Original Research Article

Evaluation of Agronomic Performance of Rice Varieties (*Oryza Sativa* L.) Selected by anther Culture in the Senegal River Valley (VFS)

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Abstract: Rice (*Oryza sativa* L.) is one of the most widely grown cereals in the world and is the staple food for much of its population. Senegal, a major consumer of rice, uses the international market to cover its needs. Improving the productivity and organoleptic characteristics of grains is one of its research areas to secure this food. In this context a screening of 120 new rice lines from varietal selection with anther culture in VFS was undertaken on the basis of seven (7) characters. This study is carried out in the experimental station of ISRA Saint-Louis, in the commune of Fanaye. Its objective is to evaluate the variability existing between 4 control varieties. The design used is an "augmented design". The results obtained show that, apart from the yield, the six (6) other parameters have significantly significant differences between the controls. The comparison of them and the controls shows very interesting agronomic performances of some of them. Frequency analysis revealed that 44.16% of the lines were extra vigorous, 15% had a greater height at maturity than those that were popularized and 12.50% had a smaller height. The combination of all these variables permitted leaving of the collection 40 best varieties to be advanced in a preliminary participatory yield trial.

Keywords: Rice, Screening "augmented design", Senegal River Valley (VFS).

INTRODUCTION

Rice has become the major source of energy for both urban and rural populations [1]. As the world's second-largest food crop and the main food source for nearly half of the world's population, rice contributes more than 20 percent of global calorie consumption [2].

West Africa covers only 60% of its needs and is therefore one of the world's major rice import poles. In Senegal, rice production accounts for only 0.30% of total West African rice production estimated at 6,136,000 tons [3]. Domestic production of paddy rice has been steadily increasing since the 2000s. Total production increased from 436,000 tons in 2013 to 559,000 tons in 2014 and 906,000 tons in 2015 [4]. However, Senegal still uses the international market. Its rice consumption is about 1,050,000 tons in 2014 [5].

The Senegalese government has made rice self-sufficiency one of its development priorities and set itself a purpose of producing 1,600,000 tons of paddy to feed a population of 14.6 million in 2018.

At present, the increase in rice production is not only related to yield improvement but also to varietal creation to solve problems related to biotic and abiotic constraints.

To face this great challenge, agricultural research has brought a new technology of variety improvement called anther culture. The latter has contributed to the reduction of production costs, the intensification of rice cultivation and the creation of new varieties with high yield potential.

The establishment of high yielding varieties depends mainly on access to the local genetic resources that are the most important raw material for the breeder and the most essential input for the farmer.

This study is conducted in Fanaye, at the ISRA experimental station in Saint-Louis, and is part of the KAFACI project, whose work aims at sustainably promoting agricultural productivity in Africa and contributing to a sustainable development consistent economic growth through technological cooperation in the agricultural and food sectors.

Its general objective is to provide producers of the VFS with rice varieties with high yield potential. Its specific objectives are to assess the suitability of each line under VFS culture conditions and to select lines for preliminary yield trials.

MATERIAL AND METHODS

Study Area

The trial was conducted in the ISRA experimental station at Fanaye (16 ° 33 N and 15 ° 46 W) in the middle Senegal River valley between February and July 2018.

Plant Material

The plant material is composed of one hundred and twenty (120) lines of rice and four (4) controls which are Sahel 134, Sahel 177, Sahel 210 and Arica 3 (Table 1).

Table-1: List of plant material

1	SR33705F2-64-3-3-HV-1	43	SR35276-2-4-3-1	85	SR35266-2-16-3-1
2	SR33705F2-76-1-1-HV-1	44	SR35276-2-4-3-2	86	SR35266-2-17-1-1
3	SR34605-HB3446-3-1	45	SR35276-2-4-3-3	87	SR35266-2-17-2-1
4	SR34609-HB3483-78-1	46	SR35278-1-7-2-2	88	SR35266-2-18-1-1
5	SR23364-133-17-1-HV-1-2	47	SR35278-1-7-3-2	89	SR35266-2-18-2-1
6	SR23364-133-261-1-HV-1-1	48	SR35278-1-9-2-1	90	SR35266-2-18-3-1
7	SR23364-133-171-1-HV-1-1	49	SR35278-1-9-2-2	91	SR35266-2-19-1-1
8	SR23364-133-184-1-HV-1-1	50	SR35278-1-9-1-2	92	SR35266-2-20-1-1
9	SR23364-128-1835-1-HV-1-1	51	SR35278-1-9-1-3	93	SR35266-2-20-3-1
10	SR23364-128-1907-1-HV-1-1	52	SR35278-1-9-3-1	94	SR35266-3-1-3-1
11	SR23364-128-1758-1-HV-1-1	53	SR35278-1-9-3-3	95	SR35266-3-1-5-1
12	SR23364-128-1762-1-HV-1-1	54	SR35278-2-8-2-1	96	SR35266-3-2-3-1
13	SR23364-128-1971-1-HV-1-1	55	SR35278-2-8-2-3	97	SR35266-3-2-4-1
14	SR23364-128-1982-1-HV-1-1	56	SR35278-2-10-1-2	98	SR35266-3-3-1-1
15	SR33705F2-60-1-1-HV-1-1	57	SR35278-2-10-1-3	99	SR35266-3-3-5-1
16	SR33705F2-60-2-2-HV-1-1	58	SR35250-1-15-1-1	100	SR34590-HB3433-1-1-1
17	SR33705F2-61-3-2-HV-1-1	59	SR35250-1-23-2-1	101	SR34590-HB3433-1-3-1
18	SR33705F2-67-1-1-HV-1-1	60	SR35250-1-23-2-3	102	SR34590-HB3433-2-1-1
19	PBR1000653-2	61	SR35250-2-3-1-1	103	SR34590-HB3433-2-2-1
20	PBR1000922-3	62	SR35250-2-4-2-3	104	SR34590-HB3433-3-3-1
21	SR34592-HB-1-HV-1	63	SR35250-2-6-2-1	105	SR34590-HB3433-4-1-1
22	SR34598-HB-7-HV-1	64	SR35250-2-15-2-2	106	SR34590-HB3433-5-1-1
23	SR34598-HB-8-HV-1	65	SR35250-2-19-1-2	107	SR34590-HB3433-6-1-1
24	SR34054-1-12-4-2-1-1	66	SR35250-2-19-3-1	108	SR34590-HB3433-7-1-1
25	SR34054-1-21-4-1-2-3	67	SR35250-2-19-3-2	109	SR34590-HB3433-7-2-1
26	SR34054-1-21-4-1-3-3	68	SR35266-2-4-1-1	110	SR34590-HB3433-7-3-1
27	SR34054-1-21-4-3-1-1	69	SR35266-2-4-4-1	111	SR34590-HB3433-8-1-1
28	SR34054-1-21-4-3-1-3	70	SR35266-2-5-2-1	112	SR34590-HB3433-8-2-1
29	SR34796-1-4-6-3-2-1	71	SR35266-2-5-3-1	113	SR34590-HB3433-8-3-1
30	SR34796-1-15-7-5-4-1	72	SR35266-2-6-1-1	114	SR35230-1-12-1-1
31	SR34034F3-71-2-1-1-3	73	SR35266-2-6-2-1	115	SR35230-1-12-1-2
32	SR34034F3-22-1-1-1-2	74	SR35266-2-7-1-1	116	SR35230-2-9-2-2
33	SR34042F3-22-1-1-1-3	75	SR35266-2-7-2-1	117	PR493
34	SR34042F3-22-1-1-5-2	76	SR35266-2-7-3-1	118	SR34590-HB3433-6-2-1
35	SR35300-1-HV-1-2	77	SR35266-2-11-1-1	119	SR34054-1-12-4-3-2-2
36	SR33705F2-60-1-2-HV-1-2	78	SR35266-2-11-4-1	120	SR33705F2-61-1-3-HV-1-1
37	SR34053 (*#5-52*)-1-4-2-10-1-2	79	SR35266-2-12-1-1	C1	SAHEL 134
38	SR34053 (*#5-52*)-1-4-2-10-3-1	80	SR35266-2-12-2-1	C2	SAHEL 177
39	SR34053 (*#5-52*)-1-4-2-10-3-2	81	SR35266-2-12-4-1	C3	SAHEL 210
40	SR35285-2-8-4-1	82	SR35266-2-12-5-1	C4	ARICA 3
41	SR35274-5-1-1-2	83	SR35266-2-16-1-1		
42	SR35274-5-1-2-1	84	SR35266-2-16-2-1		

Experimental design

The design is an augmented design with 15 blocks of 12 elementary plots each. Each elementary plot has an area of 2 m^2 and has 6 rows of 11 pockets.

Conduct of the test

The seeds are soaked and incubated for 48 hours before being sown. After four (4) weeks, the plants are transplanted with spacings of 0.20 m between the lines and 0.20 m between the pockets, due to two plants per pocket. Each variety is planted on 6 rows of 2 m long. The four (4) central lines of each parcel constitute the useful plot.

Manure application 18-46-0 was made two (2) days before transplanting at a rate of 100 kg / ha and urea was used for coverage at 300 kg / ha in three (3) inputs.

For irrigation, the frequency was based on need. Chemical weeding was carried out in all plots with propanil (8 l / ha) and weedone (1 l / ha) respectively 1.6 mm and 0.2 mm per plot. Guarding has been provided against grain-eating birds from the flowering to the harvesting.

Harvesting was done manually when 80% of panicle top grains started to turn yellow. Ten (10) panicles were collected per line for further observations in the laboratory.

Observations and measures of variables

They focused on seven (7) variables:
- Average number of tillers (NT): The count was carried out on eight (8) plants per line.
- Average height of plants at maturity (HM): Eight (8) plants per line, randomly selected, are measured from the soil surface to the end of the last leaf.
- Sowing-to-maturity cycle (NDM50): It is obtained by counting the number of days separating the sowing and the maturity of the plants when 3/4 of the panicles have a straw color.
- Sowing cycle (NDH50): This corresponds to the number of days between sowing and heading at 50%.
- Yield (YIELD): It was calculated on the basis of a weight sample taken per m^2 on each plot then extrapolated in tons per hectare.
- 1000 grains weight (W1000G (g)): 1000 well-developed whole grains dried at 14% humidity are weighed on a precision scale
- Sterility (STER): This is the ratio of the number of empty grains to the total number of grains (filled + empty) multiplied by one hundred (100). It is expressed in%.

Data Processing and Analysis

Data processing was performed using the Microsoft Office Excel 2013 Spreadsheet (Word and Excel). The ARIS software permitted us to do the statistical analysis, in particular the analysis of variance at the 5% threshold.

RESULTS AND DISCUSSION

RESULTS

The agro-morphological characteristics evaluated are recorded in table 2. They concern the number of days at 50% heading (NDH50), the number of days at 50% maturity (NDM50), the weight 1000 grains (W1000G), the yield (YIELD), the average height of the plants at maturity (AHM), the number of tillers (NT) and sterility (STER).

Table-2: Agro-morphological characteristics of the lines evaluated

Varieties		NDH50	NDM50	W1000G (g)	HM (cm)	NT	YIELD (Kg/ha)	STER (%)
Lines tested	Minimum	75	112	15	57.12	6	5312	4.8
	Maximum	153	139	32.28	120.12	25	15729	93.6
	Moyenne	108	129	23	88	14	9220	26.3
Controls	S134	92	123	21	77	20	12304	26
	S177	101	138	24	84	16	11870	55
	S210	118	133	24	91	17	11025	20
	Arica 3	121	134	21	100	20	11339	23
	Pr(>F) controls	6.50E-11	6.32E-05	9.167E-07	1.57E-06	0.0007799	0.5347688	0.0112299

Agro morphological evaluation of the lines
Number of days at 50% heading (**NDH50**)

It varies between 75 for SR34034F3-71-2-1-1-3 and 153 days for SR35278-1-9-3-1. Sahel 134 is the best control compared to other controls. Among the 120 entries, there are 8 lines, or 6.67%, which have a number of days at 50% heading (92 days) lower

than that of Sahel 134. The line SR34034F3-71-2-1-1- 3 at 50% heading is similar to Sahel 134. The remaining lines, 92.5%, are well above the average of the Sahel 134.

The analysis of the variance indicates a significant effect at the 5% threshold between the controls (p-value = 6.50E-11).
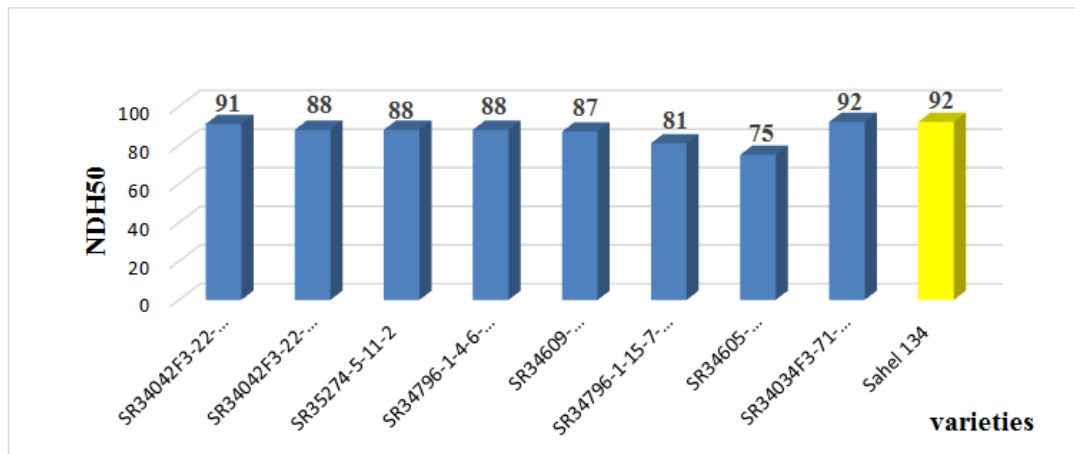
Our results are illustrated in Figure-1.

Fig-1: Variation in the number of days at 50% heading according to varieties

Number of days at 50% maturity (NDM50)

For this parameter, Sahel 134 is the best control compared to other controls with a value of 123.67 days. Fourteen (14) lines, or 11.67% have a lower average cycle than the control Sahel 134 with an average of 124 days. The remaining 106 lines all have a higher average cycle than Sahel 134.

The analysis of the variance indicates a significant effect at the 5% threshold between the controls (p-value = 6.3E-05). These results are illustrated in Figure-2.
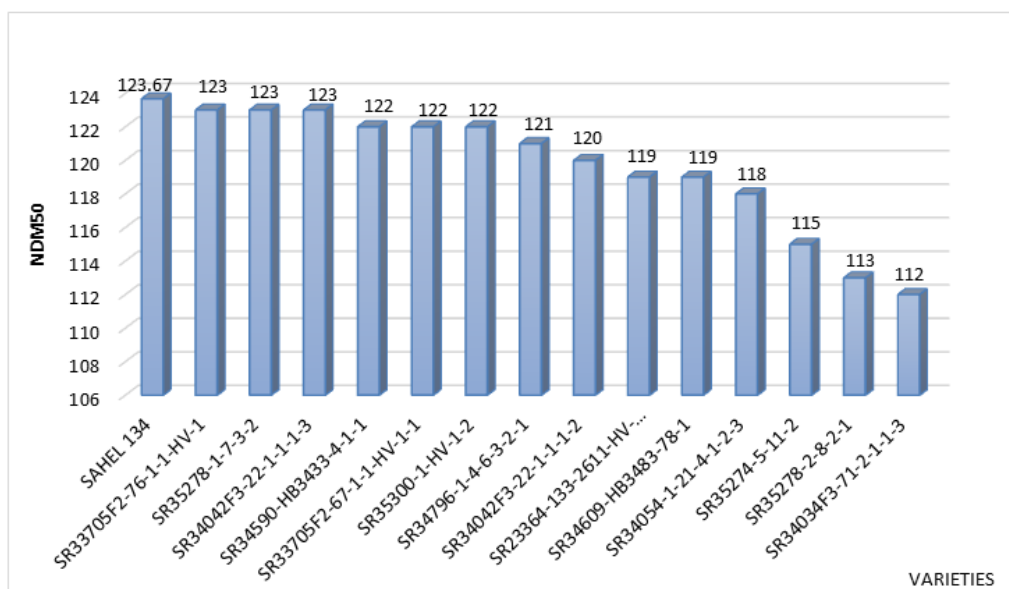

Fig-2: Variation in the number of days at 50% maturity according to the varieties

Weight 1000 grains (W1000G)

For this parameter, it is the control Sahel 210 which is better compared to the others with a value of 24.9 g. The 1000 gram weight varies between 15 and 32.28 g. For this trait, 32 lines that is to say 26.67%, have a weight of 1000 grains, located above Sahel 210 with an average weight of 24.92 g (Figure-3). The 73.33% of the remaining lines are below this control.

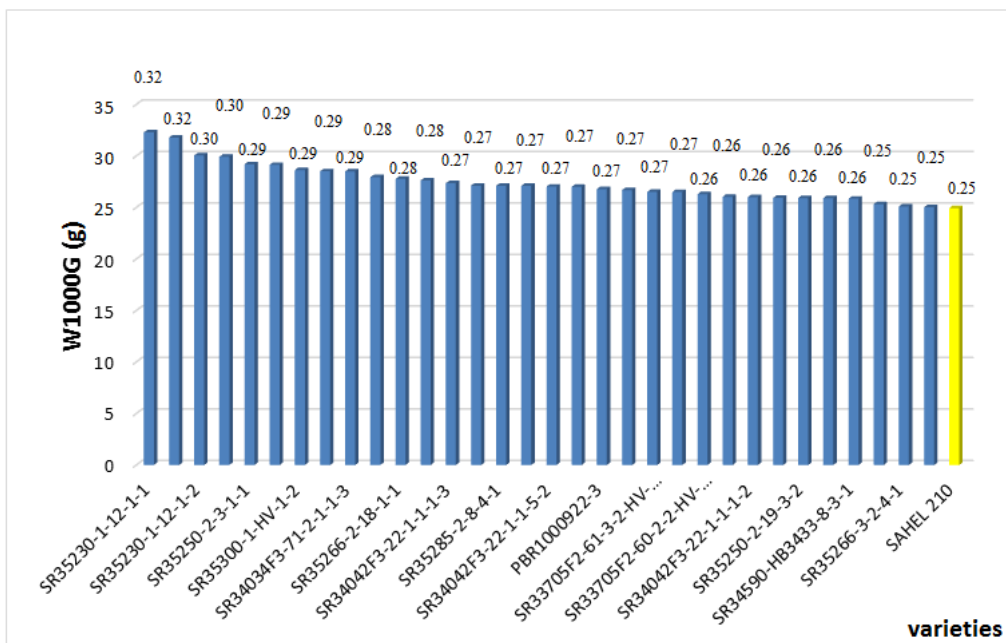Variance analysis indicates a significant effect at the 5% threshold between controls (p-value = 9.2E-07).

Fig-3: Variation of the weight of 1000 grains according to the varieties

Yield (**YIELD**)

Sahel 134 has the best performance compared to other controls.

The highest yield is achieved by line SR34605-HB3446-3-1 with 15.72 T / ha which largely exceeds Sahel 134 with an average yield of 12.3 T / ha. 11.67% of the lines (14 individuals) have a yield superior to the best of the controls, Sahel 134. 88.33% (106 individuals) of the lines have a yield below the average of the best control (Sahel 134).

The analysis of the variance does not indicate a significant effect at the 5% threshold between the control varieties (gain = 053477).

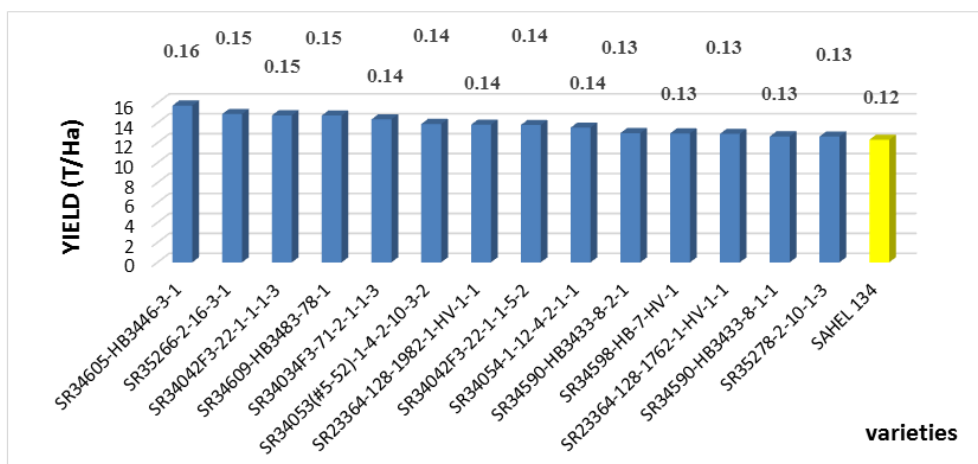Our results are illustrated in Figure-4.

Fig-4: Variation in yield by variety

Average height (AH)

The control Arica 3 reveals an average height of 100.63 cm, larger than those of the other controls. Eighteen (18) lines, or 15%, have an average height above the best control Arica 3. The line SR35300-1-HV-1-2 has the highest height with 120.12 cm much greater than that of Arica 3. 85% of the entries are below this average of Arica 3.

The analysis of the variance indicates a significant effect at the 5% threshold between the controls (gain = 1.6E-06). This makes it possible to classify the varieties into two groups: large size (Figure-5) and short size (Figure-6).
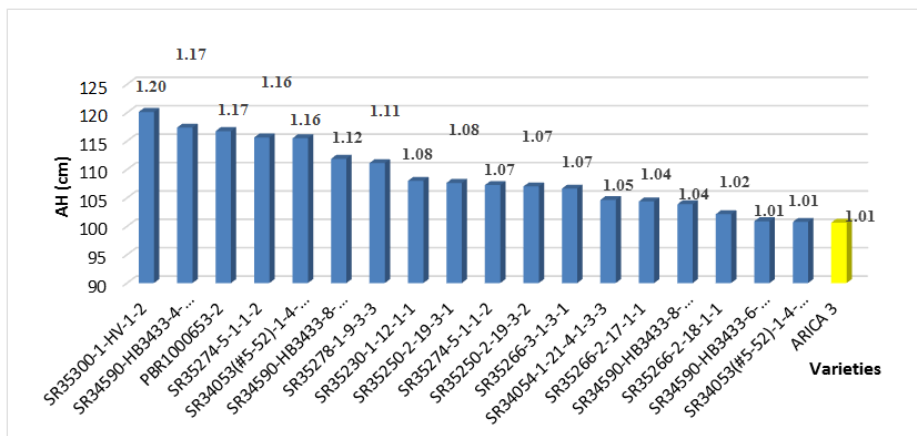
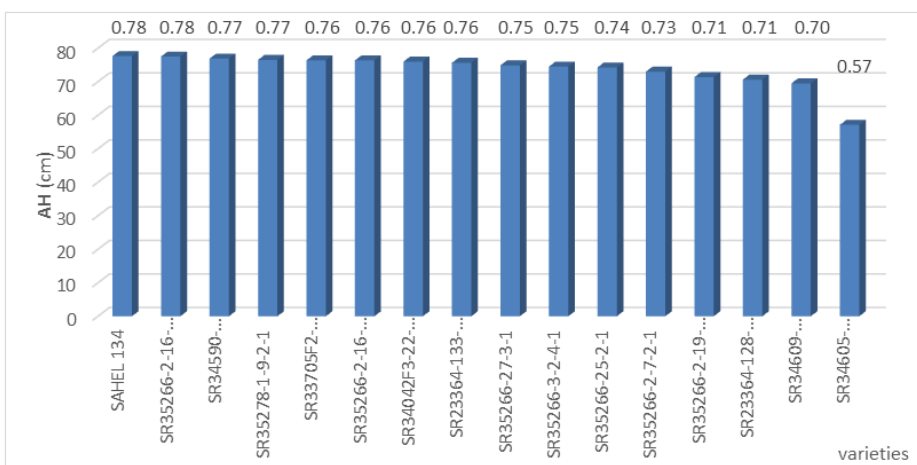**Fig-5: Large size variation according to lineages**

Fig-6: Variation in short size by variety

Fifteen (15) lines, or 12.50%, have an average height below the average of this control which is 77.65 cm. The lowest height is possessed by the SR34605-HB3446-3-1 line with an average of 57.12 cm.

Number of tillers (NT)

Sahel 134 and Arica 3 have the same number of tillers and they are the best compared to the other controls for this character. As shown in Figure-7, three (3) individuals, 2.50%, reveal a number of tillers higher than the two best controls (20 tillers). This is line SR23364-133-184-1-HV-1-1 with 25 tillers and holds the record for this parameter, followed by the SR23364-128-1762-1-HV-1-1 with 24 tillers and finally the SR23364-133-171-1-HV-1-1 with 21 tillers. 97% of the lines show a medium tillering lower than the best controls. The analysis of the variance indicates a significant effect between the controls (gain = 0.00078).
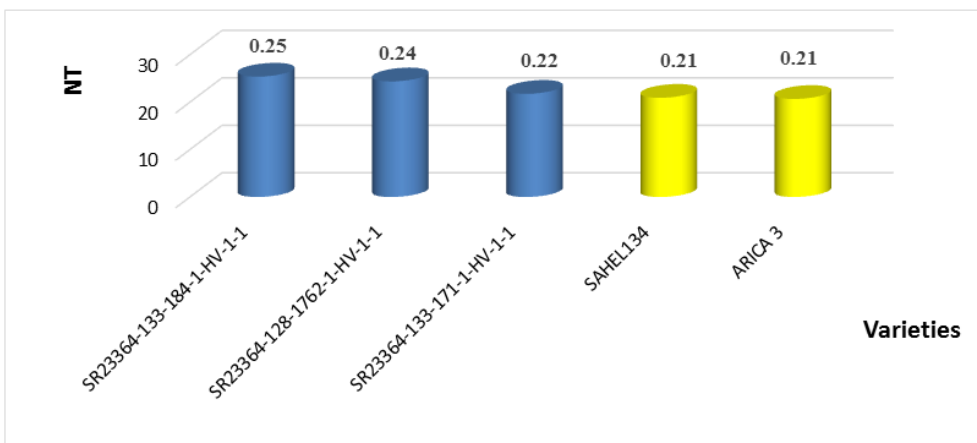

Fig-7: Variation of the number of tillers according to the varieties

Sterility (STER)

Sahel 210 is better compared to other controls for this parameter. Fifty-three (53) of the entries, 44.16%, have infertility below the average of the best control, Sahel 210. The line SR35274-5-11-2 has minimal sterility with an average of 4, 80%, much lower than that of Sahel 210, which records an average of 20.56%. 55.84% of the lines all have greater sterility than that of Sahel 210. These lines therefore have a sterility greater than 20.56%. The analysis of variance indicates a significant effect between the controls.

Characterization of Classes

The classification by the K-means method grouped the one hundred and twenty (120) lines into three classes, highly distinct from each other at the threshold of 5% on the basis of seven (07) agro-morphological variables. The means of the variables for each of the classes obtained are recorded in Table-3.

Table-3: Average parameters according to the different classes

Classes	AH	NDH50	NT	YIELD (Kg /ha)	STER (%)	NDM50	W1000G (g)
1	88.91	110.23	12.91	7203.45	27.28	130.51	23.273
2	84.60	100.31	15.81	13346.65	27.21	121.21	22.43
3	90.58	110.91	15.58	9925.185	25.00	129.53	23.16

The analysis of this classification shows essentially in class 1, high sterility, a semis-maturity cycle and a relatively short semis-heading cycle. The lines of classes 1 and 2 are those with the best tillering and good grain yields. Class 3 lines have the weakest tillering abilities. The larger lines in the collection are those that also have a large weight of 1000 grains and these lines are grouped in classes 2 and 3.

DISCUSSION

The results of the lineage classification revealed that the first class, consisting of 17 lines, contains the controls Sahel 134 and Sahel 177 which are the most used varieties in the Senegal River Valley (VFS). It can therefore be assumed, on the basis of the similarity between individuals of the same class, that these lineages would be like these popularized varieties or possess their agronomic and morphological characteristics. The second class, comprising 47 individuals, contains Sahel 210 and Arica 3. In Senegal, Sahel 210 produces an average of 12 T / ha [6]. This value is similar to the class 1 average. Such a result suggests that these lines are as efficient as the varieties certified from the point of view of productivity.

In class 3, which includes 56 lines, the control varieties are absent. It is therefore an intermediate class. The lineages that compose it, however, have quite remarkable performances. Indeed, they have the greatest weight 1000 grains (23.27g).

Class 1 lineages are to be maintained in the breeding process and will be supplemented with the best class 2 lineages with higher yield than Sahel 210.

Regarding the agro-morphological evaluation, there is an increase in the number of days at 50% heading of the control Sahel 134 of 22 days compared to those obtained in hot off-season which are on average 70 days [6]. This would be due to unfavorable climatic conditions; indeed, the cold weather often extends the cycle [7]. Eight (8) individuals have an earlier cycle than Sahel 134. The precocious cycle of SR34605-HB3446-3-1 line (mean NDH50 = 75 days) is an interesting and exploitable trait for varietal selection. These lines are promising for the intensification of double culture. The vegetative cycle is an important factor that can be used as a factor in the control of climatic chance, pests and also in guaranteeing the food security of populations [8].

Fourteen (14) lines have an earlier cycle than the Sahel 134 which has, on average, a duration of 124 days, which is a characteristic very much appreciated by the producers. Indeed, the number of days at 50% maturity (NDM50) is very decisive in the choice of varieties among farmers. Unfortunately, these varieties have not always been the most productive. There is also a decrease in the number of days at 50% maturity of Sahel 134 of 7 days compared to those obtained in hot off-season [6].

With regard to the 1000 grains weight, 26.67% of the lines have a higher W1000G than that of Sahel 210 (average W1000G = 24.92 g). There is also an increase in the weight of 1000 grains of the Sahel 210 of 2.08 g compared to those obtained in hot off-season [6]. This difference would be due to environmental variations or the technical route. So these are varieties that are apparently much more plastic opposite the rainfall regime, but this is a hypothesis that needs to be confirmed. SR35230-1-12-1-1 holds the record with 32.28 g of W1000G and dominates Sahel 210 for this trait. This shows that these lines all have large grains. Indeed, according to [9], the W1000G depends a lot on the size of the grains.

Regarding the yield of grains, there was not a significant effect between the control varieties at the 5% threshold. Fourteen (14) individuals yield above the Sahel 134 average of 12.3 T / ha. We note an increase in yield of the Sahel 134 of 2 T / ha compared to those obtained in hot off-season [6]. It could be inferred that there are lines that are more productive than control varieties. The

maximum yield is estimated at 15.729 T / ha for the variety SR34605-HB3446-3-1. These lines are really promising for ensuring people's food security. It should be noted that yield criteria often appears in the choice of varieties by producers [10].

For the variable height at maturity, there is a great variability between the control varieties at the 5% threshold. This result is confirmed by [11], who found that height is a variable that discriminates rice populations. Thus two groups have been identified for this character:

- The first group, consisting of 18 lines that have a higher average height than Arica 3 (average height = 100.62 cm). The highest height is estimated at 120.12 cm. From this result, it is deduced that there are varieties that are larger than the controls. So these lines could be victims of the phenomenon of shading, but this is not always verified. Such a result is in agreement with those of [12] that shading resistance is not correlated with plant size.
- The second group, consisting of 15 individuals with an average height below the average of Sahel 134 (mean height = 77 cm). We recall indeed a decrease in the height of Sahel 134 by 6 cm compared to the results obtained in hot off-season [6]. This could be due to the management of the water slide as confirmed by [13], who notes a 56% increase in rice size depending on the thickness of the water slide. The smallest height is 57.12 cm. From the foregoing, it is deduced that there are lines that are smaller in size than the controls.

With regard to average tillering, it should be noted that 3 individuals have a tillering located above the average of the control varieties which each record an average of 20 tillers. Our results are similar to those obtained by Anonymous [6] according to which Sahel 134 has a good tillering. The lines SR23364-133-184-1-HV-1-1, SR23364-128-1762-1-HV-1-1 and SR23364-133-171-1-HV-1-1 are the best for this trait in the entire population studied with respectively 25, 24 and 21 tillers. These results are in phase with those of Lacharme [9] who showed that the duration of the tillering phase for a medium to long cycle variety is greater and in general and its ability to taller is greater. From this result, it is deduced that there are lines that have greater tillering than the control varieties.

The inventory of qualitative character is important for an agro-morphological characterization study. The analysis of variance carried out in this study revealed that there is a great variability within the controls for the measured qualitative character. Fifty-three (53) lines, ie 44.16%, show infertility below the average of Sahel 210 (average sterility = 20.5627%). This result shows that there are lines that have a lower sterility rate than the control varieties. These are all promising lines for food security. This sterility could be due to several factors such as cold, light, water stress, wind, spacing, season, fertilizer, variety, etc. Badiane [14] confirms these results by showing that the lack of light at the time of panicle formation increases the number of sterile spikelets.

In view of the results and by combining statistical and variance analyzes on agro morphological variables, the third of the varieties, ie 40 lines, could be chosen. These are lines that are better than controls. These lines could soon be followed by a preliminary and participatory test (PET) of first yield.

CONCLUSION

This study revealed a great variability within the collection. The classification by the K-means method allowed to group the lines into 3 classes, based on seven agro-morphological variables.

Six (6) parameters out of seven (7) have significant evolutions between the controls except the yield;

Fifty three (53) lines are extra vigorous, ie 44.16% of the lines;

Fifteen per cent (15%) of the lines have a higher maturity at maturity than the popular varieties;

In addition, the study showed that the rice collection is made up of more productive lines than the control varieties with a higher number of tillers.

Overall, the characterization has made it possible to obtain a database on the agro-morphological variations of these new lineages which could be accessible to the scientific world.

ACKNOWLEDGMENTS

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