International Journal of Innovation Scientific Research and Review
Vol. 04, Issue, 01, pp.2171-2178, January 2022
Available online at http://www.journalijisr.com
SJIF Impact Factor 4.95

ISSN: 2582-6131

Research Article

ADVANCED TRIAL OF INTERMEDIATE CYCLE MILLET VARIETIES IN THE SUDANIAN AGRO-ECOLOGICAL CONDITIONS OF SENEGAL

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Received 04th November 2021; Accepted 06th December 2021; Published online 21th January 2022

ABSTRACT

Millet is a subsistence cereal farmed on the world, it occupies the 6th position after maize, rice, corn, barley and sorghum. Africa is the only region in the world where the millet production rises. Pennisetum millet is farmed in southern Sahara as well as the dry regions of Eastern and southern Africa. In Senegal, millet is the first culture in terms of sowed area before peanut and the second in terms of production behind rice (DAPSA, 2017). However, in Senegal, the agricultural sector is the most affected by the climate trends and variability because agriculture, main source of revenues for families and guarantor of food security for populations, is largely tributary of climate parameters and particularly rainfall. In the decades to come, the hypotheses of the change of rainfall regime could have global negative effect on millet, maize and sorghum production with the aggravation of food insecurity in several West African regions. In addition, if the adaptation measures are not taken into consideration, drops in cereal cultures outputs should intensify in Sub-Saharan Africa, by the year 2050. To face the problem, the use of new varieties more adapted to the new agro-climate conditions could offer farmers adaptation and resilience possibilities against climate change. Varieties with shorter, more resistant cycles to aquatic, biotic and abiotic stress could be a solution to boost agriculture in Sahel and reduce the exposition of farmers to the risks of extreme weather events. It is in this perspective that the International Institute of Research on Cultures in tropical semi-arid zones (ICRISAT) in collaboration with the Senegalese National agronomic research center (CNRA) of Bambey established several varieties of millet with intermediary cycle to serve as palliatives in Sudanese zones. The test was carried out in the experimental station of Nioro during 2019 rainy season. As vegetal material, it had 50 varieties, including 35 of landraces and 15 of improved varieties coming all from the ICRISAT/Niger millet programme. The experimental system was a Lattice Design alpha with three repetitions of five blocks each. Agronomic parameters linked to phenology, vegetative growth and output were measured. According to the results from statistical analyses, significant differences were observed for the semi-flowering-female flowering, the height of plants, the length of ears, the number of farmed ears, the weight of ears, and finally the seed outputs. In conclusion, with our results, it was noted that the landraces showed more performing than the improved varieties in terms of seed output. It is observed that the more productive varieties are successively ICMP 187017, ICMV 187006 and ICMP 187035. These varieties can be tested in multi-focal trials for adaptability and stability, as several among the rest could be helpful in the national variety creation programme.

Keywords: millet –landrace – improved varieties – performance – intermediate zone

INTRODUCTION

With recurring climate change, increasing agricultural productivity requires technological advances to increase crop yields. The use of new, better performing and more resilient crop varieties provides farmers with greater flexibility in adapting to climate change, including traits that give them drought and heat tolerance, salinity tolerance (eg due to rising sea levels in coastal areas), in order to shorten the growth period of plants and improve the resistance of species to biotic and abiotic stresses. The millet *Pennisetum glaucum* (L.) R. Br is one of the most important cereals in the world in terms of area and production. It is ranked sixth after rice, wheat, maize, barley and sorghum (FAO, 2012). It is grown on 34 million hectares with a production of 27 million tonnes (FAO, 2012). In Asia and Africa, its cultivation is mainly intended for human consumption while it is used for livestock fodder in the United States, Australia and Brazil (ICRISAT and FAO, 1996).In Africa, millet is grown on over 13 million hectares and production supports the survival of over 500 million people (Syngenta, 2013). Africa contributes 46% of global millet production. This production comes mainly from West African countries, of which Nigeria is the leader, followed by Niger, Mali and Burkina-Faso. Senegal comes in 5th position, with an annual production of nearly 600,000 tons per year (Moumouni, 2014).In Senegal, millet has become the main cereal crop and occupies the most important place in terms of sown areas. Unlike sorghum and maize, which are grown in the east and south of the country, areas where rainfall is more abundant, millet is found in all agro-ecological zones of Senegal. It remains the main food crop for the rural world, which represents nearly 70% of the national population, but it is generally cultivated extensively with little or no chemical inputs. National production is irregular and uneven depending on the nature of the rainy seasons. The low yields recorded are due to several constraints, including the use in the real world of local varieties that are not adapted to the new agro-climatic conditions. Thus, to increase production in order to feed a larger population, research institutes, including ICRISAT, have developed new highly productive open pollinated varieties (OPV) with an adapted cycle and good resistance to biotic and abiotic stresses. Before their use in the real environment, they are tested in stations in the different agro-ecological zones to assess their behavior in the target environments. Therefore, the general objective of this trial is to test and evaluate the performance

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and characteristics of a range of intermediate cycle varieties in agro-climatic zones in order to identify the best ones.
It specifically aims to:

- Evaluate the agro-morphological characteristics and performances of the inputs tested under the agro-ecological conditions of the southern center of the groundnut basin (Nioro).
- Compare the characteristics of the landraces to identify the best performers for each characteristic observed.

MATERIALS AND METHODS

Presentation of the site

The trial was conducted at ISRA at the Nioro du Rip experimental station located in the southern center of the Bassin Arachidier. The Nioro station attached to the CNRA of Bambey is located in the Kaolack region between the district of Paoskoto and the town of Nioro du Rip on the Kaolack-Ziguinchor national road. The geographical coordinates are 13°45 North and 15°48 West. The 115 ha area is made up of a main station and an annex station located on either side of the national road. The main station has an area of 80 ha and is used for agronomic trials and seed production. It should be noted that the latter also houses infrastructure (housing, warehouses, offices, etc.). The annex station commonly called BIT has an area of 35 ha and is used for agro forestry experiments and houses various plantations.

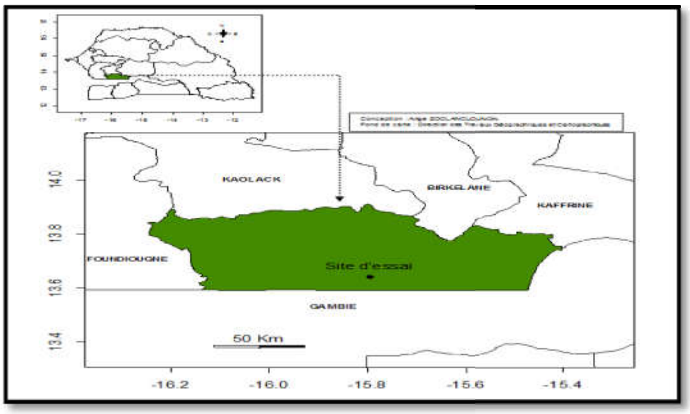


Figure 1: Situation of the Nioro station

Source: Ndiaye (2017)

The climate

It is characterized by an alternation of a dry season (from November to May) and a rainy season (from June to October), which results in significant variations in climatic parameters.

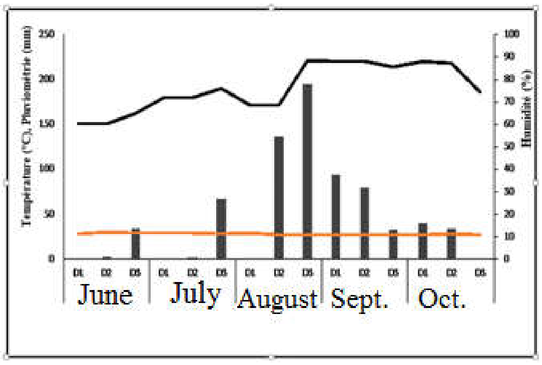
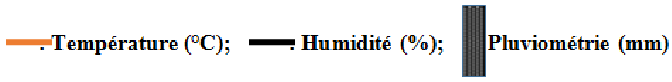


Figure 2: Evolution of rainfall, temperature and humidity during the 2019 rainy season in Nioro.

Legend

D: decade (equal to 10 days)



Temperature and humidity

Throughout the period of the experiment, a more or less variable temperature was noted and the average temperature was around 28°C The highest average temperature was recorded in August with 29.38°C and the lowest temperature was observed during the same month with 26°C. For relative humidity the general average is 76.19% and the highest humidity was recorded in September, i.e. 88.67 ¨% and the lowest in August, i.e. 68.41%. The flowering phase (early September to early October) coincided with a fairly constant temperature which reached 29°C (figure 4) .This same phase also coincided with high relative humidity of the air varying from 85 to 88% (figure 2).

Rainfall

The rains started during the last dekad of June. Indeed, the first useful rain fell on June 24 with 24 mm and the rains continued until October. However, rainfall breaks were recorded but the longest was 16 days (from July 28 to August 11) and coincided with the development phase during crops. The cumulative rainfall recorded throughout the winter was 753.83 mm for 45 days of rain.

Floor

In the experimental station, soils of the type are encountered:

- dior deck with a sandy-silty texture with less than 10% clay;
- dior deck with a sandy-silty texture with more than 15% clay;
- deck which is characterized by a silty-clay-sandy texture over the first 40 centimeters

Vegetation

The area studied is a wooded savannah marked by a clear predominance of Cordylapinnata with a fairly homogeneous distribution over the entire area. The shrub layer is characterized by three species which are the most representative: Combretumglutinosum (ratt), Guierasenegalensis (ngère) and Bauhiniareticulatum (nguiguis). These species are found, most of the time, in fairly dense regrowth on the sandy soils of the plateaus. The herbaceous layer is made up of annual grasses Andropogon and Cassiatora. It is quite abundant in uncultivated areas (cuirasses, valleys, etc.) generally used as pastures for livestock.

Plant Material

The plant material consisted of 50 accessions, including 35 landraces (ICMPs) and 15 improved varieties (ICMVs) from ICRISAT (Table 1).

ENTRY	DESIGNATION	PEDIGREE	ORIGINE
1	ICMP 187001	ICMV 167006XICMV IS 94206	NIGER
2	ICMP 187017	SOSAT-C88XICMV 167005	NIGER
3	ICMP 187019	SOSAT-C88XPE02638	NIGER
4	ICMP 187023	ICMV IS 89305XChakti	NIGER
5	ICMP 187024	ICMV IS 89305XICMV 167005	NIGER
6	ICMP 187025	ICMV IS 89305XICMV IS 92326	NIGER
7	ICMP 187026	ICMV IS 89305XICMV 187001	NIGER
8	ICMP 187029	ICMV IS 89305XICMP 177002	NIGER
9	ICMP 187031	ICMV IS 94206XICMV IS 92222	NIGER
10	ICMP 187032	ICMV IS 94206XICMV IS 90311	NIGER
11	ICMP 187033	ICMV IS 94206XICMV 167005	NIGER
12	ICMP 187035	ICMV IS 94206XICMP 177002	NIGER
13	ICMP 187037	ICMV IS 92222XICMV 167005	NIGER
14	ICMP 187038	ICMV IS 92222XICMP 177002	NIGER
15	ICMP 187040	ICMV IS 90311XICMV 167005	NIGER
16	ICMP 187041	ICMV IS 90311XPE03942	NIGER
17	ICMP 187043	ICMV IS 92326XICMV IS 99001	NIGER
18	ICMP 187045	ICMV IS 92326XICMV 167005	NIGER
19	ICMP 187049	ICMV IS 92326XICMP 177002	NIGER
20	ICMP 187051	ICMV IS 99001XICMV 167005	NIGER
21	ICMP 187053	ICMV IS 99001XICMV 167001	NIGER
22	ICMP 187056	ICMV 147144XChakti	NIGER
23	ICMP 187057	ICMV 147144XICMV 167005	NIGER
24	ICMP 187058	ICMV 147144XICMP 177002	NIGER
25	ICMP 187064	PE00349XICMV 167005	NIGER
26	ICMP 187066	PE02638XICMV 167005	NIGER
27	ICMP 187067	PE03942XICMV 167005	NIGER
28	ICMP 187069	PE05903XICMV 167005	NIGER
29	ICMP 187071	PE02783XICMV 167005	NIGER
30	ICMP 187072	PE00711XICMV 167005	NIGER
31	ICMP 187073	IP8679XICMV 167005	NIGER
32	ICMP 167164	SOSAT-C88_R1_P97xICRI-TABI	NIGER
33	ICMP 177064	SOSAT-C88_R4_P14XICRI-TABI_R3	NIGER
34	ICMP 177098	SOSAT-C88_R4_P116XICRI-TABI_R3	NIGER
35	ICMP 177119	SOSAT-C88_R4_P124XICRI-TAB	NIGER
36	ICMV 187006	Niger-Nigeria Pop C3 OPV	NIGER
37	ICMV 187003	Niger-Nigeria Pop C3	NIGER
38	ICMV 187002	Niger-Nigeria Pop variety	NIGER
39	ICMV 187005	Niger-Nigeria Pop C4	NIGER
40	ICMV 147144	2016 SRGP_C6, Set2_CinEL_C1_C2_C3	NIGER
41	ICMV 167007	Striga_Res_ExpVar_Epis_Court	NIGER
42	ICMV 167008	Striga_Res_2009_Cinzana_S1_C1_C2_C3	NIGER
43	ICMV 167011	Striga_Res_2011_Cinzana C5 Set1_S	NIGER
44	ICMV 167010	Striga_Res_2009_Cin/Sad_S1_C1_C2_C3	NIGER
45	ICMV 167012	Striga_Res_2011_Sadoré C5 Set1_S	NIGER
46	ICMV 147141	2013 SRGP_C6, Set2_CinEL_C1_C2_C3	NIGER
47	ICMV 147143	2015 SRGP_C6, Set2_CinEL_C1_C2_C3	NIGER
48	ICMV 147142	2014 SRGP_C6, Set2_CinEL_C1_C2_C3	NIGER
49	ICMVI 94206	ICMV IS 94206	NIGER
50	ICMV 167005	PE05578	NIGER

Table 1: List of varieties used

The Experimental Design

The experimental design that was used for our study is an Alpha (α) Lattice Design with 3 repetitions of 5 blocks. Thus each repetition has 50 elementary plots, each of which is composed of a single variety. Two border lines are sown at the beginning and end of each strip to lessen the border effect. The basic plot is made up of 4 lines of 4.80m, i.e. 13 pockets with spacings of 0.75 m between the lines and 0.40 m between the pockets (Figure 3).

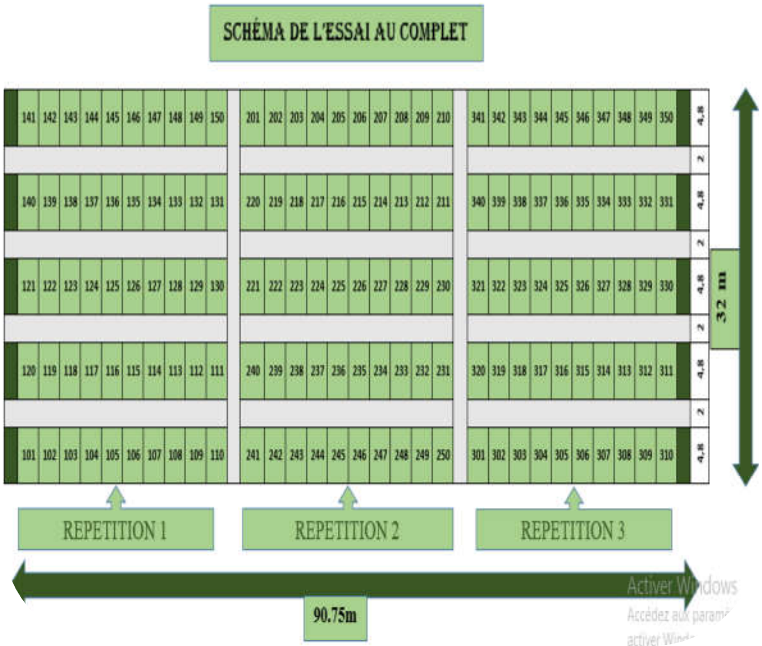


Figure 3: Diagram of the complete trial

Legend

Border line

Elementary field plot

Path bethween the plots

Elementary plot: It consists of four rows of sowing. So she has a total of 13 pockets (Figure 4). Observation plot: It is represented by the two central lines of each elementary plot in order to avoid border effects with the outer lines. (Figure 4).

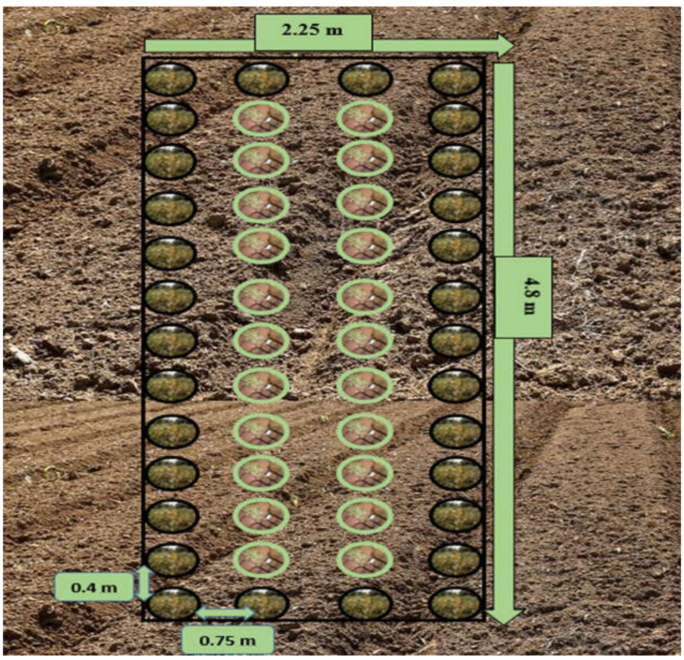


Figure 4: Elementary plot

Legend

- border line
- line of sight

- Grain harvested

Conduct Of The Trial

The trial was conducted according to the protocol designed by the millet selection service of the CNRA and ICRISAT. The main cultural operations carried out are listed as follows:

ground preparation:

Plowing was carried out to a depth of 15 cm on July 27, 2019, followed by harrowing to break up the clods of the plowed land.

Sowing

Sowing was carried out in the period from July 30 to July 31, 2019.

Unmarrying

It was carried out on the 8th day after emergence (DAL) i.e. August 9, 2019 at the rate of three plants per pocket, combined with transplanting at the level of the missing pockets to complete the numbers.

Fertilization

We used:

- As a basic fertilizer, NPK (15-10-10) at a rate of 150 kg/ha just after plowing followed by harrowing.
- In cover fertilizer, urea (46-0-0) was used in two tranches of 50kg/ha each, 15 JAL for the first, i.e. August 14, 2019 and 35 JAL for the second, i.e. September 04, 2019.

Weeding and hoeing

A first mechanical Sarclo-hoeing was carried out on 9 JAL, i.e. August 12, 2019 and a second, 15 days after the first, i.e. August 27, 2019.

Guarding

Guarding was carried out from the first to the 15th DAS (day after sowing), to prevent birds from digging up the sown seeds or rodents from damaging the small plants. It was taken from flowering until the end of harvest, to control seed-eating birds.

Harvest

It was carried out on October 31, 2019, after the complete maturity of the plants on all the pockets with ears filled with grains from the useful plot.

Drying

It was carried out just after the harvest on the panicles for 4 weeks, i.e. one month.

threshing and winnowing

It was done manually on December 02, 2019 by temporary women using mortars and pestles.

Observations And Measurements

The observations and measurements were made in the useful plot (on the 2 central lines) of each elementary plot. The different agro-morphological variables observed and/or measured are as follows:

- Number of plants emerged (NPL). A count of the number of plants was carried out from 7 to 15 DAS
- Duration Seedling female flowering (DSFF)When 50% of the plants in the useful plot have reached female flowering, the number of days elapsed between sowing and the date is recorded.
- Plant Height (HTP)

It represents the distance from ground level to the top of the head of the main tiller. It is obtained by taking the average of five (5) measurements made on five (5) plants taken at random in the useful plot. The measurement is done at maturity and with a graduated wooden ruler.

Length of Ears (LE)

It was measured at maturity and before harvest, with a metal tape on five (5) plants taken at random from each useful plot and given in centimeters (cm). Cob length starts from the base to the top of the cob

Number of ears harvested (NER)

Just after the harvest, the number of ears harvested is counted in each useful plot, those with sterile or unfilled ears, therefore without harvesting, are not considered.

Weight of Ears Harvested (PER)

After drying and before threshing, the cobs harvested from each useful plot are weighed with an electronic scale. The weight is given in grams (g).

Thousand Grain Weight (PMG)

The thousand grains were obtained by counting with the Numigral. The sample is weighed using an electronic scale and the value is given in grams (g) per plot.

Grain yield (RDT)

This is the weight of grain obtained per useful plot per hectare. This value is calculated using the following formula:RDT (kg/ha)= grain weight (g)*10 / Useful plot area (m2)

Data Processing And Analyzes

The various data collected in the field were recorded in Microsoft Excel 2013 for input, tables and graphs. The RStudio software was used for the analysis of variance (ANOVA), and the comparison of means with the HSD test function. The document was written with Microsoft Word 2013.

RESULTS AND DISCUSSION

Results

Results of the analyzes of the agro-morphological variables observed

The results of the statistical analyzes of the variables are recorded in the summary table below (Table 2).

Table 2: Summary table of the analysis of variance

In our study, 8 variables were observed (Table 2), 6 of which are significantly different: flowering (DSFF), plant height (HTR), ear length (LEP), number of ears harvested (NER) ear weight (PDE), and grain yield (RDT). Two variables did not show significant differences: the weight of 1000 seeds (PMG) and the number of plants at emergence (NPL).

VARIABLES	50% FLO (jours)	HTR (cm)	LEP (cm)	NER /ha	PDE (kg)	RDT Kg/ha	NPL /ha	PMG (g)
Minimum	36	206	28	1388	166	111	2777	6
Maximum	65	262	65	194444	4713	3166	27777	10
Moyenne	56	230	38	8333	1369	1105	22222	8
Probabilité	0.04	129.10^{-9}	17.10^{-5}	8.10^{-2}	293.10^{-6}	291.10^{-5}	0.1907	0.746
Signification du test	**	**	***	**	***	***	*	*

***: Very highly significant; 0< P (probability) < 0.01 (1%)

**: Highly significant; 0.01 (1%) < P (probability) < 0.05 (5%)

Interpretations of results:

For non-significant variables, all varieties are considered to be equivalent. Even there are arithmetical differences between the values, it is assumed that the entries do not differ with respect to the weight of a thousand grains and the percentage of emergence.

Female sowing-flowering delay

The female sowing-flowering period varies from 36 to 65 days, with a general average equal to 56 days. The analysis of variance showed a significant effect between the varieties (P=4.10-2). The comparison of the means subdivides the 50 varieties into 2 classes, the first of which presents varieties which have an intermediate flowering time [51<FLO≤65 days] and the second includes 3 varieties which have presented an early flowering [FLO≤50 days] . The latest flowering is observed with the ICMV 167008 variety, i.e. 65 days, and the earliest with the ICMP 187053 variety, with i.e. 36 days (Figure 5).

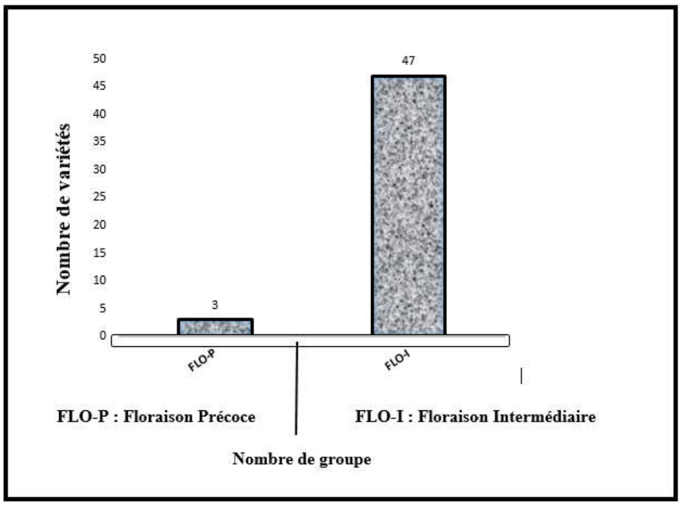


Figure 5: Distribution of varieties in classes according to female semi-flowering time

PLANT HEIGHT (HTR)

The height of the plants varied from 206 to 262 cm. Thus there are no dwarf varieties [HTR<150 cm]. The general average is 230 cm. The analysis of variance showed a very highly significant effect between the varieties (P=129.10-9). The comparison of the means subdivides the varieties into 2 classes. The first includes medium-sized varieties [180< HTR< 250 cm] and the second includes very tall varieties [HTR>250 cm]. The largest size is obtained with the ICMV IS 94206 variety and the smallest size with the ICMP 187038 variety (Figure 6).

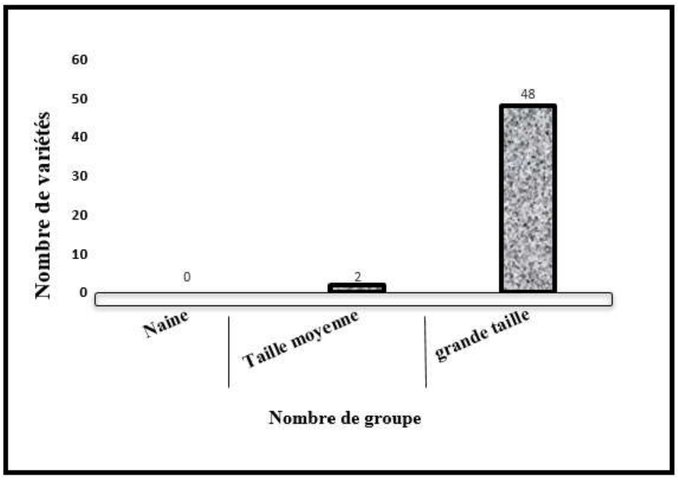


Figure 6: Subdivision of varieties into classes according to plant height.

Cobs length

At the end of the statistical analysis of the results obtained, we observe a very highly significant effect between the varieties (P=17.10-5). The average length of the ears varies from 28 to 65 cm. The general average is 38 cm and the comparison of the averages, subdivides the varieties into 13 groups which can be grouped into 4 classes, the first of which has 16 varieties which have average ears whose length is between 45<LEP<65 cm, the second counts 33 varieties with short ears 30<LEP<45 cm and the last class counts only one (1) variety (ICMP 177119) with very short ears LEP<30 cm. The longest ears were obtained with the variety ICMP 187031 or 68 cm. (Figure 7).

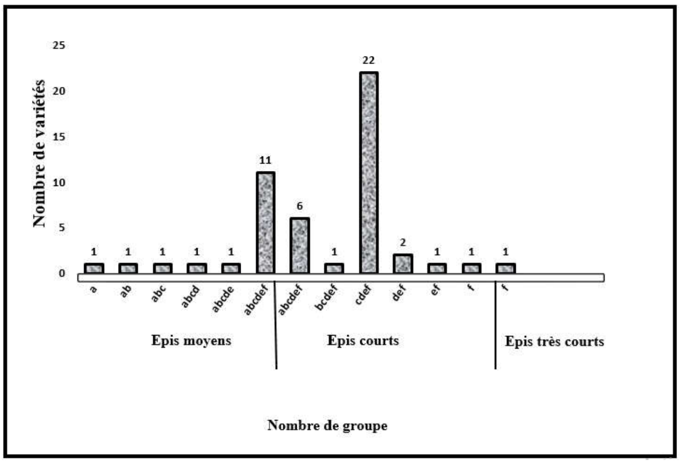


Figure 7: Subdivision of varieties into classes according to ear length.

Number of ears harvested/ha (NER)

The number of ears harvested per hectare varies from 1388 to 194444 ears, and the general average is equal to 8333 ears/ha. The analysis of variance shows the existence of a highly significant effect between the varieties for the number of ears harvested (P=8.10-2). The comparison of the means subdivides the varieties into 3 different classes (figure 12). The ICMP 187017 variety shows the best performance with 194444 ears/ha followed by the ICMP 187043 and ICMV 187006 varieties which each gave 13888 ears/ha, on the other hand the lowest number of ears is obtained with the ICMV 147143 variety i.e. 1388 cobs/ha (Figure 8).

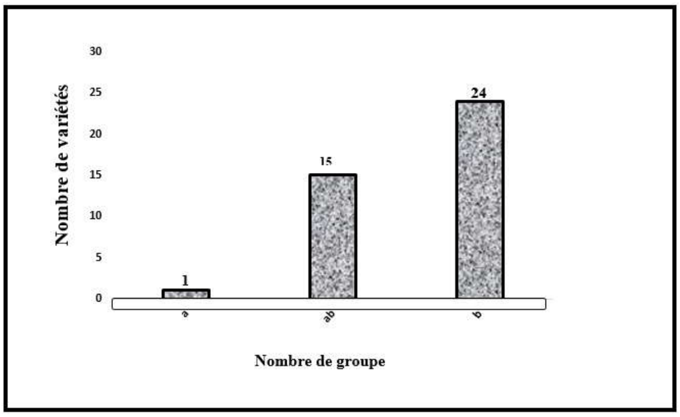


Figure 8: Subdivision of varieties into classes according to the number of ears harvested.

Weight of ears harvested (PDE)

The weight of the ears varies from 166 to 4713 kg/ha. The general average of the test is equal to 1369 kg / ha. The analysis showed a very highly significant effect between varieties (P=293.10-6). The comparison of the means gives 4 main groups: the first group consists of a single variety with a high ear weight PDE> 3500 Kg; the second group is made up of 6 varieties with an average ear weight of 2000<PDE<3500Kg; the third group has 24 varieties with a low ear weight 900<PDE<2000Kg and the fourth group has 19 varieties with a very low ear weight. The best performance is obtained with the variety ICMP 187017 and the lowest weight is obtained with the variety ICMV 147143 (Figure 8).

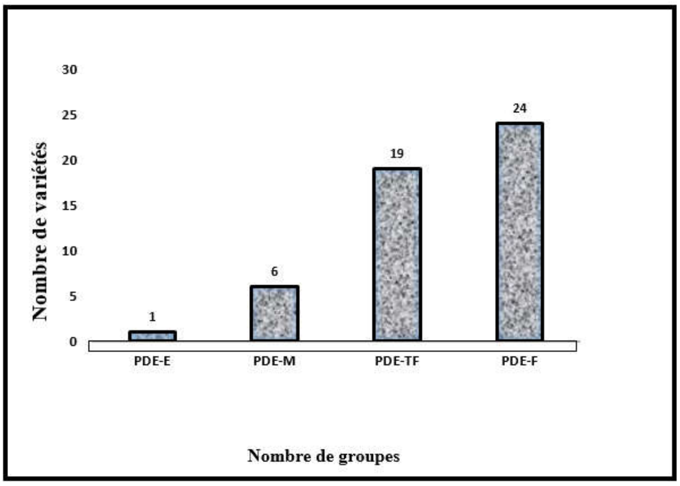


Figure 8: Subdivision of varieties into groups according to ear weight

PDE-E: high ear weight
PDE-M: average cobs weight
PDE-TF: very low ear weight
PDE-F: low cobs weight

Grain yield (RDT)

The average grain yield varies from 111 to 3166 Kg/ha and the general average is 1105 Kg/ha. The analysis of variance showed a very highly significant effect between the varieties (P= 291.10-5). The comparison of the means subdivides the 50 varieties studied into 4 classes. The first has one (1) high yield variety RDT>3000Kg/ha, the second has 3 varieties with average yield 1500<RDT<3000Kg/ha). The third class has 31 low yielding varieties 500<RDT<1500Kg/ha and the fourth class has 15 very low yielding varieties. The highest yield is obtained with the variety ICMP 187017, and the lowest with the variety ICMV 147143 (Figure 9).

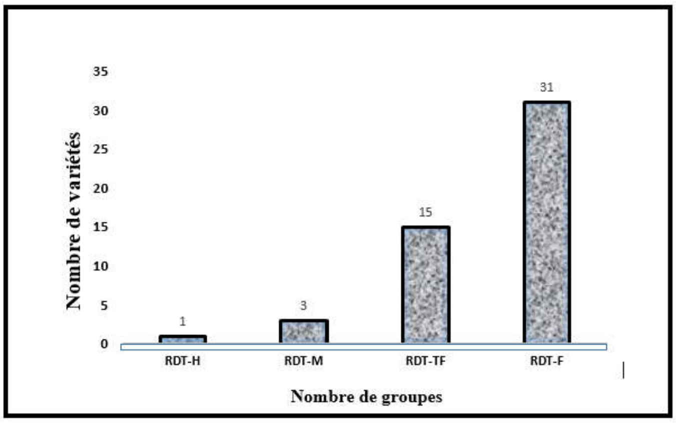


Figure 9: Subdivision of varieties into groups according to yield

RDT-H: High performance
RDT-M: Average yield
RDT-TF: Very low yield
RDT-F: Low yield

Correlations between variables

The results of the correlation analyzes between the different variables observed show that there are often very strong dependency relationships between characters. The correlation was evaluated between the variables taken two by two to estimate the relationships and dependencies between them. We see that the parameter number of plants lifted (NPL) is strongly correlated with the number of ears harvested (NER) r=0.6]. It can thus be seen that the varieties which give the best emergence rate have a better chance of giving more ears to the harvest. Ear weight (PDE) and yield (RDT) are highly dependent with r=0.6. Thus we see that the varieties that produce a lot of ears generally give a high grain yield. The number of ears harvested (NER) and grain yield (RDT) [r=0.82 the weight of ears harvested (PER) and grain yield (PDG) r=0.93 This shows that the varieties that produce more ears are those with the highest weight in ears and grains. On the other hand, we observe that the plant height variable (HTR) is weakly correlated with these yield parameters. This indicates that grain yield does not depend on plant height. Tall plants such as dwarf plants may or may not be productive. The ear length variable (LEP) is negatively correlated with all other parameters including grain yield. This shows that generally the varieties with the longest ears are not very productive in grain.

Table 3: Correlation matrix between the agro-morphological variables observed

	FLO	HTR	LEP	NPL	NER	PDE	RDT	PMG
FLO								
HTR	0.24							
LEP	-0.02	0.42						
NPL	-0.03	0.03	0.00					
NER	-0.30	-0.05	-0.12	0.62				
PDE	-0.25	0.03	-0.08	0.60	0.83			
RDT	-0.24	0.07	-0.04	0.61	0.82	0.93		
PMG	-0.19	-0.02	-0.04	0.26	0.30	0.40	0.44	

DISCUSSION

Compared to the female sowing-flowering delay, the analysis of variance subdivided the 50 varieties studied into two classes, the first of which includes 47 varieties with intermediate cycles and the second 3 varieties with early cycles. These results are consistent with the distribution of Sall (2017) which subdivided the varieties cultivated in West Africa, in the 3 agro-ecological zones, according to the cycle: early for the Sahelian zone, intermediate for the Sudanian zone (our case study) and late for the Guinean zone. The negative correlations linking the yield and flowering parameters show that the duration of the cycle can impact the final production. Long cycle varieties are less productive than short cycle varieties in the Sudanian zone. These results are in agreement with those of Sy *et al.,* (2015) who had shown that the longer the cycle, the lower the grain yield because the variety has little chance of reaching maturity to give grains. Regarding the height of the plants, our results show that the varieties observed are large (HTR greater than 200 cm) with an average of 230 cm. This result has already been found with the work of Ouendeba *et al.,* (1995) who said that most of the varieties grown in West Africa were tall because it was the preference of farmers given the different uses made of millet straw. For the length of the ears, the results of the analysis showed the existence of three classes: (1) very short ears, (2) short ears, (3) medium ears showing that the character length of the ears presents a great variability between millet accessions. These results corroborate those of Zangré *et al.,* (2009) who had shown that ear was the most discriminating character between millet ecotypes in West Africa. However, a positive but not very significant correlation was found between the length of the ears and the height parameter of the plants (r=0.42) showing that the tallest plants do not necessarily have the longest ears. These results are in line with those of Sy (2016) who found that the length of the ear does not depend on the size of the plants. Tall plants like dwarf plants can produce long spikes. For yield and these parameters (NER, PDE), the analysis of variance showed a strong correlation between them. Thus a phase evolution was observed and the highest grain weights were recorded on the varieties with the highest ear weight. These results are in agreement with those of Fané (2018) who concluded that the yield of the varieties is more important than the parameters that compose it are, and both millet and wheat are among the cereals with a high tillering capacity, therefore developing their capacity tillering becomes a yield-increasing factor. On the other hand, the low yields could be due to the 16-day rainfall break that occurred during the growth phase. Indeed the lack of water during the growth period can negatively impact the final yield and according to Haussmann et al. (2007) the germination-growth, tillering, flowering and grain filling stages are critical periods for water stress. Other authors like Sivakumar, (1992), Sultan et al. (2005) have also shown that the decrease in rainfall accumulations can explain 35 to 45% drop in crop yields in Africa and for Sultan, (2012); Berg et al. (2013) in the decades to come, the hypotheses of changes in the rainfall regime could have an overall negative effect on the production of millet, maize and sorghum.

CONCLUSION AND PERSPECTIVES

At the end of this study, which aimed to test and evaluate the performance of different millet varieties in the intermediate cycle in the Nioro area, in order to identify the most suitable varieties between the landraces and improved types, our results showed a great variability and an important diversity between the varieties. Consequently, it is observed that the varieties were subdivided into several groups according to the criterion used. Thus, with respect to the female sowing-flowering delay, it was found that the landraces as improved flowered in accordance with the standard described for their cycle. For the height of the plants, our results showed overall that the varieties studied are tall. Thus, a batch of 5 varieties emerged, including one (ICMVIS 94206) improved and four (ICMP 187031, ICMP 187025, ICMP 187072, ICMP 187033). In view of the different uses made with millet straw, it would seem that for this study the landraces are the best for the variable (HTR). Regarding the length of the ears, our results showed that the tallest plants do not necessarily have the longest ears. However, for this character which is very popular in the farming environment, we can retain a group of 16 varieties including 8 landraces and 8 improved ones which follow one another randomly so there was not much difference for these two groups of varieties for this LEP character. In terms of yield and its explanatory parameters, the results show each time a group composed of 3 varieties including 2 landraces and one (1) improved. However, it can be noted that the ICMP 187017 variety had the highest number of ears, the highest ear weight and the highest grain weight during the trial. So it would seem to be the best performing and best adapted variety in this study area South Center of the Groundnut Basin). The other varieties such as ICMV 187006, ICMP 187035, have also shown themselves to be efficient for this yield parameter.

As perspectives, we recommend:

- Repeat the station test to confirm the results obtained;
- Carry out multi-local trials to see the behavior and adaptability of these varieties in the different agro-ecological zones of Senegal
- Make a comparison between the 3 early varieties found in the trial with the local control of the farmers to evaluate the gain obtained.
- Perform biochemical analyzes on seeds and straws to assess their nutritional value in the context of improving human and animal nutrition.

At the end of this study, the most efficient varieties found to be highly productive can be used in the intermediate agro-ecological zone to serve as a solution in relation to the shortening of the rainy season and the drop in annual rainfall.

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