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Effects of organo-mineral fertilization on plant growth and grain yield of an upland rice variety (NERICA 14) in lower Casamance (South-West Senegal)

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Abstract

In Casamance, upland rice is generally practiced on sandy soils very low in organic matter with low yields (1 to 2 tons/ha). The objective of this experiment is to evaluate the effects of different doses of organic and mineral fertilizers on the growth and yield of upland rice. The test was conducted at the ISRA Djibélor station following a Fisher block design with 4 replications. The study factor is organo mineral fertilization with 9 treatments (T1 Unfertilized control; T2 = 0 kg/ha Compost (C) + 100 kg/ha NPK + 75 kg/ha Urea; T3 = 0 kg/ha C + 200 kg/ha NPK + 150 kg/ha Urea; T4 = 2.5 t/ha; T5 = 2.5 t/ha C + 100 kg/ha NPK + 75 kg/ha Urea; T6 = 2.5 t/ha C + 200 kg/ha NPK + 100 kg/ha Urea; T7 = 5 t/ha C; T8 = 5 t/ha C + 100 kg/ha NPK + 75 kg/ha Urea; T9 = 5 t/ha C + 200 kg/ha NPK + 150 kg/ha Urea). The results showed that the tillering is more important with T8 (107 ± 11.49 tillers/m^2) and T5 (96.5 ± 24.35 t tiller/m^2). The height of the plants is greater with T6 (42.3 ± 2.6 cm) and T9 (62.9 ± 6.0 cm) at booting and with T9 at flowering (92.6 ± 4.3 cm) and maturity stage (98.4 ± 1.5 cm). Paddy grain yield (2,087 ± 1,229 kg/ha) and paddy grain size (28.3 ± 2.9 g/1000 grains) are more influenced by T8. For a sustainable improvement the productivity of upland rice, it is recommended to adopt T8 combination (5 t/ha Compost + 100 kg/ha NPK + 75 kg/ha Urea) for upland rice variety in Southwestern Senegal.

Keywords: Upland rice; Fertilization; Plant Growth; Grain yield; Casamance; Senegal

1 Introduction

Senegal is one of the largest consumers of rice in Africa. The average annual consumption is 78.1 kg per capita [1]. National average production from 2014 to 2018 was 915,713 tons per year and accounted for 42% of national cereal production [2]. In Casamance, rainfed rice cultivation is generally of the family type characterized by low yields (1.5 to 2 tons/ha) unlike the river valley where the average is around 6 to 8 tons/ha [2]. This is particularly due to abiotic (rainfall deficit, salinization and acidification of rice fields, etc.), biotic (insects, diseases, weeds, etc.) and technical (inappropriate cultivation practices) constraints. Indeed, rice plateau cultivation is mainly confronted with the decline in soil fertility, thus leading to a decrease in yields. Low soil nutrient content is constantly cited as one of the major constraints to agricultural production in sub-Saharan Africa [3]. Indeed, these shallow soils have a low water retention capacity and limited availability of nutrients [3]. In addition, mineral fertilizers and organic matter, which are important sources of nutrients for plants, are used very little. Indeed, the intake rate of mineral fertilizers is less than 10 kg/ha in Sub-Saharan Africa [4, 5]. Casamance is full of potential in terms of the availability of organic matter of animal and plant origin. With the expensive cost of chemical fertilizers, the combined use of organic and mineral fertilizers remains one of the solutions to increase rice production on the one hand and improve the level of soil fertility in Casamance on the

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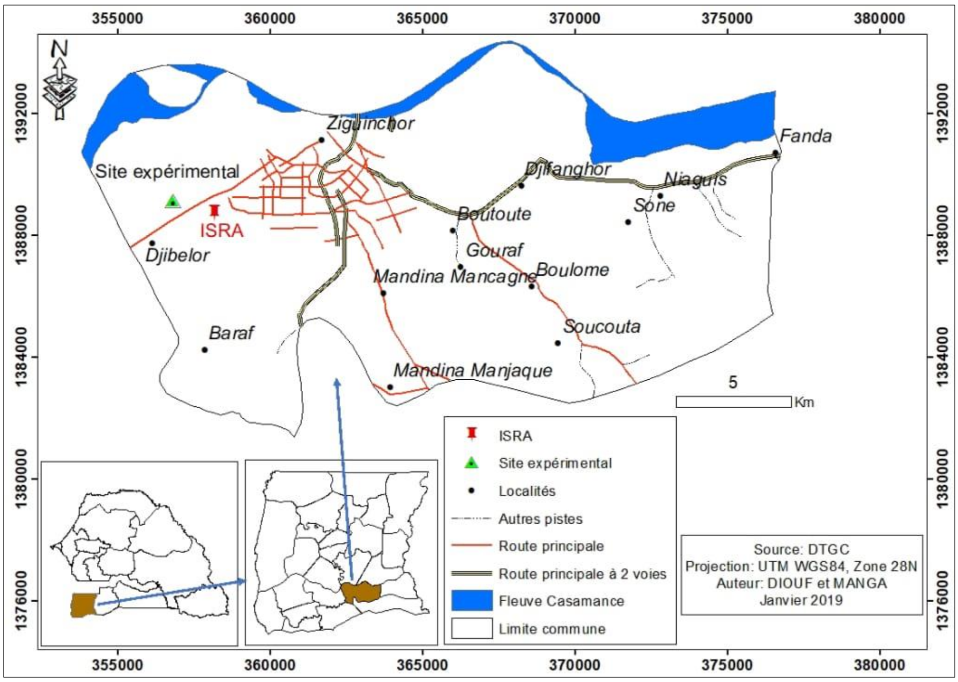
other. The purpose of this study is to evaluate the effects of fertilizers on growth and yield parameters and to determine the best manure plan for upland rice in Lower Casamance.

2 Material and methods

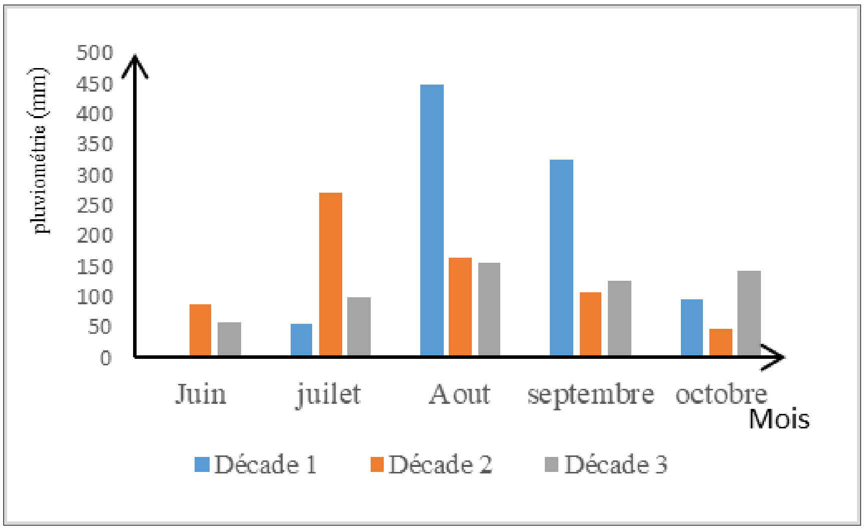
2.1 Experimental site

The experiment was conducted at Djibélor Agricultural Research Center (12°33'39"N; 16°18'25"W) (Figure 1). The soil is tropical ferruginous with a sandy texture and low organic matter content (less than 1%) [6]. The climate is south-coastal type [7]. Cumulative rainfall was 2,037 mm in 2020 (Figure 2).



Source: Manga and Diouf (2019)

Figure 1 Localization of the experimental site in lower Casamance



Source: ISRA/Djibélor station (2020)

Figure 2 Variation in month and decade of the rainfall in 2022

Table 1 Chemical characterization of the initial soil sample (T1) depth of 0-20 cm

Name Sample	C (%)	N (%)	C/N	OM (%)	Pass (ppm)	Na+ (meq/100g)	K+ (meq/100g)	Ca2+ (meq/100g)	Mg2+ (meq/100g)
T1	0.581	0.039	15.066	0.999	14.051	0.046	0.093	0.534	0.629

2.2 Study Factor and experimental design

The study factor consisted of namely nine organo-mineral fertilization (OMF) (Table 2). The experimental designe was a Fisher block design (RCDB) with four replications. The experimental unit consisted of eight (8) of 2 m-lines.

Table 2 Combinations of applied treatments

Treatment	Compost (Organic matter)	Basal fertilizer	Cover fertilizer	Combination
	C (ton/ha)	NPK (15-15-15) (kg/ha)	Urée 46% N (kg/ha)	
T1	0	0	0	0t/ha+0 kg/ha +0 kg/ha
T2	0	100	75	0t/ha+100 kg/ha+75 kg/ha (50% RDFDR FM)
T3	0	200	150	0t/ha+200 kg/ha+150 kg/ha (100% DR FM)
T4	2.5	0	0	2.5t/ha+0 kg/ha+0 kg/ha (50% DR FO)
T5	2.5	100	75	2.5t/ha+100 kg/ha+75 kg/ha
T6	2.5	200	150	2.5t/ha+200 kg+150 kg/ha
T7	5	0	0	5t/ha+0 kg/h NPK a+0 kg/ha (100% DR FO)
T8	5	100	75	5t/ha+100 kg/ha NPK+75 kg/ha
T9	5	200	150	5t/ha+200 kg/ha+150 kg/ha

DR: Recommended rate; FM: Mineral Fertilizer; FO: Organic Fertilizer

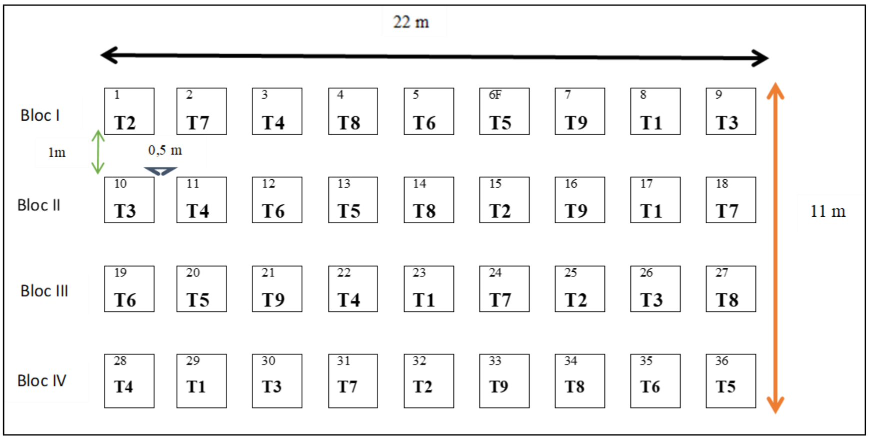


Figure 3 Experimental design

2.3 Measurements

The height of the plants was randomly measured with a sample of 5 hills in each elementary plot at 35; 50; 65 and 80 days after sowing (DAS). The grain yield and its components were evaluated with the number of tillers at 60 DAS; the number of panicles, the dry weight of aboved biomass (straw), the grain weight, the sterility panicle rate, the weight of 1000 paddy grains and the harvest index in each experimental unit. The insect damage consisted of the number of dead heards and the number of white panicles whiche were respectively evaluated on the yield square 1 m^2 quadrant in each elementary plot .

2.4 Statistical analyses

The data collected were analyzed with the XLSTAT software version 2014.5.03. These tests included the analysis of variance (ANOVA), the Fisher test for means comparison and a principal component analysis .

3 Results and discussion

Analysis of variance shows a very highly significant difference (P< 0.001) in height of plants . At 35 JAS, the highest plant height is recorded with the T6 treatment (42.3 ± 2.6 cm). This average height is statistically higher than that observed with other treatments except the T9 treatment, which recorded a height of 38.64 ± 5.59 cm (Table 3). At 50 JAS, the highest average plant heights were noted with the treatments T9 (62.93 ± 5.98 cm), T8 (62.75 ± 10.21 cm), T6 (61.0 ± 3.8 cm) and T5 (58.7 ± 3.6 cm). The heights of the plants recorded with these treatments are statistically higher than those of other treatments. At 65 JAS, as at 50 JAS, the plant heights obtained with the treatments T 9 (92.6 ± 4.3 cm), T8 (91.0 ± 6.3 cm), T6 (93.6 ± 3.6 cm) and T5 (88.8 ± 3.0 cm) are statistically higher than those of the other treatments (Table 4). At 80 JAS the height of the heights plants are noted with the treatments T9 (98.4 ± 1.5 cm) and T6 (96._ ± 4.6 cm). The plants at the level of these treatments have a statistically different height from that obtained with the other treatments except the T8 and T5. Regardless of the date of measurement, the lowest height is recorded with the tell-tale (T1). Overall, the T9 and T6 stimulate more the growth in height of rice plants. This increase can be explained by the fact that the combined application of organic manure and mineral fertilizer makes plant growth elements such as phosphorus more available as indicated by Somda et al. [8]. Nacro [9] who showed that organic fertilizer (Fertinova + Organova) combined with mineral fertilizer gave the greatest height growth of tomato plants in Burkina Faso found similar results.

Table 3 Variation in the height of rice plants according to the treatments following the date of measurement

Treatment	Height of plants (cm)			
	35 DAS	50 DAS	65 DAS	80 DAS
T1	17.4 ± 2.1 f	25.09 ± 5.29 d	43.44 ± 6.39 c	46.82 ± 9.10 e
T2	24.é ± 3.ç e	35.22 ± 7.34 c	64.56 ± 10.07 b	78.14 ± 1.10 cd
T3	28.4 ± 5.5 e	44.66 ± 7.63 b	68.00 ± 4.69 b	84.13 ± 10.58 bc
T4	29.3 ± 2.9 de	45.86 ± 6.49 b	68.50 ± 7.48 b	71.45 ± 7.46 d
T5	40.06 ± 4.71 ab	58.69 ± 3.60 a	88.82 ± 3.01 a	94.27 ± 2.36 ab
T6	42.28 ± 2.60 a	60.97 ± 3.84 a	93.57 ± 3.57a	96.79 ± 4.61 a
T7	30.73 ± 1.04 cd	45.71 ± 2.11 b	68.81 ± 2,.7 b	76.89 ± 4.61 cd
T8	35.72 ± 4.17 bc	62.75 ± 10.21 a	91.01 ± 6.28 a	88.40 ± 11.17 abc
T9	38.64 ± 5.59 ab	62.93 ± 5.98 a	92.57 ± 4.26 a	98.44 ± 1.52 a
General mean	31.86 ± 8.47	49.10 ± 13.88	75.47 ± 17.11	81.70 ± 16.78
Probability	< 0.0001***	< 0.0001***	< 0.0001***	< 0.0001***
LSD	5.577	8.163	8.721	11.655

Averages with an identical letter are statistically equivalent to the 5% threshold; *** = Very Highly Significant according to the Fisher test; LSD= Low Significant Difference

3.1 Number of dead hearts and white panicles

Fertilizer combinations significantly influenced (P <0.0001) the appearance of dead hearts and white panicle rate during tillering and maturity stage, respectively (Table 4). The lowest number of attacks is observed on the control plots (0.00 ±0.00 dead hearts/m^2 and 0.25 ± 0.35 white panicles/m^2) whereas the the highest number of dead hearts is recorded with T6 (3.88 ± 2.42 dead hearts/m^2) and T5 (4.69 ± 2.50 dead hearts/m^2). Similarly, the highest number of white panicles is noted with T5 (4.69 ± 2.50 white panicles/m^2) and T8 (3.94 ± 1.66 white panicles/m^2). The doses of fertilizers favored the appearance of insect attacks during the vegetative phase (dead hearts) and the maturity phase (white panicles). According to Brink and Belay [10] the larvae of stem borers feed inside the stem and destroy the vascular system.

Table 4 Variation in the number of dead hearts and white panicles as a function of treatment

Treatment	Number of dead hearts /m^2	Number of white panicles/m^2
T1	0.00 ±0.00 c	0.25 ± 0.35 d
T2	0.75 ± 0.29 c	1.44 ± 1.03 cd
T3	2.56 ± 1.45ab	2.25 ± 1.62 bcd
T4	1.13 ± 0.43 bc	3.19 ± 0.83 abc
T5	3.19 ± 1.26 a	4.69 ± 2.50 a
T6	3.88 ± 2.42 a	3.88 ± 2.56 ab
T7	1.13 ± 0.32 bc	2.13 ± 0.48 bcd
T8	2.88 ± 0.63 a	3.94 ± 1.66 ab
T9	2.75 ± 0.96 ab	3.00 ± 2.87 abc
General mean	2.03 ± 1.59	2.75 ± 1.54
Probability	< 0.0001***	< 0.0001***
LSD	1.691	2.408

Averages with an identical letter are statistically equivalent to the 5% threshold; *** = Very Highly Significant according to the Fisher test; LSD= Low Significant Difference

3.2 Tillering and fertility rate

T Tillering capacity and fertility rate were significantly (P <0.0001) influenced by fertilizer inputs (Table 5). Tillering is higher in plots fertilized with T9, T8, T6 and T5 compared to that with the control plot. On the other hand, the fertility of the tillers is higher with the recommended doses of mineral fertilizer (T3: 69.14 ± 7.12%) and organic (T7: 66.37 ± 12.55%). The most important tiller production is obtained with the treatment 100% compost + 50% of the recommended rate of the mineral fertilizer (107 ± 11.49 tillers/m^2). This could be explained by the contribution of urea during the beginning tillering and the compost in mineralization during the vegetative phase. This value is similar to Mendy and Nadhumat [11]. These authors showed for the same variety (NERICA 14) positive effects of organic and mineral fertilizers on tillering in Low Casamance. These results are not similar to Bamba [12] who showed a lack of positive effects of the interaction organic and fertilizer mineral on the tillering of Sanio millet in Casamance and Eastern Senegal.

The 50% compost+100% recommended rate of mineral fertilizer resulted in the highest panicle production (93.75 ± 31.70). Indeed, this treatment gave more fertile tillers. These results are not similar to those of Ndiaye and al. [13] who found a negative response of the interaction organic fertilizer * mineral fertilizer on the number of panicle Sanio millet in High Casamance.

Table 5 Variation in rice tillering and fertility rate in function treatments

Treatment	Number of tillers/m²	Fertility rate %
T1	41.00 ± 10.00 c	41.00 ± 6.16 c
T2	64.00± 14.61 bc	56.85 ± 20.60 abc
T3	70.00 ± 19.73 b	69.14 ± 7.12 a
T4	41.00 ± 3.83 c	43.65 ± 5.03 bc
T5	96.50 ± 24.35 a	59.17 ± 4.10 abc
T6	95.00 ± 17.09 a	57.30 ± 20.00 abc
T7	42.00 ± 7.66c	66.37 ± 12.55 a
T8	107.00 ± 11.49a	59.00 ± 16.91 abc
T9	88.00± 26.73ab	63.85 ± 22.28 ab
General mean	71,61 ± 29,04	57.42 ± 15.66
Probability	< 0.0001***	< 0.0001***
LSD	24.823	21.685

Averages with an identical letter are statistically equivalent to the 5% threshold; *** = Very Highly Significant according to the Fisher test; LSD= Low Significant Difference

3.3 Straw production

Fertilizers (P < 0.0001) influenced biomass yield (Table 6). The biomass produced with the T6 treatment (6100.00 ± 770.28 kg/ha) is statistically higher than that of the other treatments with the exception of that recorded with the T9 treatment (5150.00 ± 822.60 kg/ha). The lowest biomass is obtained with the control treatment (625.00 ± 125.83 kg/ha). Indeed, the combined inputs of organic and mineral fertilizers have released nutrients that are assimilated by the plant during the vegetative phase. These observations corroborate the work of Somda et al. [8] which showed an improvement in the production of above-ground biomass of Fonio and sorghum yields following organo-mineral inputs. Contrary to these results, Kanfany [14] noted in farmers field to Casamance and Oriental Senegal that the interaction between mineral fertilizer and organic matter did not induce significant effects on Fonio millet biomass.

Table 6 Biomass rice yield in function of treatments

Treatment	Biomass yield (kg/ha)
T1	625 ± 12- f
T2	2675 ± 340 de
T3	4325 ± 1330 bc
T4	1750 ± 1121 ef
T5	4825 ± 91_ b
T6	6100 ± 770 a
T7	1600 ± 337 ef
T8	3650±1190 cd
T9	5150 ± 823 ab
General mean	3411 ± 1930
Probability	< 0.001***
LSD	0.115

Values with same letter are statistically equivalent accordin the Fisher test ; *** = Very Highly Significant difference; LSD= Least Significant Difference

3.4 Grain yield and its components

Analysis of table 7 reveals that the treatments affected the number of panicles/m² (P< 0.0001), paddy sterility rate (P = 0.001) and paddy yield (P=0.043). The highest number of panicles is observed with T6 (93.75 ± 31.70 panicles/m²) and T9 (90.75 ± 33.75 panicles/m²). These treatments produced statistically higher panicles than the T1 control (29.75 ± 9.43 panicles/m²). The highest rate of sterility is recorded with T5 (61.76 ± 27.52%). This rate is statistically higher than those recorded with T2, T4, T6 and T7. Plots fertilized with the T6 dose recorded the lowest percentage of empty grains (18.80 ± 4.18%).

The highest grain yield is observed with the T8 (2087.5 ± 1229.07 kg/ha). This yield is statistically different from that obtained with T1, T2, T3, T4 and T5. Indeed, Hu et al. [15] showed that the combined effects of organo-mineral fertilization increase rice yield in a rice-wheat system. Akanza et al. [16, 17] who showed that the joint application of mineral manure and organic manure increased maize and rice production found similar results. Furthermore Akanza et al. [16] reported that organic manure improves the efficiency of mineral fertilizers. The average yield obtained from paddy (1050 ± 904.17 kg/ha) is lower than the average yield of rice in Casamance which is 2,782 kg/ha [2].

There was no significant effect of the fertilization dose on the weight 1000 grains (P=0.746) and harvest index (P=0.9). However, T8 recorded the best results with 28.33 ± 2.90 grams and 0.33 ± 0.16 respectively for the weight 1000 grains and the harvest index (Table 7). The average weight of the 1000 grains is 25.49 ± 5.93 grams. The value found is close to that obtained by Ouattara [18] who obtained a weight of 1000 grains that varies between 29.11 grams and 32.16 grams.

Table 7 Effects of organo-mineral fertilization on yield rice and component

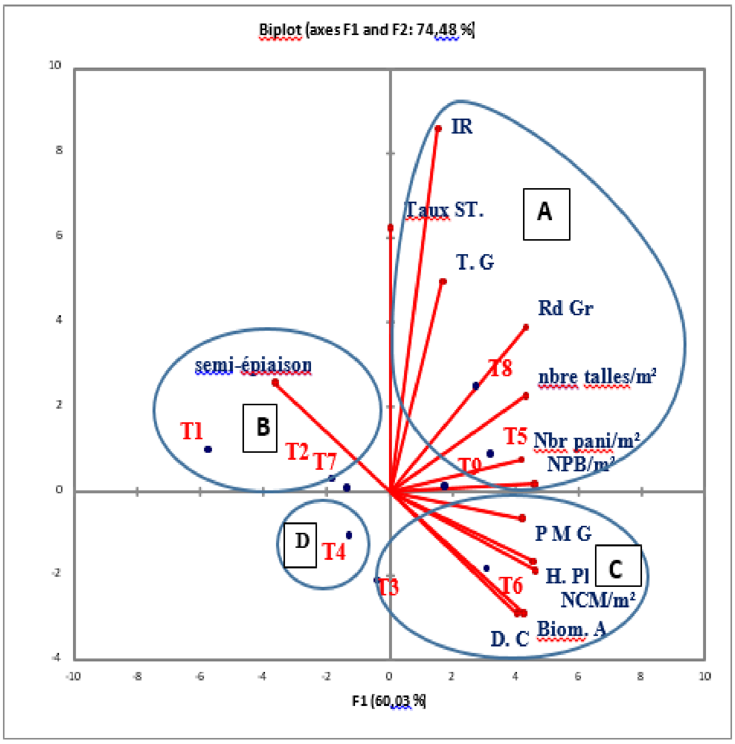
Treatment	Panicles (number/m²	Sterility paddy rate (%)	Paddy Grain Yield (kg/ha)	Weight of 1000 paddy grain (g)	Harvest Index
T1	29.7 ± 9.4 c	60.77 ± 18.79 ab	217.5 ± 323.86 d	21.00 ± 5.22 a	0.19 ± 0.25 a
T2	80.25 ± 24.39 ab	24.04 ± 12.86 cd	882.00 ± 781.93 bcd	26.58 ± 2.57 a	0.22 ± 0.15 a
T3	58.50 ± 37.60 abc	45.32 ± 28.9 abc	850.00 ± 995.82 bcd	23.25 ± 7.88 a	0.15 ± 0.17 a
T4	40.75 ± 9.11 bc	36.43 ± 20.69 bcd	337.50 ± 319.83 cd	25.12 ± 7.92 a	0.18 ± 0.13 a
T5	88.00 ± 37.92 ab	61.76 ± 27.52 a	1650.00 ± 561.24 ab	28.00 ± 0.72 a	0.25 ± 0.06 a
T6	93.75 ± 31.70 a	18.80 ± 4.18 d	1362.50 ± 554.33 abc	27.50± 1.23 a	0.18 ± 0.06 a
T7	51.00 ± 20.46 abc	37.24 ± 18.26 bcd	612.50 ± 409.01 bcd	23.62 ± 11.78 a	0.25 ± 0.14 a
T8	82.00 ± 55.20 ab	59.89 ± 3.95 ab	2087.50 ± 1229.07 a	28.33 ± 2.90 a	0.33 ± 0.16 a
T9	90.75 ± 33.75 a	55.37 ± 3.18 ab	1450.00 ± 1105.29 abc	25.99 ± 2.90 a	0.20 ± 0.12 a
General mean	68.31 ± 36.14	44.40 ± 22.17	1050.00 ± 904.17	25.49 ± 5.93	0.22 ± 0.14
Probability	< 0.0001***	0.0001***	0.043*	0.746^{ns}	0.90^{ns}
LSD	47.522	24.38	1138	8.99	0.23

Averages with an identical letter are statistically equivalent to the 5% threshold; *** = Very Highly Significant according to the Fisher test; LSD= Low Significant Difference

3.5 Correlation between treatments and variables

The analysis in Figure 4 made possibility to discriminate between three groups of treatments:

- Group A consisting of the T5, T8 and T9 treatments which resulted in a high number of panicles/m², a number of tillers/m², a number of white panicles/m² (BNP/m²), a grain yield (Rd Gr), a germination rate (T G), a sterility rate (ST rate) and a harvest index (I R);
- Group B consisting of T1, T2 and T7 treatments that induced late semi-spruce duration;
- Group C consisting of the T6 and T3 treatment that made it possible to obtain a height of the plants, a diameter at the collar, a weight of 1000 grains, a number of dead cores and a significant above-ground biomass.
- Group D consisting of the T4 treatment characterized by a grain yield and a low number of tillers/m².



Legend: P M G= weight thousand grains; Rd Gr= grain yield; H Pl= Plant height; D C = Diameter at the collet; NPB= number of white panicles; NCM= number of dead hearts; I R = harvest index

Figure 4 Principal Component Analysis

4 Conclusion

This study evaluated the effect of combinations of organic and mineral fertilizers on the growth and production of upland rice in Lower Casamance. The morphological parameters (height of the plants) are more affected by the combinations 50% Compost + 100% recommended mineral fertilization and 100% Compost + 100% of the recommended mineral fertilization. Tillering and biomass increased significantly, respectively with the combined intakes of 100% Compost + 50% of the recommended mineral fertilization rate and 50% Compost + 100% of the recommended mineral fertilization rate. The best grain yields were obtained with the treatment 100% Compost + 50% of the recommended of mineral fertilization rate.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest.

References

[1] United State Agency for International Development. Evaluation of Staple Grain Consumption in Senegal. Deliverable. Project feed the future Natal Mbay. 3 July 2017; 108.

[2] National Agency of statistics and Demographic. Monthly bulletin of economic and financial statistics. September 2020; ISSN 0850-1467; 111. Update 23 July 2022. www.ansd.sn

[3] Lahmar R, Bationo BA, Dan Lamso N, Guéro Y, Tittonell. Tailoring conservation agriculture technologies to West Africa semi-arid zones: building on traditional local pratices for soil restoration. Field Crop Res. 2012 June, 132; 158-162

[4] Bado BV. Role of legumes on the fertility of tropical ferruginous soils Guinean and Sudanese areas of Burkina Faso. Thesis, Université Laval Québec. 2002; 184.

[5] Bagayoko M, Maman N, Palé S, Sirifi S, Taonda SJB, Traore S, Mason SC. Microdose and N and P fertilizer application rates for pearl millet in West Africa. African Journal of Agricultural Research. 2011; 6(5): 1141-1150.

[6] Loyer J-Y, Boivin P, Le Brusq, J-Y, Zante. The soils of the Fluvio-marin domain of Casamance (Senegal). Recent developments and reassessment of the major constraints for their development. French Institute for Scientific Research for Development in Cooperation (ORSTOM), Dakar Senegal. 1986; 23.

[7] Sagna P. Climate dynamics and recent developments in the western part of West Africa. (Doctoral thesis), Cheickh Anta Diop University. 2005; 270.

[8] Somda BB, Ouattara AB, Serme I, Pouya MB, Lompo F, Taonda SJ, Sedogo M. Determination of optimal doses of organo-mineral manure in microdose in the Sudano-Sahelian zone of Burkina Faso. Int. J. Biol. Chem. Sci. 2017; 11(2): 670-683, April 2017 ISSN 1997-342X (Online), ISSN 1991-8631 (Print)

[9] Nacro SR. Effects of organic fertilizers on tomato production and soil chemical parameters in north-central Burkina Faso. End-of-cycle memory. 2018; 56.

[10] Brink M, Belay G. Plant resources of Tropical Africa 1. Cereals and pulses. (Translation of: Plant Resources of Tropical Africa 1. Cereals and pulses 2006). PROTA Wageningen Foundation, Netherlands/Backhuys Publishe Leiden Netherlands/CTA, Wageningen, The Netherlands. 2006; 328.

[11] Mendy M, Nadhumat Y. Organo-mineral fertilization of rainfed rice upland to Djibelor. Bachelor's thesis, Department of Agroforestry, Assane SECK University of Ziguinchor. 2016; 34.

[12] Bamba B. Analysis of cultural practices and study of sowing and fertilization techniques of Sanio millet [Pennisetum glaucum (L.) R. Br] in Eastern Senegal and Casamance (Senegal). Doctoral thesis in Agronomic Sciences and Environment University Assane Seck of Ziguinchor, UFR Sciences and Technologies. 2020; 137.

[13] Ndiaye A, Ndiaye O, Bamba B, Guèye M, Sawane O. Effects of organo-mineral fertilization on the growth and yield of mil Sanio (Pennisetum glaucum L. R. Br) in High Casamance (Senegal). European Scientific Journal November 2019; 15(33): ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431.

[14] Kanfany G. Effects of organo-mineral fertilization on the growth and yield of fonio. Memory at the National School of Agriculture of Thiès/Senegal. 2009; 45.

[15] Hu C., Li S.-L., Qiao Y., Liu D.-H. Chen Y.-F. Effects of 30 years repeated fertilizer applications on soil proprieties microbes and crop yields in rice-wheat cropping Systems ; Espl Agricol 2015, volume 51 (3) 355-360. Cambridge Univerity Press 2014 ; doi : 10.1017/S0014479714000350.

[16] Akanza K, Yoro G. Synergistic effects of mineral fertilizers and poultry manure in improving the fertility of a ferralitic soil in western Coast d'Ivoire. Agronomy Africaine. 2003; 15(3): 135-144.

[17] Akanza K, Sanogo S, Kouakou CK, N'Da HA, Yao-KA. Effects of Fertilization on Soil Fertility and Yields: Impact on the Diagnosis of Soil Deficiencies. Rev. Ivorian. Sci. Technol. 2014; 24: 299-315.

[18] Ouattara LA. Effect of Rotations and Manure based on Burkina Phosphate on the growth and yield of strict rainfed rice in the Sudanese zone of Burkina Faso. Master's thesis in plant productions, polytechnic university of Bobo Dioulasso. 2014; 59.