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Evaluation of the Agronomic Performances of a Promising Peanut Variety from the Research Environment (Flower 11) and a Local Variety (Sudanese) under the Agro-Ecological Conditions of the Bagarine Community Learning Center

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Abstract

This study aims was to evaluate a promising peanut variety from the research environment (ITRAD, Fower 11) and a local variety (Sudanese) under the agro-ecological conditions of the Bagarine site. The experimental design was a randomized complete block (Fischer Block) with 3 replications implemented in four sites (Abeche, Amleyouna, Abougoudame and Adre). During the 2019-2022 agricultural campaign, varieties of improved peanut seeds presented a very good emergence rate and then a Fisher device was adopted. The results obtained showed that with regard to the vegetative parameters, the improved variety flower 11 recorded a satisfactory and superior emergence rate, plant height and collar diameters compared to the local variety (Sudanese) which is therefore revealed to be less efficient. Regarding production parameters, the improved variety Flower 11 presented satisfactory yields of pods, seeds and biomass than that of the local variety. Observations focused on peanut kernels and biomass yields. This analysis using a partially nested model were applied to evaluate the differences between returns, the effect of each factor (variety, repetition, site and year) and their interactions. Site and variety effects were significant for peanut seed production of two types compared during the 2019-2022 agricultural season. We recommend to those responsible for the integrated resilience project to popularize this variety in the project intervention area and to future researchers to conduct the same trial in other sites in the province with an organic soil amendment.

Keywords: groundnut, production, *Arachis hypogaea L*, agro-ecological conditions, pedoclimatic zones

1. Introduction

Agricultural development is a guarantee of food security and poverty reduction in Africa. It involves the diffusion of technologies to improve crop productivity. Among the most cultivated plants in Central Africa, grain legumes are frequently consumed for their richness in protein and for their adaptation to difficult agro-ecological conditions. Peanut, *Arachis hypogaea* L., is an annual legume native to Latin America and cultivated throughout the intertropical zone; especially in arid and semi-arid regions (Kouadio, 2007; Prasad et al., 2010; Oteng et al., 2017; Parwada et al., 2020; Njoki et al., 2023). The multiplicity of its uses makes peanuts a very popular oilseed and protein crop. It is largely consumed locally in raw form (pods or seeds) or refined (oil, butter, paste, flour, confectionery, etc.) and the by-products give rise to various uses: fodder for straws; fuel, composting, chipboard for empty hulls; human or animal feed for cakes (Doikh, 2001; Schilling, 1996; Gulluoglu et al., 2017; Bakal et al., 2021). Peanuts play a positive role in maintaining soil fertility. At the social level, it constitutes a main source of food and income for women and young people. The mixed nature of production, which can be either self-consumed or marketed, as well as the possibility of achieving added value, thanks to different forms of artisanal processing,

increase its interest (Giraud, 2000; Schilling, 2002, 2003; Pulul, 2014; Ajuang et al., 2016). Peanut cultivation has long been considered an activity reserved only for women and children. But as time progressed, it aroused increasing interest men, so they raced to plant it.

The share of area reserved for this crop increases significantly to 17% in (Kadekoy, 1999; Caracas, 1996; Sharma et al., 2010; Al-Ansari and Taoufik 2016), 25% in Cameroon (Essang, 2001) and 28.5% in Chad (PASR, 1999). In Chad, it is the second largest export crop after cotton (Giraud, 2000; Goalbaye et al., 2019). In 1999, the area reserved for peanut cultivation was around 250,000 hectares. The yield varies depending on the production areas and the level of soil fertility between 600 kg/ha hulls in areas with low fertility potential to 900 kg/ha for fertile areas (PASR, 1999; Khan et al., 2001; Liao and Holbrook 2007; Umutoni et al., 2015; De Santis et al., 2023). Despite this importance, in eastern Chad, particularly in the Ouaddaï Province, local varieties are subject to multiple climatic and agronomic problems. Varietal adaptability trials or tests constitute the transition link between varietal evaluation and the popularization or popularization of new high-performance varieties (Singh et al., 1998; Josué, 1999; Ntare et al., 2008; Nyako 2015; Ansah et al., 2017; Asif et al., 2017; Adetumbi et al., 2020). Hence the need to evaluate a promising peanut variety from the research environment (ITRAD, Flower 11) and a local variety (Sudanese) in the agro-ecological conditions of the Bagarine site. Bagarine, a small town located 5 Km, from Abeche, in the province of Ouaddaï, has becomme the laboratory of community development in the region, it houses a center for learning agricultural practices aimed at improving access, availability, utilization and stability of food in the region. In this study the question is whether the F11 peanut variety evaluated presents interesting agronomic performance and does it adapt to the pedoclimatic conditions of the Bagarine site. This central question of the study illicits the following hypotheses. The seeds of the improved peanut variety evaluated are of good quality; they have a good germination capacity and a low rate of non-typical plants on one side. On the other hand, the improved peanut variety adapts well and expresses good agronomic performance. Ultimately, this study will constitute an important strategy and an essential prerequisite for any action to upgrade the peanut sector. Practically, this work made it possible to know the agronomic performance of the improved variety currently being popularized in Chad. The objectives of this study was to evaluate the yield of the two (2) varieties of peanuts Flower 11 (improved) and Sudanese (local) in the eco-climatic conditions of the Bagarine Community Learning Center to identify the best of the point from a yield point of view and likely to be recommended to farmers to increase production.

2. Method

Characteristics of the agro-ecological zones: The province of Ouaddaï in Chad, which is the subject of the study is between latitudes 7° and 24° North and longitudes 13° and 24°35' East. The test was conducted in Abeche in the villages of Bagarine, Khoumi, Arboudji, Mandafana, Atilo and Aldjazira. The climate was Sahelo-Sudanian with rainfall irregularities oscillating between 200 mm and 600 mm per year marked by a dry season (October to June) and a short rainy season (July to September) with a peak during the month of august.

Characteristics of improved peanut varieties introduced from Mali: During the 2019-2022

campaign, the Chadian Institute of Agricultural Research for Development (ITRAD) acquired peanut varieties, selected in Senegal and of a local variety (Sudan). The list of varieties as well as their characteristics are indicated in table 1.

General description of the flower 11 and local variety.

Table 1. Characteristics of the varieties testeed

Variety	Taxonomy	Port	Cycle (j)	% Oil	% Protein	Rainfall (mm)	Weight of 100 seeds (g)
Flower11	*Arachis hypogaza* L	erected	90	50%	-	300-700	50-55
Soudani	*Arachis hypogaea* L	erected	120	-	-	-	-

2.1 Experimental Design

The device is in complete randomized blocks with 3 repetitions (figure 4). The Plots, contiguous to each other (same spacing between rows), are arranged in three rows, also contiguous (continuity of the sowing line); the repetition therefore consists of three sub-blocks. Each variety is sown on 10 lines 13 m long and 5 m wide corresponding to a plot, i.e. an area of 76 m ^{2}. The sowing method must respect the average spacing of 60 cm between the lines and 15 cm between pockets on the line

Thus, each Fischer block was made up of 3 experimental plots with an area of 10 lines of 13 m each where the three (3) central lines formed the useful plot. Five (5) plants were selected from each useful line for observation purposes. Figure 1 presents the plan of Fischer's experimental setup.

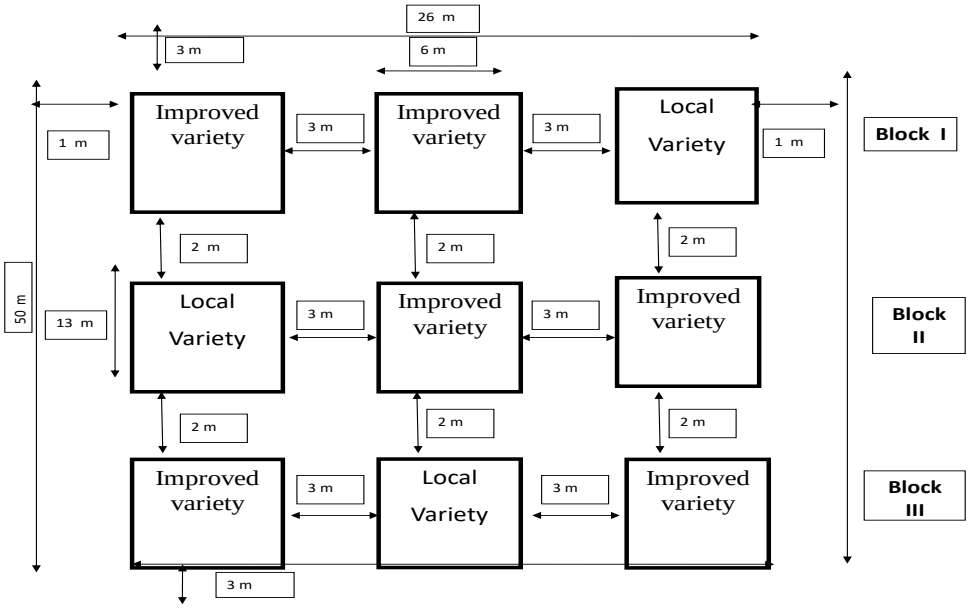

Figure 1. Experimental device

The trial was carried out in the Bagarine Community Learning Center from July to October 2021.

2.2 Preparing the Land

After choosing the plot which should house the trial, the land preparation operation began on July 1, 2021. It consisted of cleaning the plot by cutting shrubs and mowing weeds. Then, plowing was carried out by animal traction (horse) on July 3, 2021 to loosen the soil. Harrowing was carried out to prepare a good seedbed on July 5, 2021. The preparation of the plot provides a favorable environment for the emergence and growth of the crop.

2.2.1 Picketing

Staking consisted of wooden and iron stakes, a tape measure and ropes to delimit the experimental plot and to measure the distances between blocks. This operation was carried out on July 6, 2021. The picketing took place as shown in Figure 1.

2.2.2 Sowing

Sowing took place on July 8, 2021 after useful rain. It was produced online and flat and by hand using a rope marked**.** The seeds previously treated with Neem powder at a rate of 100g/1Kg of seeds were sown at the rate of one seed per pocket. A spacing of 15 cm between the pockets and 60 cm between lines has been respected. The seeding depth is 3 to 5 cm. For this plot of 1250 m^2 surface area, the density was 866 plants or 111,111 plants/ha.

2.2.2.1 Interview

Three weedings were carried out to maintain the crop: The first lasted two days, from July 23 to 25, i.e. 17 days after emergence. The second weeding was carried out on August 22, 2021, 45 days after sowing. It was a weeding operation but given the rain, we only carried out weeding. The third weeding was carried out as needed. No amendments were made during the experiment.

2.2.2.2 Harvesting/Drying/Threshing

The harvest was carried out by hand on October 9 when 80% of the pods were ripe, i.e. 91 days after sowing. Then the plants collected from each plot were put to dry in a pile, on the ground. No phytosanitary treatment was carried out.

2.3 Collection and Evaluation of Vegetative and Production Parameters

❖ *Determination of lifting percentage*

Emergence percentage is a measure of germination time course and is usually expressed as a percentage. It allows us to assess the germinative capacity of a seed. This evaluation consisted of counting the number of seedlings emerged in the field for each variety after sowing.

$$\%\text{Germination} = \frac{\text{Number of plants raised}}{\text{Total number of theoretical plants}} \quad (1)$$

❖ *Determination of the duration of appearance of the first flower after sowing*

The duration of appearance of the first flower after sowing was determined after daily observations on the experimental plot; until the very first flower appears in the elementary plots of each variety. Thus we have the number of days at which this first flower appeared as the period of beginning of flowering of the variety.

❖ *Determination of population density per hectare*

The population density was determined by counting the plants raised on the plots of each variety.

$$\text{Population density Ha} = \frac{\text{Number of plants present}}{\text{Surface area of the plot}} \times 10000$$

❖ *Determination of collar diameter*

The caliper allowed us to measure the diameter at the collar for the plants in the useful plot.

❖ *Determining the average number of pods per plant*

The determination of the average number of pods per plant was carried out by counting the ripe fruits on the plants of the useful plot of each variety after having removed them and taken the average. The number of pods per plant is one of the parameters that integrates the components that make it possible to evaluate the yield (Betdogo, 2014).

❖ *Determination of the weight of 100 pods and 100 seeds per variety*

The pods and seeds were first dried beforehand. The weight of 100 pods and 100 seed-seeds were determined by counting and weighing using a branded precision balance. The hundred pods were chosen at random. These two observations are yield components and specific characteristics of the varieties.

❖ *Determination of aboveground and belowground wet and dry biomass yield of each variety*

The yield of aboveground and belowground wet biomass makes it possible to assess the productive quality of each variety in these elements. The determination of the aboveground and belowground wet biomass yield of each variety was carried out after weighing using a TOSHIBA brand precision electronic sensitive balance. These parameters make it possible to assess the productive quality in dry and wet matter of the varieties. At the end of the campaign, the production of each of the plots was weighed, and the yields (Kg) for each of the

Experimental units were determined using the following formula:

$$\text{Yield} = \frac{\text{Production of the plot (Kg)}}{\text{Surface area of the plot (m2)}} \quad (2)$$

❖ *Statistical analysis*

At the end of the season, the data are entered into Excel, then analyzed with SPSS software (Statistical Package for the Social Sciences) and the averages were compared using the Newman- Keuls test at the 5% threshold. The histograms are constructed with the Excel spreadsheet.

3. Results and Discussion

3.1 Rainfall

Table 2 presents the variations in rainfall on 10/31/2021 in the Ouara Department. The rains were irregular and presented a considerable difference compared to 2020. The record accumulation of 456.6 mm was recorded in the Amleyouna rainfall station. At the development and maturity phase, we observed 8 days and 10 days of absence of rain

Table 2. Situation of cumulative rainfall as of October 31, 2021 in the Department of Ouara

Rain gauge stations	**Cumulative as of: 10/31/2020**		**Reminder as of: 10/31/2021**		**Deviations**	
	Height (mm)	**NbJ**	**Height (mm)**	NbrJ	**Height (mm**	**NbJ**
Abeche	656.5	48	557	45	**-99.5**	**-3**
Amleyouna	820.7	40	456.6	34	**-364.1**	**-6**
Abougoudam	753.7	39	485.9	33	**-267.8**	**-6**
Adre	591.9	39	499.4	32	**-92.5**	**-7**

NbrJ : number per day, mm: milli profession

3.2 Collection and Evaluation of Agronomic Parameters.

The observations carried out during the vegetative development and flowering phase of the plants concern emergence, population density, flowering and biomass yield.

3.3 Vegetative Parameters

Lift rate

Emergence began 4 days after sowing for the two peanut varieties studied.

Table 3. Emergence rates of two peanut varieties

Varieties	**Rate (%) of lifting in the ^{4th} AS**
Improved varieties	**95.21**
Local varieties	**63.25**

Table 3 shows that 4 days after sowing, the emergence rate was different depending on the varieties. The improved variety recorded a higher emergence rate of 95.21% than the local variety of 63.25%. This difference is significant at the threshold of p=0.05. These results could be explained by the fact that the seed of the local variety presents unselected seeds. These results are superior to those obtained by Alleidi et al. (2016) in Côte d'Ivoire for other peanut varieties. Furthermore, in our tests, germination was epigeal. At the time of the various sowings the humidity and temperature conditions were good for germination. The proof is that we obtained a germination rate of 95.21% 4 days after sowing for the improved variety F11.

Stocking Density

Ten days after sowing, the highest stand densities were obtained in the improved variety (99%) than the local variety (75%).

Phenology of the Varieties Studied

The start of flowering for the improved variety F11 occurred less than or equal to 21 days and that of the local variety at 35 days.

Table 4. Flowering of varieties studied

varieties	50% flowering
Improved varieties F11	21 JAS
Local	35 A.S.

Table 4 shows the results relating to the appearance of flowers of the peanut varieties studied. The date of fifty percent flowering (50% F) varies between 21 DAS (F11) and 35 DAS (Sudan) showed a very highly significant difference at the threshold of P = 0.05. We found that flowering is quantitatively dependent on precipitation and continues until the end of the vegetation but the flowers produced towards the end do not have time to produce ripe fruit at harvest.

Plant Height

The graph summarizes the average value on peanut growth for the two varieties tested.

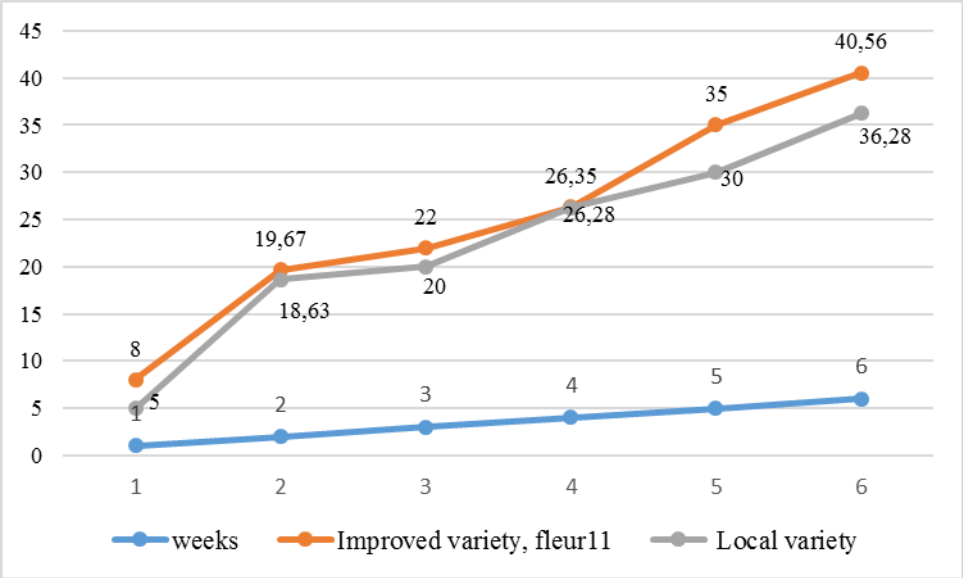

Figure 2. Average height (cm) of two peanut varieties

It appears from figure 2 that until the 28 days after sowing (4week), the height of the plants of the 2 peanut varieties remained the same. Forty-two days after sowing, the improved variety recorded the highest plant height, estimated at 49.56 cm, higher than the local variety 36.28 cm.

Diameter at Collar

The results of diameter measurements at the collar of the plants are grouped in table 6.

Table 6. Diameter at collar

Variety	**Diameter at plant collar (mm)**		
	14 JAS -	**28 JAS -**	**42 JAS -**
Improved varieties	4.37	5.71	6.16
Local varieties	3.06	3.26	4.1

On the 14 to 42 days after sowing, the improved variety gave a higher crown diameter than the local variety.

Table 7. Summary of vegetative parameters of the varieties evaluated

varieties	**Lifting rate (%) on the ^{4th} DAS**	**Population density (%) at the ^{10th} DAS**	**Plant height (cm) at ^{42nd} DAS**	**Diameter at the collar of the plants (mm) at the ^{42nd} DAS**
Improved variety	95.21	99	40.56	6.16
Local variety	63.25	75	36.28	4.1

Figure 3. Source: Seid. (2021)

Production parameters

The list of production parameters includes the percentage, weight of 100 dry and wet pods, weight of 100 dry and wet seeds and top yield.

Weight of 100 Pods

The results relating to the fresh weight of 100 pods are summarized in Table 4.

Table 8. Dry weight of 100 pods

Variety	**Fresh weight of 100 pods (kg)**
Improved variety	0.16
Local variety	0.10

Table 8 reveals that the improved variety has a weight of 100 pods (0.15kg) greater than that of the local variety (0.10kg).

Figure 4. A local variety Sudanese and B: improved variety F11

Weight of 100 seeds

Table 9 presents the results of the weight of 100 seeds of different peanut varieties studied.

Table 9. Dry weight of 100 seeds

Variety	**Dry weight of 100 seeds (g)**
Improved variety	53
Local variety	32

It appears from Table 6 that of two (2) varieties compared in our trial, the improved variety recorded the highest dry weight of 100 seeds (53g) than the local variety (32g).

Figure 5. A local variety Sudanese and B: improved variety F11

Yield in Fresh Pods

It is important to evaluate the yield of peanuts in fresh pods because the production can be sold fresh. Figure 7 summarizes the results. The pod yield is 1.9 tonnes per hectare for the improved variety F11 and 0.641 tonnes per hectare for the local variety "Sudanese". The improved variety has a higher pod yield than the local variety. This difference is significant at the threshold of P = 0.05.

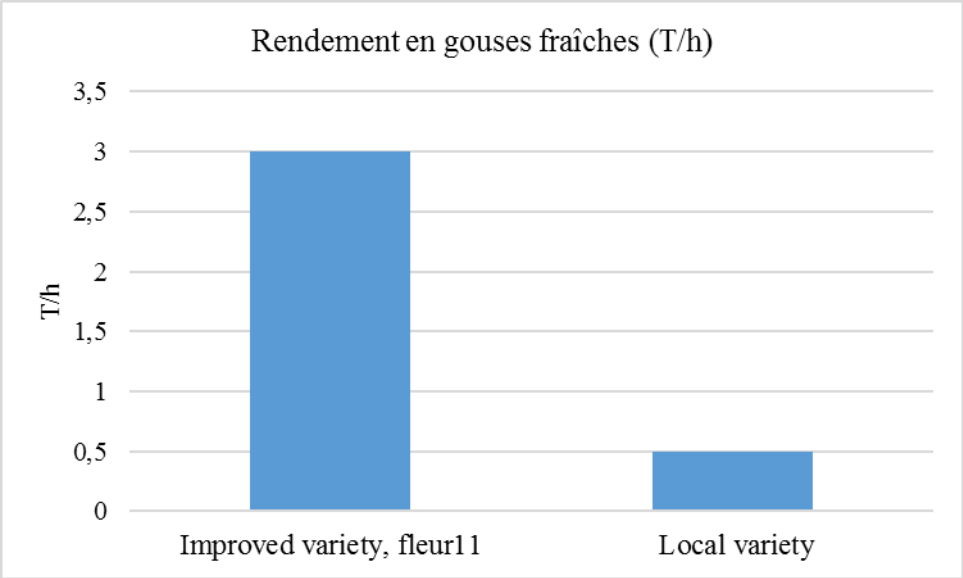

Figure 6. Yield of fresh pods (t/ha)

According to Figure 6 the improved variety showed a high pod yield (1.9 t/ha) than the local variety (0.641 t/ha). Our results are close to those obtained by **Betdogo (2014) (**2.71 t/ha **)** in Cameroon.

4. Biomass Yield of the Varieties Evaluated

The yield (t/ha) of fresh aerial biomass of the varieties studied is presented in Figure 8.

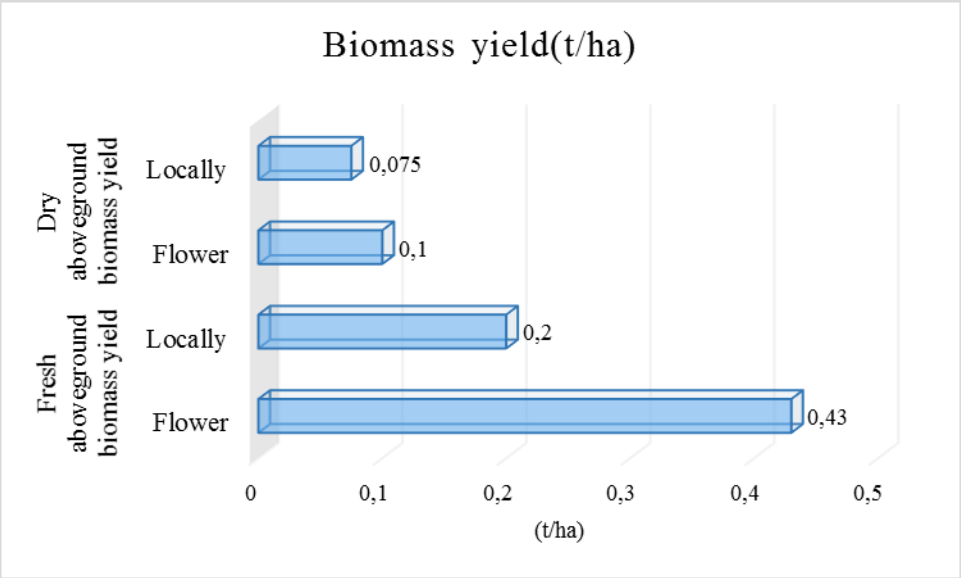

Figure 7. Biomass yield (t/ha)

Figure 7 shows that the improved variety presented a yield (t/ha) of fresh aboveground biomass higher than that of the local variety which gave a yield (t/ha). The biomass yield comparison test shows a significant difference between the improved variety, fleur11, and the local variety, Soudan at the threshold of P = 0.05.

5. Discussion

Rainfall conditions in the Ouar department are not favorable. The rains were irregular and presented a considerable difference compared to 2020. The record accumulation of 456.6 mm was recorded in the Amleyouna rainfall station. At the development and maturity phase, we observed 8 days and 10 days of absence of rain respectively. This regression could be due to climate and environmental change in the province. Peanut seed yields range from low to high depending on the experimental site, seed types and agricultural conditions. These variabilities from one variety to another during the 2019 and 2022 agricultural seasons. This state of affairs would be linked to the pedoclimatic conditions of the Abeche, Amleyouna, Abougoudam and Adré sites. Occurring in Amleyouna, Abougoudam and Abeche, the soils are sandy-clayey in texture and deferent concretions of Adre. Vegetative characteristics such as emergence rate, plant density, plant height and plant diameter at harvest are in favor of the improved variety than the local variety (Doikh, 2001; Celia et al., 2005; Etchu et al., 1014). The soils were rich in nutrients and the humidity and temperature conditions were good for germination. The proof is that we obtained a germination rate of 95.21% 4 days after sowing for the improved variety F11. These results are superior to those obtained by Alleidi et al. (2016); in Ivory Coast for other varieties of peanuts. Furthermore, in our tests, germination was epigeal. At the time of different sowing conditions. The sensitivity of the selected varieties improves and a very good emergence rate is recorded during the growing season on all sites unlike local varieties. Indeed, the water needs of the plant vary greatly during the cycle, but peanut cultivation succeeds just as well with 400 mm of rain/year, particularly in the Sahel, as in good rainfall conditions (1000 to 1300 mm/year) (Ceraas , 1996; Nigam *et al.*,

2004; Avantunde et al., 2008; Anne, 2012). The flowering-pod formation period (30-70 DAS) corresponds to a phase of sensitivity to drought, while the final maturation phase will be favored by relative drought. The advent of rain at this stage can also cause standing germination in non-dormant varieties. A rainfall of between 500 and 1000 mm during the growing season generally allows for a good harvest, but the good distribution of rainfall according to the cycle of the variety is more important than the total rainfall. Yields greater than 1 t/ha in field crops are obtained in the northern region of Senegal, under 350 mm of rain concentrated over three months, with the early drought-tolerant variety (Nigam *et al*., 1983; Ndjeunga *et al* ., 2006; Etela and Dung 2011). It is also observed that parasitic attacks and diseases influence production. Indeed, peanuts, although less exposed than other tropical legumes such as cowpeas and soybeans, are sensitive to pests and pathogens (Falisse and Lambert 1994; Herselmen 2003). Among the varieties selected, some appear tolerant or resistant to rosette, due to the fact that symptoms of this disease appearing have been rare. Rodent attacks have also been observed causing damage to seeds, affecting the level of production of groundnut crops as is the case with local varieties. However, yields of up to more than 3 t/ha are observed in Israel in irrigated cultivation. The yield level observed in China is around 1.5 t/ha, higher than that of the United States, which nevertheless exceeds one ton. One of the causes of the high yield observed in China is the high fertility of the soil, maintained by good manuring (Barbier, 1960; Ibra 1988; CILLSS 199 6; Bado 1994; ISRA, 2003; INERA 2011). In Indonesia, South America, the ton is generally achieved in a fully mechanized operation. In Colombia, yields of around 2 to 3 t/ha are recorded. Until recently, the yields observed in Africa, apart from isolated cases, did not exceed levels of between 300 and 800 kg/ha. But, currently, a level of 1,000 kg/ha is often reached and sometimes even more, thanks to newly popularized cultivation methods, especially in Senegal (Barroud et al., 2004; Nigam *et al*., 2004; Ndjeunga *et al*., 2006 ; Avantunde et al., 2007; Noba et al., 2014; Alleidi et al., 2016).

6. Conclusion

In this work, we set out to evaluate the agronomic performance of a promising peanut variety from the research environment (Flower 11) and a local variety (Sudan) in the agro-ecological conditions of the Learning Center Bagarine community. To achieve this, a Fisher device was adopted. The results obtained showed that with regard to the vegetative parameters, the improved variety flower 11 recorded a satisfactory and superior emergence rate, plant height and collar diameters compared to the local variety (Sudan) which is therefore revealed to be less efficient. Regarding production parameters, the improved variety flower 11 presented satisfactory yields of pods, seeds and biomass than that of the local variety. Considering the above, we recommend those responsible for the Integrated Resilience Project to popularize this variety in the project intervention area and to future researchers to conduct the same trial in other sites in the province with organic soil amendment.

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Authors contributions

Mr. SD, Dr. HA SD and Dr. AHM were responsible for study design and revising. Prof. AAD was responsible for data collection. Prof. MAM drafted the manuscript and Dr. IJL revised it. All authors read and approved the final manuscript. In this paragraph, also explain any special agreements concerning authorship, such as if authors contributed equally to the study.

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Macrothink Institute.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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