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RESEARCH ARTICLE **OPEN ACCESS**

ASSESSMENT OF AGRONOMIC PERFORMANCES OF AROMATIC VARIETIES IN STATIONS IN THE SENEGAL RIVER VALLEY (VFS)

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ABSTRACT

Senegal is one of the largest rice importing countries in West Africa with rice production that still fails to meet consumer demands. The State has made great efforts to make up for the deficit in local production by setting up the Program for the Acceleration of the Agricultural Cadence in Senegal (PRACAS) and the National Program for Self-sufficiency in Rice (PNAR), whose objective is to satisfy national demand with a halt in imports. To support this dynamic, the Senegalese Institute for Agricultural Research (ISRA) has revised these research activities with the introduction of a major selection component for new high-yielding rice varieties with good grain quality. It is within this framework, in partnership with BAYER, that the ISRA of Saint Louis is evaluating new varieties of hybrid rice. This study attempts to evaluate the behavior of new hybrid varieties according to two sowing methods in the Senegal River Valley. The material is composed of two hybrid varieties 6444 GOLD and TEJ GOLD and a control Sahel 108. The device is in split-plot with the sowing methods in large plots and the varieties in small plots. The effect of the sowing method on the behavior of the varieties was only noted to be significant on the cycle at maturity; the hybrids have longer cycles than the control Sahel 108 both in direct sowing and in transplanting. The varieties have different agronomic behaviors only on the weight of 1000 seeds, the length of the panicle and the duration of cycles at 50% flowering. The TEJ GOLD variety has a long panicle and a good grain load per panicle. The best performances such as very good tillering ability (6444 GOLD) and good panicle load (TEJ GOLD) were recorded in the hybrids. These hybrids would behave better in direct seeding in terms of yield, unlike the control Sahel 108. From the above, we can say that the introduction of these hybrid varieties could significantly increase rice production and productivity and contribute to achieve our self-sufficiency in rice.

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INTRODUCTION

In Africa, rice represents 25% of cereals consumed and an average per capita consumption of 60 kg/year (USAID, 2017). Despite the progress observed, in terms of extension and intensification, African rice production (31 Mt) remains very insufficient to meet the needs which are progressing under the influence of population growth, galloping urbanization and changes in eating habits (Del Villar and Bauer, 2013). Thus, only Egypt is self-sufficient (100%), followed by Madagascar at 75% and Côte d'Ivoire at 50% (FAO, 2018). In West Africa (excluding English-speaking countries and Benin), rice production reached 5.766 Mt in 2016/2017 for a consumption of 9.857 million tonnes (Mt) with a needs coverage rate of 60%.

In Senegal, the average annual rice consumption per capita is 78.1 kg with averages of 76.6 kg in urban areas (77% of cereals consumed) and 80.9 in rural areas (59% of cereals consumed) (USAID, 2014) (Del Villar and Dia, 2019). However, 742,348 tons of white rice are produced in 2020, which leads to a deficit of around 1,070,286 tons, which are imported (ANDS, 2021), which leads to foreign exchange losses of around 106 billion FCFA (APRAO, 2012). Faced with this situation, the government of Senegal has made the increase in national production a major concern. In this perspective, a production of 1,600,000 tons of paddy has been set as an objective for 2017 to achieve self-sufficiency, including a contribution of 60% from the Senegal River valley, i.e. 960,000 tons of paddy rice. However, it is clear that today this objective has not been achieved. Production is 1,015,344 tons of paddy rice, including 454,440 tons in the Senegal

River valley, i.e. 45% (FAO, 2017). One of the main constraints of this low production is the low level of cropping intensity (varieties adapted to growing conditions) (DAPSA, 2018). Among the 45 rice varieties recorded in the official catalog of species and varieties cultivated in Senegal (ISRA, 2012), less than ten (10) are currently cultivated in the Senegal River Valley (VFS), (SAED, 2015). Faced with this, the Senegalese Institute for Agricultural Research (ISRA), following the registration of the first variety of hybrid rice in Senegal "ISRIZ 09" in December 2017, has just expanded its partnership with BAYER to study the behavior of its new hybrid varieties in the Senegal River Valley. Indeed, hybrid rice known for its high yield can provide part of the solution to improve yields in the river valley. Our present study falls within this framework and tries to evaluate the agronomic performances of two hybrid varieties in station in the valley of the Senegal River. The overall objective of this study is to evaluate the agronomic performance of these hybrid varieties on station in the Senegal River valley. Specifically, it is a question of (1) characterizing the agronomic performance of these hybrids in two sowing methods and (2) comparing them to the most cultivated local varieties in the Senegal River valley.

MATERIALS AND METHODS

plant material : The plant material is composed of two varieties of hybrid rice from Compagnie BAYER (TEJ GOLD and 6444 GOLD) already approved in other West African countries such as Côte d'Ivoire. They were compared with a control, the local variety SAHEL 108 which was approved in Senegal by Africa Rice and ISRA in 1994 and has since been cultivated in the Senegal River valley. This variety is the most cultivated in the valley with more than 60% of the sown areas. It is better suited to double cropping in the face of the difficulties linked to the delay in the cropping calendar thanks to its short cycle of about 105 days in rainy season and 117 days in the dry season and its yield of 7 tons, on average, per hectare in the middle. farmer (Traoré et al., 2010). Their characteristics are summarized in the following table:

Table 1. Characteristics of plant material

Varieties	Features
SAHEL 108	- Irrigated ecology; - Potential yield 10t/ha - Good resistance to lodging; - Low shattering; Sensitive to salinity; - Good tillering, height 90 cm; - Erect panicle leaf, compact panicle; - Medium panicle exsertion, panicle length 21.5 cm - Cycle: 105 days wintering; 117 days Against hot season
6444 GOLD	- Medium cycle (135-140 days). - High production of tillers (12-15) - Resistance to bacterial leaf blight (BLB); - performing under water stress conditions. - Good machining yield (over 70%); - Suitable for direct seeding
TEJ GOLD	- Medium cycle (125-130 days). - High yield potential; - Resistance to bacterial leaf blight (BLB); - performing under water stress conditions. - good machining yield (over 70%).

METHODS

Experimental apparatus : The treatments are arranged in a split plot with three (3) repetitions. Each large plot has two (2) sub-blocks (a transplanting sub-block and a direct sowing sub-block) each containing three (3) elementary plots (varieties).

During this trial, two factors were studied:

- The sowing mode factor (main factor);
- And the varietal factor (secondary factor).

The treatments constitute the combinations of modalities of these two factors and correspond to the experimental units which are 6 in number per repetition (table 2).

Table 2. Treatments compared

sowing method / Varieties	Direct seeding (S)	Transplanting (R)
SAHEL 108 (V0)	**V0S**	**V0R**
6444 GOLD (V1)	**V1S**	**V1R**
TEJ GOLD (V2)	**V2S**	**V2R**

The assignment of the treatments to the experimental units was done with the ARIS software. The spacing between the elementary plots is 0.4 meters and between the blocks a channel ofone (1) meter. The spacing between sub-blocks is 0.5 meters. The elementary plot is 12 meters long and 7 meters wide, i.e. an area of 84 m2 and has 41 lines arranged in the direction of the width (Figure 1).

Installation and conduct of the test : The test was conducted at the ISRA station in Fanaye in Senegal in the hot off-season from February to July. The main operations during the conduct of the trial consisted of tillage, carried out with offset discs in two (2) cross passes with a depth greater than 10cm, followed by sowing of the nursery (after pre-germination and 24-hour incubation of the seeds) at a dose of 15 kg/ha for the hybrids and 40 kg/ha for the control (Sahel 108) and direct sowing carried out on the fly in a homogeneous manner over the entire plot in a blade of 5 cm of water with a dose of 30 kg/ha for the hybrids and 80 kg/ha for the control (Sahel 108). The other operations carried out were transplanting carried out three (3) weeks later, with spacings of 0.30 m between rows and 0.30 m between pockets due to two plants per pocket, fertilization with 200 kg of 9 -23-30 and 50 kg/ha of DAP in basal dressing and 300 kg/ha of 46-0-0 divided into three maintenance dressings. Finally, the water needs of the crops were met at each stage and the fight against weeds and grain-eating birds ensured throughout the trial.

The parameters measured : A sample of ten plants was chosen at random from the 37 central rows of each elementary plot and the various measurements were taken there. This is the average height at maturity, using a ruler on each plant from the base (collar) to the tip of the flag leaf at cycle maturity at 50% bloom, date where 50% of the tillers in the sample have flowered, from the cycle to maturity, determined by the number of days separating the date of sowing and the physiological maturation of the plants of a variety on an elementary plot, from the length of the panicle measured with a ruler from point of panicle insertion to tip, number of tillers/m2, number of tillers per foot, average panicle weight, 1000 grain weight and yield determined by the formula:

Grain yield in T/ha = Number of panicles per m2 * Number of grains per panicle * Percentage of full grains * Weight of 1000 grains then extrapolated in tonnes per hectare

RESULTS

The results on the variation of the agronomic parameters of the lines evaluated according to the two factors (sowing method and variety) are recorded in Table 3. They concern the number of days at 50% flowering, the number of days at 50% maturity, thousand kernel weight, yield, panicle weight, panicle length, average plant height at maturity and number of tillers per foot.

Number of days to maturity : The number of days from sowing to maturity varies from 136.67 to 111.33 days in direct sowing and from 144 to 118 days in transplanting mode (Figure 2). The two hybrids have longer cycles to maturity than the control Sahel 108 for the two sowing methods. In direct seeding, 6444 GOLD has the longest maturity cycle (136.67 days) followed by TEJ GOLD (116 days). Sahel 108, with 111 days, has the shortest cycle. In transplanting mode, 6444 GOLD, with a seedling-maturity cycle of 144 days still has the longest cycle.

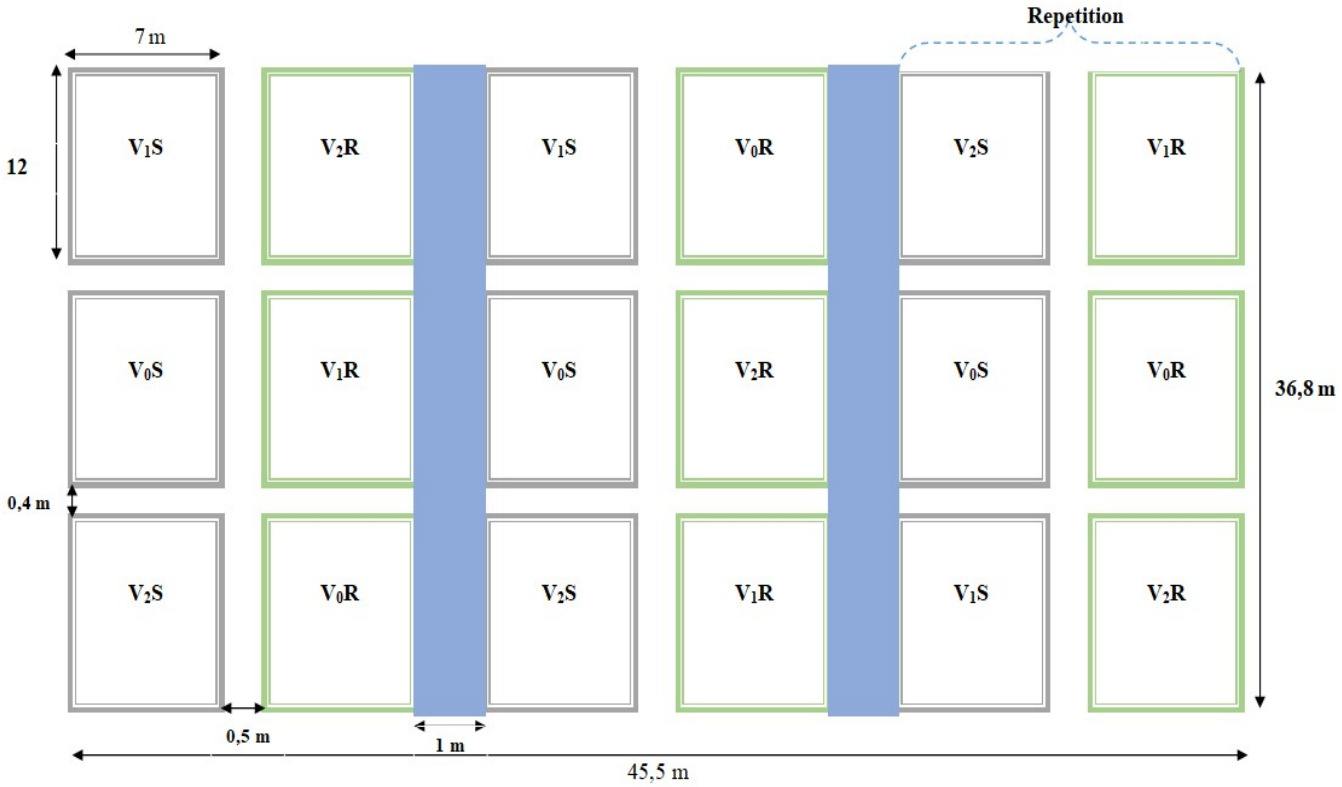

Figure 1.Diagram of the experimental device

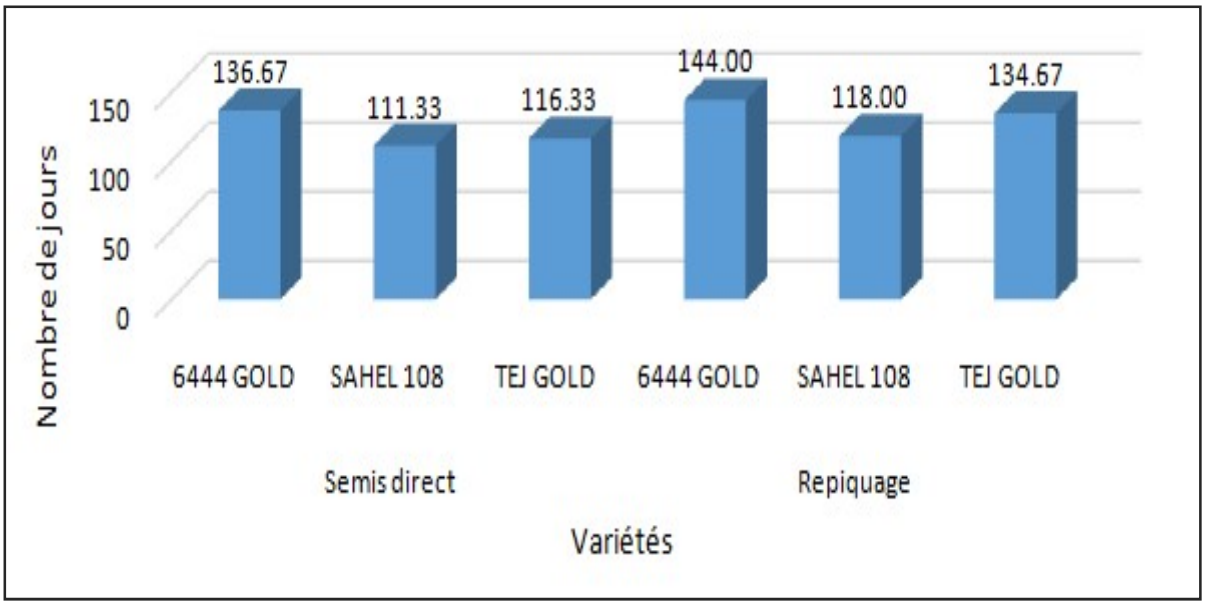

Figure 2. Number of days to maturity in the sowing methods according to the varieties

Table 3. Variation of morpho-agronomic parameters according to sowing method and variety

MODE SEMIS	Varietie	JRSMAT	HTR (cm)	JRSEP 50 %	Lpan (cm)	Ppan (g)	Tillers/m^2	PMG (g)	Tillers/feed	RDT (T)
Direct seeding	6444 GOLD	136,66	96,13	111,33	21,89	1,73	1145,66	26,20	15,66	7,43
Direct seeding	SAHEL 108	111,33	73,80	80,66	19,52	1,69	1113,66	23,06	14,46	4,96
Direct seeding	TEJ GOLD	116,33	94,80	94,33	22,70	1,67	939,00	28,11	11,86	7,46
Transplanting	6444 GOLD	144,00	100,96	117,33	24,32	2,43	317,66	30,40	27,63	4,92
Transplanting	SAHEL 108	118,00	85,70	88,33	22,61	2,50	429,33	22,53	27,23	6,95
Transplanting	TEJ GOLD	134,66	108,93	110,00	26,35	3,15	422,33	29,30	25,63	5,25
Moyenne		126,83	93,38	100,33	22,90	2,19	727,94	26,60	20,41	6,16
	CV	**13.13**	**12.77**	**14.81**	**2.73**	**0.64**	**400**	**3.9**	**7.52**	**2.53**
P-Value Semis x Var		0,04	0,30	0,27	0,45	0,11	0,35	0,41	0,91	0,28

JRSMAT: number of days between sowing and maturity; **HTR**: plant height; **JRSEP 50 %**: number of daysbetweensowing and heading; **Lpan**: Panicle length; **Ppan**: panicle weight; **Tillers/m2**: number of tillers zes per m^2; **PMG**: Thousand Grain Weight; **Tillers/feeds** : number of tillers per plant; **RDT** : Yield in T/ha.

It is always followed by TEJ GOLD with 134 days and finally, Sahel 108 which has 118 days, with the shortest cycle. The results of the analysis of variance show that the interaction of the two factors, sowing method and varieties, is significant (Pr = < 0.05) with an added value of 0.042319.

Height at maturity : The average height of the varieties varies from 94.80 to 96.13 cm in direct seeding mode. Sahel 108 has the lowest height with 73.80 cm, followed by TEJ GOLD which registers 94.8 cm. 6444 GOLD, with 96.13 cm has the greatest average height. In transplanting mode, the heights vary from 85.7 cm for Sahel 108 to 108.93 cm for TEJ GOLD. 6444 GOLD has an average height of 100.97 cm (figures 3 and 4). The analysis of variance of the sowing and variety interaction does not give a significant effect at the 5% threshold.

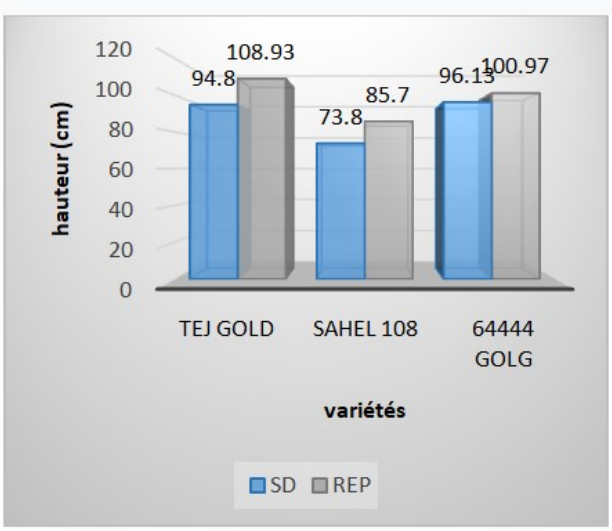

Figure 3. Height at maturity depending on the variety

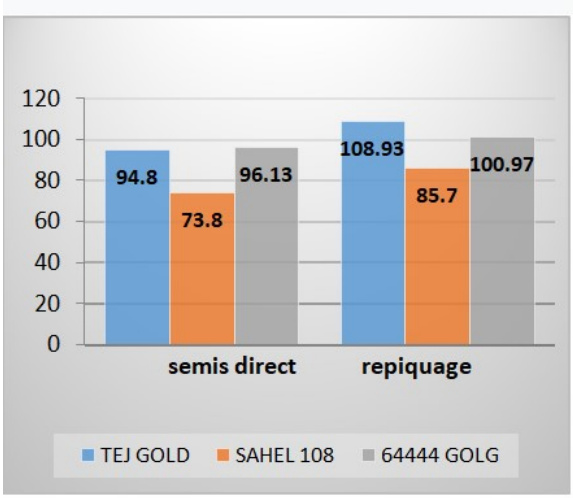

Figure 4. Height at maturity according to sowing methods

Nombre de jours du semis à 50 % épiaison : The number of days at 50% heading varies from 80.67 to 111.33 days in direct seeding mode and from 88.33 to 117.33 days in transplanting mode. In both cases, Sahel 108 is earlier and 6444 GOLD has the highest number of days at 50% flowering. The two hybrids have a much higher general cycle average at 50% heading than the control Sahel 108 with 114 days for 6444 GOLD, 102 days for TEJ GOLD and 84 days for Sahel 108 (figures 5 and 6). According to the results of the analysis of variance, we observe that the interaction between seedlings and varieties is not significant on the variation in the number of days at 50% heading of the lines tested; the general average recorded is 100 days. Also at the level of sowing mode, the difference between the means of the varieties is also not significant according to the analysis of variance. But at the varietal level, the difference is significant (Pr = < 0.05).

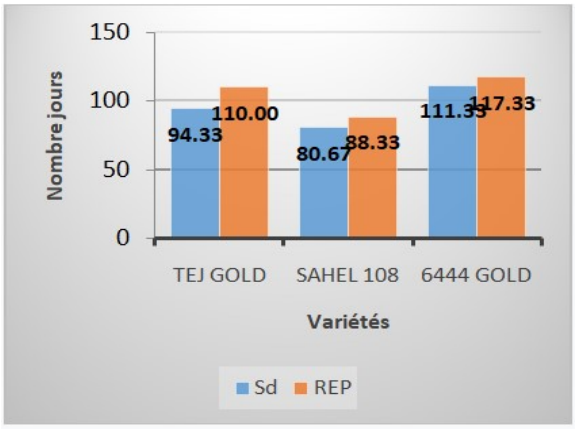

Figure 5. Number of days 50% flowering depending on the variety

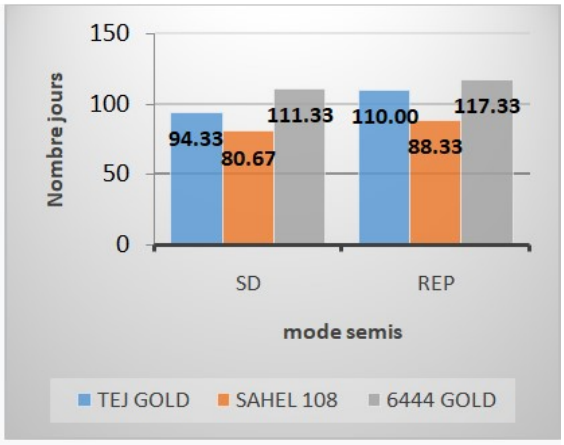

Figure 6. Number of days 50% flowering according to sowing methods

Average panicle length : The average panicle length varies from 19.52 to 22.70 cm in direct seeding mode and from 22.61 to 26.35 cm in transplanting mode. In both cases, Sahel 108 is earlier and TEJ GOLD displays the highest panicle length. The two hybrids have a general average of much greater panicle length than the control Sahel 108 with 23.11 cm for 6444 GOLD, 24.30 cm for TEJ GOLD and 21.06 cm for Sahel 108 (figures 7 and 8). The analysis of variance at the level of the interaction mode of sowing and varieties shows a non-significant difference between the averages of the treatments for the average length of the panicle. For the sowing mode also, no significant difference is recorded between the averages of the lines tested on the two sowing modes. The average recorded between the two sowing methods is 22.3 cm. At the varietal level, the difference between the means of the varieties is highly significant according to the analysis of variance (Pr≤ 0.05) with an added value of 0.0002.

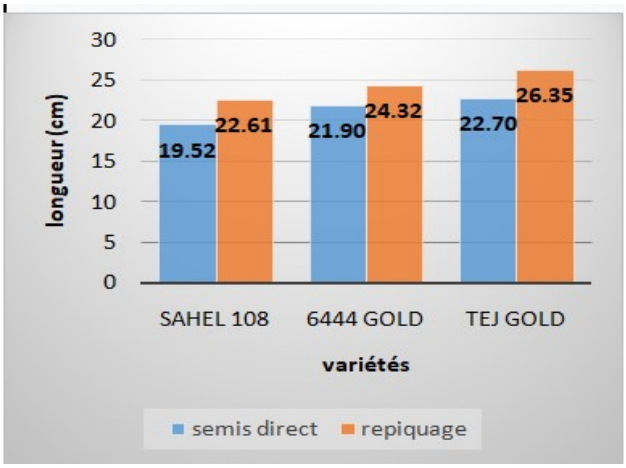

Figure 7. Panicle length depending on the variety

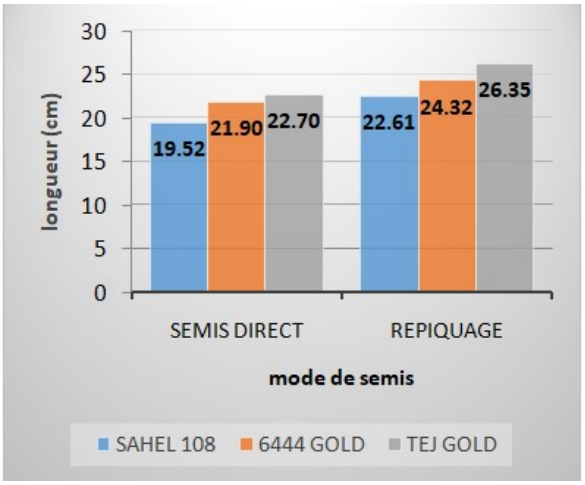

Figure 8. Panicle length according to sowing methods

Panicle weight : The average weight of a panicle varies from 1.68 to 1.73 g in direct sowing mode and from 2.44 to 3.15 g in transplanting mode. TEJ GOLD displays the lowest panicle weight in direct seeding but records the highest weight in transplanting. 6444 GOLD, which had the highest panicle weight in direct seeding, has the lowest weight in transplanting mode. On average, the panicle weight is much higher for the TEJ GOLD variety (2.40 g), followed by the control Sahel 108 (2.10 g) and the 6444 GOLD has the lowest weight (2.08 g). elsewhere, the panicle weights of the different varieties are greater in transplanting mode than in direct sowing mode (figures 9 and 10). At the level of the variety and sowing method interaction, the analysis of variance reveals that there is no significant difference between the means of the treatments. For the sowing mode too, there is no difference between the two sowing modes, the average is 2.10 g. However, at the varietal level, the difference between the means of the three varieties is significant (Pr = < 0.05).

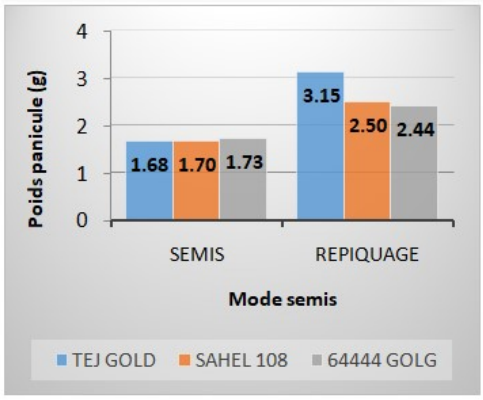

Figure 9. Panicle weight according to sowing methods

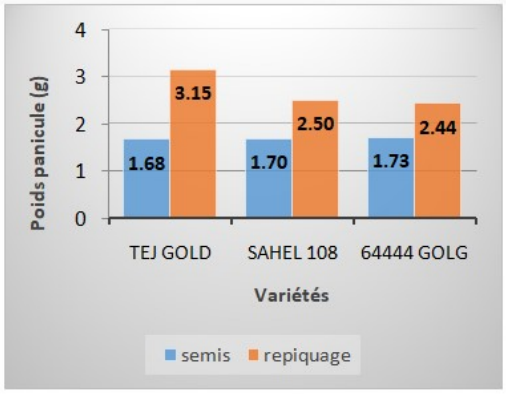

Figure 10. Panicle weight depending on the variety

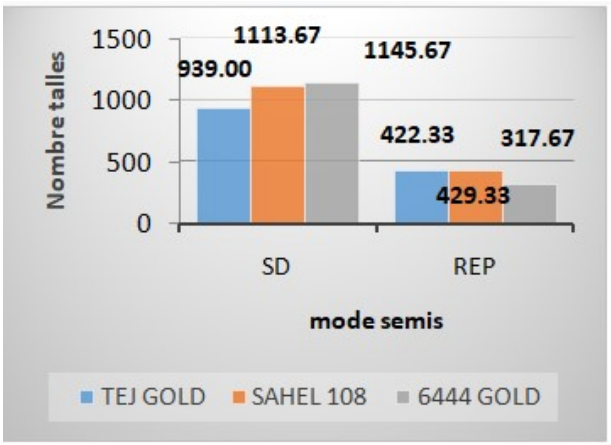

Figure 11. Number of tillersper m^2

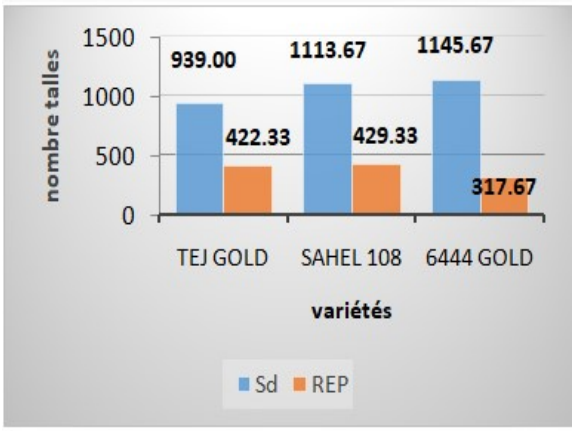

Figure 12. Number of tillersper m^2 according to sowing methodsdepending on the variety

Number of tillers per m^2 : The number of tillers per square meter varies from 939 for TEJ GOLD to 1145 for 6444 GOLD in direct sowing mode and from 317 for 6444 GOLD to 429 for Sahel 108 in transplanting mode. 6444 GOLD, which had the highest number of tillers in direct seeding, has the lowest in transplanting mode. On average, the number of tillers per square meter is much higher for the control Sahel 108 (771 tillers), followed by 6444 GOLD (731 tillers) and TEJ GOLD which has the lowest (680 tillers). Moreover, the number of tillers in the different varieties is greater in direct sowing mode than in transplanting mode (figures 11 and 12). The analysis of variance for the variety and sowing method interaction shows no difference in the variation of the means of the different varieties. For the sowing mode, the analysis reveals a significant difference at the 5% threshold. The average recorded for direct sowing is 1066 tillers and 389 tillers for transplanting. At the variety level, the difference between the different varieties put into competition is not significant; the average is 727 tillers.

Number of tillers per foot : The number of tillers per foot varies from 11.87 for TEJ GOLD to 15.67 for 6444 GOLD in direct sowing mode and from 25.63 for TEJ GOLD to 27.63 for 6444 GOLD in transplanting mode. 6444 GOLD which had the highest number of tillers in direct seeding also has the highest in transplanting mode; TEJ GOLD has the lowest number of tillers in both seeding methods. On average, the number of tillers per foot is much higher for 6444 GOLD (21.65 tillers), followed by the Sahel 108 control (20.85 tillers) and TEJ GOLD which has the lowest number of tillers per foot (18.75 tillers). Moreover, the number of tillers in the different varieties is greater in transplanting mode than in direct sowing mode (figures 13 and 14). The results of the analysis of variance show no significant difference at the 5% level for either the two factors or the interaction between the two. The general average is 20 tillers per foot.

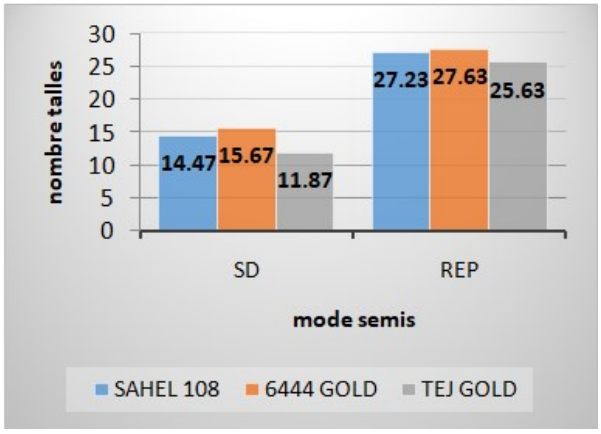

Figure 13. Number of tillers according to sowing methods

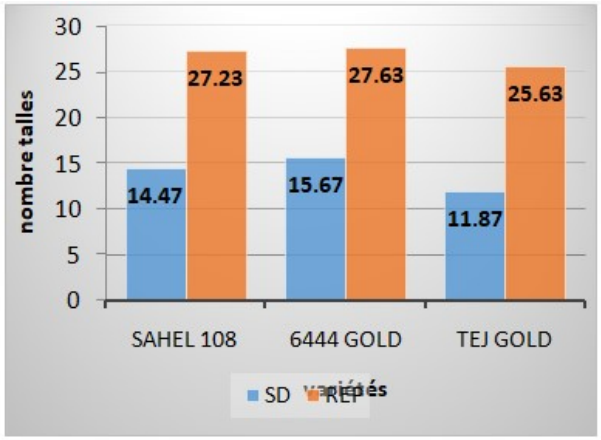

Figure 14. Number of tiller depending on the variety

1000 grain weight : The 1000-grain weight varies from 23 to 28 g in direct seeding mode and from 22 to 30 g in transplanting mode. Sahel 108 recorded the lowest 1000 grain weight in the two sowing methods. On average, the 1000 grain weight is much higher for the TEJ GOLD variety (28.40 g), followed by 6444 GOLD (28.30 g); Sahel 108 has the lowest 1000 grain weight (22.80 g). Thus, the hybrids have a greater weight than the control Sahel 108 (figures 15 and 16). The analysis of variance at the level of the sowing mode and variety interaction shows a non-significant difference between the means of the treatments. Also for the sowing mode, no significant difference is recorded between the means. The average recorded between the two sowing methods is 26.60 g. At the varietal level, the analysis of variance reveals a significant difference between the means.

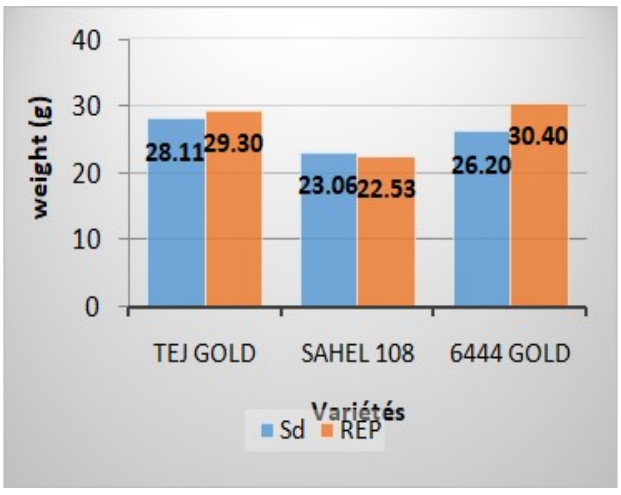

Figure 15. 1000 grain weight depending on the variety

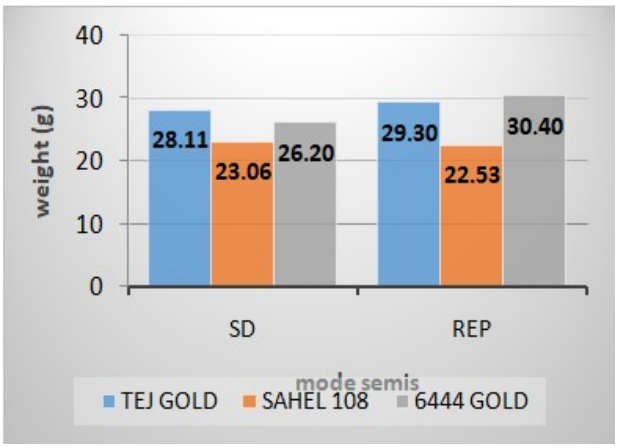

Figure 16. 1000 grain weight according to sowing methods

Average performance : The yield varies from 4.96 to 7.47 t/ha in direct sowing mode and from 4.93 to 6.96 t/ha in transplanting mode. Sahel 108 records the lowest yield in direct sowing mode but also the best yield in transplanting mode. The best yields are obtained by direct sowing. In transplanting mode, the control performs better than the others. On average, the yield is much higher for the TEJ GOLD variety (6.36 T/ha), followed by 6444 GOLD (6.18 t/ha); Sahel 108 has the lowest yield (5.96 t/ha) (figures 17 and 18). The results of the analysis of variance show no significant difference at the 5% level for the sowing method, the variety and the interaction between these two factors. The average yield is 6.16 t/ha.

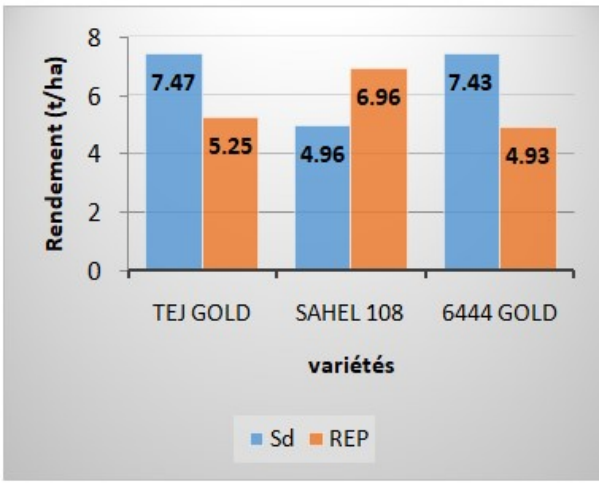

Figure 17. Average (t/ha) depending on the variety

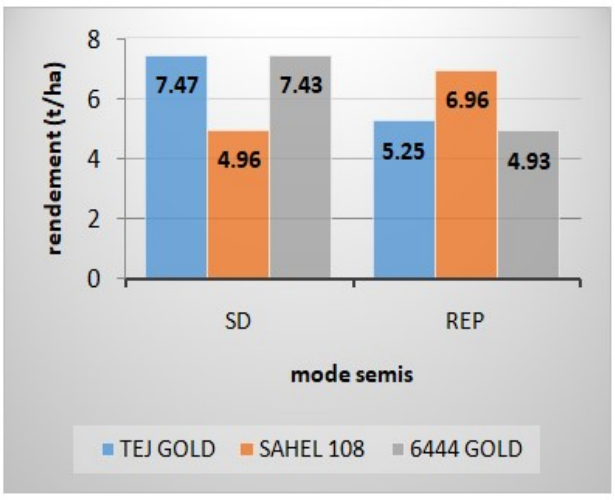

Figure 18. Average (t/ha) according to sowing methods

DISCUSSION

The sowing mode has an effect on the cycle of the varieties tested. The cycle was generally lengthened by around ten days in transplanting mode. These results are in line with the work of Lacharme (2001) and Ahmadi et al. (2002) who found that this slowness of the cycle of transplanted plants is probably due to the recovery time of the plants which varies according to the age of the plants. transplanting plants and the duration of the nursery. This recovery time is consecutive to the stress induced by the transplanting, which leads to a latency period during which the roots of the transplanted plants will get used to their new environment. The hybrid variety 6444 GOLD, which has a cycle of 144 days in transplanting and 136 days in direct sowing, could well be more suitable for wintering than in the hot off-season because of its relatively long cycle during this growing period. On the other hand, TEJ GOLD, which has a cycle somewhat similar to that of the Sahel 108 witness (134 days in transplanting and 116 in direct sowing) seems more suited to the hot dry season or even to double rice cultivation for the same reasons as above (medium cycle). This variation noted between varieties can be explained by the diversity of their genetic performance. Also, the behavior of a variety differs slightly from one sowing method to another. This variation in the varietal cycle observed according to the mode of sowing could therefore be explained by a particular adaptation of the varieties with respect to the mode of sowing. This is in line with the results of Kittika (2016) who concluded that the sowing method largely influences the sowing-maturity cycle of varieties.

The duration of the vegetative phase seems to have the same trends as the cycle at maturity. Indeed, the number of days to heading is greater for the two lines tested, 6444 GOLD and TEJ GOLD. This could be explained by environmental factors (lower temperatures) which have slowed down the cycle of these hybrids. . Indeed, during the trial, the average monthly temperatures had become low during the 2018 hot dry off-season. Remember that too low a temperature in rice can cause the plant to stop developing. (Summerfield et *al.* 1992). With regard to tillering, the results obtained show a more or less apparent diversity between the varieties. The tillering capacity of the varieties is more appreciable in the transplanting mode than in direct sowing. This confirms the work carried out by Arraudeau (1988) according to which a given variety can produce 3 to 4 tillers in direct sowing, whereas it produces 15 to 20 when it is transplanted. At the level of tillering, the hybrid varieties expressed themselves very well, the low dose of sowing allowed the varieties to express their very good potential for tillering both in direct sowing and in transplanting.

With regard to the weight of 1000 seeds, our results confirm those of Lacharme (2001) who stipulates that the PMG is a varietal factor and that the mode of sowing does not influence the filling of the grains. They also confirm the work of Rakotoarison, (2012) who had found that the weight of 1000 grains is a varietal character hardly influenced by cultural practices. On the other hand, this variability may be due to a better adaptation of the varieties to the climate of the area. during the driving period. Some varieties are more tolerant to the effect of heat which causes abortions in susceptible varieties. In addition, the various PMG of a variety according to the sowing methods can be apprehended by a better adaptation of the varieties in relation to the sowing method. Generally, the greatest PMGs were recorded at the level of direct seeding. In short, the variety as well as the mode of sowing are of great importance for the determination of the PMG and that the two hybrids had the heaviest weight 1000 grains as well in direct sowing as in transplanting mode. The yields of the new varieties varied from 4.93 to 5.25 T/ha in transplanting mode and from 7.43 to 7.47 T/ha in direct sowing. This variation in yields depending on the variety can be justified by a diversity of genetic characteristics of the varieties and the fundamental effect of the climate during the growing season (lower temperatures). According to Summerfield et al. (1992), if it is too cold (below 15°C), growth is slow and plants fail to flower. However, the differences in yields of a variety according to the sowing method does not have a genetic explanation. In terms of yields, a trend in the variation of this parameter depending on the variety was therefore observed with an advantage for hybrids in direct sowing and the opposite in transplanting. These results are in contradiction with those obtained by de Kittika (2016) who reported that the yield of the varieties was better in transplanting mode than in direct sowing mode. One could consider using these hybrids in direct sowing in the Senegal River valley where most of the sowing is carried out with this method of sowing. The variety as well as the method of sowing are of paramount importance for the production of rice.

CONCLUSION

This station study in the Senegal River valley revealed very appreciable aptitudes of the hybrid varieties 6444 GOLD and TEJ GOLD compared to the local witness Sahel 108 with regard to the agro morphological parameters. The best performances such as very good tillering ability (6444 GOLD) and good panicle load (TEJ GOLD) were recorded in the hybrids. These hybrids would behave better in direct seeding in terms of yield, unlike the control Sahel 108. From the above, we can say that the introduction of these hybrid varieties could significantly increase rice production and productivity and contribute to achieving our self-sufficiency in rice.

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