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# Agronomic Responses of *Cymbopogon schoenanthus* L. Spreng., a Sudanese Forage Grass Grown under Compost for a Bio-Ecological Pasture in the Southern Benin

Ezéchiél J-P. A. Mensah, Valentin Kindomihou, Silvère Tovignan, Aliou Saïdou, Davo Simplicé Vodouhè, Isaac Aiyelaagbe, and Brice Sinsin

## ABSTRACT

Promoting ecological and organic agriculture (including livestock) requires biological resources and alternatives. *Cymbopogon schoenanthus* is a sudano-sahelian grass species whose crude leaf essential oils, in addition to their antifungal, antimicrobial, antibacterial and acridifuge or acridicide properties, can be an alternative to chemical insecticides in preventing pests and diseases that limit crops productivities. This study tests the agronomic performances of *Cymbopogon schoenanthus* grown under three doses of compost. Stumps collected from the Park W of Niger were transplanted to the experimental farm of the Faculty of Agronomic Sciences of University of Abomey-Calavi in the Southern Benin. The experimental design was a complete randomized block with treatments (0 ton per hectare (i.e., control), 5 tons per hectare and 10 tons per hectare of compost) in four replicates. Plants responses to the compost application throughout traits such as heights, number of tillers per plant, number of flowering tillers and dry aerial biomass production, were analyzed with a one-way ANOVA using STATISTICA 9.0. The results show significant responses of the aerial organs of *C. schoenanthus* to organic fertilization ( $p < 0.05$ ) with the best performance under 5 tons of compost per hectare: height growth in magnitude of 12.72%, number of tillers multiplied in 146.06% and aerial dry biomass in 178.32%. However, fertilization did not influence flowers appearance. Further studies are required for assessing foliar, nutritional quality and essential oil responses to the compost application in order to sustainably promote small ruminants' organic production.

**Keywords:** *Cymbopogon schoenanthus*, compost, agronomic parameters, Southern Benin.

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## I. INTRODUCTION

Public opinion tends to view organic agriculture as irrelevant to its potential for food security. Yet organic agriculture, as a comprehensive system, improves the productivity and well-being of communities, including ground organisms, vegetation, livestock, and people [1]. Its primary goal is the development of sustainable and environmentally harmonized farms. Like organic agriculture, organic livestock farming (beekeeping, animal husbandry, poultry farming...) is still developing, but under foreign subsidies (French Embassy, GIZ, Biovision Africa

Trust...) in Tropics. Its general principles as adapted from the Canadian Organic Standards [2] are: (i) Protecting environment, minimizing soil degradation and erosion, reducing pollution, optimizing organic productivity, and promoting good health; (ii) Maintaining long-term soil fertility by promoting conditions conducive to biological activity; (iii) Maintaining ecological diversity in the ecosystem; (iv) Recycling materials and resources on farm; (v) Caring livestock to promote their health and meeting their behavioral needs; (vi) Preparing organic products paying attention to processing and handling methods, to maintain the biological integrity and essential qualities of

the product; and (vii) Relying on renewable resources in locally organized farming systems.

Organic herbivore meat production systems rely on the provision of a globally balanced diet of energy, protein and vitamins, mainly from grazed and conserved forages. Specifically, the organic forage crops production, as a lever, is a farming method which combines cultural, biological, and mechanical techniques for strengthening the resources cycle, maintaining the ecological balance, and preserving the biodiversity.

In this context, disease and insect control involves preventive methods such as crop rotation, genetic improvement, and the use of resistant varieties [3]. On the organic farm, integrated soil conservation and pest and weed management are important tools. Pesticides approved for use in organic agriculture are “natural” pesticides or other pest control products listed in the Permitted Substances List (PSL) of the organic production standards. The PSL determines which substances can be used as pesticides in organic agriculture [2].

The use of chemical pesticides is confronted with the development of pest resistance in Tropics [4], [5]. In order to ensure the balance of aquatic, terrestrial ecosystems and human health, the use of essential oils with proven antibacterial and antimicrobial properties, is experiencing renewed interest. But the production of “pesticidal plants” is still not very effective since most are not cultivated [5]. Facing the consumer desire to access 100% natural products that are healthy and effective [4], natural production is proving to be important for the manufacture of essential oils. *Cymbopogon schoenanthus* L. Spreng. (Poaceae) is a tropical aromatic spice, forage, medicinal and stock bio-pesticide [6]–[11]. Its essential oil contains biocidal piperitone and repellent on the aphid stage 4 adult apterans of *Aphis gossypii*, a cotton pest [8], [12]–[14]. It shows a promising management of *Plutella xylostella*, cabbage moth [15]. Its mixture with Neem oil serves as an anti-inflammatory inhibiting the growth of adult *P. xylostella* [16], or as a raw material to the biopesticide industry [15], [16]. Moreover, *C. schoenanthus* is also a consumed and well-fed Sudanese forage plant [11], [17], a perennial grass species from *Andropogoneae* tribe, growing in dense compact clumps at its base [18]. Benin Republic belongs to the Western Africa which savannas are globally marked with poor agricultural soils [18]. Therefore, organic fertilization should be the best alternative for pasture productivity. In this context, the use of irrigation and fertilization is essential for improving the biological and agronomic performances of organic pastures as previously demonstrated with *Loxodera ledermannii* [19].

The present study examines, agronomic performances of *C. schoenanthus* under organic growing conditions in view of its domestication in the context of promoting organic small ruminants farming in Benin.

Moreover, the ruminant farming in Tropics has been viewed as an agro-ecological activity [20], [21]: (i) firstly, because it is highly intensive in ecological knowledge, particularly on savannah ecosystems, and it is an art of natural resource management (pastures, water, forests); (ii) secondly, because it contributes strongly to the soil fertility improvement. It thus leads to the implementation of

sustainable and autonomous agricultural systems based on low input use. Therefore, what would be the features in organic production conditions?

Our choice of using the compost is based on the principle of “*Feed the soil to feed the plant*”, which is fundamental in Organic Agriculture. Indeed, adding compost was found increasing soil fertility and organic matter cycle autonomy [22], while its contribution to the pasture or meadows favors the soil biological activity, sanitizes the manure (destroying pathogens and weed seeds by composting), and reduces its volume and thus the doses to be spread [23], [24]. Compost has advantage of not affecting the grass palatability [25], [26], which allows quickly grazing after spreading. Moreover, the compost amended meadows are less fragile to drought and excess water [11], [27]–[29].

## II. MATERIALS AND METHODS

### A. Description of the Experimental Site

The experiment was conducted on the experimental garden of the Faculty of Agronomic Sciences, University of Abomey-Calavi (06°44'07.9" North latitude and 002°08'16.8" East longitude), at 15 km North along the National Inter-State Road 2 in the Abomey-Calavi District. The climate is Subequatorial marked by two rainy seasons alternating two dry seasons. The long rainy season covers mid-March to end-July and the short season from mid-September to mid-November. The long dry season covers mid-November to mid-March and the short season from August to mid-September. Annual values of rainfall, temperature, and relative humidity from 2010 to 2014 averaged respectively 1440 mm, 28 °C and 80%. The trials were firstly conducted from mid-August 2013 to mid-March 2014 and repeated the same period 2014–2015.

The physicochemical characteristics of the experimental site are summarized in Table I.

TABLE I: SOIL CHARACTERISTICS

Granulometry (%)	0 – 2 mm	10.4
	2 – 20 mm	2.7
	20 – 50 mm	1.9
	50 – 200 mm	19.7
	200 – 2000 mm	65.2
Chemical characteristics		Contents
pHwater		5.85
pHKcl		0.10
N total (%)		0.11
C total (%)		0.96
OM (%)		1.66
C/N		9.11
P (ppm)		2.54
CEC (meq/100g)		9.00
Ca++ (meq/100g)		3.07
Mg++ (meq/100g)		1.06
K+ (meq/100g)		0.82
Na+ (meq/100g)		0.74
Sum of bases		5.69

N total: total nitrogen; C total: Carbon total; OM: organic matter; C/N: Ratio carbon/nitrogen; Phosphorous; CEC: exchangeable cation capacity; Ca++: Calcium; Mg<sup>++</sup>: Magnesium (cation); K<sup>+</sup>: Potassium (cation), Na<sup>+</sup>: Sodium (cation); Source: Kindomihou *et al.* [30].

### B. Material

*Cymbopogon schoenanthus* strains were collected from the W Park of Niger and transplanted to the Botanical

Garden of the UAC in 2011. The fertilizing material used is the compost produced in the Market Garden Centre of Houeyiho in Cotonou (Benin). The compost is made from household waste, with a yield of 65.67%. Characteristics of this compost (Table I) results in a C/N ratio of 11.69% and a total phosphorus rate of 0.62%. The humus in the compost has a high CEC and binds mineral nutrient ions such as  $K^+$  and  $Ca^{2+}$  cations and phosphates in order to make them available to plants for their growth and development. The physico-chemical composition of the compost used meets international standards for mature compost quality [31].

### C. Methods

The experimental design is a 3-fold repeated randomized completed randomized blocs that highlights one species, i.e., *Cymbopogon schoenanthus* and 3 compost treatments in 3 doses (5 tons of compost per hectare, 10 tons per hectare compost, and 0 ton of compost (absolute control)). A total of 9 beds of 1.5 m × 2 m, one bed per treatment, were installed in a BAC system. 24 stumps were installed per bed with a spacing of 40 cm between lines and stumps. Fertilizers are applied two weeks after the installation of the plants. Compost doses are applied to each stump according to the doses defined per stump.

### D. Statistical Analysis

Mean values and standard deviations of the raw data were calculated in Excel software. A one-way Analysis of variance was performed to test agronomic responses to the compost application followed by the post hoc test based on the smallest significant difference at the 5% threshold using STATISTICA 9.0. Magnitudes assessing the compost effect were calculated as follow:

$$\Delta v = \frac{(\bar{x}_i - \bar{x}_0)}{\bar{x}_0} \times 100$$

$\Delta v$  = magnitude in %,  $\bar{x}_i$  = average value of a treatment i;  $\bar{x}_0$  = average value of the control treatment.

## III. RESULTS

Table II shows the mean values of agronomic parameters of *C. schoenanthus* along with the 1-way ANOVA result.

TABLE II: EFFECT OF COMPOST ON RECOVERY RATE, NUMBER OF TILLERS AND NUMBER OF FLOWERING TILLERS

Treatment	Regrowth rate	Number of tillers	Number of fertile tillers
TC <sub>60</sub>	45.83±8.33 a	112.94±7.49a	3.34±0.23a
TC <sub>120</sub>	50.00±7.22a	92.39±3.61b	2.39± 0.17a
T <sub>0</sub>	29.17±8.33 b	45.90±4.77c	2.33±1.00a
F(2,6)	5.73	115.49	2.67
P	*	***	ns
R <sup>2</sup>	0.54	0.96	0.29

\*, p<0.05; \*\*\*, p<0.001; ns: non-significant; a, b, c: homogenous groups at 5%.

Table II indicates that compost fertilization significantly affects the recovery rate of stumps (p<0.05) and tillering (p<0.001), while not the flowering of *C. schoenanthus*.

### A. Recovery Rate

Stumps grown under compost showed the highest recovery rates (from 45.83±8.33 to 50.00±7.22). In contrast, those grown without fertilization gave the lowest recovery rates (29.17±8.33). Thus, fertilization improved the stumps recovery rate from 57.11 % to 71.41%.

### B. Number of Tillers

*C. schoenanthus* strains grown without compost showed the lowest average number of tillers per clump (45.90±4.77 tillers) while those grown under compost showed the highest values. The dose of 60 g per plant gave the highest average number of tillers (112.94±7.49 tillers). This dose increases the number of tillers per clump in magnitude of 146.06% compared to 101.29% obtained under 120 g per plant.

### C. Total Height and Dry Biomass

Fig. 1 and 2, showed that the doses of applied compost significantly influenced the growth either in height of the clumps (p<0.01) or in the aerial biomass production (p<0.001). *C. schoenanthus* strains grown with 60 g per plant showed the highest value of heights (148.99±5.07 cm; Fig. 1) while both the controls and strains grown with 120 g/plant showed the lowest values (132.17±1.72 cm to 132.89±4.67 cm; Fig. 1). The dose of 60 g per plant appeared to promote the height in magnitude of 12.72%.

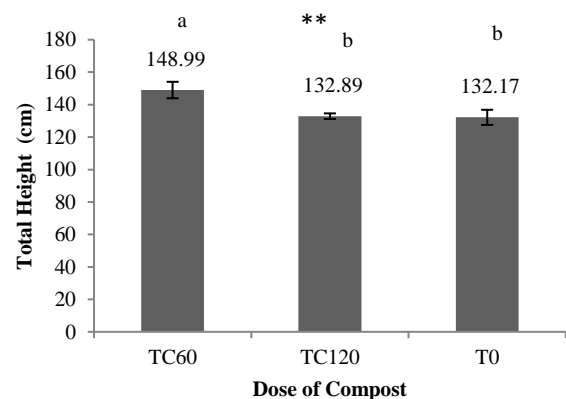


Fig. 1. Effect of compost on total stump height.

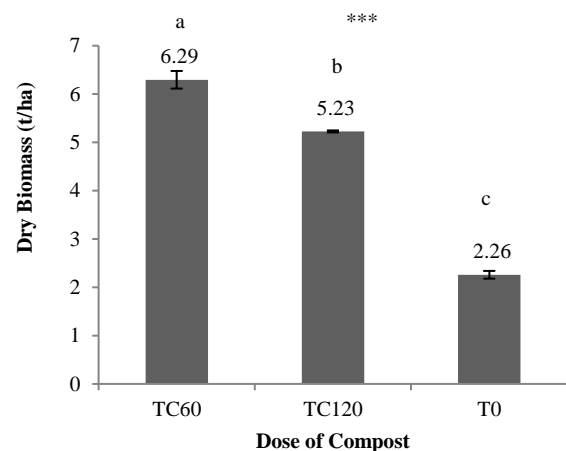


Fig. 2. Effect of compost on biomass production.

Dry biomass yield from plants grown under 60 g per plant differed significantly from that obtained from materials grown under 120 g per plant, the latter being lower

(5.23±0.02 tons per ha versus 6.29±0.18 tons per ha; Fig. 2). These doses significantly increased dry biomass, in respective magnitudes of 178.32% (under 60 g per plant) and 131.42% (under 120 g per plant).

#### IV. DISCUSSION

This study aimed to investigate the *C. schoenanthus* agronomic responses to organic fertilization. For this purpose, two doses of compost (60 g per plant i.e., 5 tons per ha; and 120 g per plant i.e., 10 tons per ha) with a control (without compost) were applied to *C. schoenanthus* strains in a complete randomized bloc's design. Stump shattering rate, total clump height, number of tillers per stump, number of flowering tillers, and dry biomass were submitted to a one-way ANOVA. Generally, organic fertilization influenced different agronomic traits except the number of flowering tillers. The strains grown under 5 tons per ha showed the best agronomic performances while the controls had the poorest performance.

Overall, previous studies conducted on the effects of fertilization (organic or mineral) on agronomic parameters of *Cymbopogon* plants as well as different other plants species mentioned the control treatments giving the poorest performances [8], [32]-[35]. Soil poverty is indicated as the reason for these different results [32]. These results suggest the need for fertilization to achieve good yields on these soils. Indeed, Aken'over & Chheda [36] proved that monospecific grassland cropping requires fertilization. As stated by Lompo [37], organic fertilization increases cation exchange capacity and therefore quantitative available nutrients, mainly N, P and K in the soil, which are involved in plant growth and development. The low level or absence of these nutrients may reduce yields which are known to be greatly influenced by nitrogen.

The strains grown without fertilization reached 132.17 cm in height while they do not exceed 120 cm in natural environment [38].

Our results showed that the dose of 5 tons of compost per hectare induced the best values for height growth (12.72%), dry biomass (178.32%) and number of tillers (146.06%). These results showed that the soil amended with N, K, and P from the compost, allowed the *C. schoenanthus* plants to meet their nutrients requirements. Indeed, nitrogenous fertilizer was found increasing Dry Mass yield of *Andropogon gayanus* Kunth in Burkina Faso [39]. Organic fertilization would increase soil organic matter, maintain the CEC, and limit the exchangeable aluminum rate through complexation process [40]. This efficiency of organic fertilization would also be a matter of water supply during the trial, because during the experiment, the plants were watered morning and evening during the first three years. Accordingly, there is a positive interaction between organic fertilization and irrigation [41]. For these authors, the irrigation increases the compost effectiveness. Consistently, Obulbiga [39] indicated that the effectiveness of positive response of *Andropogon gayanus* to fertilization like any rain fed crop is closely linked to climatic hazards, especially the rainfall spatio-temporal distribution. The biomass yield increases in response to fertilization, and the plant appears to require more water, which weakens their ability to

tolerate the drought. However, it appeared that agronomic performance declined below the application of 10 tons of compost per hectare. This result is consistent with Ballot et al. [35] who showed that increasing dose of fertilizer negatively influences height growth and biomass yield. Indeed, Mitscherlich's law states that increased yields obtained by applying increasing doses of a fertilizer are smaller and smaller as the doses applied increase [42]. Tendonkeng et al. [43] also observed a decrease in the height and diameter of *B. ruziziensis* following the application of high doses of urea. According to these authors, the responsive decrease accuses the root environment and the hydro-mineral nutrition, as previously stated by Morot-Gaudry's [44] when excessive nitrogen supply acidifies plant roots medium and disturb their hydro-mineral nutrition.

Our results therefore indicate the rate of 5 tons of compost per hectare for organic production of *C. schoenanthus*. This corroborated two previous findings from Abeokuta (Nigeria) in vegetable crop production [33], [34]. However, the best numbers of tillers and dry biomass were provided by a species from same genus i.e., *Cymbopogon citratus* with the rate of 10 tons of manure per hectare [32].

#### V. CONCLUSION

The organic livestock farming development is indeed possible in the Tropics, and the organic fodder production is an important tool to achieve this goal which is already shared by a number of policies. This study highlighted the rate of compost favoring organic production of *Cymbopogon schoenanthus*. The dose of 60 g per plant highly affected agronomic traits. Definitely, *C. schoenanthus* is sensitive to organic fertilization, showing the best performances in our subequatorial field cropping, i.e., the rate of stump sprouting from 57.11 % to 71.41%, the average number of tillers from 45.90 to 112.94 tillers, the highest average height growth i.e., 148.99 cm and the highest average above-ground dry biomass production i.e., 6.29 tons per ha. This dose which corresponded to 5 tons of compost per hectare, offering the best values and magnitudes for the growth appeared to be effective at organic forage production: Height growth in magnitude of 12.72%, number of tillers in magnitude of 146.06% and aerial dry biomass in magnitude of 178.32%. Optimal rates of compost for the best biomass and essential oil yields and socio-economic benefits of *C. schoenanthus* cultivation would be relevant. Further studies are also required on foliar nutritional quality and essential oil responses to the compost application in order to sustainably promote small ruminants' organic production in Tropics.

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