International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Evaluation of the Agro-Morphological Characteristics of Eleven (11) Hybrid Varieties in the Agro-Climatic Conditions of the Southern Center of the Groundnut Basin of Senegal (Nioro) During the Winter Season 2019

[1,3]Alpha CISSE, [2]Ousmane SY, [1]Souleymane DIA, [1]Mouhamadou Lamarana KEITA, [1]Anta DIOP, [3]Aboubacry KANE, [3]Mbacke SEMBENE
[1]Alioune Diop University Bambey
[2]National Center of Agronomic Research of Bambey
[3]Cheikh Anta Diop University
[1,3]Alpha CISSE*, corresponding Author

Abstract**—** *The objective of this trial is to evaluate the performance and agronomic characteristics of the best test-cross hybrids in Senegal under the agro-climatic conditions of the southern groundnut basin. The plant material was composed of eleven (11) hybrids from the national program and a local control (GAWANE). Among the varieties tested, the most productive is a hybrid with a grain yield equal to 2158 kg/ha despite the very difficult winter conditions experienced in 2019. Finally, we note that in the agroclimatic conditions of Nioro, the hybrids remain quite efficient with yields often reaching 2t/ha and that compared to the OPV controls, the hybrids are more productive even under water deficient conditions*.

Keywords**—** *Millet, hybrid; agro-climatic, production, varieties, wintering*.

I. INTRODUCTION

Millet, Pennisetum glaucum (L.) R. Br., is one of the most important cereals in the world. It is ranked sixth after rice, wheat, maize, barley and sorghum (FAO, 2012). It is cultivated on 34 million hectares with a production of 27 million tons (FAO, 2012). In Asia and Africa, its cultivation is mainly for human food at the time it is used for livestock feed in the United States, Australia and Brazil (ICRISAT and FAO, 1996).

In Asia, the crop is limited to two countries: India, which is the leading producer of millet in the world, with a production of about 11 million tons per year, or 40% of world production (Fao, 2012) and China. In Latin America, the crop is only grown in one region of Argentina, and its cultivation for human consumption at the same time as it is used for livestock feed in the United States, Australia and Brazil (Icrisat and Fao, 1996)

In Africa, this crop covers more than 13 million hectares and production ensures the survival of more than 500 million people (syngenta, 2013). This continent contributes 46% of the world's millet production; this production comes mainly from West African countries of which Nigeria is the leader followed by Niger, Mali and Burkina. Senegal comes in fifth position with a production of six to nine hundred thousand tons on nearly one million hectares (Mounrouni, 2014).

In Senegal, millet is the most cultivated cereal with 71% of the area planted to cereals for the 2011/2012 season and 65% for the 2012/2015 season. It represents an average of 42% of the total cereals consumed by Senegalese (COMMODAFRICA, 2015). However, there has been a decrease in arable land in general, including that sown to millet. This reduction in sown areas combined with low soil fertility will jeopardize food security if transitional solutions are not taken.

It is in this context that hybrids have been created by ISRA's national varietal creation program. Before their use in the field, these new varieties are tested in the different agro-ecological zones. The overall objective of the study is to contribute to the increase of the national millet production through the use of highly productive hybrid varieties adapted to the agro-climatic conditions of Senegal.

The trial specifically aims to:

- Evaluate the agro-morphological characteristics and performance of the tested entries in the agro ecological conditions of the southern zone of the groundnut basin of Senegal (Nioro).
- Compare the productivity of the varieties to identify the most productive and disease resistant ones.
- To identify the best in productivity and stability for testing in multi-local trials before release.

II. MATERIAL AND METHODS

Presentation of the Experimental Station
Geo-administrative situation

The trial was conducted during the winter of 2019 at the CNRA/ISRA of Bambey in the experimental site of Nioro du rip which is on the national road N4 that links Kaolack to Ziguinchor (Senegal). The station is located about 60km southeast of Kaolack and 27km from the border with The Gambia. The geographical coordinates are: 13°45'00" North latitude 15°48'00' West longitude.

Alpha CISSE, Ousmane SY, Souleymane DIA, Mouhamadou Lamarana KEITA, Anta DIOP, Aboubacry KANE, and Mbacke SEMBENE, "Evaluation of the Agro-Morphological Characteristics of Eleven (11) Hybrid Varieties in the Agro-Climatic Conditions of the Southern Center of the Groundnut Basin of Senegal (Nioro) During the Winter Season 2019," *International Research Journal of Advanced Engineering and Science*, Volume 7, Issue 2, pp. 227-231, 2022.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

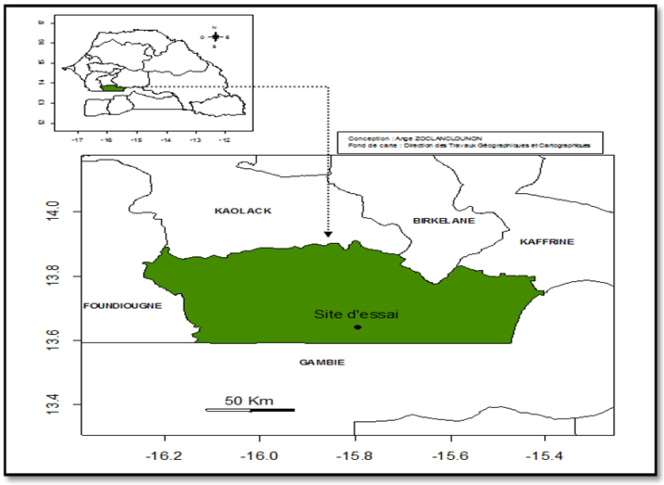

Fig. 1. Situation of the Nioro station
Source : Ndiaye (2017)

Biophysical Framework

The climate

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

Temperature and humidity

The decadal evolution of the average temperature during the winter season 2019 is between a minimum value of 26.88°C during the third dekad of August and a maximum value of 33.06°C during the second dekad of June. It is during this month or we record the most important decadal average with an average equal to 29.32 ° C followed by the month of July (28.82 ° C) followed by the month of August (27.96 ° C) followed by the month of October (27.66 ° C) and finally September (27.55 ° C).

Humidity remained stable at 81.21% - 88.61% from the third dekad of August to the second dekad of October before decreasing to 74.43% during the third dekad of October.

Rainfall

It has a uni-modal distribution, with a maximum recorded in the third dekad of August at a value equal to 194.7mm. A rainfall was recorded during the first dekad of August

Plant material

The plant material consists of 12 entries including 11 hybrids from the national program in Senegal, and a local control from the zone (table 1).

TABLE 1. Characterization of plant material

Entered	Designation	Pedigree	Origin
1	ISMH01	SDEA41-60 ×SL111	National Program
2	ISMH02	SDEA41-60×SL126	National Program
3	ISMH03	SDEA41-60×SL175	National Program
4	ISMH04	SDEA41-60×SL317	National Program
5	ISMH05	SDEA41-60×SL220	National Program
6	ISMH06	SOSAT C88A×SL123	National Program
7	ISMH07	87CS88A-BHT×SL126	National Program
8	ISMH08	LMA-90×SL175	National Program
9	ISMH09	87CS88A-BHT×SL123	National Program
10	ISMH10	ICMA-90×SL123	National Program
11	ISMH11	ICMA-90×SL175	National Program
12	GAWANE	TEMOIN/variété OPV	National Program

Method

Experimental design

A single factor, the variety, was studied in a randomized complete block design or Fisher block with 4 replications.

Each block consisted of 12 elementary plots, each containing one variety. The blocks were separated by 2m wide alleys.

The elementary plot consisted of 6 rows of 7.20 m in length, each with 10 bunches. The distance between the rows is 0.80m, between the blocks 0.80m. Thus, the total surface of the test was then of 34,80m*56,80m=1976,60m².

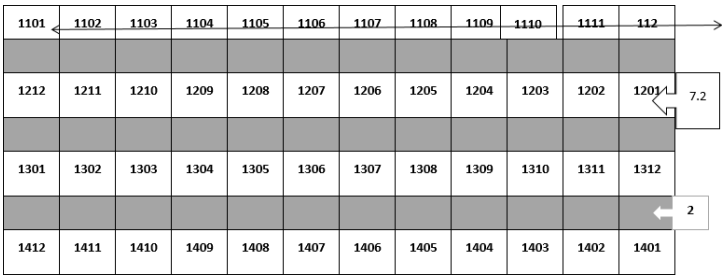

Fig. 2. Diagram of the experimental set-up

Crop management

Land preparation

Plowing was done to a depth of 15 cm on July 1, 2019, followed by harrowing to break up the clods in the plowed soil

Sowing

Sowing was done on July 30, 2019 in wet conditions with 10 to 15 seeds per bin

Disbudding

It was carried out between the 8th day after emergence (JAL) and the 15th day after emergence corresponding to the date of August 20 and 26 at a rate of three plants per poquet,

Fertilization

The NPK fertilizer (15-10-10) was applied just after ploughing followed by harrowing at a rate of 150kg/ha.

Then a spreading of urea was done twice. A first time after the preparation of the ground on August 28, 2019 and the second was made after the second weeding corresponding to the date of September 11, 2019.

Phytosanitary treatments were made for several times corresponding to the following dates: 03, 09, 25 September, 2019 also on 11 and 18 October, 2019

Weeding

A first weeding has been done twice (8 days after emergence and 15 days after the first weeding) corresponding to the dates 26 August and 09 September 2019

Guarding

A guarding was carried out from the emergence until the harvest to protect the young seedlings against the biting birds from the sowing to the first hoeing and to drive out the granivorous birds from the beginning of the filling of seeds until the harvest;

Harvest

It was carried out for each plot after complete maturity without waiting for the late plots, that is to say on 31/10, 2019 on the set of clusters with filled grains of the useful plot.

Alpha CISSE, Ousmane SY, Souleymane DIA, Mouhamadou Lamarana KEITA, Anta DIOP, Aboubacry KANE, and Mbacke SEMBENE, "Evaluation of the Agro-Morphological Characteristics of Eleven (11) Hybrid Varieties in the Agro-Climatic Conditions of the Southern Center of the Groundnut Basin of Senegal (Nioro) During the Winter Season 2019," *International Research Journal of Advanced Engineering and Science*, Volume 7, Issue 2, pp. 227-231, 2022.

Drying

It was carried out just after the harvest that during three (3) weeks.

Threshing

It was done manually from 02 to 06 December 2019 by temporary women using mortars and pestles.

Agro-morphological variables observed

The observations and measurements were made in the useful plot (on the central lines) of each elementary plot.

The different agro-morphological variables observed and/or measured are the following:

Number of emerged plants (NPL)

A count of the number of plants was carried out from 7 to 15 JAS.

Incidence of mildew (DM)

The number of plants infested by mildew was counted in order to calculate its incidence in the reproductive phase. The result obtained is the percentage of plants showing symptoms of late blight. The observation is made at the reproductive phase and before harvest. The following formula was used to calculate the incidence of the disease:

IM%= (Number of attacked plants x 100)/Total number of plants)

Flowering time (FLO)

The observation was made when 50% of the plants had reached the emergence of the stigmas of the main spike. The parameter is given in number of days separating the date of sowing and that of 50% female flowering of the ears of the useful plot.

Height of the Plant (HTR)

It represents the distance from the ground level to the top of the main spike. It is obtained by averaging three (3) measurements made on three (3) plants taken at random in the working plot. The measurement is made at maturity and with a graduated wooden ruler.

Length of spikes (LEP)

It was measured at maturity and before harvest, with a metal tape on three (3) plants taken at random in each useful plot and given in centimeters (cm). The length of the ear starts from the base to the top of the ear

Ear Circumference (EC)

The measurements were made at full maturity and before harvest. To make it, we measure the diameter of the ear taken in the middle between the base and the tip. The device used is a caliper. The value is obtained by averaging three (3) measurements on three (3) different plants taken at random per useful plot.

Number of harvested ears (NER)

Immediately after harvesting, the number of harvested ears is counted in each useful plot, those with sterile or unfilled ears harvested are not considered.

Weight of harvested ears (WHE)

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

Grain weight (PDG)

After threshing, the grains obtained from each useful plot are weighed with an electronic scale. The weight is given in grams (g).

Thousand kernels weight (TKW)

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

Yield of dry matter (RDTMS)

This yield corresponds to the total stem and leaves obtained after harvesting, its value obtained by making the ratio between the weight of dry matter in kilograms (kg) on the area of the useful plot in hectares (ha).

Grain yield (RDT)

This is the weight of grain obtained per useful parcel of land per hectare. This value is calculated through the following formula:

RDT (kg/ha) = weight of grains (kg) / total area of the plot (ha)

III. Results and Discussion

Results

Presentation of the results

The results of the statistical analyses (ANOVA) on the measured variables are shown in the summary table (Table 2). It is observed that for all the observed parameters, a non-significant effect except for the number of harvested bunches (NPR) and the weight of ears (PDE).

Summary of the analysis of variance

TABLE 2. Summary of the analysis of variance

VARIETY	FLO	HTR	LEP	NER	NPR	PDE	PDG	PMG	RDTMS	RDT	VAL	CIR
ISMH 01	73	206	43,4	110	28	4760	2727,5	7,8	2109	1494	4	6,15
ISMH 02	73	207	38, 3	92	37	3135	3860	8,8	2426	1594	5	6,5
ISMH 03	72	202	38,5	104	32	3960	3362,5	8,5	2260	1548	4	6,82
ISMH 04	72	198	44,1	98	36	3880	4067,5	7,9	2304	1761	5	6,5
ISMH 05	69	226	42,5	98	31	3915	3615	8,5	2783	1708	5	7,2
ISMH 06	68	201	42,0	59	35	2170	2760	9,1	2446	1225	4	6,47
ISMH 07	72	220	47,3	145	27	5430	2805	8,5	1972	1533	4	6,05
ISMH 08	76	215	48,2	116	34	4822	3665	8,6	3247	1704	5	6,22
ISMH 09	73	217	47,5	151	30	5810	2715	8,0	2768	1412	4	6,31
ISMH 10	72	231	48,4	136	32	5200	3460	9,2	3637	1640	5	6,15
ISMH 11	74	205	43,5	121	12	5070	1510	8,0	1665	2158	4	6,4
TEMOIN	72	211	41,7	138	29	5310	3740	9,3	3061	2012	4	6,7
AVERAGE	72	212	43,8	114	30	4455	3190,6	8,5	2556	1649	4	6,42
Probability	1,00	0,87	0,70	0,10	0,00	0,04	0,23	0,70	0,05	0,24	0,71	0,67
PPSD (5%)	22,73	41,02	12,30	57,25	10,59	2084,97	1758,50	1,70	1131,70	626,03	1,15	1,06
CV (5%)	21,86	13,48	19,60	34,91	24,05	32,63	38,43	14,10	30,86	26,46	17,31	11,53

Alpha CISSE, Ousmane SY, Souleymane DIA, Mouhamadou Lamarana KEITA, Anta DIOP, Aboubacry KANE, and Mbacke SEMBENE, "Evaluation of the Agro-Morphological Characteristics of Eleven (11) Hybrid Varieties in the Agro-Climatic Conditions of the Southern Center of the Groundnut Basin of Senegal (Nioro) During the Winter Season 2019," *International Research Journal of Advanced Engineering and Science*, Volume 7, Issue 2, pp. 227-231, 2022.

Interpretation of the results

The results of the statistical analyses show that for most of the observed variables, there is no significant difference between the entries. The varieties are equivalent for these traits of interest. This strange phenomenon can be explained by the configuration of the wintering period with more or less long rainfall breaks, sowing, resowing, all of which is crowned by continuous soil degradation. Thus the variables that do not differentiate the varieties are: flowering (FLO), plant height (HTR), ear length (LEP), number of harvested ears (NER), grain weight (PDG), thousand seed weight (PMG), dry matter yield (RDTMS), and grain yield (RDT).

In relation to the cycle or time from sowing to flowering (FLO), we find that all entries are equivalent even in the arithmetic values differ from one variety to another. The longest cycle length is: 76days. This duration is obtained by the entry ISMH-11 and the earliest is ICMH06 with 71 days;

Regarding the height of the plants (HTR), although the height of the plants varies between 198cm and 231cm, the entries are not statistically different. The important difference between the tallest variety ISMH10 and the shortest Gawane is due to chance and would not have allowed to differentiate the entries;

As for the length of the ears (LEP), we find that there are important differences between the variety with the longest ears and the variety with the shortest ears. However, this difference does not explain any difference between the entries. With an overall average of 44cm, we see that all the entries are in the group of varieties with long ears according to the FAO classification (2008).

Concerning the number of harvested ears (NER), we can see that all varieties are more or less productive with a general average of 114 ears per plot. The variety with more harvested ears is the hybrid ISMH-09 with 151 ears and ISMH-06 has the lowest number of harvested ears with 59 ears.

In relation to the weight of 1000 grains (PMG), we find that the local control GAWANE obtained the highest weight per thousand grains with a PMG value of 9.315g and the variety with the lowest weight grains is the hybrid ISMH01 with 7.9g. Even if this difference is statistically due to chance and does not allow to differentiate the varieties, we still find a certain variability between the accessions in relation to the heaviness of the grains;

Considering the yield in harvested straw per plot (RDTMS), even if the varieties are equivalent, we observe that the hybrid ISMH-10 had the highest yield in biomass with 3638kg/ha while the hybrid ISMSH-11 had the lowest yield in biomass with 1665kg/ha. Only hybrid ISMH-10 produced more biomass than the control used, namely Gawane, which still yielded 3062kg/ha;

Regarding the productivity of the entries, it is found that there is no significant difference between the entries. The yields obtained with the most productive entries namely hybrid ISMH-11 with 2159kg/ha and the control Gawane with 2013kg/ha show that the hybrids are highly productive even if the crop conditions are special and difficult like the wintering season 2019.

Number of harvested bins (NPR)

The analysis of variance (ANOVA) showed a significant effect (P=0.00496). Thus, the entries are different according to the number of harvested bunches. The largest number of harvested bunches was obtained by the hybrid ISMH-02 with 37 bunches while ISMH-11 obtained the smallest number with 12 bunches, it is followed respectively by ISMH-04 (36 bunches), ISMH-06 (35 bunches), ISMH-08 (34 bunches), ISMH-03 and ISMH-10 (32 bunches), ISMH-05 (31 bunches), ISMH-09 (30 bunches), ISMH-01 (28 bunches), ISMH-07 (27 bunches). The control with 29 bunches has the majority of hybrids. Thus, these hybrids, which are more productive than the control, are good and can be retained for multi-local tests.

The test of comparison (PPSD) of the means at the threshold of α=5% made it possible to classify them in two categories (a and b)

Weight of the ears (PDE)

The highest weight is obtained by ISMH-09 with weight of ears equal to 5810g and the lowest weight obtained by ISMH-06 with PDE equal to 2170g. For the other varieties: ISMH-01(4760g); ISMH-02(3135g); ISMH-03(3960g); ISMH-04(3880g); ISMH-05(3915g); ISMH-07(5430g); ISMH-08(4822.5g); ISMH-10(5200g); ISMH-11(5070g); TEMOIN (5310g).

Analysis of variance (ANOVA) showed a significant effect (P=0.0413). The test of comparison of means (PPSD) at the threshold of α=5% allowed to have a classification of varieties in five categories which are: a, ab, abc, bc and c.

Discussion

As regards the sowing-flowering cycle, the results showed a non-significant difference between the varieties tested and the local control used. These results seem to be in contradiction with those of Mauder (1998) according to which the heterosis of the hybrids can be manifested by the precocity. However, it must be recognized that the control used is not related to any of the hybrids tested and was chosen for its earliness and productivity as a PVP variety. Referring to the parents, which are local populations of low productivity and late, we can say that significant gains were made on the cycle and grain yield. Thus, the results obtained would be in line with those of Tiko (2005) who found that hybridization can lead to a shortening of the cycle ranging from 2 to 31% compared to the late parent.

Regarding the height of the plants, the results show us that for all the hybrids studied, their averages are higher than the control. This can be explained by the heterosis effect that hybrids have for height. This confirms the results of Tiko (2005), showing that in general hybrids can express positive heterosis for plant height with a considerable increase in size.

For thousand kernel weight, the results showed that there was no difference between the hybrids and the control. Since the OPV variety is not related parentally to any of the hybrids, these results are in line with those of Chantereau and Nicou (1991) that thousand grain weights are variety dependent. With respect to mildew incidence, we see that the tested entries are little or not at all sensitive. These results seem to contradict those of Mbaye et al. 1986, who stated that no variety could be

Alpha CISSE, Ousmane SY, Souleymane DIA, Mouhamadou Lamarana KEITA, Anta DIOP, Aboubacry KANE, and Mbacke SEMBENE, "Evaluation of the Agro-Morphological Characteristics of Eleven (11) Hybrid Varieties in the Agro-Climatic Conditions of the Southern Center of the Groundnut Basin of Senegal (Nioro) During the Winter Season 2019," *International Research Journal of Advanced Engineering and Science*, Volume 7, Issue 2, pp. 227-231, 2022.

resistant to mildew, which remains the greatest pandemic for millet in the Sahel. The negative relationship between flowering cycle and yield indicates that later varieties are less likely to produce well in the Nioro area. These results are consistent with those of Ndiaye, (1987), who argues that late flowering can only be associated with good yield if climatic conditions are favorable.

Similarly, our results show that most hybrid varieties are less productive than the control. These results are contradictory with those of cheikh et al, (2006) who said that because of the phenomenon of heterosis, the hybrid varieties are more productive than the conventional varieties even if the control Gawane was chosen for its short cycle and its high productivity.

Concerning the biomass weight, the results of the analyses show that the highest biomass yield is obtained by a hybrid ISMH-11 with 3638kg/ha. Regardless of the fact that the control was chosen only for earliness and grit production, these results can be considered contradictory with the findings of Sy et al., 2015 who said that local varieties were characterized by large plants and a lot of biomass.

IV. Conclusion and Outlook

The results showed that the best yield was obtained by a hybrid from the national program (ISMH-10) followed by the control Gawane. The latter showed good performance with respect to the selection criteria based on earliness and grain production.

In relation to the objective set by the CNRA hybrid program, i.e. zero attack of mildew, it can be said that the hybrids gave overall satisfaction with a low incidence of mildew despite the difficult rainfall conditions favorable to the development of mildew:

-To repeat the trial in order to find favorable agroclimatic situations and to have correct data on the potentialities of the tested entries.

To conduct multi-local trials with the hybrid ISMH10, which has shown its precocity and high grain yield despite difficult climatic situations;

-To test the hybrids in other agro climatic zones such as the North of the country in view of the precocity of the entries;

References

[1]. Chantereau J., Nicou R., Sorghum. The tropical agriculture technician. No. 18. Maisonneuve and Larose, Rome, 159p 1991.
[2]. Sheik, O.T.A. ; Savadogo, A.; Bayane, Y. & Traore, S.A., A comparative study on nutritional and technological quality of fourteen (14) cultivars of Pearl millet [Pennisetum glaucum (L) Leeke] in Burkina Faso. Pakistan Journal of Nutrition 5(6), p:512-521. 2006.
[3]. FAO and ICRISAT, The world Sorghum and Millet Economies: Facts, Trends and Outlook. Basic Foodstuffs Service, FAO Commodities and Trade Division and the Socioeconomics and Pollicy Division, International Crops Research Institute for the Semi-Arid Tropics. ICRISAT, Andhra Pradesh; FAO, Rome 1996.
[4]. FAO, West African Catalog of Plant Species and Varieties. Rome: CEDAO UEMOA-CILSS, 109p 2008.
[5]. ICRISAT, Proceedings of the International Pearl Millet Workshop. ICRISAT Center, Patancheru, India, 354 p. 1987.
[6]. Mauder, A.B., - why hybrids?. In Axtell J.D., INRAN (Editors) "West African workshop on hybrid sorghum and millet seeds". Nigeria, 560p. 1998
[7]. Mbaye, D.F., Simple method for evaluating losses caused by downy mildew (S. graminicola), smut (J. penicelluriue) and ergot (C. fusufomis) of millet. ICRISAT Millet Workshop, Zaria, Nigeria, 10p. 1988.
[8]. Moumouni, Construction of a genetic map for millet, Pennisetum glaucum (L.) R. Br., using a genotyping by sequencing (GBS) approach. Master's thesis in plant biology. Laval University, Quebec, Canada, 93 p. 2014.
[9]. Ndiaye, M., Internship report from September 14 to December 4, 87 at ITA, Abidjan-Nigeria, 36p. 1987.
[10]. Oumarou Abdoulaye MOUSSA 1 *, Issoufou Hassane BIL-ASSANOU 2, Abdelkader, Mahamane SOULE 3, Ali Mahamane 4, Mahamane SAADOU 1 and Maïnassara ZAMAN-ALLAH 1., Relationship between yield and its components under water deficit conditions in maize (Zea mays L.). Africa SCIENCE 16(1) (2020) 21 - 29 21 ISSN 1813-548X.
[11]. Sy, O.; Fofana, A.; Cisse, N.; Noba, K.; Diouf, D.; Ndoye, I.; Sane, D.; Kane, A.; Kane, N.A.; Haussman, T.H. & Elwegan, E., Study of the agromorphological variability of the national collection of local millets in Senegal. Journal of Applied Biosciences 87, p:8030-8046. 2015.
[12]. Tiko H., Evaluation of the morphological characteristics of sorghum guinea hybrids (Sorghum bicolor (L) Moench). Thesis of agricultural engineer, Institute of Rural Development/Polytechnic University of Bobo-Dioulasse, 63p 2005.

Alpha CISSE, Ousmane SY, Souleymane DIA, Mouhamadou Lamarana KEITA, Anta DIOP, Aboubacry KANE, and Mbacke SEMBENE, "Evaluation of the Agro-Morphological Characteristics of Eleven (11) Hybrid Varieties in the Agro-Climatic Conditions of the Southern Center of the Groundnut Basin of Senegal (Nioro) During the Winter Season 2019," *International Research Journal of Advanced Engineering and Science*, Volume 7, Issue 2, pp. 227-231, 2022.