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Effects of seeding density and organo-mineral fertilization on growth and yield of a new rice variety (ISRIZ 7) in Lower Casamance (South West, Senegal

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1 ABSTRACT

Rice is one of the most important staple cereals cultivated and consumed in Senegal, Rice cultivation is the primary activity for small-scale farmers in Casamance (South West, Senegal). This study, conducted at the new rice growing station in Agriculture Research Center of Djibélor during the 2023 rainy season, aimed to assess the effects of different sowing densities and organo-mineral fertilization on the growth and yield of the lowland rice variety ISRIZ 7. The goal was to identify the optimal combination of seeding density and fertilization for maximum production. A split-plot design with four replicates was used, with fertilization as the main factor and seeding density as the secondary factor. Four fertilization treatments were tested: (T) control (no fertilization or no amendment), (FM1) 200 kg/ha NPK (15-15-15) + 150kg/ha urea (46%N), (FM2) 5tons/ha compost + 200kg/ha NPK (15-15-15) + 150kg/ha urea, and (FM3) 5tons/ha compost. Seeding densities were: (DeS1) 98plants/m², (DeS2) 61plants/m², and (DeS3) 41plants/m². Results showed that the highest plant heights occurred with low-density sowing (68.8 ± 6.1cm) and fertilization (72.2 ± 5.3cm for organo-mineral and 66.4 ± 4.7cm for mineral fertilization). Insect damage was greater in high-density plots with mineral fertilization. Tillering and panicle production increased with mineral (14.6 ± 3.8tillers/plant; 425 ± 116 tillers/m²) and organo-mineral fertilization (351 ± 99panicles/m²). The highest grain and straw yields were recorded at low seeding density (5437 ± 3359kg/ha and 6197 ± 3566kg/ha, respectively) and with mineral fertilization (4388 ± 2711kg/ha and 4930 ± 2837kg/ha). However, collar diameter, fertility rate, 1000-kernel weight, and harvest index were unaffected by either seeding density or fertilization.

2 INTRODUCTION

Rice is one of the most important staple cereals cultivated and consumed in Senegal. It occupies approximately 20% of the total cereal-growing area, with a national production of 842,819tons of white rice (DAPSA, 2024; MAERSA, 2023). However, despite the substantial output, domestic production covers only 52% of the national consumption demand, which averages 117kg per capita annually (MAERSA, 2023). Consequently, Senegal is one of the largest rice consumers in West Africa, relying significantly on imports to meet the population's needs (Del Villar & Dia, 2019). Two primary rice cultivation systems are practiced in Senegal such as irrigated rice farming and rainfed rice farming. The irrigated system is predominant in the Senegal River Valley and the Anambe Basin, where the availability of water resources supports intensive rice production (Seck *et al.,* 2013). In contrast, rainfed rice cultivation is widely practiced in the Casamance region, Eastern Senegal, and the Southern Groundnut Basin. In the rainfed system, rice cultivation is generally family-based and is mainly practiced in the natural region of Casamance, where it is generally concentrated in the lowlands (Gueye, 2004; Manzelli *et al.,* 2015). Rainfed rice cultivation in Senegal, particularly in the Casamance region, faces several constraints that significantly impact productivity. Low yields remain a persistent challenge, mainly attributed to many factors. Limited access to certify seeds as farmers often use traditional or low-yielding varieties that are poorly adapted to environmental stresses (Gueye, 2004). Also, the continuous cropping and poor soil management contribute to soil nutrient depletion and, many smallholder farmers struggling to afford chemical fertilizers despite government subsidies, limit soil nutrient replenishment and reduce productivity over time (Bationo *et al.,* 1998 ; APRAO, 2010 ; Akanza & Yao, 2011 ; Kanfany, 2014). The use of new high-performance varieties (ISRIZ) adapted to the agro-ecological conditions of the Casamance region in southern Senegal combined with good agricultural practices (sowing and fertilization techniques) could significantly increase the rice production (Faye *et al.,* 2018). Improved rice varieties, such as ISRIZ 7, have been bred for higher yields, disease resistance, and better adaptation to local climatic conditions (WARDA, 2008). Studies in West Africa have shown that the introduction of modern varieties can increase rice yields by 30-50% when coupled with appropriate soil fertility management practices (Saito *et al.,* 2013). The proper spacing of rice seedlings plays a crucial role in optimizing growth and yield. Studies indicate that planting density significantly affects tillering capacity, grain filling, and overall productivity (Saito & Futakuchi, 2009). Additionally, balanced fertilization adjusting nitrogen, phosphorus, and potassium inputs can maximize grain yield while maintaining soil health (Fageria, 2007). Soil fertility restoration is a key factor in improving crop productivity. Research has demonstrated that the combination of organic matter (compost, manure) with mineral fertilizers enhances soil structure, microbial activity, and nutrient availability (Akanza & Yao, 2011 ; Bationo *et al.,* 2012). Integrated nutrient management has been successful in other West African countries, significantly increasing rice yields (Zeinabou *et al.,* 2014 ; Bamba, 2020a)

Given the importance of improving rice productivity in Casamance, this study aims to:

- Evaluate the morphological and yield-related parameters of the ISRIZ 7 variety under different seedling spacings and fertilization levels.
- Identify the best combination of plant density and fertilization strategy to optimize rice production under rainfed conditions.

3 MATERIALS AND METHODS

3.1 Experimental site: The experiment was conducted at the Djibélor Agricultural Research Center (12°33′39″N; 16°18′25″W) in Ziguinchor region located in the south-west of Senegal (Figure 1). The soil is tropical ferruginous with a sandy texture and a low organic matter content (less than 1%) (Loyer *et al.,* 1986).

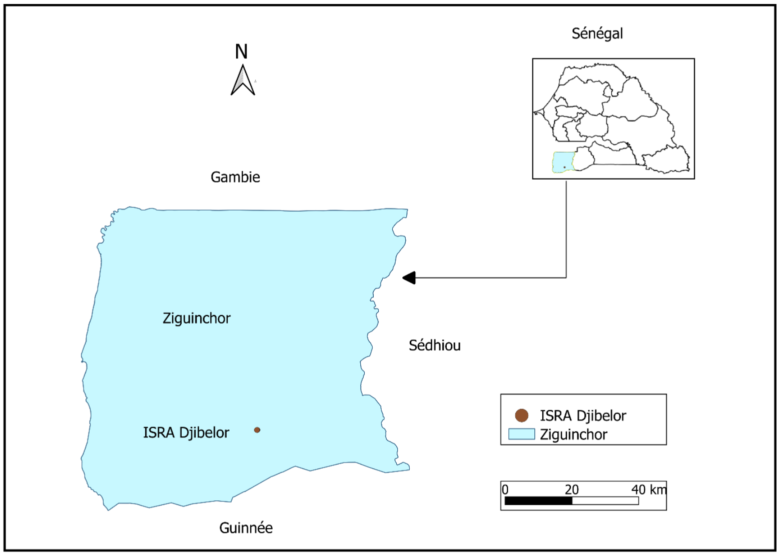

Figure 1: Geographical location of the experimental site

The climate of the region is of the Sudanian South Coastal type (Sagna, 2005). Ziguinchor experiences two distinct seasons: a rainy season, which lasts for approximately four months from July to October, with an average rainfall of 1300 mm between 1991 and 2021, and a dry season, which lasts for about eight months, from November to June. Figure 2, which illustrates the rainfall variability in Ziguinchor from 1991 to 2022, highlights the years 1999 ; 2008 ; 2015 and 2020 as those with the highest recorded rainfall (exceeding 1700mm/year). In contrast, the years 1992, 2002, 2007, and 2021 are characterized by lower rainfall, with totals under 1300mm/year.

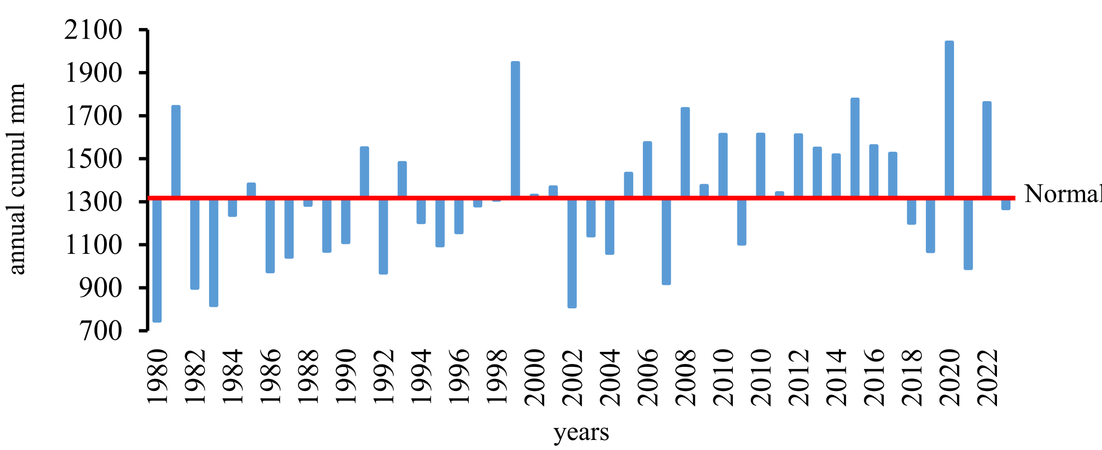

Figure 2: Rainfall variation in Ziguinchor from 1980 to 2023 (data source: ANACIM Ziguinchor)

3.2 Plant material: The evaluated variety is ISRIZ 7, a lowland rice variety with a plant height of 80 cm. The seed-maturity cycle is 106 days during the rainy season and 123 days under irrigation. The potential grain yield is 12.500kg/ha at the research station and 7.500kg/ha in farmers' fields.

3.3 Factors studied and experimental design: Two factors were studied in this experiment: organo-mineral fertilization as the first factor, with four modalities (T: control with no amendment or fertilization; FM1: 200 kg/ha NPK (15-15-15) + 150kg/ha Urea (46% N); FM2: 5tons/ha compost + 200kg/ha NPK (15-15-15) + 150kg/ha Urea (46%N); and FM3: 5tons/ha compost), and seeding density (plant density) as the second factor, with three levels (DeS1: 98plants/m²; DeS2: 61plants/m²; DeS3: 41plants/m²). A split-plot design was adopted with four blocks (Figure 3). Each block contained 12 randomized treatments, for a total of 48 elementary plots. The surface area of each elementary plot was 4m². The distances between elementary plots and between blocks were 1m and 1.5m, respectively. The usable parcel consisted of the central lines, excluding the borders (Figure 3).

3.4 Trial management: Plant transplanting was done with 2 plants per hill according to the tested densities, using a 3-week-old nursery. Bottom fertilizer (15N-15P-15K and compost) was applied immediately after transplanting. Cover fertilizer (Urea 46%N) was applied in two equal fractions of 75kg/ha at 15 and 45days after transplanting (DAT). Three weeding operations were carried out at 15 ; 30 ; and 40DAT.

3.5 Collected data: Morphological parameters: diameter of the collar and plant height at 65 and 80 days after transplanting, the number of tillers per plant, fertility rate, and the number of white panicles per square meter due to insect pest damage. Production parameters: the number of panicles per square meter, the number of grains per panicle, sterility rate, straw and grain yields, weight of 1000grains, and the harvest index.

3.6 Statistical analysis: An analysis of variance (ANOVA) was performed using the XLSTAT 5.03 2014 edition software. The Fisher's test was used for mean comparisons at the 5% significance level (Gomez & Gomez, 1984; Dagnelie, 2012). Principal component analysis (PCA) was conducted to establish the correlation matrix of the variables, employing the Pearson technique.

4 RESULTS

4.1 Plant growth: Plant density and organo-mineral fertilization did not affect the collar diameter at any of the measurement dates (Table 1). The mean collar diameter was 4.9 ± 1.0mm at 65DAT and 5.3 ± 1.4mm at 85DAT. Regarding seeding density, the highest diameter values (5.3 ± 1.0mm at 65 DAT and 5.6 ± 1.7mm at 85DAT) were observed with low-density seeding. Similarly, the highest collar diameter was obtained with organic matter (5.2 ± 1.0mm) at 65DAT and with organo-mineral fertilization (5.6 ± 1.5mm) at 80DAT. Plant height was significantly influenced ($Pr < 0.001$) by fertilization and by the density associated with the fertilization at both observation dates. In terms of fertilization, plant height was significantly higher in treatments with only chemical fertilization (49.8 ± 2.3cm) and with chemical fertilization combined with compost (50.1 ± 4.0cm) at 65DAT. At 85DAT, the addition of both mineral and organic fertilizers resulted in the highest plant height, with 66.4 ± 4.7cm and 66.1 ± 4.4cm, respectively. Regarding seeding density, the largest and statistically equivalent plant heights were observed at intermediate (67.8 ± 5.7cm) and low (68.8 ± 6.1cm) densities at 80DAT.

Table 1: Collar diameter and plant height according to the density of plants and fertilization level

Treatment	**Collar diameter mm**		**Plant height cm**	
	65DAT	80DAT	65DAT	80DAT
Seeding density				
DeS1 : 98plants/m²	4.6 ± 1.0	4.8 ± 1.2	46.7 ± 5.0	63.1 ± 5.6a
DeS2 : 61plants/m²	4.7 ± 1.0	5.5 ± 1.2	46.7 ± 4.9	67.8 ± 5.7b
DeS3 : 41plants/m²	5.3 ± 1.0	5.6 ± 1.7	47.1 ± 5.0	68.8 ± 6.1b
Fertilization				
Unfertilized control	4.4 ± 1.0	4.9 ± 1.4	42.4 ± 3.2a	61.4 ± 5.5a
F1 : 200kg/ha NPK + 150kg/ha Urea	4.8 ± 1.0	5.4 ± 1.3	49.8 ± 2.3b	66.4 ± 4.7b
F2 : 5t/ha compost + 200 kg/ha NPK + 150kg/ha Urea	5.0 ± 1.1	5.6 ± 1.5	50.1 ± 4.0b	72.2 ± 5.3c
F3 : 5t/ha compost	5.2 ± 1.0	5.3 ± 1.4	44.4 ± 3.9a	66.1 ± 4.4b
General mean	4.9 ± 1.0	5.3 ± 1.4	46.8 ± 4.1	66.6 ± 5.3
Probability				
DeS	0.085^{ns}	0.252^{ns}	0.946^{ns}	0.002*
F	0.255^{ns}	0.660^{ns}	<0.001***	<0.001***
DeS*F	0.117^{ns}	0.495^{ns}	<0.001***	<0.001***

Values (Means±SE) bearing different letters in a row differ significantly (*P<0.05). ns=not significant; *significant; ** highly significant; *** very highly significant; DAT : days after transplanting

4.2 Insect pest susceptibility: Plant density and fertilization significantly influenced the presence of insect pests (Pr = 0.043) on rice (Table 2). Insect pest damage was more pronounced in plots with higher seeding density (1.6 ± 0.2white panicles/m²) and in plots where only chemical fertilization was applied (1.6 ± 0.3white panicles/m²). Conversely, plots with low seeding density and those with only organic fertilizer showed lower susceptibility to insect pests, with 0.9 ± 0.1 and 0.7 ± 0.2white panicles/m², respectively. These results suggest that higher plant densities and the application of only chemical fertilizers may increase insect pest pressure, whereas organic fertilization and lower plant densities may help reduce pest damage.

Table 2: Number of white panicles in rice as function of density and fertilization

Treatment	**Number of white panicles/m²**
Seeding density	
DeS1 : 98plants/m²	1.6 ± 0.2b
DeS2 : 61plants/m²	1.2 ± 0.2ab
DeS3 : 41plants/m²	0.9 ± 0.1a
Fertilization	
Unfertilized control	1.4 ± 0.2ab
F1 : 200kg/ha NPK + 150kg/ha Urea	1.6 ± 0.3b
F2 : 5t/ha compost + 200kg/ha NPK + 150kg/ha Urea	1.3 ± 0.2ab
F3 : 5t/ha compost	0.7 ± 0.2a
General mean	1.24 ± 0.2
Probability	
DeS	0.016*
F	0.037*
DeS*F	0.007*

Values (Means±SE) bearing different letters in a row differ significantly (*P<0.05). ns=not significant; *significant.

4.3 Tillering and fertility: The effects of plant density and fertilization on tillering and plant fertility are shown in Table 3. Only fertilization and the interaction between density and fertilization had a significant effect on rice tillering. Tillering was higher in plots with a combination of organic and chemical fertilizers (14.6 ± 3.8tillers/plant) and in plots with mineral fertilization (12.8 ± 3.3tillers/plant). Control plots and those amended only with compost recorded significantly fewer tillers (9.9 ± 2.5tillers/plant and 11.1 ± 2.9tillers/plant, respectively). The fertility rate did not vary significantly according to plant density or fertilization type. It was highest in plots with low-density seeding (84.0 ± 12.9%) and with organo-mineral fertilization (84.0 ± 11.5%), with an overall average of 78.4 ± 14.1%.

Table 3: Tillering and fertility as function of density and fertilization

Treatment	Number of tiller/plant	Fertility rate %
Seeding density		
DeS1 : 98plants/m²	11.0 ± 2.8	73.8 ± 16.3
DeS2 : 61plants/m²	13.2 ± 3.4	77.5 ± 13.2
DeS3 : 41plants/m²	12.2 ± 3.2	84.0 ± 12.9
Fertilization		
Unfertilized control	9.9 ± 2.5a	77.2 ± 14.1
F1 : 200kg/ha NPK + 150kg/ha Urea	12.8 ± 3.3bc	70.5 ± 14.5
F2 : 5t/ha compost + 200kg/ha NPK + 150kg/ha Urea	14.6 ± 3.8c	84.0 ± 11.5
F3 : 5t/ha compost	11.1 ± 2.9ab	79.3 ± 16.1
General mean	12.2 ± 3.2	78.4 ± 14.1
DeS	0.090^{ns}	0.282^{ns}
F	0.001**	0.146^{ns}
DeS*F	0.001**	0.166^{ns}

Values (Means±SE) bearing different letters in a row differ significantly (*P<0.05). ns=not significant; *significant; ** highly significant; *** very highly significant.

4.4 Yield and components: The effects of plant density and fertilization on rice yield and its components are shown in Table 4. Tillering (Pr = 0.0001) and panicle production per square meter (Pr =0.0002) were affected only by fertilization. Mineral fertilization alone and compost combined with mineral fertilization resulted in the statistically highest number of tillers and panicles: 428 ± 116 tillers/m² and 299 ± 84panicles/m² for mineral fertilization, and 425 ± 115tillers/m² and 351 ± 99panicles/m² for compost combined with mineral fertilization. Grain yield (Pr <0.0001) and straw yield (Pr = <0.0001) varied significantly according to plant density, fertilization type, and their interaction. Low plant density combined with chemical fertilization resulted in the highest straw production (6197 ± 3566kg/ha; 4930 ± 2837kg/ha) and paddy grain yield (5437 ± 3359kg/ha; 4388 ± 2711kg/ha). Mineral and organo-mineral fertilization produced statistically similar values. The number of grains per panicle (Pr = 0.0001) was affected solely by plant density, with values increasing as plant density decreased. Intermediate and low densities yielded statistically higher values. In general, the sterility rate (11.3% ± 2.7%), grain size (24.0 ± 1.0grams), and harvest index (0.47 ± 0.1) were not influenced by plant density or fertilization.

4.5 Correlation matrix: Principal component analysis (PCA) using the Pearson correlation technique revealed several key relationships between rice yield components (Table 5). The analysis showed a strong positive correlation between straw yield and grain yield (r= 0.886). A similar positive correlation was found between the number of tillers at harvest and the number of panicles (r= 0.729). Additionally, there was a positive correlation between plant height at 85DAT and the number of grains per panicle (r= 0.500). In contrast, the number of tillers at 60DAT was negatively correlated with several other parameters: number of grains per panicle (r= -0.296) ; straw yield (r= -0.364), grain yield (r= -0.408). These findings indicate that while certain parameters, like straw yield and grain yield, tend to increase together, other factors like the number of tillers at early stages (60DAT) show a negative impact on final yield components.

Table 4: Grain yield and components of yield as function plant density and fertilization

Treatment	Number of tiller/m²	Number of panicle/m²	Number of grain/panicle	Sterility rate %	Straw yield kg/ha	Grain yield kg/ha	1000 grain weight g	Harvest index
Seeding density								
DeS1 : 98plants/m²	395 ± 107	285 ± 81	81 ± 15a	11.0 ± 4.0	2433 ± 1400a	1914 ± 1183a	24.1 ± 1.0	0.46 ± 0.1
DeS2 : 61plants/m²	381 ± 103	292 ± 83	97 ± 18b	11.6 ± 3.6	2939 ± 1691a	2778 ± 1716b	24.1 ± 1.0	0.49 ± 0.1
DeS3 : 41plants/m²	333 ± 90	272 ± 77	103 ± 19b	11.4 ± 5.0	6197 ± 3566b	5437 ± 3359c	23.6 ± 0.9	0.46 ± 0.1
Fertilization								
Unfertilized control	325 ± 88a	248 ± 84a	88 ± 16	11.7 ± 1.7	2664 ± 1419a	2525 ± 1560a	23.8 ±0.9	0.49 ± 0.1
F1 : 200kg/ha NPK + 150kg/ha Urea	428 ± 116b	299 ± 84ab	94 ± 17	10.2 ± 2.8	4930 ±2837b	4388 ± 2711b	23.9 ± 0.9	0.48 ± 0.1
F2 : 5t/ha compost + 200kg/ha NPK + 150kg/ha Urea	425 ± 115b	351 ± 99b	99 ± 20	11.5 ± 1.0	4793 ±2727b	4089 ± 2526b	24.3 ± 1.0	0.47 ± 0.1
F3 : 5t/ha compost	299 ± 81a	235 ± 66a	92 ± 17	11.8 ± 1.3	3038 ±1879a	2503 ± 1546a	23.7 ± 0.9	0.45 ± 0.1
General mean	370 ± 100	283 ± 80	93 ± 17	11.3 ± 2.7	3856 ± 2219	3376 ± 2086	24.0 ± 1.0	0.47 ± 0.1
Probability								
DeS	0.079^{ns}	0.696^{ns}	0.0001**	0.917^{ns}	<0.0001***	<0.0001***	0.244^{ns}	0.746^{ns}
F	0.0001**	0.001**	0.290^{ns}	0.907^{ns}	<0.0001***	0.0001**	0.363^{ns}	0.901^{ns}
DeS*F	0.0002**	0.003*	0.0001***	0.743^{ns}	<0.0001***	<0.0001***	0.510^{ns}	0.946^{ns}

Values (Means±SE) bearing different letters in a row differ significantly (*P<0.05). ns=not significant; *significant; ** highly significant; *** very highly significant

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Table 5: Variable Correlation Matrix

Variables	Number tiller/plant	Tiller/m^2 60DAT	Crown Diameter 65DAT mm	Plant height 65DAT cm	Crown Diameter 85DAT mm	Plant height 80DAT cm	Number white panicle/ m^2	Number tiller/ m^2 harvest	Number Panicle /m^2	Fertility rate %	Number grain/ panicle	Sterility rate %	Straw yield Kg/ha	Grain yield kg/ha	Harvest index	Weight 1000 grain g
Number tiller/plant																
Tiller/m^2 60DAT	**0,414**															
Crown Diameter 65DAT mm	0,223	-0,120														
Plant height 65DAT cm	**0,373**	0,143	**0,381**													
Crown Diameter 85DAT mm	-0,004	-0,283	-0,031	0,085												
Plant height 80DAT cm	**0,498**	-0,058	0,156	**0,494**	**0,354**											
Number white panicle/ m^2	0,139	**0,442**	0,061	0,111	-0,216	-0,003										
Number tiller/m^2 at harvest	0,165	**0,290**	0,039	**0,445**	-0,091	0,238	0,190									
Number Panicle/m^2	**0,290**	0,185	0,208	**0,397**	-0,064	**0,371**	0,193	**0,729**								
Fertility rate %	0,175	-0,118	0,193	-0,052	0,045	0,222	0,029	**-0,289**	**0,424**							
Number grain/ panicle	**0,331**	**-0,294**	0,031	0,197	**0,323**	**0,500**	**0,299**	0,089	0,112	0,056						
Sterility rate %	0,099	0,023	0,058	0,093	0,185	0,090	-0,016	-0,101	0,006	0,108	0,057					
Straw yield Kg/ha	**0,351**	**-0,364**	0,272	**0,372**	**0,297**	**0,428**	-0,156	0,031	0,224	0,241	**0,471**	0,007				
Grain yield kg/ha	**0,328**	**-0,408**	0,190	**0,292**	0,277	**0,398**	-0,192	0,177	**0,397**	**0,294**	**0,457**	-0,011	**0,886**			
Harvest index	-0,029	-0,067	-0,274	-0,131	-0,048	0,062	-0,011	0,255	**0,296**	0,128	0,058	-0,143	-0,258	0,157		
Weight 1000 grain g	0,120	**0,288**	-0,052	0,040	-0,107	0,083	0,059	**0,331**	**0,294**	0,008	0,040	-0,183	-0,084	0,033	0,222	

5 DISCUSSION

The observed negative effect of plant density and organo-mineral fertilization on collar diameter in this study may be attributed to the early uptake of nutrients from mineral and organic fertilizers during the vegetative phase. A similar trend has been reported in previous studies, where organo-mineral fertilization was shown to promote stem diameter growth in maize (*Zea mays*) and upland rice in Lower Casamance, Senegal (Ndiaye & Diatta, 2020 ; Essy *et al.,* 2022). Additionally, studies on cassava (*Manihot esculenta*) found that organo-mineral fertilization positively influences stalk diameter, which is linked to increased plant vigour and nutrient availability (Kotaix *et al.,* 2013 ; Ognalaga *et al.,* 2017).The increase in plant height under low plant density and organo-mineral fertilization may be explained by two key factors: (i) competition for light, which stimulates vertical growth, and (ii) the gradual nutrient release from compost and mineral fertilizers, which sustains vegetative growth over time. Studies on millet (*Pennisetum glaucum*) and maize confirm that lower seeding density combined with organo-mineral fertilization enhances plant height, as it allows each plant greater access to nutrients and light (Bamba, 2020b ; Essy *et al.,* 2022). Similarly, Kouassi *et al.* (2017) demonstrated that seeding density significantly influences the growth of okra (*Abelmoschus esculentus*), with lower densities favoring taller plants. However, these findings contrast with those of Lopy (2018), who observed an increase in millet plant height under high seeding densities, likely due to intra-specific competition that forces plants to grow taller. In this study, higher plant densities and organo-mineral fertilization were associated with increased insect attacks, particularly the presence of white panicles during the maturation phase. Stem borers (*Chilo zacconius; Sesamia calamistis*, and *Maliarpha separatella*) are among the primary pests responsible for this damage, as their larvae feed inside the stems, destroying the plant's vascular system and leading to panicle sterility (Brink & Belay, 2006 ; Nwilene *et al.,* 2006). These results suggest that dense plant populations may create microenvironments conducive to pest proliferation, while the increased nitrogen availability from fertilizers could enhance plant palatability for insect pests (Horgan *et al.,* 2018). In contrast to plant density, organo-mineral fertilization significantly increased tillering and panicle production. This positive effect is likely due to the application of urea at early tillering stages, which promotes vegetative growth, combined with compost mineralization that sustains nutrient availability throughout the growth cycle. These findings align with those of Coly *et al.* (2021), who reported that compost combined with mineral fertilizers enhances tiller production in Sanio millet, although they observed a negative effect on the number of ears per hectare. Similarly, Guèye (2016) demonstrated that tillering in fonio (*Digitaria exilis*) is significantly influenced by the application of chemical amendments in Bandafassi, southeastern Senegal. Moreover, research on the NERICA 14 rice variety in Lower Casamance confirmed positive effects of organic and mineral fertilization on tillering (Mendy & Nadhumat, 2016). However, contrary to these findings, Bamba (2020b) reported no significant effect of organo-mineral fertilization on tillering in Sanio millet, suggesting that crop response may vary depending on species and agro-ecological conditions. The increase in straw and grain yields under low plant density may be attributed to improved light interception and reduced competition for resources. Studies have shown that seeding density affects the amount of light received by crops, which directly influences biomass accumulation and grain filling (Siene *et al.,* 2010). However, these findings contrast with those of Payne (1997) and Bagayogo (2012), who reported that higher plant densities result in greater total dry biomass and grain yield per hectare. Additionally, De Rouw (2004) argued that high seeding rates are not always necessary to achieve high yields in the Sahel, suggesting that optimal planting density depends on soil fertility, climate, and crop variety. The observed increase in straw and grain yields with organo-mineral fertilization is likely due to the gradual nutrient release, which improves plant growth and grain formation. These findings are consistent with the results of Somda *et al.* (2017), who demonstrated that organo-mineral inputs enhance above-ground biomass and grain yield in fonio and sorghum. Similarly, Diouf (2001) predicted that under optimal water supply conditions, nitrogen fertilization significantly increases grain yield in Souna millet. However, Badiane *et al.* (2023) found that organic and mineral fertilization had no significant effect on lowland rice grain yield in Lower Casamance, highlighting potential variations based on soil type and water availability. Sowing density and organo-mineral fertilization had no significant effect on the thousand-grain weight of rice, which averaged 24.0 ± 1.0 grams. This suggests that high plant density did not induce strong competition for water, light, or nutrients, ensuring proper grain filling. According to Thibault (2001), when vital resources are limited, inter-plant competition affects the weight of grains in maize. The values obtained in this study are comparable to those reported by Ouattara (2014), where thousand-grain weight varied between 29.11 and 32.16 grams in rice crops under different fertilization regimes.

6 CONCLUSION

This study aimed to evaluate the effects of seeding density and organo-mineral fertilization on the growth and yield of lowland rice in Lower Casamance. The results indicated that high seeding density (98plants/m²) combined with mineral and organo-mineral fertilization, promotes plant height growth but also increases susceptibility to pest attacks. In contrast, the combination of low seeding density (41plants/m²) and organo-mineral and mineral fertilization enhances yield and its components, including the number of panicles/m², the number of grains per panicle, grain yield, and straw yield.

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