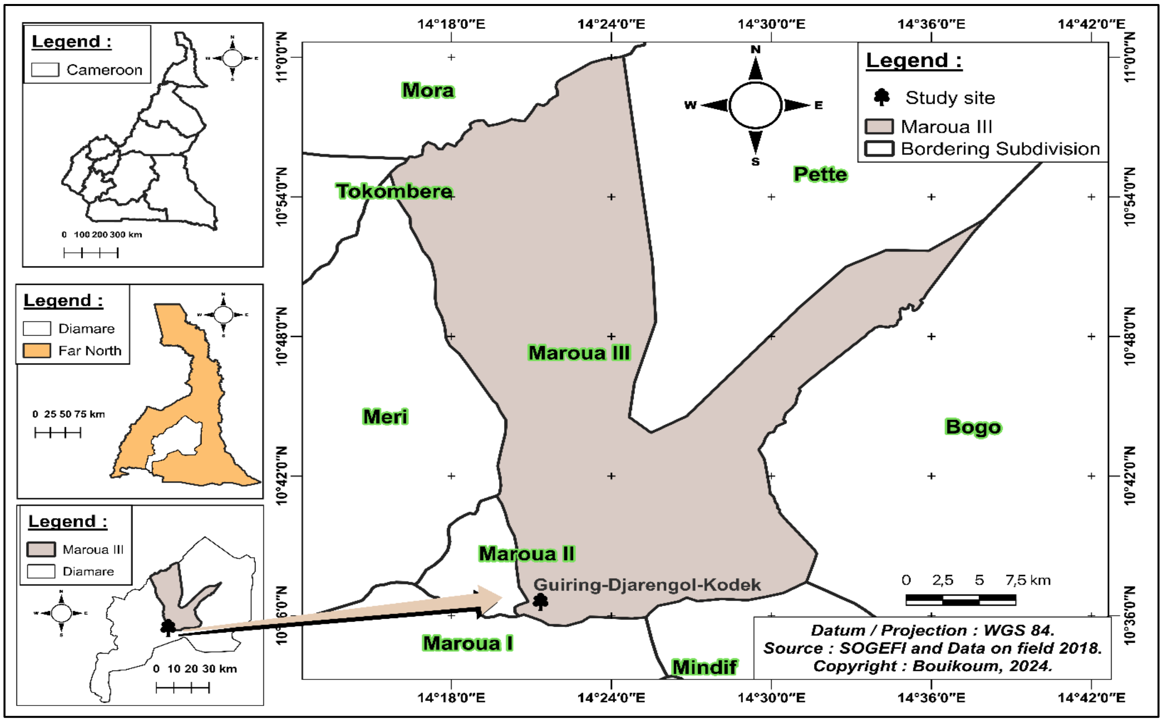

Figure 1. Location map of the study site in Guiring (Djarengol-Kodek).

Plant material

The plant material consists of 15 accessions of Bambara groundnut from a selection of 36 accessions collected from farmers and traders in five division of the Far North region of Cameroon from November 2014 to June 2015. The 15 accessions selected are those that presented better agro-morphological characteristics and were appreciated by farmers (Wassouo et al., 2019). A number (code) identified each accession. Table 2 presents the areas of origin of the 15 accessions of Bambara groundnut and the geographical coordinates of the collection points of said accessions.

Table 2. Accessions of Bambara groundnut collected in Far North Cameroon.

N°	Accessions	Areas of collection			Geographical points of collection		
		Divisions	Subdivisions	Villages	N	Eo	Alt
1	Acc. 1	Mayo-Tsanaga	Bourha	Guili	10,34	13,56	755m
2	Acc. 2	Mayo-Tsanaga	Bourha	Guili	10,34	13,56	755m
3	Acc. 3	Mayo-Tsanaga	Roua	Madakonai 2	14,05	10,79	682m
4	Acc. 6	Mayo-Sava	Mora	Houdouwiyam-Malika	11,00	14,04	494m
5	Acc. 7	Mayo-Sava	Mora	Houdouwiyam-Malika	11,00	14,04	494m
6	Acc. 8	Mayo-Sava	Mora	Golda II	10,95	14,02	793m
7	Acc. 9	Mayo-Sava	Mora	Golda II	10,95	14,02	793m
8	Acc. 12	Mayo-Kani	Guidiguis	Guidiguis	10,13	14,71	369m
9	Acc. 18	Mayo-Kani	Porhi	Touloum	10,18	14,83	329m
10	Acc. 19	Mayo-Sava	Mora	Mémé	10,97	14,23	414m
11	Acc. 20	Mayo-Sava	Mora	Mémé	10,97	14,23	414m
12	Acc. 24	Mayo-Danay	Kar-Hay	Doukoula	10,11	14,97	332m
13	Acc. 25	Mayo-Danay	Kalfou	Bougaye	10,25	15,10	342m
14	Acc. 27	Mayo-Danay	Kalfou	Kalfou	10,28	14,93	347m
15	Acc. 36	Mayo-Danay	Datcheka	Zouaye	10,00	15,13	335m

Experimental plot design

The experimental design is a factorial block comprising 8 densities to be tested (Table 3) and 15 accessions, repeated 4 times. The different defined spacings are: 40cmx20cm, 40cmx25cm, 40cmx30cm, 40cmx40cm, 50cmx20cm, 50cmx25cm, 50cmx30cm, 50cmx40cm and correspond respectively to the densities D1 (125000 plants/ha), D2 (100000 plants/ha), D3 (83333 plants/ha), D4 (62500 plants/ha), D5 (100000 plants/ha), D6 (80000 plants/ha), D7 (66667 plants/ha) and D8 (50000 plants/ha). The treatments are therefore the combinations between accessions and densities. Four hundred and eighty (480) experimental units were used for data collection. The experimental units measure 1,6mx2,5m or 4 m^2 and 2mx2,5m or 5 m^2. A distance of 0,5 m separates the experimental units. The blocks are 1 m apart on either side.

Conduct of the trial

The trial was carried out on the study site in Guiring for three successive years (2016, 2017, and 2018) and performed during rainy season. The densities tested and the corresponding surface areas are recorded in Table 3. The previous crop on this site was rainy-season sorghum. Cleaning the plot consisted of collecting non-biodegradable plastics. The plot was ploughed in the 1st year of the trial on 18 July 2016, followed by sowing on 21 July 2016. In the 2nd year of the trial, ploughing was carried out on 11 July 2017, followed by sowing on 19 July 2017; in the 3rd year of the trial, ploughing was carried out on 13 July 2018 followed by sowing on 17 July 2018. The seeds were treated with MOMTAZ 45 WS (20% thiram + 25% imidacloprid). Two Bambara groundnut seeds were sown per pocket at a depth of 3-5 cm. Weeding was carried out three weeks after sowing using hoes, followed by one plant per hole thinning. The treatment against aphids and greenflies was carried out three times during the experiment using a broad-spectrum systemic foliar insecticide: PACHA 25 EC, having the active ingredient constituted of Lambda-Cyhalothrin 15g/l and Acetamiprid 10g /L. The 1st treatment occurred at pre-flowering, the 2nd at flowering and the 3rd treatment at the beginning of pod formation. The harvest occurred on 17 November 2016 for the 1st year, 20 November 2017 for the 2nd year, and 10 November 2018 for the 3rd year.

Table 3. Densities and number of corresponding plants per experimental unit and per hectare

Variables	Spacings between lines (cm)	Spacings between pockets (cm)	Number of plants/EU	Density/ha Plants/ha
D1	40	20	50	125000
D2	40	25	40	100000
D3	40	30	33	83333
D4	40	40	25	62500
D5	50	20	50	100000
D6	50	25	40	80000
D7	50	30	33	66667
D8	50	40	25	50000

D1=density 1 D3=density 3 D5=density 5 D7=density 7 UE= Expérimental Unit
D2=density 2 D4=density 4 D6=density 6 D8=density 8

Data collected

The geographical coordinated point of the trial site and the marking of the points of collection of Bambara groundnut accession were carried out using the Global Positioning System, brand GARMIN, Oregon 300. To take the yield parameters, the harvest concerned the two central lines of each experimental unit according to the method described by Mustefa (2014). The average number of pods was obtained by physically counting the pods; the average weight yield of pods and seeds was obtained by weighing and reducing per square yield to $4m^2$ and $5m^2$ then extrapolating in kg/ha.

Results further indicate that the pods and seeds' dry weight was obtained by weighing and after receiving a constant dry weight using an electronic balance with a sensitivity of 0,001g such as ACCULAB GS 200. Vanounou (1997) and Touré (2016) proposed the following formulas for estimating yield.

$$\text{Yield}\left(\frac{\text{t}}{\text{ha}}\right) = \frac{\text{Obtained production}}{\text{surface area of an elementary plot}} \text{ X } 10000$$

Data analysis

The geographical coordinated points of the trial site and the different points of collection of Bambara groundnut were entered into the Microsoft Office Excel 2013 spreadsheet and loaded into the Quantum GIS software (QGIS 3.4). The Cameroon Shapefile was uploaded to SOGEFI and displayed on QGIS to extract the map of the Far North Cameroon region and certain administrative divisions. The layout of this data in QGIS allowed the export of the map as an image or pdf file. The raw yield data was entered and formatted using the Microsoft Office Excel 2013 spreadsheet. These data were subsequently imported as text files into the GenStat statistical package 12th edition software for analysis. For each yield trait measured, variance analyses were carried out when the conditions of Shapiro-Wilt normality and Bartlett's homogeneity of variances were previously verified. When a significant difference is noted between morphotypes for a given character, the DUNCAN test completes the ANOVA at the 1% significance level. This test made it possible to highlight homogeneous groups (Dagnelie, 1998; 2012).

RESULTS

Average number of Bambara groundnut pods on the different densities

Tables 4, 5 and 6 present the yields in an average number of Bambara groundnut pods according to densities during the three years of trials (2016, 2017 and 2018). Significant variations in the average number of pods are observed depending on the densities and accessions tested over the three years of cultivation.

The average number of pods in year 1 (2016) at D1 (40cmx20cm) varies from 395x10^{3}±2,58^{aC}pods/ha (Acc.1) to 880x10^{3}±13,89^{hD} pods/ha (Acc.6); in year 2 (2017) at D1 (40cmx20cm), it varies from 105x10^{3}±1,77^{aA} pods/ha (Acc.8) to 472x10^{3}±1,20^{nG} pods/ha (Acc.7), and in year 3 (2018) at D1 (40cmx20cm), it varies from 220x10^{3}±2,04^{aE} pods/ha (Acc.8) to 699x10^{3}±2,39^{lH} pods/ha (Acc.25).

In 2016 with D2 (40cmx25cm), it varied from 385x10^{3}±10,23^{aB} pods/ha (Acc.19) to 738x10^{3}±14,29^{gC} pods/ha (Acc.6); in 2017 at D2 (40cmx25cm), it varies from 123x10^{3}±1,88^{aC} pods/ha (Acc.8) to 419x10^{3}±2,60^{lH} pods/ha (Acc.20), and in 2018 at D2 (40cmx25cm), it varies from 210x10^{3}±1,44^{aE} pods/ha (Acc.19) to 686x10^{3}±2,39^{lG} pods/ha (Acc.3).

In 2016 with D3 (40cmx30cm), it varied from 388x10^{3}±3,59^{aB} pods/ha (Acc.8) to 880x10^{3}±7,80^{hG} pods/ha (Acc.27); in 2017 at D3 (40cmx23cm), it varies from 110x10^{3}±1,77^{aB} pods/ha (Acc.1) to 411x10^{3}±3,61^{lG} pods/ha (Acc.20), and in 2018 at D3 (40cmx30cm), it varies from 217x10^{3}±2,14^{aE} pods/ha (Acc.8) to 619x10^{3}±2,39^{jG} pods/ha (Acc.18).

In 2016 with D4 (40cmx40cm), it varied from 323x10^{3}±19,62^{aA} pods/ha (Acc.9) to 718x10^{3}±11,96^{hF} pods/ha (Acc.18); in 2017 at D4 (40cmx40cm), it varies from 132x10^{3}±1,88^{aB} pods/ha (Acc.19) to 380x10^{3}±1,77^{lF} pods/ha (Acc.3), and in 2018 at D4 (40cmx40cm), it varies from 182x10^{3}±1,57^{aB} pods/ha (Acc.8) to 526x10^{3}±1,61^{jF} pods/ha (Acc.18).

In 2016 with D5 (50cmx20cm), it varied from 268x10^{3}±7,79^{aA} pods/ha (Acc.8) to 824x10^{3}±11,82^{jD} pods/ha (Acc.20); in 2017 at D5 (50cmx20cm), it varies from 124x10^{3}±1,41^{aC} pods/ha (Acc.8) to 370x10^{3}±2,06^{lF} pods/ha (Acc.20), and in 2018 at D5 (50cmx20cm), it varies from 181x10^{3}±1,71^{aD} pods/ha (Acc.19) to 408x10^{3}±1,50^{nF} pods/ha (Acc.25).

In 2016 with D6 (50cmx25cm), it varied from 254x10^{3}±5,35^{aA} pods/ha (Acc.8) to 638x10^{3}±12,50^{iD} pods/ha (Acc.7); in 2017 at D6 (50cmx25cm), it varies from 84x10^{3}±1,71^{aA} pods/ha (Acc.1) to 310x10^{3}±1,41^{kD} pods/ha (Acc.20), and in 2018 at D6 (50cmx25cm), it varies from 110x10^{3}±1,41^{aB} pods/ha (Acc.19) to 398x10^{3}±1,83^{mD} pods/ha (Acc.18).

In 2016 with D7 (50cmx30cm), it varied from 256x10^{3}±4,19^{aA} pods/ha (Acc.8) to 674x10^{3}±4,97^{jE} pods/ha (Acc.7); in 2017 at D7 (50cmx30cm), it varies from 104x10^{3}±1,71^{aB} pods/ha (Acc.1) to 306x10^{3}±2,22^{kF} pods/ha (Acc.12), and in 2018 at D7 (50cmx30cm), it varies from 140x10^{3}±1,41^{aB} pods/ha (Acc.1) to 354x10^{3}±1,71^{nC} pods/ha (Acc.18). In 2016 with D8 (50cmx40cm), it varied from 320x10^{3}±4,50^{aA} pods/ha (Acc.1) to 550x10^{3}±1,26^{fA} pods/ha (Acc.20); in 2017 at D8 (50cmx40cm), it varies from 100x10^{3}±0,82^{aA} pods/ha (Acc.19) to 302x10^{3}±1,83^{mC} pods/ha (Acc.20), and in 2018 at D8 (50cmx40cm), it varies from 91x10^{3}±0,50^{aA} pods/ha (Acc.19) to 321x10^{3}±1,71^{mC} pods/ha (Acc.24).

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Table 4. The average number of Bambara groundnut pods per hectare (ha) depending on densities in 2016.

Densities	Acc. 36	Acc. 1	Acc. 2	Acc. 3	Acc. 6	Acc. 7	Acc. 8	Acc. 9	Acc. 12	Acc. 18	Acc. 19	Acc. 20	Acc. 24	Acc. 25	Acc. 27
D1	650x10^{3}±3,59^{deE}	395x10^{3}±2,58^{aC}	697x10^{3}±23,06^{fD}	573x10^{3}±2,14^{cD}	880x10^{3}±13,89^{hD}	868x10^{3}±8,68^{hG}	443x10^{3}±7,79^{bC}	685x10^{3}±16,71^{efG}	578x10^{3}±7,71^{cF}	473x10^{3}±3,59^{bBC}	630x10^{3}±5,10^{dE}	698x10^{3}±15,15^{efC}	645x10^{3}±10,63^{deD}	648x10^{3}±21,38^{deDE}	753x10^{3}±19,91^{gF}
D2	578x10^{3}±9,91^{cdD}	435x10^{3}±2,14^{bD}	615x10^{3}±7,66^{deB}	650x10^{3}±24,92^{efE}	738x10^{3}±14,29^{gC}	605x10^{3}±16,21^{dCD}	408x10^{3}±7,24^{abB}	600x10^{3}±2,58^{cdF}	420x10^{3}±4,45^{abB}	570x10^{3}±11,79^{cdE}	385x10^{3}±10,23^{aB}	688x10^{3}±18,94^{fC}	555x10^{3}±5,14^{cC}	668x10^{3}±8,90^{fE}	693x10^{3}±12,60^{fE}
D3	690x10^{3}±8,02^{gF}	505x10^{3}±7,93^{cE}	475x10^{3}±7,80^{bcA}	578x10^{3}±11,29^{deD}	568x10^{3}±16,04^{dB}	580x10^{3}±11,50^{defC}	388x10^{3}±3,59^{aB}	450x10^{3}±9,07^{bD}	565x10^{3}±10,66^{dF}	390x10^{3}±4,72^{aA}	410x10^{3}±12,31^{aC}	615x10^{3}±21,43^{eB}	543x10^{3}±13,32^{dC}	565x10^{3}±3,29^{dC}	880x10^{3}±7,80^{hG}
D4	568x10^{3}±8,10^{eD}	400x10^{3}±3,87^{bC}	658x10^{3}±6,57^{gC}	600x10^{3}±10,08^{fD}	728x10^{3}±9,40^{hC}	470x10^{3}±16,21^{cB}	458x10^{3}±12,25^{cC}	323x10^{3}±19,62^{aA}	520x10^{3}±7,41^{dE}	718x10^{3}±11,96^{hF}	410x10^{3}±7,71^{bC}	563x10^{3}±12,35^{eA}	568x10^{3}±4,45^{eC}	705x10^{3}±9,21^{hF}	565x10^{3}±4,08^{eD}
D5	646x10^{3}±3,30^{hE}	336x10^{3}±8,66^{bAB}	598x10^{3}±6,68^{gB}	694x10^{3}±18,45^{iF}	552x10^{3}±10,66^{fAB}	714x10^{3}±12,66^{iF}	268x10^{3}±7,79^{aA}	536x10^{3}±12,83^{fE}	366x10^{3}±4,32^{cA}	480x10^{3}±10,50^{eC}	498x10^{3}±10,28^{eD}	824x10^{3}±11,82^{jD}	500x10^{3}±2,16^{eB}	428x10^{3}±1,26^{dA}	532x10^{3}±3,30^{fCD}
D6	488x10^{3}±7,04^{fB}	316x10^{3}±15,17^{bA}	464x10^{3}±3,74^{efA}	472x10^{3}±10,03^{efB}	524x10^{3}±15,63^{gA}	638x10^{3}±12,50^{iD}	254x10^{3}±5,35^{aA}	422x10^{3}±2,16^{dCD}	450x10^{3}±5,35^{deC}	544x10^{3}±2,50^{ghD}	348x10^{3}±3,40^{cA}	536x10^{3}±6,80^{gA}	566x10^{3}±10,20^{hC}	630x10^{3}±6,60^{iD}	430x10^{3}±2,16^{dA}
D7	524x10^{3}±3,56^{hC}	348x10^{3}±7,41^{bB}	470x10^{3}±6,85^{fgA}	380x10^{3}±3,27^{cA}	536x10^{3}±6,55^{hAB}	674x10^{3}±4,97^{jE}	256x10^{3}±4,19^{aA}	382x10^{3}±2,87^{cB}	630x10^{3}±4,11^{iG}	464x10^{3}±8,64^{fBC}	490x10^{3}±1,41^{gD}	662x10^{3}±6,02^{jC}	412x10^{3}±5,35^{dA}	436x10^{3}±1,71^{eA}	522x10^{3}±19,51^{hC}
D8	462x10^{3}±3,69^{cdA}	320x10^{3}±4,50^{aA}	440x10^{3}±8,73^{cA}	516x10^{3}±8,63^{eC}	538x10^{3}±4,23^{efAB}	412x10^{3}±6,16^{bA}	398x10^{3}±6,68^{bB}	392x10^{3}±17,21^{bBC}	482x10^{3}±1,82^{dD}	448x10^{3}±6,34^{cB}	324x10^{3}±6,95^{aA}	550x10^{3}±1,26^{fA}	478x10^{3}±8,52^{dB}	522x10^{3}±8,18^{eB}	478x10^{3}±4,99^{dB}

Mean values bearing the same letters are statistically homogeneous at $p<0{,}01\%$ significance

Lowercase letters following the lines compare the yield of accessions at fixed densities

The capital letters following the columns compare the yield of an accession at different sowing densities

Table 5. Average number of Bambara groundnut pods per hectare (ha) depending on densities in 2017.

Densities	Acc. 36	Acc. 1	Acc. 2	Acc. 3	Acc. 6	Acc. 7	Acc. 8	Acc. 9	Acc. 12	Acc. 18	Acc. 19	Acc. 20	Acc. 24	Acc. 25	Acc. 27
D1	295x10^{3}±1,77^{iDE}	171x10^{3}±1,61^{bE}	304x10^{3}±1,61^{jG}	399x10^{3}±1,61^{mG}	356x10^{3}±2,14^{lG}	472x10^{3}±1,20^{nG}	105x10^{3}±1,77^{aA}	259x10^{3}±0,72^{fD}	275x10^{3}±1,77^{gE}	229x10^{3}±1,61^{dD}	224x10^{3}±1,61^{cE}	336x10^{3}±1,20^{kE}	249x10^{3}±2,98^{eB}	279x10^{3}±1,61^{ghD}	283x10^{3}±1,77^{hE}
D2	291x10^{3}±1,57^{gD}	138x10^{3}±2,28^{bD}	215x10^{3}±1,02^{dD}	358x10^{3}±1,44^{jE}	403x10^{3}±2,28^{kH}	304x10^{3}±1,61^{hC}	123x10^{3}±1,88^{aC}	290x10^{3}±1,02^{gF}	201x10^{3}±1,61^{cB}	315x10^{3}±1,77^{iG}	259x10^{3}±1,61^{fF}	419x10^{3}±2,60^{lH}	361x10^{3}±1,61^{jF}	401x10^{3}±3,44^{kG}	250x10^{3}±3,23^{eC}
D3	299x10^{3}±0,72^{gE}	110x10^{3}±1,77^{aB}	208x10^{3}±1,02^{cC}	324x10^{3}±2,17^{hC}	251x10^{3}±1,57^{eB}	374x10^{3}±1,61^{kF}	168x10^{3}±1,20^{bE}	280x10^{3}±2,28^{fE}	365x10^{3}±1,20^{iG}	206x10^{3}±1,57^{cB}	256x10^{3}±2,17^{eF}	411x10^{3}±3,61^{lG}	236x10^{3}±2,39^{dA}	325x10^{3}±2,14^{hF}	331x10^{3}±2,58^{iG}
D4	335x10^{3}±1,02^{jF}	175x10^{3}±1,57^{bE}	240x10^{3}±1,02^{eE}	380x10^{3}±1,77^{lF}	336x10^{3}±2,14^{jF}	345x10^{3}±1,02^{kE}	209x10^{3}±1,61^{cF}	219x10^{3}±1,61^{dB}	205x10^{3}±1,77^{cB}	269x10^{3}±1,61^{fF}	132x10^{3}±1,88^{aB}	281x10^{3}±4,13^{gB}	240x10^{3}±2,14^{eA}	298x10^{3}±2,77^{hE}	319x10^{3}±2,60^{iF}
D5	185x10^{3}±2,38^{cC}	128x10^{3}±2,06^{aC}	249x10^{3}±1,29^{fF}	352x10^{3}±1,71^{kD}	326x10^{3}±1,41^{iE}	332x10^{3}±0,82^{jD}	124x10^{3}±1,41^{aC}	263x10^{3}±1,73^{gD}	230x10^{3}±1,83^{dC}	237x10^{3}±1,92^{eE}	148x10^{3}±1,26^{bC}	370x10^{3}±2,06^{lF}	333x10^{3}±1,29^{jE}	231x10^{3}±1,92^{dC}	270x10^{3}±1,83^{hD}
D6	157x10^{3}±1,29^{dB}	84x10^{3}±1,71^{aA}	154x10^{3}±1,41^{dA}	234x10^{3}±0,96^{gA}	283x10^{3}±1,92^{jC}	305x10^{3}±2,08^{kC}	111x10^{3}±1,92^{bB}	216x10^{3}±1,26^{fB}	258x10^{3}±1,41^{hD}	267x10^{3}±1,29^{iF}	145x10^{3}±2,08^{cC}	310x10^{3}±1,41^{kD}	288x10^{3}±0,96^{jD}	203x10^{3}±1,29^{eA}	151x10^{3}±2,08^{cdB}
D7	148x10^{3}±2,50^{cA}	104x10^{3}±1,71^{aB}	180x10^{3}±1,26^{dB}	243x10^{3}±1,16^{gA}	292x10^{3}±1,89^{jD}	256x10^{3}±1,71^{hA}	129x10^{3}±1,92^{bD}	208x10^{3}±1,71^{eA}	306x10^{3}±2,22^{kF}	220x10^{3}±2,82^{fC}	182x10^{3}±1,50^{dD}	255x10^{3}±1,29^{hA}	273x10^{3}±1,73^{iC}	215x10^{3}±1,29^{fB}	253x10^{3}±1,73^{hC}
D8	186x10^{3}±2,16^{gC}	106x10^{3}±2,16^{bB}	152x10^{3}±1,63^{eA}	292x10^{3}±1,50^{lB}	217x10^{3}±1,29^{iA}	290x10^{3}±2,22^{lB}	122x10^{3}±1,63^{cC}	238x10^{3}±1,50^{jC}	172x10^{3}±1,50^{fA}	198x10^{3}±1,83^{hA}	100x10^{3}±0,82^{aA}	302x10^{3}±1,83^{mC}	270x10^{3}±2,06^{kC}	216x10^{3}±1,83^{iB}	142x10^{3}±1,71^{dA}

- Mean values bearing the same letters are statistically homogeneous at p<0,01% significance
- Lowercase letters following the lines compare the yield of accessions at fixed densities
- The capital letters following the columns compare the yield of an accession at different sowing densities

Table 6. Average number of Bambara groundnut pods per hectare (ha) depending on densities in 2018.

Densities	Acc. 36	Acc. 1	Acc. 2	Acc. 3	Acc. 6	Acc. 7	Acc. 8	Acc. 9	Acc. 12	Acc. 18	Acc. 19	Acc. 20	Acc. 24	Acc. 25	Acc. 27
D1	$389x10^{3}\pm2,60^{fF}$	$394x10^{3}\pm4,15^{fG}$	$303x10^{3}\pm2,70^{bD}$	$634x10^{3}\pm3,61^{jF}$	$374x10^{3}\pm3,73^{eF}$	$656x10^{3}\pm2,39^{kG}$	$220x10^{3}\pm2,04^{aE}$	$486x10^{3}\pm2,95^{hE}$	$406x10^{3}\pm1,88^{gE}$	$506x10^{3}\pm2,39^{iE}$	$339x10^{3}\pm1,88^{dH}$	$315x10^{3}\pm2,04^{cC}$	$514x10^{3}\pm2,60^{iG}$	$699x10^{3}\pm2,39^{lH}$	$409x10^{3}\pm3,75^{gF}$
D2	$436x10^{3}\pm2,60^{gG}$	$413x10^{3}\pm2,58^{fH}$	$378x10^{3}\pm2,77^{dF}$	$686x10^{3}\pm2,39^{lG}$	$383x10^{3}\pm3,13^{deG}$	$575x10^{3}\pm1,44^{iF}$	$387x10^{3}\pm1,88^{eF}$	$338x10^{3}\pm2,58^{bcD}$	$332x10^{3}\pm2,37^{bC}$	$634x10^{3}\pm1,61^{kH}$	$210x10^{3}\pm1,44^{aE}$	$339x10^{3}\pm3,29^{cF}$	$601x10^{3}\pm2,39^{jH}$	$378x10^{3}\pm1,44^{dE}$	$456x10^{3}\pm2,17^{hG}$
D3	$445x10^{3}\pm2,04^{iH}$	$321x10^{3}\pm2,17^{dE}$	$344x10^{3}\pm2,39^{fE}$	$441x10^{3}\pm3,13^{iE}$	$354x10^{3}\pm2,39^{gE}$	$339x10^{3}\pm2,60^{efC}$	$217x10^{3}\pm2,14^{aE}$	$340x10^{3}\pm2,28^{efD}$	$382x10^{3}\pm2,77^{hD}$	$619x10^{3}\pm2,39^{jG}$	$236x10^{3}\pm2,14^{bG}$	$347x10^{3}\pm1,57^{fgG}$	$334x10^{3}\pm2,95^{eD}$	$442x10^{3}\pm2,58^{iG}$	$304x10^{3}\pm2,98^{cC}$
D4	$316x10^{3}\pm2,39^{dE}$	$335x10^{3}\pm1,02^{eF}$	$287x10^{3}\pm2,14^{cC}$	$384x10^{3}\pm2,60^{gD}$	$331x10^{3}\pm2,95^{eD}$	$496x10^{3}\pm4,27^{iE}$	$182x10^{3}\pm1,57^{aB}$	$222x10^{3}\pm2,37^{bA}$	$499x10^{3}\pm2,60^{iF}$	$526x10^{3}\pm1,61^{jF}$	$220x10^{3}\pm3,06^{bF}$	$281x10^{3}\pm2,39^{cA}$	$358x10^{3}\pm2,70^{fE}$	$363x10^{3}\pm1,57^{fD}$	$391x10^{3}\pm2,39^{hE}$
D5	$215x10^{3}\pm2,63^{cC}$	$248x10^{3}\pm1,41^{eD}$	$266x10^{3}\pm1,50^{gB}$	$306x10^{3}\pm0,96^{hB}$	$376x10^{3}\pm1,83^{lFG}$	$373x10^{3}\pm1,50^{lD}$	$208x10^{3}\pm1,83^{bD}$	$237x10^{3}\pm1,92^{dB}$	$337x10^{3}\pm1,92^{jC}$	$253x10^{3}\pm1,00^{fA}$	$181x10^{3}\pm1,71^{aD}$	$332x10^{3}\pm1,63^{iE}$	$384x10^{3}\pm1,50^{mF}$	$408x10^{3}\pm1,50^{nF}$	$345x10^{3}\pm1,00^{kD}$
D6	$227x10^{3}\pm1,50^{fD}$	$175x10^{3}\pm2,06^{bC}$	$344x10^{3}\pm1,41^{jE}$	$367x10^{3}\pm1,89^{lC}$	$230x10^{3}\pm1,41^{fB}$	$340x10^{3}\pm0,82^{jC}$	$184x10^{3}\pm1,35^{cB}$	$298x10^{3}\pm1,83^{hC}$	$210x10^{3}\pm1,71^{dB}$	$398x10^{3}\pm1,83^{mD}$	$110x10^{3}\pm1,41^{aB}$	$325x10^{3}\pm2,06^{iD}$	$293x10^{3}\pm1,26^{gA}$	$353x10^{3}\pm0,96^{kC}$	$217x10^{3}\pm0,96^{eA}$
D7	$196x10^{3}\pm0,96^{eB}$	$140x10^{3}\pm1,41^{aB}$	$265x10^{3}\pm1,50^{iB}$	$312x10^{3}\pm1,63^{lB}$	$266x10^{3}\pm2,45^{iC}$	$244x10^{3}\pm2,16^{hA}$	$174x10^{3}\pm0,97^{cA}$	$215x10^{3}\pm1,00^{fA}$	$182x10^{3}\pm1,83^{dA}$	$354x10^{3}\pm1,71^{nC}$	$154x10^{3}\pm0,82^{bC}$	$321x10^{3}\pm1,92^{mD}$	$303x10^{3}\pm1,73^{kB}$	$274x10^{3}\pm0,82^{jA}$	$235x10^{3}\pm2,22^{gB}$
D8	$120x10^{3}\pm0,82^{cA}$	$106x10^{3}\pm1,71^{bA}$	$162x10^{3}\pm1,50^{dA}$	$246x10^{3}\pm1,63^{iA}$	$214x10^{3}\pm2,22^{ghA}$	$301x10^{3}\pm2,38^{lB}$	$196x10^{3}\pm1,50^{fC}$	$216x10^{3}\pm0,82^{hA}$	$187x10^{3}\pm1,50^{eA}$	$296x10^{3}\pm0,96^{kB}$	$91x10^{3}\pm0,50^{aA}$	$288x10^{3}\pm0,00^{jB}$	$321x10^{3}\pm1,71^{mC}$	$317x10^{3}\pm1,73^{mB}$	$211x10^{3}\pm1,71^{gA}$

- Mean values bearing the same letters are statistically homogeneous at p<0,01% significance
- Lowercase letters following the lines compare the yield of accessions at fixed densities
- The capital letters following the columns compare the yield of an accession at different sowing densities

The comparison of accessions according to densities during the three years of experimentation (2016, 2017, and 2018) made it possible to determine the densities by grouping accessions that present a fairly high number of pods (Table 7).

Table 7. Accessions presented a high number of pods during the three years of experimentation (2016, 2017 and 2018) according to different densities.

Years	Densities					
	D1	D2	D3	D4	D5	D7
2016	697x10^3±23,06^{fD} Acc.2 880x10^3±13,89^{h} ^{D}Acc.6 868x10^3±8,68^{hG} Acc.7 685x10^3±16,71^{ef} ^{G}Acc.9 630x10^3±5,10^{dE} Acc.19 645x10^3±10,63^{de} ^{D}Acc.24		690x10^3 ±8,02^{gF}Acc.36 505x10^3±7,93^{cE} Acc.1 880x10^3±7,80^{hG} Acc.27	458x10^3±12,25^{c} ^{C}Acc.8 718x10^3±11,96^{h} ^{F}Acc.18 705x10^3±9,21^{hF} Acc.25	694x10^3±18,45^{i} ^{F} Acc.3 824x10^3±11,82^{j} ^{D}Acc.20	630x10^3±4,11^{i} ^{G}Acc.12
Acc. rate	40%		20%	20%	13,33%	6,67%
2017	304x10^3±1,61^{jG}Acc.2 399x10^3±1,61^{mG} Acc.3 472x10^3±1,20^{nG} Acc.7	403x10^3±2,28^{k} ^{H}Acc.6 290x10^3±1,02^{gF} Acc.9 315x10^3±1,77^{iG} Acc.18 259x10^3±1,61^{fF} Acc.19 419x10^3±2,60^{jH} Acc.20 361x10^3±1,61^{jF} Acc.24 401x10^3±3,44^{k} ^{G}Acc.25	365x10^3±1,20^{jG} Acc.12 331x10^3±2,58^{iG} Acc.27	335x10^3±1,02^{jF} Acc.A 175x10^3±1,57^{bE} Acc.1 209x10^3±1,61^{eF} Acc.8		
Acc.rate	20%	46,67%	13,33%	20%		
2018	656x10^3±2,39^{kG} Acc.7 486x10^3±2,95^{hE} Acc.9 339x10^3±1,88^{dH} Acc.19 699x10^3±2,39^{lH}Acc.25	413x10^3±2,58^{fH} Acc.1 378x10^3±2,77^{d} ^{F}Acc.2 686x10^3±2,39^{lG} Acc.3 383x10^3±3,13^{de} ^{G}Acc.6 387x10^3±1,88^{eF}	445x10^3±2,04^{iH} Acc.36 347x10^3±1,57^{fg} ^{G}Acc.20	499x10^3±2,60^{iF} Acc.12		

		Acc.8 634x10^3±1,61^{k} ^{H}Acc.18 601x10^3±2,39^{jH} Acc.24 456x10^3±2,17^{h} ^{G}Acc.27		
Acc. rate	26,67%	53,33%	13,33%	6,67%

D1=40cmx20cm D3=40cmx30cm D5=50cmx20cm ; Acc.=accession ;
D2=40cmx25cm D4=40cmx40cm D7=50cmx30cm Acc. rate=accession rate

In 2016, D1 (125000 plants/ha) brought together 40% of accessions (Acc.2, Acc.6, Acc.7, Acc.9, Acc.19 and Acc.24) which presents a total of 440x10^3 pods/ha; followed by D3 (83333 plants/ha) which brought together 20% of accessions (Acc.36, Acc.1, Acc.27) and which presents 2075x10^3 pods/ha; D4 (62500 plants/ha) which grouped 20% of accessions (Acc.8, Acc.18, Acc.25) with 1881x10^3 pods/ha; D5 (100000 plants/ha) which brought together 13,33% of accessions (Acc.3, Acc.20) with 1518x10^3 pods/ha and D7 (66667 plants/ha) which brought together 6,67% of accessions (Acc.12) with 630x10^3 pods/ha.

In 2017, D2 (100000 plants/ha) brought together 46,67% of accessions (Acc.6; Acc.9; Acc.18; Acc.19; Acc.20; Acc.24; Acc.25) which presented a total of 2448x10^3 pods/ha; followed by D1 (125000 plants/ha) which brought together 20% of accessions (Acc.2, Acc.3, Acc.7) with 1175x10^3 pods/ha; of D4 (62500 plants/ha) which grouped 20% of accessions (Acc.36; Acc.1, Acc.8) with 719x10^3 pods/ha and D3 (83333 plants/ha) which grouped 13,33 % of accessions (Acc.12; Acc.27) with 696x10^3 pods/ha. In 2018, D2 (100000 plants/ha) brought together 53,33% of accessions (Acc.1; Acc.2; Acc.3; Acc.6; Acc.8; Acc.18; Acc.24; Acc.27) with 3938x10^3 pods/ha; followed by D1 (125000 plants/ha) which brought together 26,67% of accessions (Acc.7; Acc.9; Acc.19; Acc.25) with 2180x10^3 pods/ha; of D3 (83333 plants/ha) which brought together 13,33% of accessions (Acc.36; Acc.20) with 792x10^3 pods/ha and D4 (62500 plants/ha) which brought together 6,67% of accessions (Acc.12) with 499x10^3 pods/ha.

Average weight of Bambara groundnut pods on the different densities

Observation of tables 8, 9 and 10 shows significant variations in the average weight of the pods depending on the densities and accessions during the three years of cultivation. The average weight of pods in year 1 (2016) at D1 (40cmx20cm), varies from 384,25±4,82^{aBC} kg/ha (Acc.3) to 814±9,33^{fF} kg/ha (Acc.19); in year 2 (2017) at D1 (40cmx20cm), it varies from 87,5±4,56^{aA} kg/ha (Acc.8) to 290,6±4,13^{kF} kg/ha (Acc.3), and in year 3 (2018) to D1 (40cmx20cm), it varies from 339,4±2,57^{aE} kg/ha (Acc.20) to 756±1,72^{jF} kg/ha (Acc.25).

In 2016 with D2 (40cmx25cm), it varied from 323±3,27^{aB} kg/ha (Acc.12) to 644,5±11,05^{fD}kg/ha (Acc.27); in 2017 at D2 (40cmx25cm), it varies from 96,9±4,38^{aD} kg/ha (Acc.1) to 262,5±5,10^{jF} kg/ha (Acc.6), and in 2018 at D2 (40cmx25cm), it varies from 335,9±2,91^{aD} kg/ha (Acc.1) to 686,3±2,00^{kH} kg/ha (Acc.18). In 2016 with D3 (40cmx30cm), it varied from 377±9,08^{aB} kg/ha (Acc.2) to 836,5±3,03^{gE}kg/ha (Acc.27); in 2017 at D3 (40cmx23cm), it varies from 75±4,90^{aB} kg/ha (Acc.1) to 262,5±4,21^{hF} kg/ha (Acc.12), and in 2018 at D3 (40cmx30cm), it varies from 381,2±0.54^{fE} kg/ha (Acc.8) to 623,9±2,78^{nG} kg/ha (Acc.18).

In 2016 with D4 (40cmx40cm), it varied from 311,25±10,21^{aA} kg/ha (Acc.7) to 671±13,02^{gE} kg/ha (Acc.18); in 2017 at D4 (40cmx40cm), it varies from 128,1±3,73^{aE} kg/ha (Acc.1) to 259,4±3,73^{gDE} kg/ha (Acc.3), and in 2018 at D4 (40cmx40cm), it varies from 320±1,86^{aE} kg/ha (Acc.19) to 563,3±1,35^{jF} kg/ha (Acc.12). In 2016 with D5 (50cmx20cm), it varied from 222,8±6,68^{aA} kg/ha (Acc.12) to 641,2±8,48^{iF} kg/ha (Acc.20); in 2017 at D5 (50cmx20cm), it varies from 90±1,83^{aCD} kg/ha (Acc.1) to 265±2,52^{kE} kg/ha (Acc.3), and in 2018 at D5 (50cmx20cm), it varies from 168,8±1,36^{aBC} kg/ha (Acc.1) to 401,1±1,60^{kD} kg/ha (Acc.25). In 2016 with D6 (50cmx25cm), it varied from 281,6±3,22^{aA} kg/ha (Acc.1) to 675,8±24,28^{gE} kg/ha (Acc.24); in 2017 at D6 (50cmx25cm), it varies from 62,5±2,22^{aA} kg/ha (Acc.1) to 215±1,92^{jE} kg/ha (Acc.20), and in 2018 at D6 (50cmx25cm), it varies from 151,8±1,06^{aC} kg/ha (Acc.19) to 421,4±1,82^{lD} kg/ha (Acc.3). In 2016 with D7 (50cmx30cm), it varied from 291,4±4,50^{aA} kg/ha (Acc.8) to 544±7,08^{gF} kg/ha (Acc.12); in 2017 at D7 (50cmx30cm), it varies from 74,5±2,22^{aB} kg/ha (Acc.1) to 215±2,08^{iE} kg/ha (Acc.12), and in 2018 at D7 (50cmx30cm), it varies from 142,2±1,23^{aB} kg/ha (Acc.19) to 316,1±0,94^{lB} kg/ha (Acc.3). In 2016 with D8 (50cmx40cm), it varied from 292±2,52^{aA} kg/ha (Acc.1) to 459±4,62^{gAB} kg/ha (Acc.6); in 2017 at D8 (50cmx40cm), it varies from 80±2,45^{aBC} kg/ha (Acc.1) to 220±2,58^{jB} kg/ha (Acc.3), and in 2018 at D8 (50cmx40cm), it varies from 124,9±1,18^{aA} kg/ha (Acc.1) to 305,8±1,95^{lC} kg/ha (Acc.24).

Table 8. Average weight of Bambara groundnut pods (kg/ha) depending on densities in 2016.

Densities	Acc. 36	Acc. 1	Acc. 2	Acc. 3	Acc. 6	Acc. 7	Acc. 8	Acc. 9	Acc. 12	Acc. 18	Acc. 19	Acc. 20	Acc. 24	Acc. 25	Acc. 27
D1	599,75 ±4,49^{dD}	389,25 ±2,31^{aC}	520,75 ±20,56^{cE}	384,25± 4,82^{aBC}	779,5± 16,19^{fD}	603,75 ±7,98^{dD}	521,25 ±4,15^{aD}	658,5± 16,42^{eE}	465± 7,33^{bE}	406,5± 13,40^{aBC}	814± 9,33^{fF}	591± 3,77^{dE}	498± 7,57^{bcC}	541,5± 22,37^{cE}	649,5± 24,46^{eD}
D2	544,5± 8,17^{cdC}	420±3, 26^{bD}	505,5± 7,30^{cDE}	556,75± 25,36^{cdfE}	611,25± 17,11^{efC}	402,5± 13,24^{bB}	416,5± 5,98^{bB}	588,25 ±23,11^{deD}	323± 3,27^{aB}	509,25 ±11,70^{cD}	493,5± 17,01^{cCD}	548,75± 21,04^{cdD}	448± 9,52^{bB}	536,25± 25,40^{cdDE}	644,5± 11,05^{fD}
D3	643,25 ±8,05^{fE}	470± 8,01^{bE}	377± 9,08^{aB}	493,25± 14,16^{bcdD}	489,75± 27,34^{bcB}	408,75 ±8,85^{aB}	467,25 ±4,59^{bC}	417,75 ±9,58^{aB}	481± 8,95^{bE}	421,25 ±6,30^{aC}	501,75± 22^{bcdeCD}	462,75± 9,70^{bC}	536± 12,59^{ceD}	487,5± 2,97^{bcCD}	836,5± 3,03^{gE}
D4	591,75 ±11,34^{fD}	401,5± 3,95^{bC}	576± 8,06^{fF}	478± 10,10^{dD}	626,75± 14,86^{fC}	311,25 ±10,21^{aA}	609,5± 16,02^{fE}	420,25 ±19,79^{bcB}	423± 6,32^{bcD}	671± 13,02^{gE}	536,75± 12,25^{eDE}	400,25± 11,42^{bAB}	483± 6,83^{dC}	460,25± 27,88^{cdBC}	474,5± 5,87^{dC}
D5	593,8± 5,44^{hD}	308,2± 7,11^{bB}	480,4± 8,67^{fgD}	565,2± 26,20^{hE}	491,6± 8,08^{fgB}	460,8± 7,15^{fC}	285,2± 12,45^{bA}	502,4± 10,64^{gC}	222,8± 6,68^{aA}	391,4± 3,30^{dB}	570,6± 12,44^{hE}	641,2± 8,48^{iF}	350,4± 4,27^{cA}	353,6± 1,95^{cA}	422,6± 3,67^{eB}
D6D	460,6± 7,49^{eB}	281,6± 3,22^{aA}	334,4± 2,68^{bA}	362± 14,37^{bcB}	423,8± 10,59^{dA}	442,2± 9,82^{deC}	290,4± 9,75^{aA}	420,2± 2,93^{dB}	338,8± 9,86^{bB}	427,2± 6,12^{dC}	438,2± 7,51^{deB}	383± 7,18^{cA}	675,8± 24,28^{gE}	520,4± 10,71^{fDE}	350± 2,72^{bA}
D7D	461± 7,70^{fB}	317± 5,66^{abcB}	425,4± 18,01^{eC}	297,4± 1,64^{abA}	461,6± 10,89^{fAB}	460,2± 5,07^{fC}	291,4± 4,50^{aA}	324,8± 2,13^{bcdA}	544± 7,08^{gF}	357,4± 9,25^{dA}	454± 9,31^{efBC}	469,2± 5,82^{fC}	355,8± 4,81^{dA}	347,8± 4,41^{cdA}	442,4± 26,37^{efBC}
D8D	410,6± 3,39^{efA}	292± 2,52^{aA}	371,4± 8,31^{cdB}	408,2± 9,21^{efC}	459± 4,62^{gAB}	307± 5,44^{aA}	451,4± 6,24^{gC}	340,8± 18,85^{bA}	368,6± 2,12^{cdC}	390,8± 7,21^{deB}	350,6± 10,77^{bcA}	420,8± 2,23^{fB}	379,6± 5,57^{dA}	424± 6,19^{fB}	411± 5,37^{efB}

- Mean values bearing the same letters are statistically homogeneous at p<0,01% significance
- Lowercase letters following the lines compare the yield of accessions at fixed densities
- The capital letters following the columns compare the yield of an accession at different sowing densities

Table 9. Average weight of Bambara groundnut pods (kg/ha) depending on densities in 2017.

Densities	Acc. 36	Acc. 1	Acc. 2	Acc. 3	Acc. 6	Acc. 7	Acc. 8	Acc. 9	Acc. 12	Acc. 18	Acc. 19	Acc. 20	Acc. 24	Acc. 25	Acc. 27
D1	231,2± $4,84^{hC}$	131,2± $3,31^{bE}$	206,2± $3,31^{gE}$	290,6± $4,13^{kF}$	243,8± $3,31^{iE}$	256,2± $4,27^{jF}$	87,5± $4,56^{aA}$	187,5± $3,54^{efB}$	181,2± $2,98^{eD}$	146,2± $2,60^{cB}$	228,1± $2,77^{hF}$	203,1± $2,14^{gD}$	165,6± $3,59^{dA}$	196,9± $2,14^{fgD}$	190,6± $2,58^{efC}$
D2	228,1± $6,72^{hC}$	96,9± $4,38^{aD}$	140,6± $5,98^{cdC}$	250,6± $3,44^{ijD}$	262,5± $5,10^{jF}$	146,9± $4,13^{deB}$	118,8± $4,27^{bC}$	237,5± $3,68^{hiD}$	125± $3,23^{bcA}$	190,6± $3,73^{gF}$	237,5± $2,70^{hiG}$	246,2± $4,27^{hijF}$	250± $3,68^{ijE}$	175± $2,70^{fgC}$	165,6± $2,77^{efB}$
D3	231,2± $4,27^{fgC}$	75± $4,90^{aB}$	140,6± $4,38^{bC}$	234,4± $4,38^{gC}$	187,5± $4,21^{dB}$	203,1± $2,77^{eE}$	166,9± $4,49^{cE}$	206,2± $3,75^{eC}$	262,5± $4,21^{hF}$	134,4± $3,59^{bA}$	225± $2,28^{fgF}$	253,1± $2,77^{hF}$	184,4± $2,77^{dB}$	221,9± $2,77^{fF}$	231,2± $3,31^{fgE}$
D4	234,4± $3,73^{fC}$	128,1± $3,73^{aE}$	171,9± $3,73^{cD}$	259,4± $3,73^{gDE}$	256,2± $3,31^{gF}$	190,6± $3,73^{dD}$	231,2± $2,60^{fF}$	153,1± $5,53^{bA}$	137,5± $2,70^{abB}$	178,1± $2,58^{cdE}$	130,6± $1,57^{aB}$	181,2± $3,89^{cdB}$	181,2± $2,60^{cdB}$	209,4± $3,44^{eE}$	225± $2,28^{efDE}$
D5	137,5± $2,36^{cB}$	90± $1,83^{aCD}$	162,5± $2,22^{eD}$	265± $2,52^{kE}$	215± $2,08^{gD}$	164,5± $2,22^{efC}$	125± $2,52^{bCD}$	210± $1,63^{gC}$	170± $1,63^{fC}$	160± $2,71^{eD}$	142,5± $2,22^{cC}$	247,5± $1,71^{jF}$	240± $1,41^{iD}$	152,5± $1,50^{dB}$	224± $1,83^{hD}$
D6	145± $2,08^{eB}$	62,5± $2,22^{aA}$	117,5± $2,36^{cB}$	165± $1,92^{gA}$	202,5± $2,22^{iC}$	165± $2,08^{gC}$	100± $2,45^{bB}$	157,5± $1,71^{fA}$	177,5± $1,71^{hCD}$	182,5± $2,22^{hEF}$	150± $2,58^{eD}$	215± $1,92^{jE}$	200± $1,63^{iC}$	130± $0,82^{dA}$	100± $1,83^{bA}$
D7	117,5± $1,71^{bA}$	74,5± $2,22^{aB}$	117,5± $2,50^{bB}$	170± $2,45^{fA}$	205± $2,08^{hC}$	137,5± $2,22^{dA}$	127,5± $2,75^{cD}$	157,5± $1,71^{eA}$	215± $2,08^{iE}$	157,5± $1,50^{eCD}$	172,5± $0,96^{fE}$	137± $1,92^{dA}$	202,5± $0,96^{hC}$	132,5± $2,06^{cdA}$	185,5± $0,96^{gC}$
D8	137,5± $2,36^{eB}$	80± $2,45^{aBC}$	104,5± $1,71^{cA}$	220± $2,58^{jB}$	145± $2,65^{fA}$	160± $2,16^{gC}$	105± $2,08^{cB}$	195± $1,29^{iB}$	120± $2,45^{dA}$	150± $2,45^{fBC}$	97,5± $2,36^{bA}$	190± $1,41^{hiC}$	187,5± $0,96^{hB}$	156± $1,41^{gB}$	102± $1,41^{bcA}$

- Mean values bearing the same letters are statistically homogeneous at p<0,01% significance
- Lowercase letters following the lines compare the yield of accessions at fixed densities
- The capital letters following the columns compare the yield of an accession at different sowing densities

Table 10. Average weight of Bambara groundnut pods (kg/ha) depending on densities in 2018.

Densities	Acc. 36	Acc. 1	Acc. 2	Acc. 3	Acc. 6	Acc. 7	Acc. 8	Acc. 9	Acc. 12	Acc. 18	Acc. 19	Acc. 20	Acc. 24	Acc. 25	Acc. 27
D1	502,8±1,25^{fG}	548,8±2,58^{gG}	476,9±2,67^{eG}	618,4±2,72^{iF}	618±2,67^{iF}	499,2±2,69^{fH}	387,5±3,14^{bEF}	555,8±2,68^{gG}	591,6±1,88^{hG}	432,7±2,73^{cF}	446,5±2,46^{dG}	339,4±2,57^{aE}	625,4±2,38^{iH}	756±1,72^{jF}	619,9±1,98^{iG}
D2	425,2±1,85^{dF}	335,9±2,91^{aD}	525,2±1,88^{hH}	683,2±2,94^{kG}	611,6±3,03^{jF}	472,4±3,12^{gG}	445,6±2,71^{eG}	471,3±2,52^{gF}	407,1±1,74^{cE}	686,3±2,00^{kH}	399,4±2,52^{bF}	617,9±1,47^{jH}	589,1±2,75^{iG}	458,4±2,21^{fE}	458,3±3,08^{fF}
D3	540,7±1,49^{mH}	410,8±1,84^{hF}	429,9±2,14^{jE}	421,9±1,27^{iD}	330,9±3,62^{cC}	344,4±3,82^{dE}	381,2±0,54^{fE}	473,4±2,77^{lF}	332,9±3,04^{cC}	623,9±2,78^{nG}	400,2±2,64^{gF}	373,7±2,27^{eF}	449,6±1,80^{kF}	298,9±1,97^{bB}	282,2±2,76^{aD}
D4	410,8±1,10^{efE}	376,4±1,11^{cE}	440,2±3,67^{gF}	477,1±2,93^{iE}	340,5±2,33^{bD}	438,1±1,50^{gF}	395,3±2,46^{dF}	437±1,62^{gE}	563,3±1,35^{jF}	373,1±2,65^{cE}	320±1,86^{aE}	418±2,94^{fG}	416,1±2,21^{fE}	405,2±1,24^{eD}	452,8±1,55^{hF}
D5	300,1±1,49^{fC}	168,8±1,36^{aBC}	303,4±1,17^{fC}	372,9±2,15^{jC}	376,4±0,93^{jE}	291,8±0,21^{eD}	299,2±1,77^{fD}	310,2±1,31^{gC}	374,3±1,65^{jD}	243,7±1,53^{bA}	253,5±1,63^{cD}	261,4±1,11^{dB}	368,6±1,38^{iD}	401,1±1,60^{kD}	318,2±0,92^{hE}
D6	308,5±1,40^{jD}	170,3±1,35^{bC}	314,2±1,25^{jD}	421,4±1,82^{lD}	272,8±2,32^{hA}	265,5±1,46^{gC}	210,3±6,35^{dB}	349,3±1,10^{kD}	188,2±0,58^{cB}	255,7±1,25^{fB}	151,8±1,06^{aC}	286,8±1,24^{iC}	278,7±1,63^{hB}	352,1±0,15^{kC}	233,7±1,62^{eC}
D7	274,7±0,39^{hB}	163,9±2,16^{bB}	180±1,28^{cA}	316,1±0,94^{lB}	281,2±1,72^{iB}	196,4±1,70^{eA}	166,5±1,00^{bA}	247±1,62^{fA}	191,6±1,64^{dB}	307,8±1,50^{kD}	142,2±1,23^{aB}	304,9±1,55^{jD}	269,2±1,40^{gA}	303,2±1,25^{jB}	195,9±1,27^{eA}
D8	256,6±1,52^{hA}	124,9±1,18^{aA}	220,1±1,66^{eB}	291,1±1,67^{kA}	269,4±1,07^{jA}	245,4±1,60^{gB}	225,9±1,33^{fC}	262,5±2,39^{iB}	180,7±1,03^{cA}	293,3±1,86^{kC}	134,2±1,52^{bA}	253,7±0,85^{hA}	305,8±1,95^{lC}	221,1±1,15^{eA}	214,1±1,68^{dB}

- Mean values bearing the same letters are statistically homogeneous at p<0,01% significance
- Lowercase letters following the lines compare the yield of accessions at fixed densities
- The capital letters following the columns compare the yield of an accession at different sowing densities

The comparison between the accessions according to densities during the three years of experimentation (2016, 2017, and 2018) made it possible to group the accessions which present a high weight of pods (Table 11).

Table 11. Accessions presented a high average weight of pods during the three years of experimentation (2016, 2017 and 2018) according to different densities.

Years	Densities						
	D1	D2	D3	D4	D5	D6	D7
2016	779,5±16,1^{fD}Acc.6 603,8±7,98^{dD}Acc.7 658,5±16,42^{eE} Acc.9 814±9,33^{fF}Acc. 19 514,5±22,37^{cE} Acc.25		643,3±8,05^{fE}Acc.36 470±8,01^{bE}Acc.1 836,5±3,03^{gE}Acc.27	576±8,06^{fF}Acc.2 609,5±16,02^{fE} Acc.8 671±1,02^{gE}Acc.18	565,2±26,20^{hE} Acc.3 641,2±8,48^{iF}Acc.20	675,8±24,28^{gE} Acc.24	44±7,08^{gF} Acc.12
Acc rate	33,33%		20%	20%	13,33%	6,67	6,67%
2017	131,2±3,31^{bE} Acc. 1 206,2±3,31^{gE} Acc. 2 290,6±4,13^{kF} Acc. 3 256,2±4,27^{jF} Acc. 7	262,5±5,10^{jF} Acc. 6 237,5±3,68^{hiD} Acc. 9 190,6±3,73^{gF} Acc. 18 237,5±2,70^{hiG} Acc. 19 250±3,68^{ijE} Acc. 24	166,9±4,49^{cE} Acc.8 262,5±4,21^{hF} Acc.12 253,1±2,77^{hF} Acc.20 221,9±2,77^{fF}Acc.25	234,4±3,73^{fC} Acc.36 225±2,28^{efDE}Acc.27			
Acc. rate	26,67%	33,33%	26,67%	13,33%			
2018	548,8±2,58^{gG} Acc.1 618±2,67^{iF} Acc.6 499,2±2,69^{fH} Acc.7 555,8±2,68^{gG} Acc.9 591,6±1,88^{hG} Acc.12 446,5±2,46^{dG} Acc.19 625,4±2,38^{iH} Acc.24 756±1,72^{jF}	525,2±1,88^{hH} Acc.2 683,2±2,94^{kG}Acc.3 445,6±2,71^{eG}Acc.8 686,3±2,00^{kH} Acc.18 617,9±1,47^{jH}Acc.20	540,7±1,49^{mH} Acc.36				

	Acc.25 619,9±1,98^{iG} Acc.27		
Acc. rate	60%	33,33%	6,67%

D1=40cmx20cm D3=40cmx30cm D5=50cmx20cm ; Acc.=accession ;
D2=40cmx25cm D4=40cmx40cm D7=50cmx30cm Acc. rate =Accession rate

In the 1st year of cultivation (2016), D1 (125000 plants/ha) brought together 33,33% of accessions (Acc.6; Acc.7; Acc.9; Acc.19; Acc.25) with 3397,25 kg/ha; followed by D3 (83333 plants/ha) which brought together 20% of accessions (Acc.36; Acc.1; Acc.27) with 1949,75 kg/ha; D4 (62500 plants/ha) which brought together 20% of accessions (Acc.2, Acc.8, Acc.18) with 1856,5 kg/ha; D5 (100000 plants/ha) which brought together 13,33% of accessions (Acc.3, Acc.20) with 1206,4 kg/ha; of D6 (80000 plants/ha) which brought together 6,67% accession (Acc.24) with 675,8 kg/ha and D7 (66667 plants/ha) which brought together 6,67% accession (Acc.12) with 544 kg/ha. D1 (125000 plants/ha) has the most accessions in the first year of cultivation (2016). In the 2nd year of cultivation (2017), D2 (100000 plants/ha) brought together 33,33% of accessions (Acc.6; Acc.9; Acc.18; Acc.19; Acc.24) with 1178,1 kg/ha; followed by D3 (83333 plants/ha) which brought together 26,67% of accessions (Acc.12; Acc.20; Acc.25; Acc.27) with 968,7 kg/ha; of D1 (125000 plants/ha) which also brought together 26,67% of accessions (Acc.1; Acc.2; Acc.3; Acc.7) with 884,2 kg/ha and D4 (62500 plants /ha) which brought together 13,33% of accessions (Acc.36; Acc.8) with 465,6 kg/ha. D2 (100000 plants/ha) has the most accessions to the second year of cultivation in 2017.

In the 3rd year of cultivation (2018), D1 (125000 plants/ha) brought together 56,25% of accessions (Acc.1; Acc.6; Acc.7; Acc.9; Acc.12; Acc.19 ; Acc.24; Acc.25; Acc.27) with 5261,2 kg/ha; followed by D2 (100000 plants/ha) which brought together 33,33% of accessions (Acc.2; Acc.3; Acc.8; Acc.18; Acc.20) with 2958,2 kg/ha and the D3 (83333 plants/ha) which brought together 6,66% of accessions (Acc.36) with 540,7 kg/ha.

Average weight of Bambara groundnut seeds based on different densities

Tables 12, 13 and 14 present the yields in average weight of Bambara groundnut seeds according to densities and accessions during three years of experimentation (2016, 2017 and 2018). Significant variations in the average weight of Bambara groundnut seeds are observed depending on densities and accessions over the three years of cultivation.

The average weight of seeds in year 1 (2016) at D1 (40cmx20cm), varies from 269,5±2,77^{aB} kg/ha (Acc.3) to 611,75±8,21^{gE} kg/ha (Acc.19); in year 2 (2017) at D1 (40cmx20cm), it varies from 78,1±3,73^{aAB} kg/ha (Acc.8) to 214,4±2,77^{iH} kg/ha (Acc.3), and in year 3 (2018) to D1 (40cmx20cm), it varies from 222,3±1,49^{aD} kg/ha (Acc.20) to 527,3±1,93^{lF} kg/ha (Acc.6). In 2016 at D2 (40cmx25cm), it varied from 239,95±2,43^{aB} kg/ha (Acc.12) to 482,25±7,06^{fD}kg/ha (Acc.27); in 2017 at D2 (40cmx25cm), it varies from 75±3,23^{aC} kg/ha (Acc.1) to 215,6±1,88^{hF} kg/ha (Acc.25), and in 2018 at D2 (40cmx25cm), it varies from 238,8±2,35^{aC} kg/ha (Acc.1) to 441,5±2,61^{nG} kg/ha (Acc.3). In 2016 at D3 (40cmx30cm), it varied from 266,25±6,86^{aA} kg/ha (Acc.2) to 604,5±2,34^{gE} kg/ha (Acc.27); in 2017 at D3 (40cmx23cm), it varies from 62,5±2,70^{aB} kg/ha (Acc.1) to 196,9±2,14^{hE} kg/ha (Acc.12), and in 2018 at D3 (40cmx30cm), it varies from 211,1±2,87^{aC} kg/ha (Acc.12) to 442,1±1,57^{kG} kg/ha (Acc.18). In 2016 at D4 (40cmx40cm), it varied from 240,53±7,30^{aA} kg/ha (Acc.7) to 463,25±10,37^{fC} kg/ha (Acc.6); in 2017 at D4 (40cmx40cm), it varies from 101,9±3,44^{aD} kg/ha (Acc.1) to 193,8±3,31^{gE} kg/ha (Acc.6), and in 2018 at D4 (40cmx40cm), it varies from 244,9±2,01^{aC} kg/ha (Acc.6) to 350,2±2,29^{jD} kg/ha (Acc.27).In 2016 at D5 (50cmx20cm), it varied from 165,26±3,99^{aA} kg/ha (Acc.12) to 473,4±5,76^{jF} kg/ha (Acc.20); in 2017 at D5 (50cmx20cm), it varies from 72,5±1,50^{aC} kg/ha (Acc.1) to 202,5±2,22^{lG} kg/ha (Acc.3), and in 2018 at D5 (50cmx20cm), it varies from 116,2±0,91^{aB} kg/ha (Acc.1) to 269±1,47^{jD} kg/ha (Acc.6).

In 2016 at D6 (50cmx25cm), it varied from 209±5,96^{aA} kg/ha (Acc.1) to 490,6±18,35^{gF} kg/ha (Acc.24); in 2017 at D6 (50cmx25cm), it varies from 50±1,41^{aA} kg/ha (Acc.1) to 162,5±2,22^{jC} kg/ha (Acc.20), and in 2018 at D6

(50cmx25cm), it varies from 101,1±2,04^{aA} kg/ha (Acc.19) to 263,1±1,66^{kC} kg/ha (Acc.3). In 2016 at D7 (50cmx30cm), it varied from 214,6±1,30^{aA} kg/ha (Acc.3) to 401±5,69^{gF} kg/ha (Acc.12); in 2017 at D7 (50cmx30cm), it varies from 57,5±0,96^{aAB} kg/ha (Acc.1) to 170±1,83^{jC} kg/ha (Acc.6), and in 2018 at D7 (50cmx30cm), it varies from 76,6±1,19^{aA} kg/ha (Acc.8) to 215,2±0,41^{jB} kg/ha (Acc.9). In 2016 at D8 (50cmx40cm), it varied from 213,8±2,05^{aAB} kg/ha (Acc.1) to 389±14,77^{jCD} kg/ha (Acc.25); in 2017 at D8 (50cmx40cm), it varies from 60±1,83^{aB} kg/ha (Acc.1) to 152,5±2.06^{jC} kg/ha (Acc.9), and in 2018 at D8 (50cmx40cm), it varies from 88,9±1,59^{aA} kg/ha (Acc.1) to 206,7±1,77^{kB} kg/ha (Acc.24).

Table 12. Average weight of Bambara groundnut seeds (kg/ha) depending on densities in 2016.

Densities	Acc. 36	Acc. 1	Acc. 2	Acc. 3	Acc. 6	Acc. 7	Acc. 8	Acc. 9	Acc. 12	Acc. 18	Acc. 19	Acc. 20	Acc. 24	Acc. 25	Acc. 27
D1	355,75±7,35^{bA}	270,5±1,47^{aC}	381,25±15,23^{bcC}	269,5±2,77^{aB}	574,5±11,17^{fD}	455,5±5,58^{dE}	405,5±2,83^{cD}	499±11,75^{eF}	350,75±6,16^{bE}	297,25±7,36^{aAB}	611,75±8,21^{gE}	442,25±2,59^{dE}	360,25±5,47^{bDE}	394,75±16,55^{cDE}	462,75±17,84^{dD}
D2	413,25±6,50^{cdeB}	305±2,13^{bD}	383±4,16^{cC}	402,75±17,63^{cdD}	451,25±11,90^{eC}	302,25±11,69^{bB}	312,5±4,60^{bB}	440,5±16,79^{deE}	239,95±2,43^{aB}	383,75±8,78^{cC}	378,25±14,24^{cC}	401,5±16,09^{cdD}	324,25±7,05^{bC}	420±6,02^{cdeE}	482,25±7,06^{fD}
D3	484±6,01^{fD}	334,5±6,37^{bcdE}	266,25±6,86^{aA}	355,5±8,13^{cdeC}	364±20,23^{deB}	322,25±6,48^{bcBC}	359,5±2,99^{cdeC}	308±3,17^{bC}	353,75±6,94^{cdeE}	312,25±3,99^{bB}	380,25±17,04^{eC}	341±7,26^{bcdeC}	379,25±7,98^{eE}	362,25±2,12^{deC}	604,5±2,34^{gE}
D4	440,5±8,95^{efC}	293,75±2,85^{bD}	412,75±5,04^{eD}	342,5±7,37^{cdC}	463,25±10,37^{fC}	240,53±7,30^{aA}	461,75±15,06^{fE}	310,75±15,20^{bcC}	314,75±4,89^{bcD}	375,25±15,90^{dC}	413,25±8,94^{eD}	286,75±7,86^{bA}	350,5±4,29^{dD}	451,75±11,06^{fF}	363±3,50^{dC}
D5	445,4±4,48^{iIC}	216,8±4,38^{bAB}	345,8±5,93^{fgB}	405±18,02^{hD}	368,2±5,91^{gB}	345,2±4,96^{fgCD}	221,8±9,45^{bA}	366,2±7,28^{gD}	165,26±3,99^{aA}	287,6±3,12^{dAB}	327,8±7,39^{efB}	473,4±5,76^{jF}	253,2±3,00^{cA}	299,6±9,45^{dB}	309,6±2,42^{deB}
D6D	341,8±6,09^{eA}	209±5,96^{aA}	253,2±1,64^{bA}	269,4±9,76^{bcB}	318,8±7,72^{deA}	340,6±7,58^{eCD}	223,4±7,55^{aA}	287,6±10,31^{cAC}	247,4±6,56^{bB}	313,6±5,47^{dB}	339,6±6,48^{eB}	287±4,10^{cA}	490,6±18,35^{gF}	384±5,36^{fCD}	254±2,36^{bA}
D7	352,8±4,02^{fA}	228,8±4,31^{abB}	323±12,96^{eB}	214,6±1,30^{aA}	342,2±7,50^{efAB}	353,2±3,51^{efD}	228,2±3,56^{abA}	252,2±1,80^{bcdA}	401±5,69^{gF}	262,6±6,64^{cdA}	348,6±7,81^{efBC}	347,8±4,69^{efC}	262,2±3,48^{dAB}	236,4±1,46^{abcA}	361,2±17,63^{fC}
D8	357,8±7,84^{iIA}	213,8±2,05^{aAB}	272,6±5,51^{cdA}	296,4±6,43^{defB}	343±3,41^{hiAB}	238,4±3,94^{bA}	328±3,59^{ghBC}	253,8±13,72^{bcA}	271,2±1,06^{cdC}	280,4±5,20^{cdeAB}	270,4±8,21^{cdA}	311,4±1,61^{fgB}	281,8±4,29^{cdeB}	389±14,77^{jCD}	302,2±3,85^{efB}

- Mean values bearing the same letters are statistically homogeneous at p<0,01% significance
- Lowercase letters following the lines compare the yield of accessions at fixed densities
- The capital letters following the columns compare the yield of an accession at different sowing densities

Table 13**.** Average weight of Bambara groundnut seeds (kg/ha) depending on densities in 2017.

Densities	Acc. 36	Acc. 1	Acc. 2	Acc. 3	Acc. 6	Acc. 7	Acc. 8	Acc. 9	Acc. 12	Acc. 18	Acc. 19	Acc. 20	Acc. 24	Acc. 25	Acc. 27
D1	175± 2,28^{fE}	106,2± 4,27^{bD}	159,4± 3,73^{eE}	214,4± 2,77^{iH}	184,4± 2,77^{gD}	206,2± 2,60^{hF}	78,1± 3,73^{aAB}	137,5± 2,70^{dB}	137,5± 2,28^{dC}	121,9± 2,58^{cB}	184,4± 2,77^{gF}	156,2± 2,60^{eC}	128,1± 2,77^{cA}	153,1± 2,77^{eD}	150± 2,28^{eD}
D2	159,4± 3,13^{eD}	75± 3,23^{aC}	103,1± 2,77^{bBC}	193,8± 2,60^{gF}	181,2± 3,89^{fD}	112,5± 2,04^{cA}	103,1± 2,77^{bC}	187,5± 2,04^{fgE}	106,2± 2,60^{bcB}	156,2± 3,31^{eD}	184,4± 2,77^{fF}	193,8± 3,89^{gE}	184,4± 2,58^{fE}	215,6± 1,88^{hF}	134,4± 2,77^{dC}
D3	175± 3,23^{fgE}	62,5± 2,70^{aB}	109,4± 2,14^{bC}	175± 2,04^{fgD}	171,9± 2,77^{fC}	177,5± 2,28^{fgE}	140,6± 3,13^{dD}	162,5± 2,04^{eD}	196,9± 2,14^{hE}	109,4± 2,77^{bA}	125± 3,23^{cD}	181,2± 1,61^{gD}	143,8± 2,60^{dBC}	175± 2,28^{fgE}	175± 2,70^{fgG}
D4	153,1± 2,77^{dD}	101,9± 3,44^{aD}	131,2± 3,61^{cD}	184,4± 2,77^{fE}	193,8± 3,31^{gE}	145,6± 2,14^{dD}	181,2± 2,98^{fE}	121,9± 2,14^{bA}	106,2± 3,31^{aB}	121,9± 2,14^{bB}	103,1± 2,14^{aB}	146,9± 1,88^{dB}	134,4± 2,95^{cAB}	134,4± 2,14^{cC}	168,8± 2,60^{eF}
D5	107,5± 1,71^{cC}	72,5± 1,50^{aC}	127,5± 1,50^{fD}	202,5± 2,22^{lG}	167,5± 0,96^{jC}	142,5± 1,71^{hCD}	102± 1,63^{bC}	157,5± 1,26^{iCD}	135± 1,92^{gC}	122,5± 1,71^{eB}	115± 1,92^{dC}	182,5± 1,71^{kD}	156± 1,41^{iD}	117,5± 1,71^{dB}	157,5± 1,26^{iE}
D6	99,5± 1,71^{dB}	50± 1,41^{aA}	82,5± 1,71^{cA}	125± 2,08^{fB}	160± 1,41^{jB}	137,5± 0,96^{hC}	72,5± 1,50^{bA}	125± 1,29^{fA}	134± 1,41^{ghC}	130± 1,63^{gC}	125± 1,29^{fD}	162,5± 2,22^{jC}	155± 1,29^{iD}	105± 1,92^{eA}	75± 1,29^{bA}
D7	82,5± 1,71^{bA}	57,5± 0,96^{aAB}	95± 1,29^{cB}	132,5± 1,71^{hC}	170± 1,83^{jC}	112,5± 1,50^{eA}	105± 1,73^{dC}	120± 2,16^{fA}	167,5± 1,50^{jD}	125± 2,08^{gBC}	152± 1,63^{iE}	117,5± 0,96^{fA}	152,5± 1,50^{iCD}	102,5± 2,22^{dA}	132,5± 1,71^{hC}
D8	112,5± 1,71^{fC}	60± 1,83^{aB}	82,5± 1,71^{cA}	117,5± 2,50^{fgA}	117,5± 1,71^{fgA}	127,5± 1,71^{hB}	85± 2,38^{cB}	152,5± 2,06^{jC}	95± 1,29^{dA}	105± 2,08^{eA}	70± 1,83^{bA}	145± 1,92^{iB}	152,5± 1,71^{jCD}	120± 1,41^{gB}	82,5± 0,06^{cB}

- Mean values bearing the same letters are statistically homogeneous at p<0,01% significance
- Lowercase letters following the lines compare the yield of accessions at fixed densities
- The capital letters following the columns compare the yield of an accession at different sowing densities

Table 14. Average weight of Bambara groundnut seeds (kg/ha) depending on densities in 2018.

Densities	Acc. 36	Acc. 1	Acc. 2	Acc. 3	Acc. 6	Acc. 7	Acc. 8	Acc. 9	Acc. 12	Acc. 18	Acc. 19	Acc. 20	Acc. 24	Acc. 25	Acc. 27
D1	353,5±1,59^{fF}	365,7±0,57^{gF}	341,6±2,62^{eF}	345,8±1,96^{eF}	527,3±1,93^{lF}	354,7±2,76^{fF}	334,2±2,62^{dF}	389,3±2,42^{hH}	403,8±1,73^{iF}	265,9±1,73^{bD}	308,3±1,91^{cF}	222,3±1,49^{aD}	416,6±1,48^{jG}	521,4±1,40^{kG}	363,6±2,04^{gE}
D2	361,8±1,08^{gG}	238,8±2,35^{aC}	353,9±3,46^{fG}	441,5±2,61^{nG}	413±2,72^{lE}	342,5±2,17^{eE}	400,3±3,20^{kH}	355,3±2,36^{fG}	277,3±2,58^{bD}	423±1,91^{mF}	305,8±2,40^{cF}	382,8±2,07^{iG}	391,3±1,24^{jF}	321,3±1,77^{dF}	375±2,04^{hF}
D3	401,1±2,27^{jH}	284,1±1,67^{fE}	321,7±2,56^{hE}	332,3±2,80^{iE}	263,9±1,76^{dD}	222,1±2,51^{bC}	315,3±1,60^{hE}	334,1±2,78^{iF}	211,1±2,87^{aC}	442,1±1,57^{kG}	272,2±2,47^{eD}	254±0,99^{cE}	304,1±1,88^{gE}	273,8±2,70^{eE}	253±2,18^{cC}
D4	294,9±3,23^{deE}	257,9±1,62^{bD}	299,3±2,29^{eD}	305,5±1,98^{fD}	244,9±2,01^{aC}	322±1,77^{gD}	339,8±1,19^{iG}	309,7±2,04^{fE}	337,5±2,15^{iE}	330,5±0,78^{hE}	278,3±1,33^{cE}	288,8±1,50^{dF}	293,2±1,76^{deD}	245±1,96^{aD}	350,2±2,29^{jD}
D5	228,5±2,11^{gC}	116,2±0,91^{aB}	201,5±1,94^{dC}	245,8±2,29^{hB}	269±1,47^{jD}	183,7±1,59^{cB}	208,8±1,58^{efD}	225,1±1,05^{gC}	211,4±1,42^{fC}	204,9±1,12^{deC}	168,1±0,51^{bC}	186,7±1,32^{cB}	254,2±1,04^{iC}	227,5±1,45^{gC}	203,7±0,51^{dB}
D6	236,8±1,34^{iD}	113,3±1,42^{bB}	198±1,98^{gC}	263,1±1,66^{kC}	200,7±1,75^{gA}	151,1±1,83^{cA}	144,5±1,48^{cB}	246,9±1,22^{jD}	170,9±1,53^{dB}	180,4±0,73^{deA}	101,1±2,04^{aA}	184,7±1,79^{efB}	191,6±9,62^{fgA}	225,9±0,92^{hC}	173,1±0,78^{dA}
D7	205,2±0,86^{iB}	117±1,70^{bB}	165,4±2,04^{dB}	194,4±1,82^{ghA}	209,4±0,76^{iB}	151,8±0,96^{cA}	76,6±1,19^{aA}	215,2±0,41^{jB}	173,2±1,04^{eB}	197,1±1,01^{hB}	120,3±0,99^{bB}	207,3±0,99^{iC}	186,1±1,71^{fA}	192,6±1,68^{gB}	170,2±0,75^{eA}
D8	190,2±1,13^{hiA}	88,9±1,59^{aA}	152±1,86^{cA}	193,6±1,41^{ijA}	197,3±0,85^{jA}	182,4±0,68^{gB}	153,1±1,42^{cC}	186,9±0,63^{hA}	162,9±1,26^{dA}	195,7±1,64^{jB}	97±0,86^{bA}	169,8±0,92^{eA}	206,7±1,77^{kB}	164,4±1,15^{dA}	175,2±0,70^{fA}

- Mean values bearing the same letters are statistically homogeneous at p<0.01% significance
- Lowercase letters following the lines compare the yield of accessions at fixed densities
- The capital letters following the columns compare the yield of an accession at different sowing densities

Table 15. Accessions presented a high average weight of seed during the three years of experimentation (2016, 2017 and 2018) according to different densities.

Years	Densities						
	D1	D2	D3	D4	D5	D6	D7
2016	574,5±11,17^{fD}Acc.6 55,5±5,58^{dE}Acc.7 499±11,75^{eF}Acc.9 611,75±8,21^{gE}Acc19	383,75±8,78^{cC}Acc.18	484±6,01^{fD}Acc.A 334,5±6,37^{bcdE}Acc1 604,5±2,34^{gE}Acc27	412,75±5,04^{eD}Acc.2 461,75±15,06^{fE}Acc.8 451,75±11,06^{fE}Acc25	405±18,02^{hD}Acc.3 473,4±5,76^{jF}Acc.20	490,6±18,35^{gF} Acc.24	01±5,69^{gF} Acc.12
Acc. rate	26,66%	6,67%	20%	20%	13,33%	6,67%	,67%
2017	175±2,28^{fE} Acc.A 106,2±4,27^{bD} Acc.1 159,4±3,73^{eE} Acc.2 214,4±2,77^{iH} Acc.3 206,2±2,60^{Hf} Acc.7 184,4±2,77^{gF} Acc.19	187,5±2,04^{fgE} Acc.9 156,2±3,31^{eD} Acc.18 193,8±3,89^{gE} Acc.20 184,4±2,58^{fE} Acc.24 215,6±1,88^{hF} Acc.25	196,9±2,14^{hE} Acc.12 175±2,70^{fgG} Acc.27	193,8±3,31^{gE} Acc.6 181,2±2,98^{fE} Acc.8			
Acc. rate	40%	33,34%	13,33%	13,33%			
2018	365,7±0,57^{gF} Acc.1 527,3±1,93^{iF} Acc.6 354,7±2,76^{fF} Acc.7 389,3±2,42^{hH} Acc.9 403,8±1,73^{iF} Acc.12 308,3±1,91^{cF} Acc.19 416,6±1,48^{jG} Acc.24 521,4±1,40^{kG} Acc.25	353,9±3,46^{fG} Acc.2 441,5±2,61^{nG} Acc.3 400,3±3,20^{kH} Acc.8 382,8±2,07^{iG}Acc.20 375±2,04^{hF} Acc.27	401,1±2,27^{jH} Acc.A 442,1±1,57^{kG}Acc 18				
Acc. rate	53,33%	33,34%	13,33%				

D1=40cmx20cm D3=40cmx30cm D5=50cmx20cm ; Acc.=accession
D2=40cmx25cm D4=40cmx40cm D7=50cmx30cm Acc. rate=accession rate

In 2016, D1 (125000 plants/ha) brought together 26,66% of accessions (Acc.6; Acc.7; Acc.9; Acc.19) with 2140,75 kg/ha; followed by D3 (83333 plants/ha) which brought together 20% of accessions (Acc.36; Acc.1; Acc.27) with 1,423 kg/ha; D4 (62500 plants/ha) which also included 20% of accessions (Acc.2; Acc.8; Acc.25) with 1326,25 kg/ha; D5 (100000 plants/ha) which brought together 13,33% of accessions (Acc.3; Acc.20) with 878,4 kg/ha. D6 (80000 plants/ha) which brought together 6,67% of accessions (Acc.24) with 490,6 kg/ha; D7 (66667 plants/ha) which brought together 6,67% of accessions (Acc.12) with 401 kg/ha and D2 (100000 plants/ha) which brought together 6,67% of accessions (Acc. 18) with 383,75 kg/ha.

In 2017, D1 (125000 plants/ha) brought together 40% of accessions (Acc.36; Acc.1; Acc.2; Acc.3; Acc.7; Acc.19) with 1045,6 kg/ha ; followed by D2 (100000 plants/ha) which brought together 33,34% of accessions (Acc.9; Acc.18; Acc.20; Acc.24; Acc.25) with 937,5 kg/ha; D4 (62500 plants/ha) which brought together 13,33% of accessions (Acc.6; Acc.8) with 375 kg/ha and D3 (83333 plants/ha) which brought together 13,33% of accessions (Acc.12; Acc.27) with 371,9 kg/ha.

In 2018, D1 (125000 plants/ha) brought together 53,34% of accessions (Acc.1; Acc.6; Acc.7; Acc.9; Acc.12; Acc.19; Acc.24; Acc.25) with 3287,1 kg/ha; followed by D2 (100000 plants/ha) which brought together 33,33% of accessions (Acc.2; Acc.3; Acc.8; Acc.20; Acc.27) with 1953,5 kg/ha and the D3 (83300 plants/ha) which brought together 13,33% of accessions (Acc.36; Acc.18) with 843,2 kg/ha.

D1 (125000 plants/ha) followed by D2 (100000 plants/ha) were the densities that grouped the most accessions with better yields in average seed weight over the three consecutive years. Accessions 1, 6, 7, 9 and 19 presented better yields in average seed weight successively for at least two years of cultivation at D1 (125000 plants/ha); followed by accession 20 which presented a better yield in average seed weight successively for two years of cultivation at D2 (100000 plants/ha) and finally accessions 36 and 27 which offered better performance in average seed weight successively for two years of cultivation at D3 (83333 plants/ha).

DISCUSSION

Average number of Bambara groundnut pods on the different densities

The variance analysis results concerning the average number of Bambara groundnut pods show very significant differences (p=.001<.01) between the accessions at fixed densities. This suggests the existence of a strong heterogeneity within the accessions which could be explained by the genetic material which would differ from one accession to another; similarly, the environmental conditions due to the origin of the accessions could explain this observed variation. Furthermore, very significant differences (p=.001<.01) between the eight densities are observed; this shows that the densities differ. The variation observed between densities could be explained by the different defined spacing. Although the average number of pods differed between accessions at fixed densities, some were statistically homogeneous over the three years of cultivation. It is the same with the eight densities tested, some of which were statistically homogeneous. Very highly significant interactions (p=.001<.01) between accessions and seeding densities are also observed during the three years. This suggests that the performance of a density also depends on that of the accessions. We cannot consider the classification of a density without considering those of the accessions. However, no accession kept a constant yield in an average number of pods whatever the density practised during the three years of cultivation; this is explained by environmental fluctuations, and particularly the quantity and distribution of rainfall which were not constant during the three years of experimentation (Table 1). Likewise, a very highly significant interaction (p=.001<.01) is observed between the three years of cultivation; this suggests that the years differ in their pedoclimatic characteristics. Low rainfall and its poor distribution recorded during the year (2017) has created a sensitivity of the plants to drought explain the drop in yield observed in 2017, unlike in 2016 and 2018. Sharma and Lavanya (2002) have shown that drought constitutes one of the main factors limiting crop production in the world. It emerges from the comparison of accessions according to densities (Table 7) during the three years of experimentation (2016, 2017 and 2018) that D2 (100000 plants/ha), and D1 (125000 plants/ha) were the densities having grouped more accessions presenting a fairly high number of Bambara groundnut pods during the three years of culture. Furthermore, accessions 2, 7, 9 and 19 presented better yields in an average number of pods successively for at least two years of cultivation at D1 (125000 plants/ha); followed by accessions 6, 18 and 24 which presented better yields in average number of pods successively for at least two years of cultivation with D2 (100000 plants/ha); then accessions 36 and 27 which also presented better performances successively during two years of cultivation with D3 (83333 plants/ha) and finally accession 8 which presented better performance at D4 (62500 plants/ha) during two years of cultivation. These results clearly show that Bambara groundnut produces more pods at high seeding densities. The same observations were made by Konlan et al. (2013) in Ngana, Ahmad et al. (2007) in Pakistan, Mayeux and Maphanyane (1989) in Botswana and Mayeux (1990) in Botswana who obtained high yields in average number of pods at high seeding density. These results differ from those of Awal and Lija Aktar (2015) and Touroumgaye et al. (2017) who showed that yields in average number of pods increase. The observations of Touroumgaye et al. (2017) are rather similar to the results we obtained. Indeed, the four densities that they experimented with, namely 125751 plants/ha; 167417 plants/ha; 143286 plants/ha and 133934 plants/ha are all higher than the eight densities tested in this study. They obtained better yields in an average number of pods with a density of 125751 plants/ha, corresponding to the highest seeding density used in this study.

Average weight of Bambara groundnut pods on the different densities

Significant variations are observed for the average weight of the pods over the three years of cultivation. As for the average number of pods, we observe very significant differences (p=.001<.01) between the accessions at fixed densities, suggesting strong heterogeneity within the accessions. This strong heterogeneity could be explained by the nature of the genotypes of the plants, which differ from one accession to another. Very highly significant differences (p=.001<.01) are also observed between the densities experienced over the three years. During the three years of cultivation, the average weight of pods was statistically homogeneous with others depending on densities and accessions. The results also showed very highly significant interactions (p=.001<.01) between accessions and seeding densities, and very highly significant interactions (p=.001<.01) between years of culture. During the three years of cultivation, the potential average pod weigt fluctuated within the different densities; this could be explained by environmental fluctuations, particularly the rainfall that was not constant during the three years of cultivation. The highly significant interactions (p=.001<.01) observed between the years suggest that the years differ in soil and climatic characteristics. It also emerges from the comparison of accessions according to densities (Table 11), concerning the average weight of Bambara groundnut pods during the three years of experimentation (2016, 2017 and 2018) that, D1 (125000 plants/ha) gathered more accessions, followed by D2 (100000 plants/ha). Accessions 1, 6, 7, 9, 19 and 25 also presented better yields in average weight of pods successively for at least two years of cultivation at D1 (125000 plants/ha); followed by accession 18 which presented better yield in average weight of pods successively during two years of cultivation with D2 (100000 plants/ha) and accession 36 which presented better performances successively during two years of cultivation with D3 (83333 plants/ha). These densities can be considered optimal, because they present better yields in average pod weight.

Average weight of Bambara groundnut seeds on the different densities

The results of the analysis of variance concerning the average weight of Bambara groundnut seeds revealed very significant differences (p=.001<.01) between the accessions according to densities, and between the densities themselves during the three years of experimentation. Likewise, a highly significant interaction is observed between accessions and seedling densities (p=.001<.01); this shows that the different factors interact. A very significant interaction is also observed between the years (p=.001<.01); this shows that the years differ from each other due to their pedoclimatic conditions, particularly the rainfall which fluctuated considerably during the three years of experimentation. Indeed, in North Cameroon, several studies (Lienou, 2007; Djoufack et al., 2012; Aretouyap et al., 2014) have shown that the region has experienced significant fluctuations in rainfall for several years. M'biandoum and Olina (2006), working on rainfall in the Sudano-Sahelian region in northern Cameroon using climatic data from four stations, have shown that this area has a rainfall characterized by a great variability in space and time, a strong aggressiveness of the rains, a poor distribution of this rainfall, rainfall deficits which can occur in June, July and August and a possibility of early end of the rains. These rainfall disturbances have serious consequences on populations and crops, given that they are more than 80% rural with agriculture as their main activity (Benoît and Seydou, 2011). The drop in yield observed in the second year of cultivation (2017) could be explained by this irregularity of precipitation and its poor distribution in time and space unlike in 2016 and 2018. Overall, D1 (125000 plants/ha) and D2 (100000 plants/ha) made it possible to group more accessions with better yields in average weight of pods and seeds over three years of cultivation (Table 11 and 15). This study shows that the average weight of pods and seeds increases at high seeding densities. Virender and Kandhola (2007), Abdullah et al. (2007) and Virk et al. (2005) who obtained an increase in yield at high seeding densities made the same observations. Similarly, Muneer et al. (2017) and Mustefa (2014) significantly improved crop yield by increasing seeding densities. These results differ from those of Sumarno and Adie (1995); Konlan et al. (2013) and Yadeta (2014) who observed an increase in seed weight at low seeding densities. Likewise, Nasraoui et al. (2005) showed that seed weight is higher at low seeding density. For these authors, low densities allow plants to explore more living space. Their results are similar to those of Niringiye et al. (2005), who showed that increasing densities contributes to the reduction of seed weight and the quantities of total seeds produced by plants. These authors explain this by the large population of plants, which unfortunately, is conducive to the development of fungal diseases, which quantitatively and qualitatively affect production. Others, however, like Gharbi and Maamouri (1994), M'hedhbi et al. (1994) and Touroumgaye et al. (2017) reported the absence of a significant difference in seeding density on seed weight. Vidya (2013), Mustefa (2014) and Muneer et al. (2017) reported that seeding density has a significant effect on growth and yield parameters. For these authors, yields increase at high seeding density. Tesfu and Yamoah (2010), working on the effect of seeding density on carrots recorded high yields at high seeding densities. This result is similar to the observations of Azam Ali (2003) in Nigeria, where he obtained better yields in seed weight at a density of 250000 plants/ha in pure Bambara groundnut culture. Adekpe et al. (2007) and Khodadadi and Nosrati (2012) showed no single seeding density. Mustefa (2014) and Muneer et al. (2017) showed that it varies according to plant genotypes, the fertility state of the plots, cultural practices and environmental conditions. Regarding environmental conditions, Sharma and Lavanya (2002) showed that drought is one of the main factors limiting crop production worldwide; these authors show that water stress could indeed cause strong competition between plants and lower production in the case of high seeding densities. Laouar et al. (2001) showed that water deficit affects not only the growth; but also the yield of legumes. The rainfall distribution varied considerably over the three years of cultivation (Table 1). The precipitation recorded in 2016 was 709.7 mm distributed over 53 days, compared to 668.7 mm distributed over 53 days in 2017. In 2018, 1043.95 mm of precipitation distributed over 66 days was recorded. The low amount of precipitation recorded in 2017, and their poor distribution over time coincided with the flowering and fruiting phases causing disturbances. Indeed in 2017, at the time of sowing and just after emergence (July 2017), the young seedlings did not yet experience a high-water requirement (259,3 mm), unlike the other development phases where they received less of water as in August (149,3 mm) and September (98,2 mm) when the majority of plants were flowering. The critical periods for water requirements of Bambara groundnut are flowering and fruiting. Linnemann and Craufurd (1994) and Linnemann et al. (1995) showed that fruiting could be delayed by drought and photoperiod. The lack or insufficiency of water and/or light during these development phases would have had consequences on the formation and filling of the pods. Indeed, when a plant is subjected to a water deficit, it suffers a significant loss of water at the cell level, which causes a dysfunction of photosynthesis and growth and, consequently, a reduction in yield. This could explain the drop in yields observed in 2017. Despite the amount of precipitation observed in 2018 (1043,95 mm), a drop in yield was recorded compared to 2016. Indeed, although the host crop is a legume, it was cultivated successively during three agricultural seasons on the same site, without amendment. Sánchez-Coronado et al. (2007), and Solomon (2012) show that water and nutritional deficits (phosphate deficiency) are among the main causes of reduced crop yields. Morel et al. (2006) showed that phosphate is after nitrogen, the essential element for the proper functioning of plants because of their low availability in the soil. Lynch and Deikman (1998) and Vance et al. (2003) show that phosphate constitutes a limiting factor for crop yield on more than 30% of the planet's arable land. The low yields obtained in 2018 could be attributable to the drop in this element (phosphate) in the soil. D1 (125000 plants/ha), and D2

(100000 plants/ha) corresponding to the spacing (40cmx20cm) and (40cmx25cm) significantly improve the yield of Bambara groundnut cultivation. They could be recommended to farmers to improve their farming techniques and effectively increase yields. Ali (2003) observed densities of 2500 plants in mixed cultivation in Botswana. This suggests that loose densities could be used in the context of cultural associations with other species in order to optimize yields on the plots. Touré et al. (2012) have shown that the association of legumes with cereals constitutes an interesting nutritional supplement for many populations. This means that sowing density is an important parameter to consider when determining crop yields.

CONCLUSION

The evaluation of the sowing densities depending on the accessions showed significant yield variations. The best yield in an average number of pods, and average weight of pods and seeds was obtained at high densities. Thus, the density D1(125000 plants/ha) and D2(100000 plants/ha) corresponding respectively to the spacing of 40cmx20cm and 40cmx25cm make it possible to group more Bambara groundnut accessions presenting better yields that could help producers increasing their yield. Significant interactions were also observed between the different years; this also shows that the years differs.

Future Research

Because of the knowledge of the agro morphological characteristics of the fifteen (15) Bambara groundnut accessions, and taking into account the knowledge of the best crop densities obtained during this study, we recommend multi-local trials to determine locality that occurs best performances in an average number of pods, an average weight of pods and seeds in the Far North Region of Cameroon.

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