GLOBAL SYMPOSIUM ON SALT-AFFECTED SOILS | FAO HQ |ROME, ITALY, 20-22OCTOBER 2021

EFFECTS OF DIFFERENT TYPES OF COMPOSTS, PHOSPHOGYPSUM AND MINERAL FERTILIZATION ON THE CHEMICAL AND BIOCHEMICAL PROPERTIES OF AN ACID SULPHATE SOIL AND THE YIELD OF RICE IN DJIBÉLOR (LOWER CASAMANCE)

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Presentation Outline

- Introduction (Context and justifications)
- Objectives
- Materials and methods
- Results and discussion
- Conclusions

Introduction

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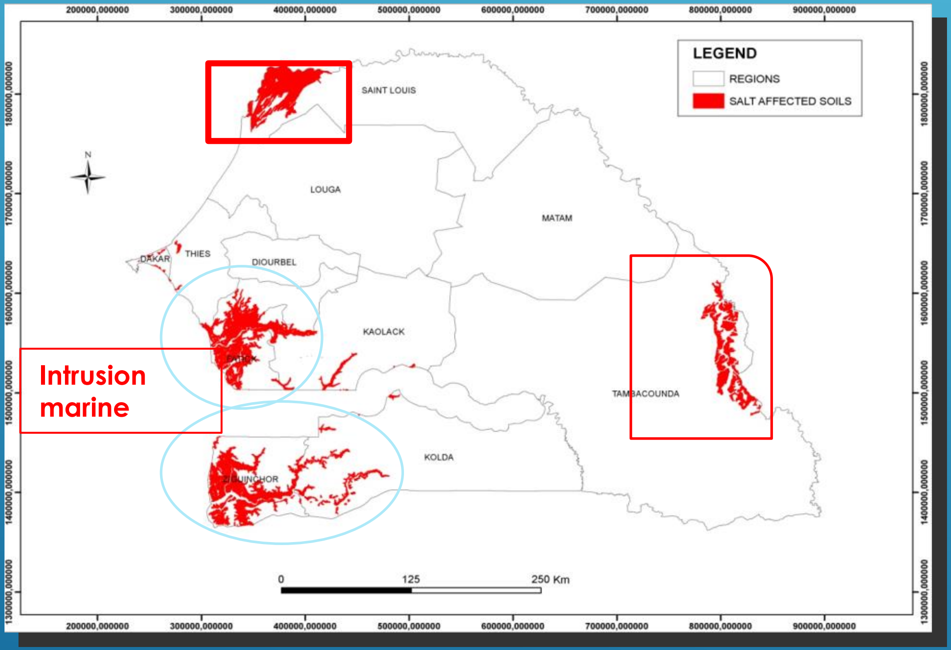
- In Senegal, soil salinization affects arable land (1.3-1.7 Million hectares). More than 1/3 of the land affected by salinization in Senegal is represented in Casamance (around 600,000 ha)



Location of areas affected by salt in Senegal (INP, 2009)

Mudflats and tannes in Lower and Middle Casamance

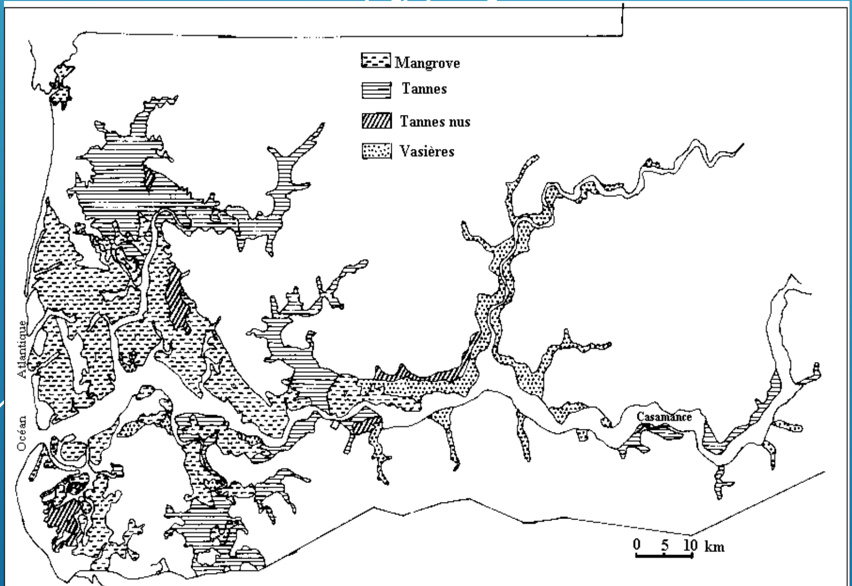
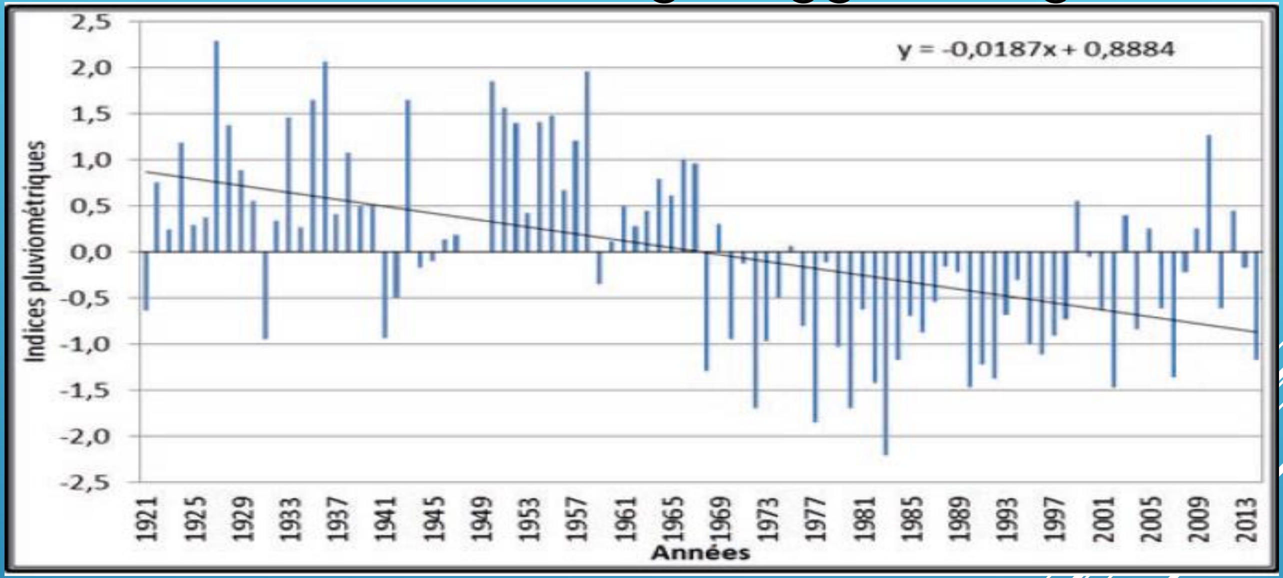


Figure 6 : Carte des zones humides (mangroves, tannes et vasières) de la Basse et Moyenne Casamance.

Introduction

Effects of Climate Change: Aggravating factor



Interannual evolution of rainfall indices in Senegal from 1921 to 2014.

The results of recent studies made by Sagna et al., 2015 allow us to divide the rainfall series from 1921 to 2014 into two periods:

- a first wet period from 1921 to 1967, i.e. over 47 years, with an average rainfall of 803.2 mm;
- a second dry period from 1968 to 2014, i.e. also over 47 years, with an average rainfall of 613.8 mm (Figure 2). The deficit of the second period compared to the first is 23.6%.

Introduction

The deterioration of climatic conditions observed in Casamance and the strong rise in salt by capillary action in the valleys had the major consequence of acidifying the alluvial soils.

The harmful effects of this degradation of the climate and soils by salinization on the living conditions of the populations, on the distribution of local water resources and overall on the local economy have long worried the public authorities.

Thus, in order to find solutions aiming to reduce the effects of salinization on rice-growing lands in Casamance and to increase their yields, organic amendments based on compost formulas of variable composition with respect to phosphogypsum and mineral fertilization have been tested.

OBJECTIFS

General objective:

The main goal of this study is to contribute to the increase of the carbon content of the soil and to promote agroecological practices

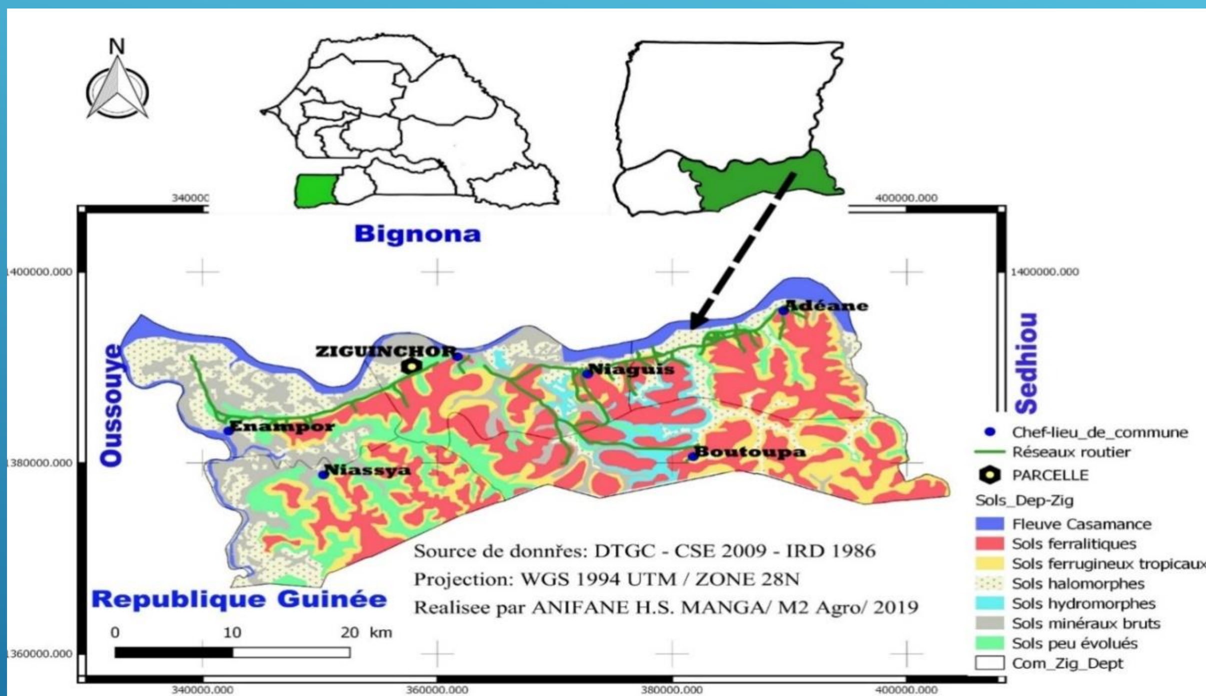
Specific objective:

To study the effects of two types of composts, phosphogypsum and mineral fertilization on the chemical and biochemical parameters of the soil and on the agronomic parameters in acidic saline sulphate soils.

Material and methods

The study was carried out at the rice station of the Agricultural Research Center (ARC) of Djibélor (;) in the commune of Niaguis, Ziguinchor Senegal.

This station is geographically located at 12°33'39" latitude north and 16°18'25" longitude west (Fig 1).



Ziguinchor is characterized by a southern coastal sudanian climate (Sagna, 2005) with two seasons: a dry season of 7 to 8 months which lasts from November to May and a rainy season which lasts. 4 to 5 months (June to October). The annual average temperature is around 27 °C (1984 and 2012). The minimum and maximum temperatures are 15.5 and 37 ° C.

The average annual rainfall is estimated at 1316 mm.

Experimental design

- The experimental design was carried in Fisher blocks with four repetitions. In each block, there are five elementary plots (2 m^2) corresponding to the treatments. These treatments were randomly placed in the plots. The treatment was single factor organo-mineral fertilization.
- Five treatment levels were studied: control (T0), mineral fertilization (MF) (200kg/ha 15N-15P-15K + 150 kg/ha Urea 46N-0P_2O_5-0K_2O), phosphogypsum (Pho, 1 t/ha), the dose of compost formula 1(F1, 7t/ha) and compost formula 2 (F2, 7t/ha).

Formulas	Ashes of dead wood	Manur crumb	**Rice straw (orizea sativa**	Poultry droppings	**Crushed oyster shells**	Fresh green residus of *crotalria retusa l.*	Peanut powder	**Sraw of *andropognon gayanus k.***	**Urea**	**Phosphogypsum**	Total (kg)
F1	25	93	**190**	37	**4**	2	85	**0**	**0**	**0**	436
F2	25	93	**0**	29	**0**	2	85	**190**	**8**	**2**	434

- The compost formulas (F1) and (F2) have the characteristics of organic matter described by Badiane *and al.,* (2019). The F1 is based on rice straw (Oryza sativa L.), manure crumb and peanut powder. F2 consists of Andropogon gayanus Khunth, phosphogypsum and urea. The other components are common to both formulas

Soil analysis

Soil sampling was carried out in 0-20 cm and 20-40 cm of each elementary plot To determine the pH, the salinity and the microbial enzymatic activities, soil samples were taken before and after the application of the treatments.

Soil pH and electrical conductivity (EC) were measured in a slurry with a 1: 2.5 and 1: 5 soil-to-water ratio (w/v), respectively.

β-glucosidase and acid phosphatase activities were analyzed for each sample. β-glucosidase was analyzed using the method of Hayano, (1973) and acid phosphatase analysis followed the Tabatabai and Bremner, (1969) procedure.

Agronomic measures

The plant recovery rate (PRR) was calculated as the ratio of the number of plants that survived (NPS) to the total number of plants (NPT) multiplied by one hundred.

The grains yield of rice expressed as dry matter (drying in an oven at 65 ° C during 72h) was measured from samples of the 0.64 m^2 yield squares in the center of the elementary plot of 2 m^2

Data processing and analysis

Analyzes of variance (ANOVA) at the 5% threshold, Fisher's means comparison tests were performed to establish the significance of the differences and the comparison of treatments.

Results on the soil variation according to treatments in each horizon

- Before the application of the treatments, there is no significant difference between the pH values of the soil regardless of the horizon

deph (cm)	Treatments	T0Day	T15Days	T30days	T45Days	T60Days	T75Days	T90Days	T105Days	T120Days
0-20	Control T0	3.80 ± 0.2^{a}	4.46 ± 0.57^{bc}	5.10 ± 0.26^{a}	4.86 ± 0.50^{b}	6.66 ± 0.15^{a}	6.33 ± 0.15^{a}	5.96 ± 1.1^{ab}	3.86 ± 0.25^{bc}	4.16 ± 0.05^{cd}
	F1	3.80 ± 0.2^{a}	5.30 ± 0.60^{a}	5.06 ± 0.66^{a}	5.80 ± 0.2^{a}	6.80 ± 0.3^{a}	6.43 ± 0.05^{a}	6.63 ± 0.55^{a}	4.76 ± 0.06^{a}	4.90 ± 0.10^{a}
	F2	3.80 ± 0.2^{a}	4.43 ± 0.20^{bc}	4.86 ± 0.50^{ab}	5.86 ± 0.15^{a}	6.33 ± 0.60^{ab}	6.43 ± 0.11^{a}	6.16 ± 0.49^{ab}	4.56 ± 0.06^{a}	4.63 ± 0.23^{b}
	FM	3.80 ± 0.2^{a}	4.66 ± 0.51^{b}	5.06 ± 0.63^{a}	5.86 ± 0.58^{a}	5.90 ± 0.36^{bc}	6.36 ± 0.40^{a}	5.60 ± 0.98^{abc}	4.06 ± 0.06^{b}	4.23 ± 0.05^{c}
	Pho	3.80 ± 0.2^{a}	4.90 ± 0.52^{ab}	5.03 ± 0.21^{a}	5.66 ± 0.75^{a}	6.60 ± 0.31^{a}	6.13 ± 0.30^{a}	6.13 ± 0.32^{ab}	3.86 ± 0.21^{bc}	4.10 ± 0.10^{cde}
20-40	Control T0	3.66 ± 0.30^{a}	3.96 ± 0.15^{c}	4.46 ± 0.23^{abc}	4.53 ± 0.23^{b}	5.40 ± 0.21^{c}	4.63 ± 0.41^{b}	4.33 ± 0.57^{d}	3.63 ± 0.11^{c}	3.83 ± 0.04^{f}
	F1	3.66 ± 0.30^{a}	3.96 ± 0.12^{c}	4.46 ± 0.32^{ab}	4.63 ± 0.15^{b}	5.93 ± 0.23^{bc}	4.53 ± 0.47^{b}	4.53 ± 0.55^{cd}	4.06 ± 0.46^{b}	4.03 ± 0.1^{de}
	F2	3.66 ± 0.30^{a}	3.96 ± 0.11^{c}	4.16 ± 0.23^{c}	4.70 ± 0.2^{b}	5.76 ± 0.21^{bc}	4.60 ± 0.43^{b}	5.10 ± 0.4^{bcd}	3.83 ± 0.15^{bc}	4.00 ± 0.05^{def}
	FM	3.66 ± 0.30^{a}	3.93 ± 0.11^{c}	4.33 ± 0.41^{bc}	4.73 ± 0.47^{b}	5.66 ± 0.11^{c}	4.63 ± 0.25^{b}	5.20 ± 10^{bcd}	4.10 ± 0.26^{b}	3.93 ± 0.06^{ef}
	Pho	3.66 ± 0.30^{a}	3.96 ± 0.15^{c}	4.10 ± 0.17^{c}	4.90 ± 0.26^{b}	5.80 ± 0.88^{bc}	5.03 ± 0.55^{b}	4.70 ± 0.52^{cd}	3.93 ± 0.32^{bc}	3.93 ± 0.05^{ef}
	Pr > F	0.987	0.0001	0.021	0.0001	0.002	0.0001	0.007	0.0001	0.0001
	Significance	ns	yes	yes	yes	yes	yes	yes	yes	yes

- Fifteen days after application of the treatments, significant effects ($p<0.0001$) were observed in the 0-20 cm horizon, The pH recorded in F1 (5.30) is significantly higher than F2 (4.43), T0 (4.46), MF (4.66) and Pho (4.90**).**
- The soil pH did not vary significantly between treatments on the 30th, 75th and 90th days in horizon 0-20 cm. On the 105th days, the pH of F1(4.767) and F2 (4.567) were significatively higher ($p <0.000$) than T0 (3,86), MF (4,067) and Pho (3,86)
- In the horizon 20-40 cm, there were no significant effects of treatments on pH from 15 to 90 days. However, on the 105th and 120th days, the pH of T0 was is more acidic than the other treatments.
- Overall, the results show that the pH is higher in 0-20 cm than in 20-40 cm. the effect of the inputs was superficial and limited during the start of the test in the 0-20 cm soil layer.

Results on the soil level of salinity and enzymatic activities

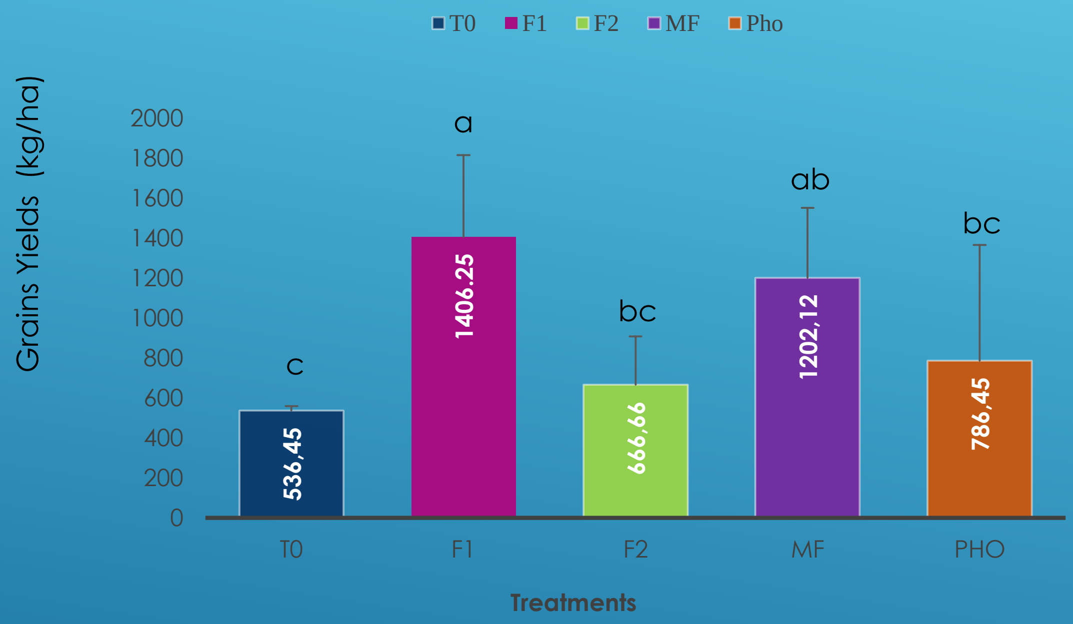
Before the application of the treatments, soil enzymatic activities and salinity did not vary significantly ($p>0.05$) between the horizons.

		T0Day			T120days		
Deph (cm)	Treatments	β-glucosidase (µg p-Np/g dry soil/h	Phosphatase Acide (µg p-Np/g dry soil/h	Salinité (‰)	β-glucosidase (µg p-Np/g dry soil/h	Phosphatase Acide (µg p-Np/g dry soil/h	Salinité (‰)
0-20	Control T0	14.22 ± 4.24^{a}	60.32 ± 24.79^{a}	102.68 ± 4.90^{a}	122.61 ± 47.72^{ab}	16.63 ± 27.40^{cd}	53.67 ± 12.81^{a}
	F1	14.22 ± 4.24^{a}	60.32 ± 24.79^{a}	102.68 ± 4.90^{a}	114.13 ± 5.99^{ab}	76.42 ± 9.87^{a}	48.42 ± 12.81^{a}
	F2	14.22 ± 4.24^{a}	60.32 ± 24.79^{a}	102.68 ± 4.90^{a}	128.58 ± 14^{a}	56.98 ± 33.24^{ab}	53.67 ± 18.21^{a}
	FM	14.22 ± 4.24^{a}	60.32 ± 24.79^{a}	102.68 ± 4.90^{a}	102.41 ± 23.87^{b}	23.08 ± 10.35^{cd}	53.67 ± 10.57^{a}
	Pho	14.22 ± 4.24^{a}	60.32 ± 24.79^{a}	102.68 ± 4.90^{a}	8.80 ± 0.26^{c}	35.47 ± 16.17^{bcd}	42.37 ± 25.01^{a}
20-40	Control T0	17.98 ± 14.05^{a}	42.32 ± 16.60^{a}	109.92 ± 18.79^{a}	6.00 ± 3.34^{c}	9.52 ± 8.04^{d}	73.50 ± 20.14^{a}
	F1	17.98 ± 14.05^{a}	42.32 ± 16.60^{a}	109.92 ± 18.79^{a}	10.44 ± 3.43^{c}	29.20 ± 16.19^{bcd}	52.50 ± 3.89^{a}
	F2	17.98 ± 14.05^{a}	42.32 ± 16.60^{a}	109.92 ± 18.79^{a}	15.38 ± 10.36^{c}	38.61 ± 19.07^{bc}	68.66 ± 25.59^{a}
	FM	17.98 ± 14.05^{a}	42.32 ± 16.60^{a}	109.92 ± 18.79^{a}	7.85 ± 2.55^{c}	19.38 ± 19.66^{cd}	42.81 ± 12.13^{a}
	Pho	17.98 ± 14.05^{a}	42.32 ± 16.60^{a}	109.92 ± 18.79^{a}	18.24 ± 11.44^{c}	24.05 ± 8.28^{cd}	52.50 ± 33.23^{a}
Pr > F		0.999	0.777	0.985	0.0001	0.002	0.63
Significance		ns	ns	ns	yes	yes	yes

- At 120 days, the treatments had a significant effect ($p<0.05$) on soil enzymatic activities. For the acide phosphatase, the higher values were recorded in F1 and F2 and the lower in T0 in the horizon 0-20 Cm. The β-glucosidase activity was significantly higher in F2 compared to FM and phosphogypsum.
- The treatments did not influence significantly ($p=0.630$) the salinity at 120 days.

Results on the rice plant mortality rate according to treatments

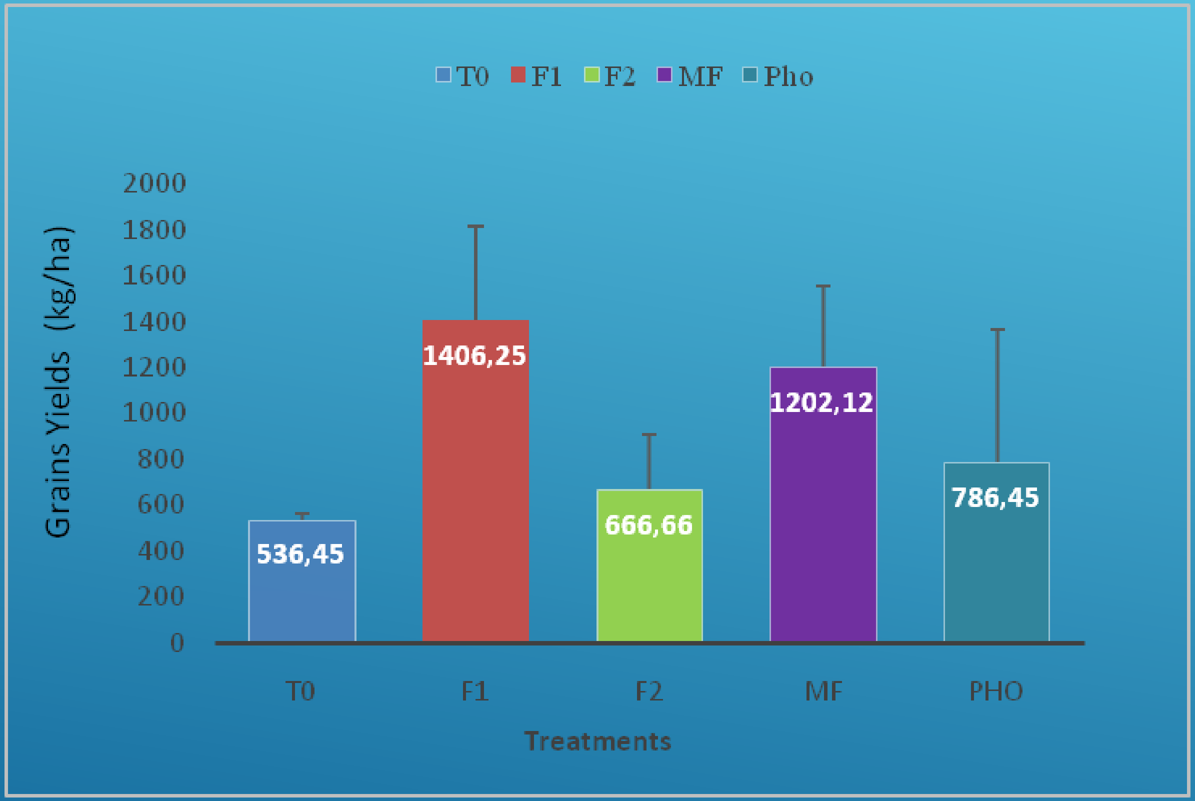
The mortality rate of the plants was not significantly (Pr = 0.304) affected by soil amendment and mineral fertilizer.



The trends show that phosphogypsum gave the lowest plant mortality rate (3.03%) followed by F1 (10.28%). On the other hand, the highest plant mortality rate was recorded at the control level (21.71%).

Results on the grain yield (kg/ha)

The highest grain yield is obtained with compost made from rice straw and crushed shellfish (F1) followed by mineral fertilizer (MF).
The grain yield between the phosphogypsum treatments, the) compost (F2 and the control (T0) are not significantly different.



The rate of increase in grain yield is 162.14% for F1 compared to control (T0) followed by FM (124.1%) and the lowest rate is recorded at the level of the treatment with phosphogypsum (46%) and compost F2 (24. 7%).

Discussions

- Organic matter has a greater effect on the parameters measured. This could be explained on the one hand by a significant presence of microorganisms (density) due to composts compared to phosphogypsum. Indeed, even if it has the action of replacing sodium (Na^+) attached to the complex absorbing calcium (Ca^{2+}) that it contains (Ndiaye, 1999), phosphogypsum does not provide additional nutrients to the body. Beyond the role of Ca^{2+} on the leaching of the Na^+ salt.

- The hypothesis of a denaturation of the enzymatic reaction in the presence of this product would be plausible with a considerable reduction in the function of the responsible microorganisms.

- Important note on compost amendments (F1 and F2) could explain the more pronounced expression of these on biological parameters. Referring to the studies by Dick et al. (1988), soil pH influences the rate of enzymatic reactions by impacting ionization and solubility of enzymes and cofactors. In addition, acid phosphatase activity dominates at pH substantially equal to 5 (Eivazi and Tabatabai, 1977; Dick et al., 2000). On the other hand, Dick (1992) asserts that organic inputs increase biological activity. This could explain the weak effects of control and phosphogypsum observed on chemical and biological parameters.

Discussions

- The positive action of phosphogypsum on the survival rate of rice plants could be explained by an immediate effect of reducing salinity. According to Mutsaars and Van Der Velden, (1973), gypsum leaches sodium ions (Na^+) and (Cl^-) in favor of bivalent ions (Ca^{2+}), (Mg^{2+}) and (SO_4^{2-}). This is not the case with other types of amendments. However, compared to the control, the compost formulas had positive effects on the survival rate.

- Also, the presence of organic matter in the soil is essential to maintain soil fertility and to reduce nutrient loss (Inckel et al., 2005). The significant effect of the amendments is also marked at the level of grain yield and aboveground biomass. This effect is more observed at the level of the amendments in F1. This could be due to the rice straw and the oyster shell crumbs that make this formula so special.

- In fact, the oyster shell crumb, rich in calcium, fixes the salts present in the soil, while the easily degradable rice straw enriches the soil with elements necessary for the development of the plant. According to Inckel et al. (2005) organic matter contains important nutrients such as nitrogen (N), phosphorus (P) and potassium (K) which will be available to plants after decomposition. Moreover, these results are also supported by a few studies (SOLAG, 2016) which affirm that calcium participates in the formation of the clay-humic complex, in soil conservation and also to raise the pH as well as the availability of nutrients. Also, nitrogen is a determining nutrient in plant growth (Wageningen, 1996).

Conclusions

- The results of this study show that Organic amendments from compost increase pH, density and microbial activity. This promotes good behavior of the rice plants and better yields.

- The addition of organic amendments based on improved compost formulas could be an alternative to the use of phosphogypsum (polluted with heavy minerals) for the valorization of degraded lands, in particular by salinity in Senegal.

Thanks

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