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Effects of Increasing Doses of Auxins (A.I.A.) on the Field Recovery of Shoots and Juvenile Growth of *Pennisetum purpureum* Schum. on Degraded Soil in Kisangani

Bamuhiga K.D.[1], Okatala Y.F.[2], Likay I.G.[2], Wungu O.D.A.[2], Katusi L.R.[3], Kotongo, N.D.M.[4], Pyame M.L.D.T.[4], Makangi W.K.C.[5], Kambale K.T.[6] and Utshudi D.J.B.[2, 4*]

[1]Water and Forestry Section; Higher Institute of Agro-Veterinary and Nature Conservation of Minembwe, South-Kivu, D. R. Congo

[2]General Agronomy Section; Higher Institute of Agronomic Studies of Yatolema, BP 2324 Kisangani, D. R. Congo

[3]Laboratory of Ecology and Management of Plant Biodiversity (LEGEBIV), Department of Ecology and Plant Resource Management, Faculty of Sciences, University of Kisangani, D. R. Congo

[4]Laboratory of Agroecology, Faculty of Management of Renewable Natural Resources, University of Kisangani, D. R. Congo

[5]Rural Development Section, Higher Institute of Rural Development of Goma, North-Kivu, D. R. Congo

[6]Water and Forestry Section; Higher Institute of Agronomic, Veterinary and Forestry Studies of Butembo, North-Kivu, D. R. Congo

Abstract. Our study was initiated to evaluate the effects of increasing doses of auxins (A.I.A.) on the field recovery of shoots and juvenile growth of *Pennisetum purpureum* on degraded soil in Kisangani.

The crop was installed under real conditions in Kisangani on an area of 462.5 m^2. The agronomic parameters observed are notably the rate of recovery, the tillering index as well as the major growth parameters of the transplanted *Pennisetum purpureum* shoots in the field, including the diameter at the collar and the height of the plants.

We adopted a randomized complete block design, following the provisions related to agroforestry experiments.

The results showed that organo-mineral fertilization used in the transplanting beds, under the conditions of our trials, clearly influenced rhizogenesis and the metabolic activity of the vegetative apparatus of the nursery seedlings. This suggests that a residual effect related to the nutrient content of the plant material would accompany the transplantation of well-fed nursery offshoots into the field. And the application of auxin, under the conditions of use defined during our experiments, did not sufficiently influence the average height of the plants and the average number of leaves per plant.

Key words: auxin, *Pennisetum purpureum*, rhizogenesis, degraded soil, fertilizers

Introduction

Auxin stimulates mitosis, but this action does not occur indiscriminately in all meristems: auxin has little or no effect on proliferation in primary meristems. On the other hand, it has a very marked action on the proliferation of cambiums (Owino *et al.*, 2006; Barbez *et al.*, 2012).

Auxin contributes to the growth of stems and branches, starting from the apical or axillary buds. Its action on length growth in the subapical elongation zone is maximal for relatively high auxin concentrations. However, the elongation of internodes is not caused by auxin. One of the most striking organogenic effects of auxin is its rhizogenicity: applied at high enough concentrations, auxin induces the appearance of roots (Lopez-Zamora *et al.*, 2002; De Smet *et al.*, 2011).

[*]Corresponding Author

In a grass fallow or temporary grassland, the soil structure can be regenerated very clearly under a carpet of *Pennisetum purpureum*, *Panicum maximum*, *Paspalum notatum*, etc., which are distinguished by their efficiency in structural elaboration and enrichment in humus-bearing organic matter (Kashiwagi *et al.*, 2006; Jouquet *et al*., 2014).

Tall perennial and fibrous grasses can be used after mowing to establish plant litter and especially crops of shallow-rooted tree species (Johnson-Maynard *et al.,* 2007; Pyame *et al.*, 2021).

When establishing fallow grasslands with tall perennial grasses including *Pennisetum purpureum*, offshoots and/or stump fragments are usually removed from nurseries and fields and transplanted to a newly developed site. On infertile and/or degraded land, such operations often end in failure, especially since the farmer is poor and unable to finance expensive replanting and weeding.

The main question raised is whether nurseries enriched with various inputs (hormones, bio-stimulants, etc.), in order to stimulate growth on degraded soils, would communicate residual nutrients or residual inputs to the emerging fallow-grasslands, through the offshoots and fragments of the stump, which could then have a positive influence on the resumption and juvenile growth of the new herbaceous stand.

The application of microdoses of hormones (auxins AIA) in the nursery positively influences the recovery rate of *Pennisetum purpureum* sprouts/shoots, as well as their tillering coefficient and juvenile growth at field establishment.

Materials and Methods

Environment

Geographic location and experimental period

Our experimental field was established in Kisangani, capital of the province of Tshopo, in the Democratic Republic of Congo, more precisely at PK12 on the Banalia axis, in the annex commune or Collectivité-Secteur of Lubuya-Bera, at the agroforestry station of the Faculty of Management of Renewable Natural Resources (FGRNR) of the University of Kisangani.

The geographical coordinates of the city of Kisangani are as follows Latitude: 0° 11' North; Longitude: 25° 1' East; Altitude: 390 to 410m with an average of 400m. The city of Kisangani is located in the central basin straddling the Congo River. Its relief is a set of plateaus intersected by river beds and streams (Pyame, 2015).

The experimentation, undertaken at the "participatory research-action station in integrated agroforestry" of the VLIR-UNIKIS cooperation project, was carried out over a period from May 5 to October 15, 2021.

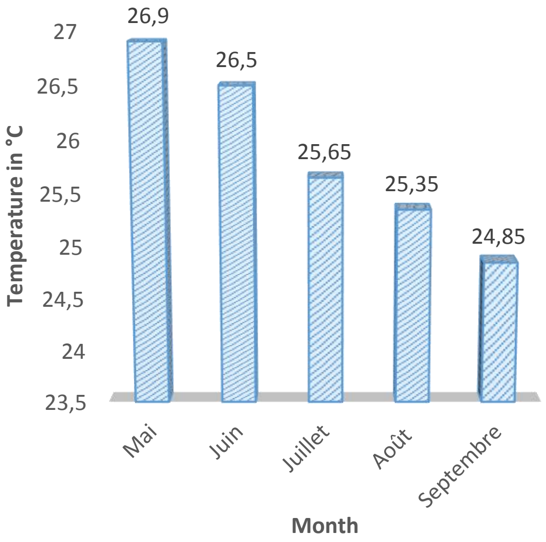
Climate

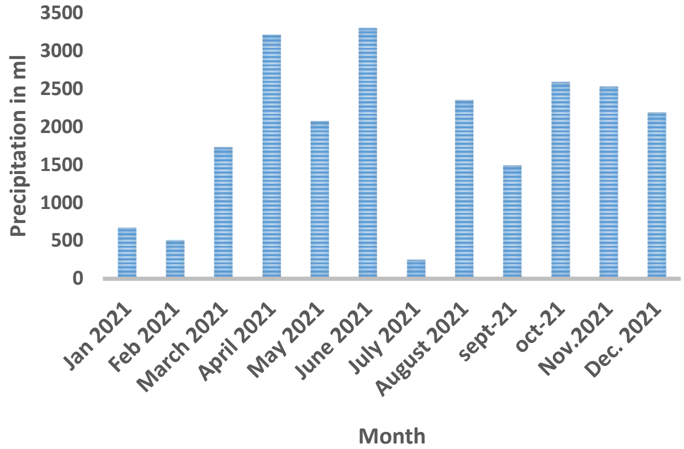
The city of Kisangani has an equatorial climate, characterized by great heat and high humidity. This makes Kisangani an environment where total hydrolysis predominates.

According to the classification of KOPPEN, this climate is of the Af type characterized by a monthly height of precipitations of the driest month superior to 60mm and an annual average temperature superior or equal to 24°c. The average relative humidity is very high all year round and is between 80 and 88%, the annual average being 84%. The insolation is 1972 hours.

The annual rainfall is over 1800mm and is divided into two seasons, one very rainy (mid-August to mid-December) and the other rainy month (mid-March to mid-June).

The climatic data recorded during our experiment are shown in Figures 1 and 2 below.





Figures 1 and 2: Average monthly temperatures (°C) and rainfall (ml)
Source: Meteorological Service, Department of Hydrobiology, CSB/ UNIKIS, Kisangani station (2021)

Soil of the experimental site and previous crop

The soil of our experimental site, as for all the soils around Kisangani, is ferralitic (Pyame, 2015). The previous crop was cassava and soybean. Some grasses such as *Cyperus sp* (Cyperaceae), *Croton Hirtus* (Euphorbiaceae), *Comelina diffusa* (Comelinaceae), *Euphorbia heterophilla* (Euphorbiaceae), *Panicum maximum* (Poaceae), *Spermacos latifolia* (Rubiaceae), *Pueraria phaseolides* (Fabaceae), and *Cynodon dactylon* (Poaceae) were also observed and predominated.

The summary characterization of the topsoil (0-15 cm layer) of the experimental site was presented as follows.

Table 1: Summary characterization of the topsoil (0- 15 cm layer) at the experimental site

Chemical properties of the soil				Granulometry		
P^H water	P^HKcl	Total acidity (méq/100 g)	Al (méq/100 g)	Sands (%)	Silts (%)	Clays (%)
4,5	4,4	2,6	2,0	80,2	14,2	5,6
				Sandy soil		

Source: Chemical analysis of soil at the Lab. Pedology Lab (December 2021)

Materials Used

A variety of materials were used during the accomplishment of this study. It is about the small current material and the glassware of use to the laboratory of pedology, the aratoire material used during the works of opening and maintenance of the field (nursery), the reagents of laboratory, the hormone of the kind auxin (Indole Acetic Acid) and the material of propagation made of cuttings of *Pennisetum purpureum.*

Experimental setup

We adopted a randomized complete block experimental design, following the provisions relating to agroforestry experiments, according to Pyame (2015). The sketch below shows the schematic diagram of this design.

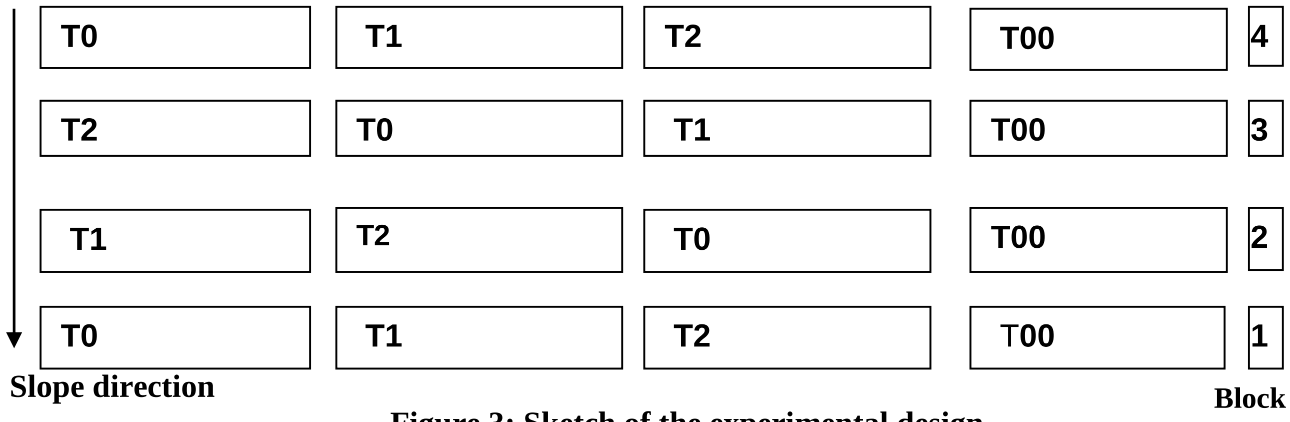


Figure 3: Sketch of the experimental design

Legend: T00= Current planting practice, direct cuttings in the field; T0= production of shoots in the nursery without any additional input; T1= production of shoots in the nursery with a single basal application of auxin (AIA) as growth hormone; T2= production of shoots in the nursery with two basal applications of auxin (AIA) as growth hormone

Methodology of the experiment

The methodology used in the data collection consists of: clearing the land, cleaning the experimental field, plowing, delimiting the experimental plots, cutting the *Pennisetum purpureum* cuttings, planting the cuttings in the plots, watering the treatment plots (except for the absolute control), applying the improvement treatments, weeding, and collecting the data according to the experimental parameters selected.

Preparatory work for the research

The site is delimited, completely cleared and cleaned, after cutting and transporting the cuttings of *Pennisetum purpureum*. Sap-filled stems, 3 m high, were carefully cut with a machete; the cuttings with 3 internodes were then stored in the shade for 24 h.

Planting of cuttings and application of improving inputs

Pennisetum purpureum cuttings were planted in the 6 m x 1.2 m beds, with 2 cuttings in stacks spaced 30 cm apart in all directions. The hormone solution used was Indole Acetic Acid (I.A.A.) auxin, at a concentration of 10 micromoles per liter, which was then increased to 1µmole/l and 1l/m2 was applied to the base of the cuttings in the bed. A second application was made 15 days later for the T2 treatment, increasing the dose to 2 µmoles/m2.

Maintenance of the nursery

This consisted of 2 weedings and regular watering once every 3 days on the different treatments, except for the absolute control representing the current practice of planting *Pennisetum purpureum* in the environment.

Data Collection according to the Selected Parameters

Regrowth rate and number of tillers one month after sowing

The number of resprouts was collected, after 15 days after sowing, on 20 plants sampled per block at a rate of 5 in 4 lines. The number of tillers was collected in the same way by noting the average of each of the 4 sample lines.

Growth parameters during the observation period

The observation period lasted one month from the time of sowing. Six of the 30 plants sampled per block were randomly determined and indexed, to record weekly measurements of crown diameter, plant height, and number of leaves per plant. Calipers and tape measures were used to measure crown diameter and plant height, respectively.

Statistical processing of the data

The data of the study were processed by means of the Excel program and the "Statgraphics" software, using in turn the analysis of variance and Duncan's tests for the significance of the differences between the evaluated treatments**.**

Results

This chapter presents and interprets the results below, followed by a brief discussion.

We present alternately (1) the average recovery rates and average tillering indices of the transplants after field transplanting, (2) the average collar diameters, the average plant heights and the average numbers of leaves for the treatments confronted.

Average Recovery Rates and Average Tillering Indices of Transplanted Shoots

These results are presented in Figure 4 below.

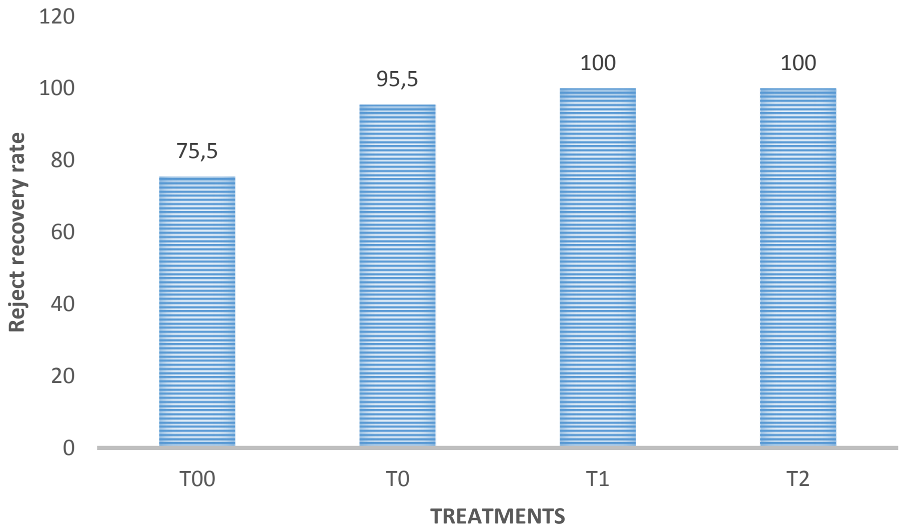


Figure 4: Average recovery rates for transplanted rejects

If we examine the results in the figure above, we can see that the rates of regrowth of shoots are much higher in the three treatments using nursery work (T0, T1 and T2) than in the absolute control (T00) using simple cuttings without roots and leaves as propagation material!

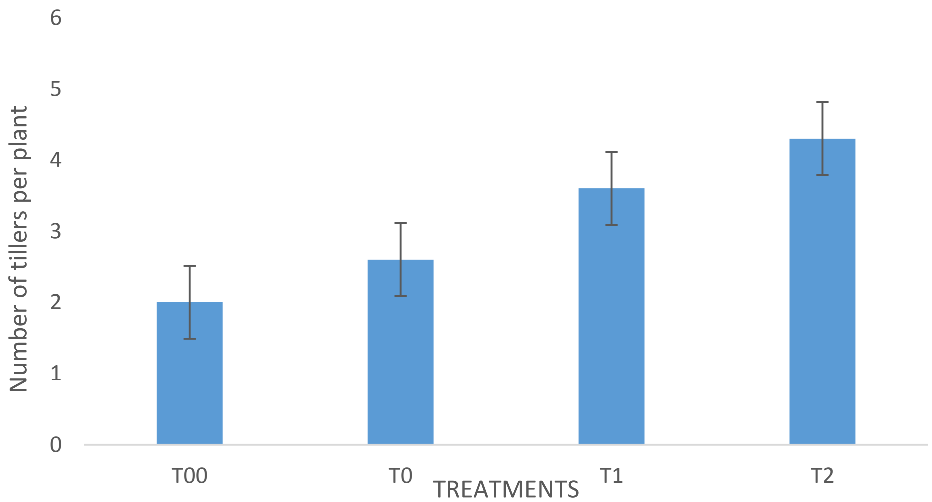


Figure 5: Number of tillers per plant

When examining the results in the figure above, it can be seen that the tillering indices of the shoots are clearly higher in the three treatments using nursery work (T0, T1 and T2) than in the absolute control (T00) bypassing the latter. However, these results do not allow us to discriminate between these three treatments because they do not show a significant difference (p).

It can be said that auxin, the growth hormone applied to cuttings in the nursery, did not sufficiently influence rhizogenesis at soil level after transplanting to the field.

Growth Parameters of *Pennisetum purpureum* after Field Transplantation

Diameter at the crown (plant vigor)

These results are presented in Figure 6 below.

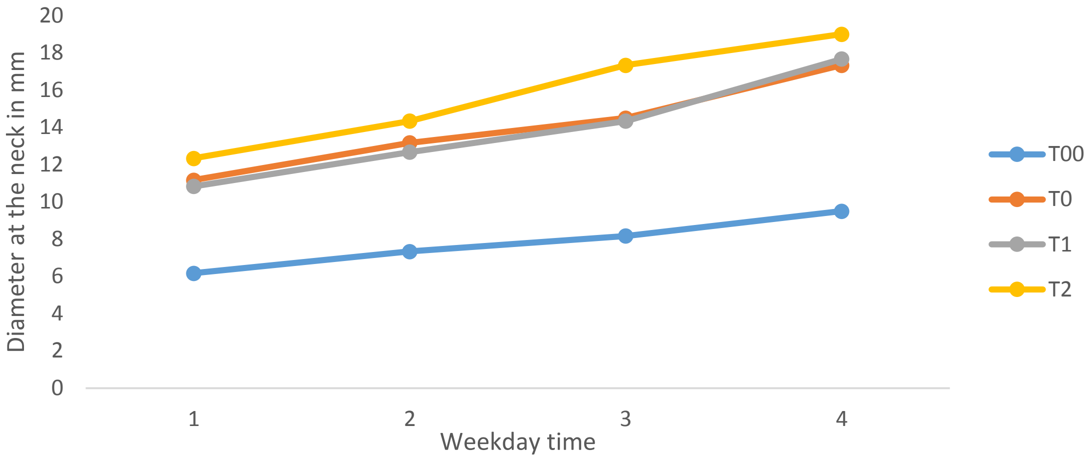


Figure 6: Evolution of the diameter at the collar of *Pennisetum purpureum* after final placement

From the examination of the results in this figure, it can be seen that the growth curves for the different treatments are more or less distinct, but they overlap more or less proportionally with the doses of auxins used, the absolute control representing the current practice of establishing *Pennisetum purpureum* by direct cuttings being the least efficient treatment

Plant height

These results are presented in Figure 7 below.

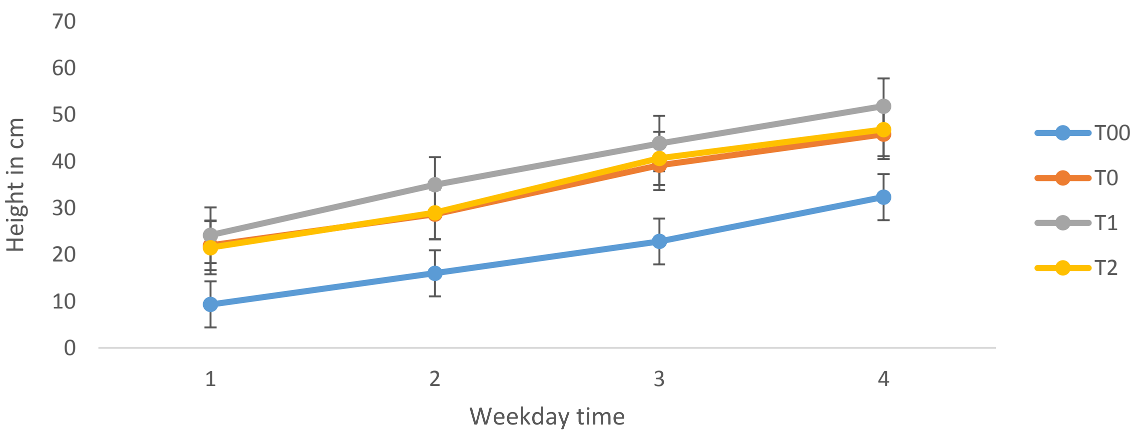


Figure 7: Evolution of the height of *Pennisetum purpureum* plants after final placement

When examining the results in Figure 7, it should be noted that the growth curves for the different treatments developed in the nursery were significantly higher than the absolute control curve, which represents the current practice of establishing *Pennisetum purpureum* by direct cuttings and is therefore considered to be the least effective.

However, the curves for treatments using hormonal applications on nursery cuttings did not differ from each other. This clearly shows that A.I.A. auxin, under the conditions of use defined in our experiments, did not sufficiently influence the average height of plants.

Average number of leaves per plant

These results are presented in Figure 8 below.

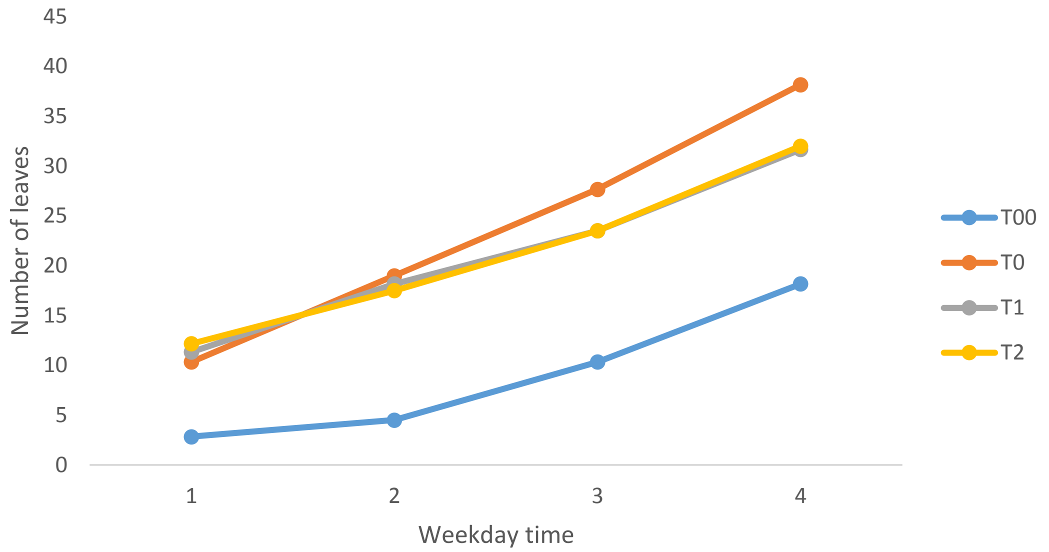


Figure 8: **Number of leaves per plant of *Pennisetum purpureum* according to treatments**

When examining the results in Figure 8, it should be noted that the growth curves for the different treatments developed in the field were significantly higher than the absolute control curve for the current practice of establishing *Pennisetum purpureum* by direct cuttings, which is therefore considered the least effective.

Furthermore, the curves for the treatments using increasing doses of auxin in the field combined with a constant dose stood out from each other.

Discussion

The question raised at the beginning of this research was whether nurseries enriched with various inputs (hormones, bio-stimulants...), to stimulate growth on degraded soils, would communicate residual nutrients or residual inputs to the emerging fallow-grasslands, through the shoots and stump fragments, which could then positively influence the recovery and juvenile growth of the new herbaceous stand.

At the end of this work, it can be said that auxin, the growth hormone applied to cuttings in nursery, has globally influenced the rate of resumption of shoots at transplanting compared to the practice of direct cutting in the field (100% against 75%) at soil level after transplanting in the field.

Similarly, the tillering index increased with the use of auxin, i.e. 1.9%, 2.1%, 3% and 4%, respectively, for direct cutting in the field without watering, no use of auxin in the nursery and the use of 10 and 20 micromoles of auxin (AIA).

The difference in number of tillers between these four treatments was not statistically significant at the 5% level (ANOVA: $F = 3.568$; ddl = 3; p-value = 0.0835).

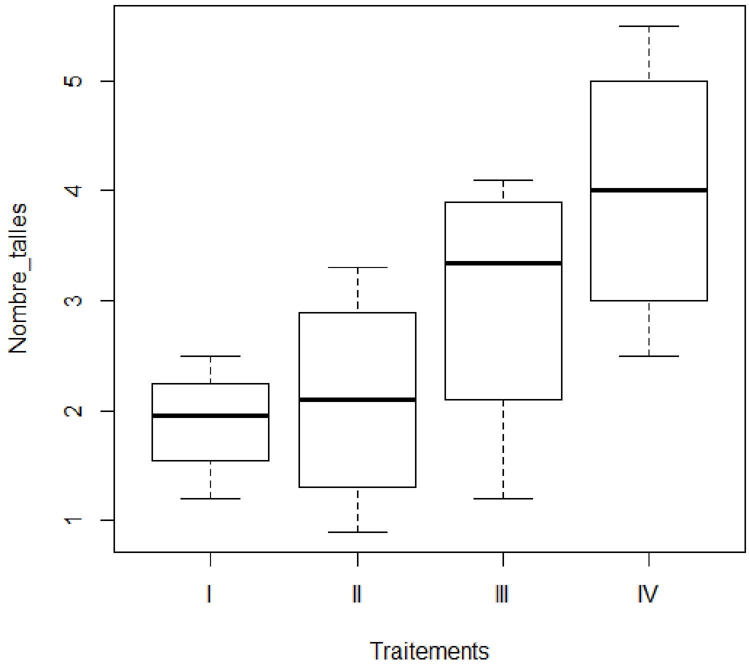


Figure 9: Number of tillers per plant of *Pennisetum purpureum* according to treatments

Similar research using fertilizer inputs under grass cover has been undertaken by different authors: (1) a high level of microbial activity and assimilable P was found to be directly proportional to the density of the hairy root system and the amount of inputs regularly accumulated on the surface under conservative cultivation (Salinas-Garcia *et al*., 2001; Whyte, 1959; Rosolem *et al.*, 2012; Dos Santos *et al*., 2011); (2) perennial grass hedges, especially those of grasses, as well as micro-pools play an effective role in reducing water, ion and soil losses under cultivation and soil humus richness (Comino & Druetta, 2010; Wabnik *et al*., 2011; Xiao *et al*., 2012),

With respect to growth parameters, in general, the nursery-developed shoot treatments clearly outperform T00, the local practice of direct field planting of *Pennisetum purpureum* cuttings. Thus, there is a clear advantage to pre-production of cuttings in the nursery, with or without chemical inputs.

However, the curves for the treatments using rejects from hormone applications on nursery cuttings did not differ from each other. This clearly shows that auxin AIA, under the conditions of use defined in our experiments, did not sufficiently influence with time neither the diameter at the collar of the plants nor the average height nor even the number of leaves per plant.

The application of increasing doses of auxins did not, therefore, have a positive influence on the growth parameters of *Pennisetum purpureum* in the field. There is reason to believe that auxin must have concentrated its effects in the soil. Again, its effects were severely limited by the mineral deficiency characterizing this clearly degraded soil (Pyame *et al*., 2015).

Additional application of chemical fertilizers, even in relatively low doses, could clearly highlight the effects of auxin applications in the production of grassland establishment offspring.

Indeed, research undertaken on the modalities of applying increasing doses of NPK fertilizer to *Pennisetum purpureum* green cover associated with legumes has shown great success on the yields of integrated food crops, namely rice, maize and banana (Pyame, 2015; Ntamwira, 2021).

Conclusion

The aim of our research was to measure experimentally the recovery rate, the tillering index and the major growth parameters of *Pennisetum purpureum* shoots transplanted in the field, in response to the application in the nursery of increasing microdoses of hormones (auxins A.I.A).

In relation to the recovery rate and the tillering index of *Pennisetum purpureum* shoots at field establishment, it is also clear that the tillering indexes of the shoots are significantly higher in the three treatments using nursery work (T0, T1 and T2) than in the absolute control (T00) bypassing the latter. However, these results do not allow us to discriminate between these three treatments because they do not show a significant difference (p). It can be said that auxin, the growth hormone applied to the cuttings in the nursery, did not sufficiently influence rhizogenesis at soil level after transplantation to the field.

Regarding the growth parameters (collar diameter, plant height, number of leaves) of *Pennisetum purpureum* cuttings at field placement, the curves for the treatments using hormone applications on nursery cuttings did not differ from each other. This clearly shows that auxin A.I.A., under the conditions of use defined in our experiments, did not sufficiently influence the different growth parameters.

We suggest that further studies could be carried out with longer duration trials, for diversified plant hormones and for a wider range of species of both food crops, cover crops and fertilizer trees.

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