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EFFECTS OF MICRODOSE FERTILIZATION ON SANIO MILLET (*Pennisetum glaucum* (L.) R. Br) IN LOW CASAMANCE (SOUTHERN SENEGAL)

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ABSTRACT

This study aims to evaluate the agronomic performance of microdose fertilization on sanio millet. Specifically, the effect of microdosing on growth and production parameters of sanio millet was tested. To do this, a complete randomized block trial was set up with four blocks, each with six treatments: control (T0); 2) farm practice (T1): 10 t. ha^{-1} of manure; 3) microdose (T2), 10 t. ha^{-1} + 3 g NPK (15-15-15) + 2 g urea per plant. The NPK and urea were applied in a 5 cm deep hole about 7 cm from the plant; 4) research recommendation (T3), 10 t. ha^{-1} of manure + 9.6 g NPK (15-15-15) + 6.4 g urea per plant; 5) (T4): 10 t. ha^{-1} of manure + 75% of T3 fertilizer rate; 6) 10 t. ha^{-1} of manure + 50% of T3 fertilizer rate. This study demonstrated the effect of organic fertilization and the effect of organo-mineral fertilization on the growth and production parameters of Sanio millet. The microdose was effective on growth parameters compared to the farmer's traditional practice. However, the differences in straw biomass, the number of ears, and the weight of ears were not significant between the microdose and the farmer's traditional practice. The Straw biomass and the number of ears were significantly higher on T3 compared to the microdose. Given the results, it would be interesting to repeat this study at the station and at the same time in the farmers' field to draw conclusions and make recommendations regarding the microdose fertilization technique.

Keywords: Microdose, Sanio millet, agronomic performance, manure, organo-mineral fertilization, farmer's traditional practice.

1. INTRODUCTION

Millet (*Pennisetum glaucum*) is one of the main food crops in Senegal and is the most important cereal in terms of production behind rice (*Oryza sativa*). It is grown on more than 60 % of the country's arable land (Sy et al., 2015), with production estimated at 1,144,855 tons in 2020 (DAPSA, 2021). Two types of millet varieties are mainly grown in Senegal: the Souna millet or early type (generally non-photoperiodic) which is grown almost nationwide (ISRA et al., 2005), while the late type or Sanio millet (generally photoperiodic) is mainly grown in Casamance and Eastern Senegal (Bamba et al., 2019). In Basse Casamance, Sanio millet is the most important crop behind rice, groundnut (*Arachis hypogaea*), and cowpea (*Vigna unguiculata*) (Sané, 2017). Its production in the zone is estimated at 3,878 tons in 2019, or only 0.5 % of national production

(DAPSA, 2021). Despite its importance in this area, Sani millet is grown in bush fields in small areas with low yields (< 700 kg/ha) (Bamba et al., 2019). This low yield is explained by the use of traditional varieties, poor access to agricultural inputs, and poor understanding of soil amendment and fertilization technologies (Coly et al., 2021). The fertilization of plots in Lower Casamance is essentially based on the addition of organic manure. However, some farmers also use mineral fertilizers. The use of organic amendments and mineral fertilizers in this area is limited by, among other things, the high cost and inaccessibility of mineral fertilizers, but also a problem of availability of organic manure (Bamba et al., 2019). In addition, farmers do not receive enough support and training from technical and extension services (Sané, 2017).

In this context, the empowerment of farmers to acquire new cultivation practices and skills, particularly fertilization techniques such as microdosing, combining organic and mineral fertilizers, could contribute to the improvement of soil quality and crop yields, especially that of Sanio millet in Lower Casamance.

The objective of this study is to evaluate the effects of the microdosing fertilization technique on the growth and production of Sanio millet in Basse Casamance.

2.MATERIALS AND METHODS

2.1 Experimental site

The study was conducted in Lower Casamance/Senegal, with a continental South Sudanian Climate (Sagna et al., 2012). This region of Casamance accounts for most of the rainfall in the Country. Over the period 1992 to 2022, the rainfall recorded in the Ziguinchor region varied between 800 and 2100 mm, or an average of 1367 mm (Figure 1). The rainy season lasts approximately five months in this zone, from June to October (Ndiaye et al., 2019; Tounkara et al., 2022). The year 2022 was marked by a surplus rainfall of 1,415 mm (Figure 1). The average annual temperature of the area ranges from 20.7°C to 34.1°C (Sané, 2017). Leached tropical ferruginous type soils (or beige soils) are very present in Lower Casamance as they are found almost everywhere outside the fluviomarine domain (Sané, 2017).

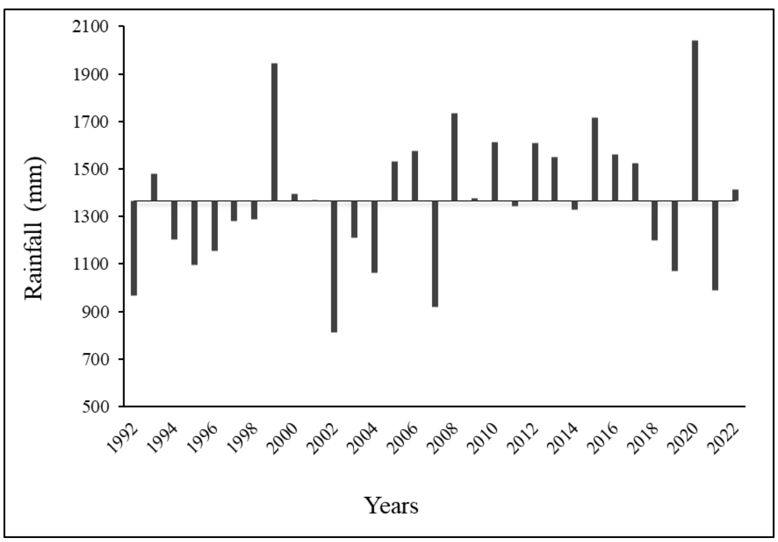

Figure 1: Inter-annual variation in rainfall from 1992 to 2022 in Lower Casamance recorded at

the Ziguinchor regional weather station.

The test plot site is located at Assane Seck University in Ziguinchor region at 12°78'33" North and 16°21'66" West (Figure 2).

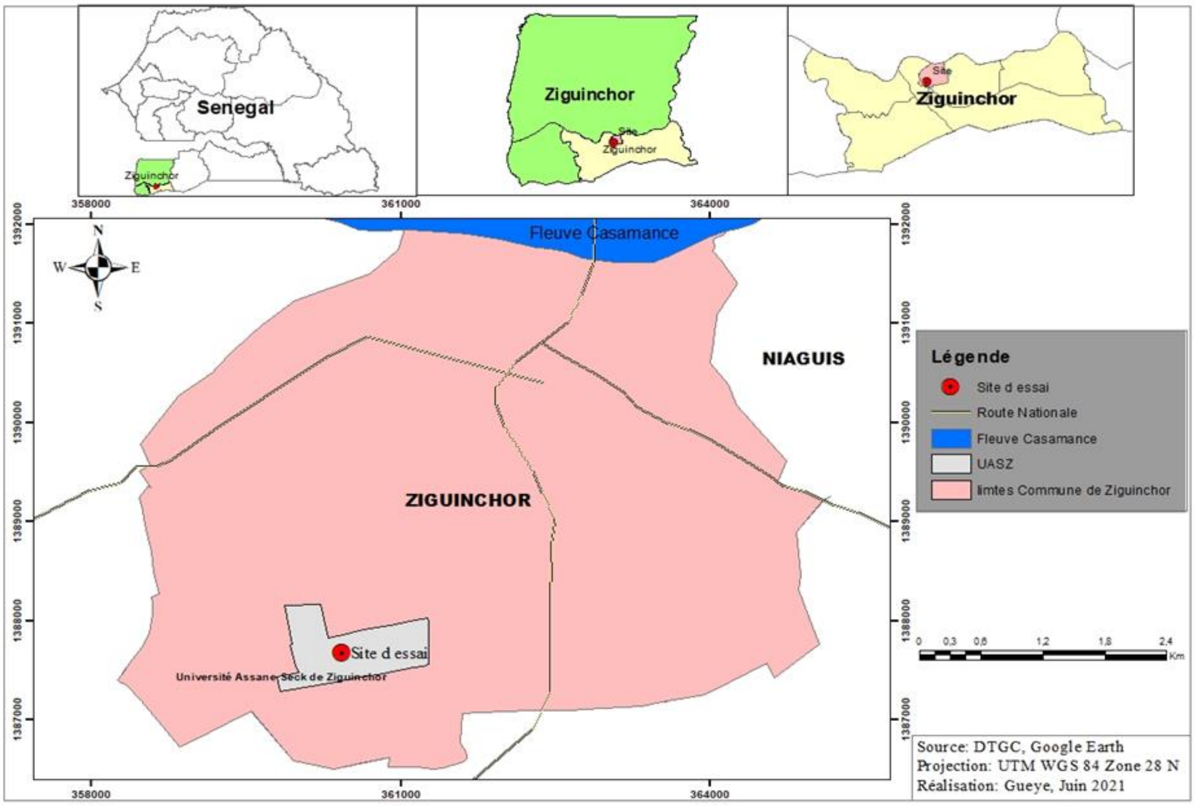

Figure 2: Location of the experimental site (Tounkara et al., 2022)

2.2 Plant material

The plant material used is a Sanio millet cultivar grown in Casamance. It has a height of 3 to 3.5 m, a cropping cycle of 130 to 150 days with aristate ears and it is photoperiodic (ISRA et al., 2005; Bamba et al., 2019; Ndiaye et al., 2019; Coly et al., 2021; Tounkara et al., 2022).

2.3 Experimental Design

This study was conducted during two years, the 2021 and 2022 rainy seasons. The experiment design is a randomized complete block design with four treatments and four replicates or blocks. There was a total of 16 plots of 16 m² (4 m x 4 m) each. The treatments were 1) control (**T0**), with no fertilizer application; 2) farm practice (**T1**): which is the usual practice of farmers (on millet) in Lower Casamance with the application of 10 t. ha^{-1} before sowing; 3) microdose (**T2**), manure was applied at a rate of 10 t. ha^{-1} before sowing. 3 g of NPK (15-15-15) per plant at 10 DAG (days after germination) and 2 g of urea per plant at 30 DAG were then applied. The NPK and urea were applied in a 5 cm deep hole about 7 cm from the plant. The hole was buried after application; 4) research recommendation (**T3**), where 10 t. ha^{-1} of manure was applied before sowing. In addition, 9.6 g NPK (15-15-15) + 3.2 g urea per plant were applied at 10 DAG, then 3.2 g urea per plant at 30 DAG. NPK and urea were applied around the crop and buried after application; 5) 75% T3 (**T4**), manure was applied at the same rate (10 t. ha^{-1}) as on T3, but NPK and urea were reduced by 25% compared to T3, i.e. 7.2 g of NPK (15-15-15) + 2.4 g of urea were applied per plant at 10 DAG and 2.4 g of urea per plant at 30 DAG; 6) 50% T3 (**T5)** where manure was applied at the same rate of 10 t. ha^{-1} as on T3, but NPK and urea are reduced by 50% compared to T3, i.e. 4.8 g of NPK (15-15-15) + 1.6 g of urea per plant at 10 DAG, then 1.6 g of urea per plant at 30 DAG.

2.4 Land preparation, fertilizer application, and crop planting

Experimental plots were weeded and tilled before the application of fertilizers. The manure, a mixture of sheep dung and poultry droppings, was applied to the corresponding plots a week before planting. The millet was sown on August 12, 2022, with five seeds per plant at an 80 cm spacing and a density of 15 625 plants per hectare. The NPK fertilizer was applied in two fractions, at 10 and 30 DAG. Urea was applied at 30 DAG. The three-plant-per-bunch weeding was carried out at 15 DAG. Three weedings were carried out respectively at 15 DAG, 30 DAG and 45 DAG.

2.5 Measured parameters

The number of tillers per m^2 was counted on 5 random plants of each treatment, every 10 days starting 21 DAG to 71 DAG. Plant height was assessed on these five plots. The straw biomass, the number of ears, and their weight were determined at harvest on each treatment. Grain yield was not assessed due to birds eating some of the crop samples.

2.6 Statistical analysis

Analyses of variance (ANOVA) were performed with STATISTICA software (Stat Soft. Inc. (2007)) to assess the effect of treatments on the different variables measured. The mean difference was compared using the Student Newman Keuls test at a significance level of 5%.

3. RESULTS

3.1 Sanio millet plant height according to treatments and measurement dates

The analysis of variance revealed a significant difference in plant height between treatments at the 21st, 31st, 41st, 51^{st,} and 61st DAG (Day After Germination) (Table 1). Overall, treatment T3 (recommended mineral fertilization) had the highest average height (2.09 ± 0.38 m), followed by treatment T5 (50% T3) with an average height of 2.06 ± 0.41 m and T2 (microdose) with an average height of 1.91 ± 0.30 m at 61st DAG. There was no significant difference between T2, T3, T4, and T5 within the same date, however, there was a significant difference in plant height between T2 (microdose) and T1 (farming practice). The control (T0) and T3 gave the lowest heights with 0.78 ± 0.21 m and 1.47 ± 0.32 m respectively at 61st DAG.

Tableau 1: Variation in plant height (m) according to treatments and measurement dates. DAG: the day after germination. T0 = control ; T1= farmer practice ; T2 = microdose ; T3 = recommended mineral fertilization ; T4 = 75% T3 ; T5 = 50% T3.

Measurement dates					
Treatments	**21 DAG**	**31 DAG**	**41 DAG**	**51 DAG**	**61 DAG**
T0	0.23 ± 0.14 b	0.28 ± 0.11 b	0.47 ± 0.10 d	0.54 ± 0.12 d	0.78 ± 0.21 c
T1	0.33 ± 0.10 a	0.67 ± 0.14 a	0.82 ± 0.12 c	0.95 ± 0.20 c	1.47 ± 0.32 b
T2	0.41 ± 0.11 a	0.64 ± 0.15 a	0.97 ± 0.16 ab	1.30 ± 0.16 b	1.91 ± 0.30 a
T3	0.39 ± 0.10 a	0.66 ± 0.13 a	1.03 ± 1.12 a	1.43 ± 0.17 a	2.09 ± 0.38 a
T4	0.31 ± 0.08 a	0.62 ± 0.10 a	0.97 ± 0.10 a	1.22 ± 0.16 b	1.84 ± 0.31a
T5	0.35 ± 0.10 a	0.68 ± 0.12 a	0.88 ± 0.11 bc	1.23 ± 0.31 b	2.06 ± 0.41 a
Average	**0.33**	**0.59**	**0.86**	**1.11**	**1.69**
Probability	**< 0.0001**	**< 0.0001**	**<0.0001**	**< 0.0001**	**<0.0001**

3.2 Sanio millet tillers production according to treatments and measurement dates

Analysis of variance indicated a significant effect of treatments on millet tillers production for all measurement dates (Table 2). No significant difference between T2, T3, T4, and T5 at 71st DAG, however, there is a significant difference in the number of tillers produced between T2 (microdose) and T1 (farming practice). The lowest number of tillers produced was recorded at this date with the control T0 (2 ± 1 tillers/m^2) and T1 (3 ± 1 tiller/m^2).

Tableau 2: variation of the number of tillers produced per m² by Sanio millet according to the treatments

Measurement dates						
Treatments	**21 DAG**	**31 DAG**	**41 DAG**	**51 DAG**	**61 DAG**	**71 DAG**
T0	0.67 ± 0.14 b	0.90 ± 0.32 c	0.99 ± 0.39 d	0.93 ± 0.60 c	1.18 ± 0.67 c	1.89 ± 0.82 c
T1	0.77 ± 0.33 b	1.82 ± 0.67 b	2.5 ± 0.77 c	2.34 ± 1.18 b	2.43 ± 1.22 b	2.75 ± 1.36 b
T2	1.28 ± 0.46 a	2.53± 0.87 a	3.2 ± 0.75 b	4.38 ± 2.70 a	4.61 ± 2.56 a	5.82 ± 3.08 a
T3	1.22 ± 0.46 a	2.72 ± 0.90 a	3.74 ± 0.84 a	5.06 ± 2.79 a	5.34 ± 2.59 a	5.92 ± 2.78 a
T4	1.06 ± 0.48 a	2.66 ± 1.22 a	3.01 ± 0.83 b	4.58 ± 2.69 a	4.77 ± 2.56 a	5.31 ± 2.57 a
T5	1.15 ± 0.49 a	2.94 ± 0.87 a	3.23 ± 0.64 b	3.94 ± 1.77 a	4.06 ± 1.70 a	4.51 ± 1.78 a
Average	**1.02**	**2.26**	**2.78**	**3.54**	**3.73**	**4.36**
Probability	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

3.3 Straw biomass of Sanio millet

Analysis of variance showed a highly significant difference (p=0.00095) in straw production between treatments (Figure 3). The straw biomass of treatment T3 (5,495 kg. ha^{-1}) was significantly higher than all other treatments except treatment T4 (3,569 kg. ha^{-1}). The T0 control has the lowest straw biomass with 103 kg. ha^{-1}. The difference in straw biomass is significant between T0 and T1 (980 kg. ha^{-1}), but not significantly different between T1 and T2 (2,547 kg. ha^{-1}).

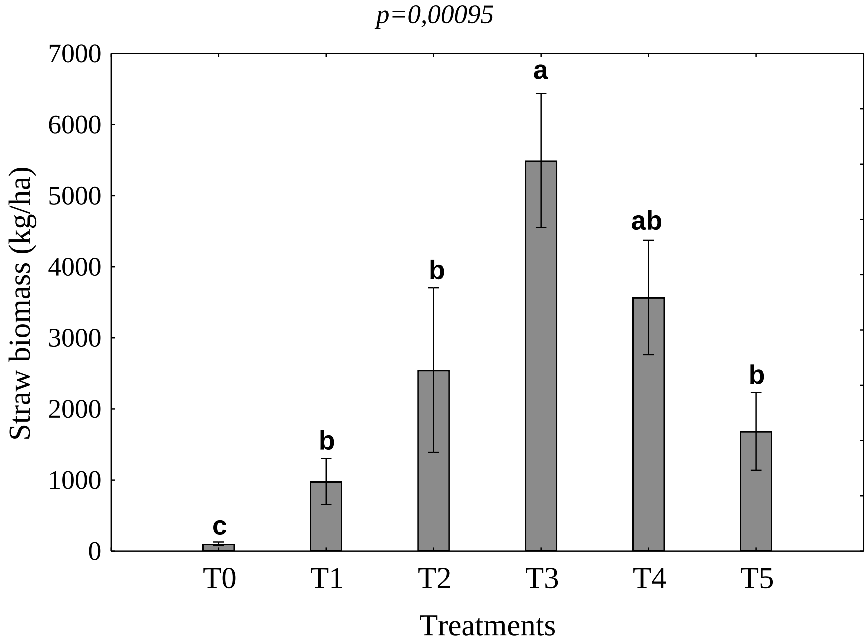

Figure 3: Effects of treatments on millet straw biomass

3.4 Sanio millet ears production

Analysis of variance showed a highly significant difference (p=0.00095) in the number of ears produced per ha between treatments (Figure 4). The number of ears produced in treatment T3 (59,375 ears. ha^{-1}) was significantly higher than all other treatments except treatment T5 (55,000 ears. ha^{-1}). The T0 control has the lowest number of ears produced with 7,5 ears. ha^{-1}. The difference in ears produced is significant between T0 and T1 (31,406 ears. ha^{-1}), but not significantly different between T1, T2 (37,656 ears. ha^{-1}), T4 (37,5 ears. ha^{-1}) et T5.

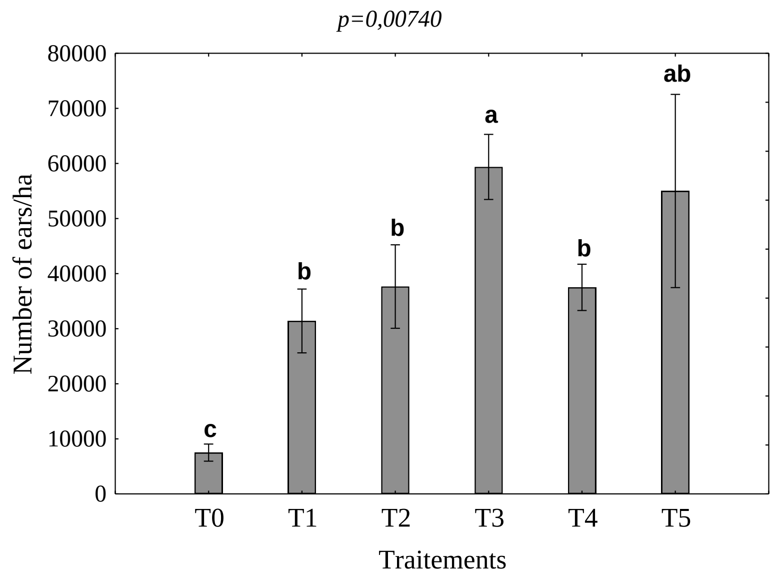

Figure 4: Effect of treatments on the number of ears Sanio millet ears produced per hectare

3.5 Biomass production in ears of Sanio millet

Analysis of variance revealed a significant difference (P=0.00020) in ears biomass as a function of treatments (Figure 5). The ears biomass in treatment T3 (841 kg. ha^{-1}) was significantly higher than all other treatments except treatment T2 (616 kg. ha^{-1}). The T0 control has the lowest ears biomass with 103 kg. ha^{-1}. The difference in ears biomass is significant between T0 and T1 (405 kg. ha^{-1}), but not significantly different between T1, T2, T4 (338 kg. ha^{-1}) et T5 (534 kg. ha^{-1}).

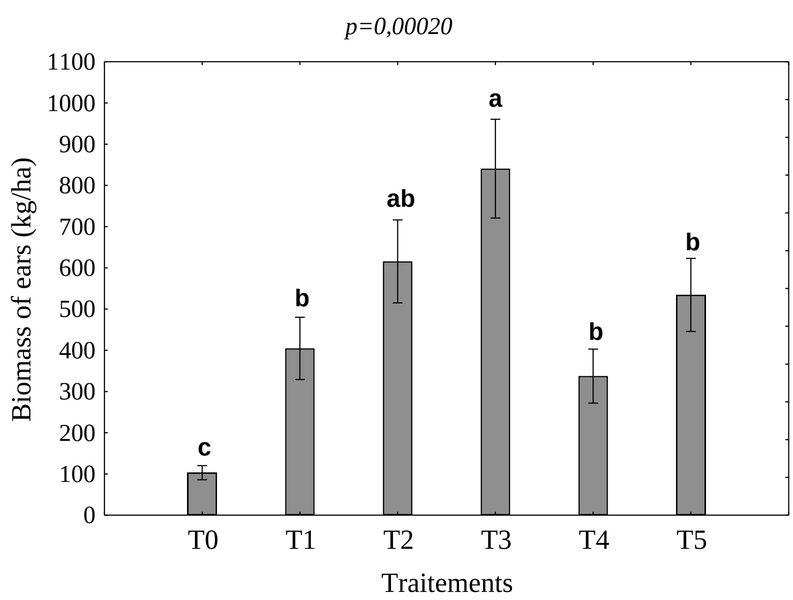

Figure 5: Effect of treatments on the Sanio millet cob biomass

3.6 Relation between number of ears and number of ears per plant

Figure 6 shows the variation in the number of ears per plant as a function of the number of tillers formed per plant. The number of tillers remains a key element for the number of spikes per plant: the more tillers/plant, the more ears/plant. Also, the best-fertilized treatments recorded the most tillers and therefore the greatest number of ears. Nevertheless, we notice that only half (53%) of the tillers give ears.

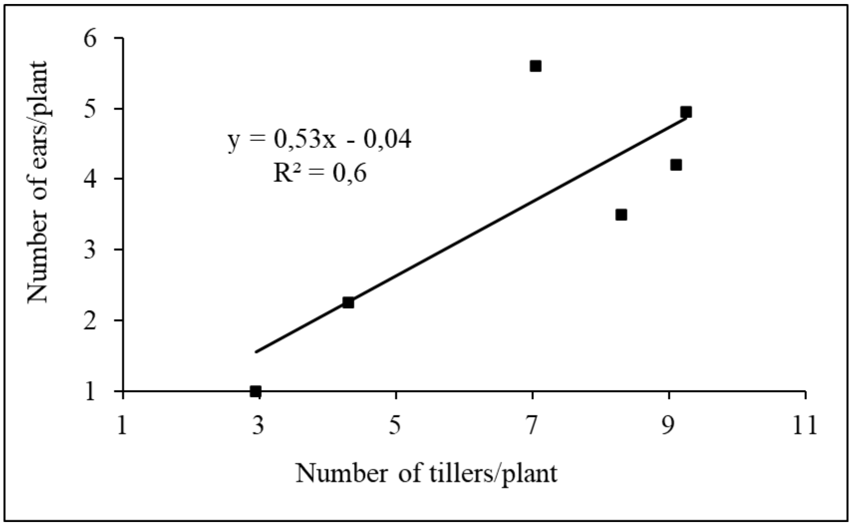

Figure 6 : Relation between number of ears and tillers per plant

4.DISCUSSION

The height and number of tillers were significantly higher on the treatment with organic amendment only (T1) compared to the control without fertilizer (T0). This effect of organic amendment on millet growth parameters corroborates with the results of Cissé (1988) and Ndiaye et al. (2019) on millet. However, these results are not in line with those of Diallo et al. (2019) who show no effect of organic fertilizer on millet growth. Treatments that received organo-mineral fertilization were more effective on the growth parameters of Sanio millet. These results agree with those of Ndiaye et al. (2019), Coly et al. (2021), and Tounkara et al. (2022) who showed a positive effect of organo-mineral fertilization on height and tillers production of Sanio millet.

As for the growth parameters, organic amendment and organo-mineral fertilization had a significant effect on the production parameters of Sanio millet. Indeed, the organic amendment had a positive effect on the straw biomass, the number of ears, and the weight of the ears of Sanio millet. These results are in line with those of Badiane (1986) who showed a positive response of manure application on the weight of ears, stem biomass, and grain weight of the millet Souna variety. Tounkara (2021) also showed the effect of manure application on the yield of Souna millet. However, these results are not in line with those of Ndiaye et al. (2019) who show no effect of organic amendment on the yield components of Sanio millet. The positive effect of organo-mineral fertilization on production parameters (straw biomass, number of ears, and weight of ears) agrees with results reported in the literature on the effects of organo-mineral fertilization on millet yield and yield components (Badiane et al., 2001; Coly et al., 2021; Pale et al., 2021; Tounkara et al., 2020).

On growth parameters, the microdose (T2) was significantly different from the farmer's practice (T1). On production parameters, although the best results were recorded on T2, the differences were not significant compared to T1. Tounkara et al. (2022) and Tounkara et al. (2023) had shown the positive effect of microdosing on the growth and yield of Sanio millet compared to the farmer's practice. On the production parameters, T3, which received the recommended dose of mineral fertilizer, was significantly different from the other treatments. But the weight of the ears was not significantly different between T3 and T2. The straw biomass, the number of cobs, and cob weight were higher on the microdose (T2) compared to the farmer practice (T1), however, the differences were not significant. The results of Tounkara et al. (2022) showed no significant difference in Sanio millet yield between the microdose and the recommended fertilizer dose. Results from CORAF (2011) also showed no significant difference in millet yield between the microdose technique and the recommended fertilizer.

The positive effect of the organic amendment on the growth and production parameters of Sanio millet could be due to an after-effect of the organic manure applied in 2021 on T1 but also to rapid mineralization of the poultry manure that is applied in this experiment. Indeed, according to Etter (2017), poultry manure is rapidly mineralized, as early as the first months after application.

The relationship between the number of ears and the number of tillers (Figure 6) suggests that, for an increase in millet yield, good mineral nutrition combined with organic fertilizer is needed to obtain good tillering and consequently good heading.

5.CONCLUSION

This study demonstrated the effect of organic fertilization and the effect of organo-mineral fertilization on the growth and production parameters of Sanio millet. The application of organic amendment at 10 t. ha^{-1} had a positive effect on the growth and production parameters of Sanio millet. The microdose was effective on growth parameters compared to the farmer's traditional practice. However, the differences in straw biomass, the number of ears, and the weight of ears were not significant between the microdose and the farmer's practice.

Straw biomass and the number of ears were significantly higher on T3 compared to the microdose.

Applications of 50% and 75% of the recommended mineral fertilizer rate (T3) significantly improved the height and number of tillers compared to the farmer's practice, but production parameters were not significantly different.

Compared to the microdose, applications of 50% and 75% of the recommended mineral fertilizer dose had no significant effect on the growth and production parameters of Sanio millet.

Given the results, it would be interesting to repeat this study at the station and at the same time in the farmers' field to draw conclusions and make recommendations regarding the microdose fertilization technique.

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