

Influence of Different Dosages of Costus Afer Fermented Extract on Rice Growth

Guety Thierry Philippe^{1,*}, Brahima Koné¹, Koné Aminata², Boidi Hien Marie Paule¹, Kanaté Ladji³

¹Pédologie et Agriculture Durable, Université Felix Houphouët-Boigny; 22 BP 582 Abidjan 22, Cote d'Ivoire

²AfricaRice M'bé Research Station, 01 BP 2551, Bouaké, Côte d'Ivoire

³Sucrerie d'Afrique (SUCAF SA), BP 150. Ferkessédougou - Côte d'Ivoire

*Corresponding author: thierryguety@yahoo.fr

Received September 02, 2024; Revised October 03, 2024; Accepted October 09, 2024

Abstract: Peat soils are a valuable agroecosystem because of their rarity in Africa (< 4%) and their high carbon sequestration capacity (3% C), which is nevertheless disturbed by farming. It is therefore necessary to explore regenerative agricultural practices as part of organic farming. An agronomic trial was set up on peaty soil in Songon (west of Abidjan) to test doses of aqueous *Costus afer* extracts on the growth and production of flood rice and soil properties. Five (5) doses (0, 250, 500, 750, and 1000 liters/ha) of fermented aqueous extracts (6 months) of *Costus afer* were applied in a randomized complete block design in three replications with 6 treatments (T0, T1, T2, T3, T4, T5) and the rice variety VA6 was transplanted at a spacing of 20 cm × 20 cm. Rice growth and yield parameters were collected. The results obtained showed a greater number of tillers (324/m²) and greater heights were noted for T1, contrasting with a relatively lower weed biomass for the higher doses (T4 and T5), with a significant effect (P<0.05) at different physiological stage of the rice. No significant difference was observed between yields, although T5 (7.58 t/ha) outperformed the control (T0) by 49%. However, a dose of 649 l.ha⁻¹ is required for better rice yields.

Keywords: agroecosystem, biofertilizer, organic farming, rice cultivation, peat soils, Côte d'Ivoire

Cite This Article: Guety Thierry Philippe, Brahima Koné, Koné Aminata, Boidi Hien Marie Paule and Kanaté Ladji, "Influence of Different Dosages of *Costus Afer* Fermented Extract on Rice Growth." *American Journal of Food Science and Technology*, vol. 12, no. 5 (2024): 155-159. doi: 10.12691/ajfst-12-5-3.

1. Introduction

Mire or Peat soils [1] are in considerable demand in agriculture due to their organic matter content, which favors chemical restitution, and their high moisture retention capacity [2]. Their agricultural development requires drainage, which leads to a partial loss of their carbon sequestration function, emitting 6% of anthropogenic CO₂ [3]. It is becoming increasingly important to find an agricultural method capable of preserving the ecological balance of these peatlands. Crops adapted to flooded environments, such as rice, could meet this need. However, the impact of chemical fertilizers and other conventional agricultural products on biodiversity and soil functioning [4] supports the need for innovation in rice cultivation in peatlands.

The use of biofertilizers [5] could be one of the solutions in the context of regenerative agriculture [6]. In particular, some plants have high concentrations of photosynthesis carbohydrates and high levels of chemical elements that can be assimilated by crops [7].

With this in mind, fertilization trials using the aqueous extract of *Costus afer* were conducted on upland rice in pots, revealing high concentrations of N, P, and K [8]. The results showed no significant difference between the

optimal dose of 500 ml and the use of conventional fertilizers, suggesting some efficacy of this extract. This work aims to confirm this result, which could provide lasting support for the ecological functions of peat soils, by testing several doses of fermented aqueous extracts of *Costus afer* in the field on rice crops to assess their effects on the growth and yield of irrigated rice compared to other conventional practices [9]. Ultimately, the study will make it possible to offer rice farmers a low-cost alternative practice that preserves the ecological function of hydromorphic peat soils.

2. Materials and MEthods

2.1. Study Site

The study area is located in the commune of Songon. This commune is bordered to the east by the commune of Yopougon, to the north by the commune of Anyama, to the west by the commune of Dabou, and to the south by the Ebrié lagoon. It covers an area of about 584 km². The study area is located in a third-order lowland with geographical coordinates of 5°19'32"N and 4°10'17"W (Figure 1). Annual rainfall in the area varies from 1,500 to 2,500 mm, with 90 to 180 days of precipitation, with a minimum of 32 mm in February and August and a

maximum of 457 mm in June. The monthly temperature range is 7°C in the dry season and 5°C in the rainy season [10] [11] [12]. The geological formations in the area are mainly Cretaceous sandstones of the terminal continental period. This parent rock has undergone extensive alteration to produce ferrallitic soils [13], classified by [14] as acrisols and marginally as basal Petrosols on plateaus between 40 and 60 m in altitude. In swampy areas the soils are hystosols.

2.2. Plant Material

The plants used in this work are:

Costus afer: This is a large herbaceous perennial medicinal plant, unbranched, with a creeping rhizome. The organs used for the preparation of aqueous extracts of *Costus* are the stem and leaves. The plants used in this study are more than one (01) year old [15].

Rice VA6: This is a variety obtained from a segregating population in the 12th generation of AfricaRice hybrid (AR 051H). It has a 90-day cycle and a yield of 4 t.ha⁻¹ in the field. It is a lowland variety.

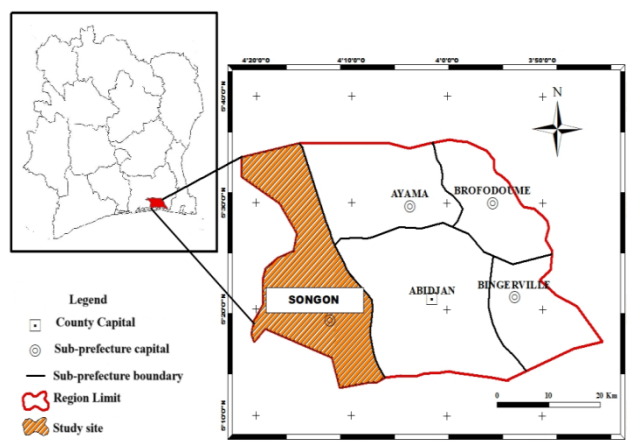


Figure 1. Location of study site

2.3. Aqueous Extraction

The technique involved grinding the harvested *Costus* afer in a mortar. After grinding, the extract was diluted with 1 litre of tap water, then the aqueous solution was stirred manually by mixing the solid residues in the water. Using a clean cloth, the solution was filtered by wringing out the residue in the cloth used as a filter. This operation was repeated until a clear filtrate was obtained, i.e. fourteen (14) times for as many filtrates making up the aqueous extracts of *Costus* afer. A composite sample of the solutions was conditioned with 500ml of each of the 14 filtrates. The extracts obtained were then collected in canisters before being stored away from the sun under ambient conditions (28 - 30°C) in order to be used after 4 months of fermentation.

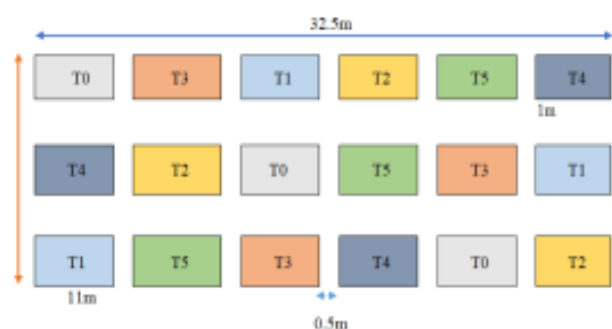
2.4. Cultivation

The VA6 rice variety chosen was dried for 24 hours to lift dormancy before being soaked in water for another 24

hours. The seed was then wrung out and dried under cover for 24 hours to pre-germinate. The pre-germinated seeds were lightly buried in the soil under protective mulch. The nursery lasted 11 days and transplanting took place on the 12th day with a spacing of 20 cm × 20 cm between plants.

2.5. Treatments Application

An area of 357.5 m² was cleared and divided into 18 microplots of 15 m² each, divided into three (03) blocks of 6 microplots. In a randomised complete block design (Figure 2), different doses of fermented aqueous extract were applied. Each treatment was repeated 03 (three) times. A distance of one (01) metre was left between the replicates. Within the same repetition, the microplots were separated by 0.5 metres. The treatments applied are described in Table 1.



T0 : Control treatment
T1 : 250ml when ploughing
T2 : 500ml when ploughing
T3 : 750ml when ploughing
T4 : 250ml when ploughing; 250ml at planting; 250ml at the time of tillage; 250ml at head
T5 : 1000ml when ploughing

Figure 2. Experimental design

Table 1. For each treatment, the dose, amount and stage of application

Treatment	Dose (l.ha ⁻¹)	amount (cc)	Stage of application
T0	0	0	
T1	166.66	250	ploughing
T2	333.32	500	ploughing
T3	499.98	750	ploughing
T4	166.6	250	ploughing
	166.6	250	planting
	166.6	250	tillage
	166.6	250	head
T5	666.66	1000	ploughing

2.6. Data Collection

Two types of parameters were determined: agro-morphological parameters and rice yield.

Plant height and number of tillers were determined at different stages of rice development: tillering, heading and maturity. The height (H) of the rice plants was measured from the soil surface to the tip of the highest tillers (the tip often being taken as the end of the longest tillers leaf) using a decimeter. The number of tillers per 1 m² (experimental unit) was counted to determine tillering density.

When the rice was ripe, it was harvested by hand with

sickles over an area of 8 m², leaving 2 border rows. After drying and threshing, the rice grains were winnowed. The straw and the grains were dried in the sun and weighed separately using an electronic balance with a capacity of 100 kg for the straw and 7000 g for the grains. The moisture content of the rice grains was determined after drying in an oven at 70°C for 24 hours, and the grain yield was calculated with the standard moisture content of 14%. Grain yield (RDG) and straw yield (RDP), total dry matter (TDM), and harvest index (HI) were calculated using the following formulae:

$$IR = (RDG / TDM) \times 100 \quad (1)$$

avec RDG = Grain yield et TDM = total dry matter;

$$TDM (t.ha^{-1}) = RDG + RDP \quad (2)$$

avec RDP = straw yield ;

$$RDG (t.ha^{-1}) = (\text{dry weight of grain (kg)} / 8(m^2)) \times (10000/1000) \times ((100-H)/86) \quad (3)$$

$$RDP (t.ha^{-1}) = (\text{straw dry weight (kg)} / 8(m^2)) \times (10000/1000) \times ((100-H)/86) \quad (4)$$

With H (p.c. humidity) = [M. initial – M. Final / M. initial] × 100 (5)

avec M= Mass of rice quantity taken from each microparcels.

2.7. Data Processing

The data obtained were entered using Excel software. The data on height (HAUT) and number of tillers (TAL) were subjected to an analysis of variance (ANOVA) with a threshold of $\alpha = 0.10$ using SAS software version V 9 to test the effect of the treatments applied on the vegetative development of the rice plants. Classification of the means using the Newman and Keuls method was used to identify the treatments for which the levels of vegetative development were significantly different. Grain yield (RDG), straw yield (RDP) and harvest index (HI) data were also subjected to ANOVA to test the treatment effect. Classification of the means using the Newman and Keuls method was used to identify the treatments for which the agronomic performances were significantly different.

3. Results

Overall, the highest biomass was observed in T1 (57.89a) and T2 (56.44a). Treatment T4 (39.22a) recorded the lowest amount of biomass.

Table 2. Mean values for the height of the rice, the number of tillers (m²) and the biomass of the weeds according to the treatments

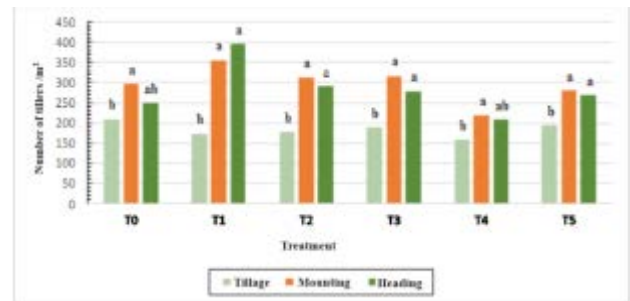
Treatment	Height (cm)	Number of tiller/m ²	Biomass of the weeds (g/m ²)
T0	59.99a	256bca	48.67a
T1	61.31a	309a	57.89a
T2	58.80a	261ba	56.44a
T3	61.76a	262ba	52.78a
T4	55.70a	195c	39.22a
T5	59.31a	248bc	40.89a
MG	59.48	254	49.31
Pr>F	0.9837	0.0784	0.68

The letters a, b and c indicate mean values that are significantly different at the $\alpha = 0.10$ threshold.

Treatment T3 (61.76a) recorded the highest value for plant height, while treatment T4 (55.70a) had the lowest height. The treatment had no significant effect on either of these two parameters, with the exception of the number of tillers recorded per square metre, which had a significant probability ($P = 0.07$) at $\alpha = 0.10$.

The lowest values for the number of tillers were recorded for T3 (262) and T5 (248) respectively, compared with a higher value (309) for T1. However, the value observed for T1 is statistically different from the values observed for the other treatments.

Figure 3 shows the average values for the number of tillers at different physiological stages, depending on the treatment. Throughout the vegetative phase, there was a significant difference between tillering and bolting. The number of tillers increased steadily until the bolting phase, when T1 treatments had the highest number of tillers. The number of tillers continued to increase right up to heading for the treatments in contrast to the other treatments:



Les lettres a et b indiquent les valeurs moyennes différentes de façon significative au seuil de $\alpha = 0,10$

Figure 3. Number of tillers observed per treatment at different physiological stages of the rice crop

Table 3 shows the average weed biomass values in each treatment as a function of physiological stage. Overall, there was a decrease in weed biomass during the physiological development of the rice. There were significant effects of treatments T4 ($P = 0.0067$) and T5 ($P = 0.0078$) on weed biomass, with a significant difference between the mean values observed.

Table 3. Weed biomass values according to treatments at each physiological stage

Physiological stages	Weed biomass (g/m ²)					
	T0	T1	T2	T3	T4	T5
Tillage	52.67a	62.67a	79.33a	65.33a	82.67a	72.67a
Mounting	51.33a	59a	42.67a	51.67a	27.67b	34b
Heading	42.00a	52a	41.33a	41.33a	7.33b	16b
MG	48.66	57.88	56.44	52.77	39.22	40.88
Pr>F	0.88	0.91	0.35	0.60	0.0067	0.0078
CV(%)	59.43	55.31	55.22	53.64	47.94	35.22

The letters a and b indicate mean values that differ significantly at the threshold of $\alpha = 0.05$.

A correlation analysis was carried out between rice height and weed biomass on the one hand, and between this biomass and the number of tillers on the other. The results in Table 4 show significant correlations for treatments T4 and T5. The correlations were very strong negative respectively.

Table 4. Correlation between weed biomass and rice plant height and the number of rice tillers per square metre

Parameters	Treatment	R	Weed biomass P> r
Height	T0	-0.13	0.72
	T1	-0.16	0.66
	T2	-0.43	0.23
	T3	-0.25	0.51
	T4	-0.89	0.001
	T5	-0.80	0.009
Number of tillers /m ²	T0	-0.03	0.92
	T1	0.09	0.80
	T2	-0.40	0.27
	T3	-0.18	0.62
	T4	-0.63	0.06
	T5	-0.70	0.03

The rice grain and straw yields, as well as the total dry matter and harvest index recorded in Table 5, show that the highest grain (7.63 t.ha⁻¹) and straw (29.84 t.ha⁻¹) yields were observed for treatment T5. However, there was no significant treatment effect and no significant difference was observed between the mean values for any of the parameters studied. The response curve shows an optimum dose of 649 l.ha⁻¹.

Table 5. Effect of treatment on yields according to doses

Treatment	Dose (l.h ⁻¹)	RDG (t.ha ⁻¹)	RDP (t.ha ⁻¹)	TDM (t.ha ⁻¹)	IR (%)
T0	0	5.12a	26.97a	32.09a	25.65a
T1	166.66	6.80	21.36a	28.16a	30.04a
T2	333.32	6.21a	16.06a	22.27a	26.75a
T3	499.98	7.01a	26.38a	33.39a	22.48a
T4	666.66	6.67a	21.12a	27.82a	34.53a
T5	666.66	7.63a	29.84a	37.47a	24.17a
MG		2.16	75.54	83.55	57.54
CV%		24.43	40.58	28.61	56.54
Pr>F		0.55	0.56	0.40	0.93

Table 6. Pearson correlation between 1000-grain weight and grain yield and weed biomass for each treatment

Parameters	Treatment	R	Weed biomass P> r
Grain yield	T0	0.10	0.92
	T1	-0.97	0.14
	T2	0.98	0.10
	T3	0.59	0.59
	T4	0.91	0.25
	T5	0.75	0.45
Dry weight of 1000 grains	T0	0.38	0.74
	T1	0.74	0.46
	T2	0.40	0.73
	T3	0.90	0.28
	T4	-0.62	0.56
	T5	0.80	0.40

The correlation test between grain yield and weed biomass as well as the dry weight of 1000 grains and weed biomass indicates that the treatments are not very significant (Table 6). However, the probability for T2 is significant (0.10) and the correlation between grain yield and weed biomass is strong (0.98). There was a weaker positive correlation (0.40) between weed biomass and the

dry weight of 1000 grains.

4. Discussion

4.1. Improving Soil Structure

The soil studied has a lumpy structure with good porosity due to the presence of earthworms and microorganisms that produce organic molecules, thus contributing to soil cohesion [16]. Although it is well known that organic matter improves soil structure, little is known about the effect of adding an aqueous plant extract. Macroscopic observation shows that fungi are dominant in the aqueous extract of *Costus afer*. The functions of decomposition of organic matter, physiological processes including hydric and mineral plant nutrients and biostimulant mechanisms are therefore dominant in fungi [17]. This role is reinforced by the presence of bacteria in the aqueous solution of *Costus afer*, as they feed on carbon and nitrogen [18], which they return to the soil via their corpses, thus providing structural carbon (carbon saturation). This demonstrates the potential for regenerating peat soils using such a simple practice as the application of an aqueous extract of *C. afer*.

The results of this work also highlight a new biofertiliser practice that requires less technical skill on the part of farmers and few financial resources: the aqueous extract of *Costus* is odourless after six months' conservation and is applied in the water that overflows the soil after ploughing, particularly for rice growing. This practice also makes up for the shortcomings of organic farming, which suffers from a lack of raw material.

4.2 Yield Potential of Rice with *Costus Afer*

Although treatment T1 (166.6 l.ha⁻¹) recorded the highest value for the number of tillers (306/m²), no significant difference was observed between the mean values for grain yield (RDG) and those for the other indicators (RDP, MST and IR) of rice production under the effect of the aqueous extract of *Costus afer*. However, rice grain yield varied from 5.12 (T0) to 7.63 t.ha⁻¹ (T5) with values equal to or close to 7.00 t.ha⁻¹ for the other doses. These yields are much higher than those recorded at national level (1.5 - 5.5 t.ha⁻¹) [19]. The genetic potential of VA6 has therefore improved, probably due to better adaptation to the environment. In any case, since genetic potential represents only part of the production factors (30 - 40%), we should note here the high agricultural value of peat soils, as observed at Songon with a grain yield of 5.12 t.ha⁻¹ without any input to the soil. The response curve, which was not significant, predicts a grain yield of 5.6 t.ha⁻¹ without any input and an optimum dose of 649 l.ha⁻¹, which should be confirmed with further studies.

5. Conclusion

This study highlighted the importance of peatlands for lowland rice production, with grain yields well above the national average in Côte d'Ivoire, using a promising variety, VA6.

Differences in vegetative growth were observed, particularly in tillering, although this did not affect grain yield. With no significant difference, the grain yields were in favour of applying doses of *Costus afer*. A simple and inexpensive application. However, it is important to reinforce the results obtained by quantifying the carbon stored in the soil in order to assess its effectiveness in the soil's ecological function.

References

- [1] Payette, S et Rochefort, L. Introduction. Saint Nicolas, les presses de l'Université Laval, 2001, P 1-5.
- [2] Campbell-Renaud E., L'exploitation des tourbières dans une perspective de développement durable. Maîtrise en environnement, Université de Sherbrooke. Septembre 2014. 93p.
- [3] Cris, R., Buckmaster, S., Bain C., and Reed M. Global Peatland Restoration Demonstrating SUCCESS. Edinburgh: IUCN UK National Committee Peatland Programme, 2014, 40p.
- [4] Parish, F. Sirin, A. Charman, D. Joosten, H. Minayeva, T. Silvius, M. et Stringer, L. Assessment on Peatlands, Biodiversity and Climate Change. (ed): Kuala Lumpur et Wageningen: Global Environment Center and Wetlands International, 2008, 23p.
- [5] Alabouvette, C. et Cordier, C. Fertilité biologique des sols: des microorganismes utiles à la croissance des plantes. Innovations Agronomiques, INRAE, 2018, 69p.
- [6] Rhodes, C. J. The imperative for regenerative agriculture. Sci. Prog. 2017, 80–129p.
- [7] Han, W., Fang, J., Guo, D., Zhang Y., Leaf nitrogen and phosphorus stoichiometry across 753 terrestrial plant species in China. New Phytol, 2005, 168p.
- [8] Meité, B. Activité biofertilisants d'extraits aqueux de *Costus afer* sur la croissance et le développement du riz (*Oryza sp.*) en Côte d'Ivoire. Master 2, Université Felix Houphouët- Boigny, Cocody. 2018, 79:40p.
- [9] Yoboué, D.D. Effet de diverse fumure en riziculture. Master II, Université Felix Houphouët-Boigny, Cocody, Abidjan. 2020, 70p.
- [10] Combres, J.C. et Eldin, M. Eléments généraux du climat. In Atlas Côte d'Ivoire. Ministère du plan/ORSTOM/ Institut de Géographie Tropicale, Abidj2 pl. texte, 1 pl. carte, 1971.
- [11] Tapsoba, S.A.. Etude géologique et hydrogéologique du bassin sédimentaire de la Côte d'Ivoire : Recharge et qualité des eaux dans l'aquifère côtier (Région de Jacqueville). DEA, Université Cheick Anta Diop-Dakar, 1995, 69p.
- [12] Kouamé, K.I. Pollution physico-chimique des eaux dans la zone de la décharge d'Akouédo et analyse du risque de contamination de la nappe d'Abidjan par un modèle de simulation des écoulements et du transport des polluants. Thèse de doctorat, Université d' Abobo-Adjamé, Abidjan, 2007, 229p.
- [13] CPCS (Commission de Pédologie et de Cartographie des Sols),. Classification des sols. Travaux Commission de Pédologie et de Cartographie des Sols 1963-1967. ENSA, Grignon, 1967, pp 57-66.
- [14] FAO (Food and Agricultural Organization),. Base de référence mondiale pour les ressources en sols. Système international de classification des sols pour nommer les sols et élaborer des légendes de cartes pédologiques. Rapport sur les ressources en sols du monde n° 106. FAO, Rome, Italie, 2014, 216p.
- [15] Koné B.; Guety TP; Devisme B. J; Koné A.; Kanaté L; Brahima C., Improvement of soil biology and rice yield in peat land ecology using aqueous extract of *Costus afer*: Exploring soil regenerative agriculture under rice cropping. Journal of Ecology and Natural Resources, Volume 7 Issue 2, 2023, 12p.
- [16] Ritz, K., and Myoung, I. Interactions between soil structure and fungi. Mycologist, 2004, pp 52-59.
- [17] Yuvaraj, M., & Ramasamy, M.. Role of fungi in agriculture. Biostimulants in Plant Science, 2020, pp 1-12. DOI: 10.5772/intechopen.89718.
- [18] McInerney, M.J. Sieber, J.R. Gunsalus, R.P. Syntrophy in anaerobic global carbon cycles. Curr Opin Biotechnol, 2009, 20p.
- [19] ADERIZ. Tableau de bord de la filière riz 2012-2018. ADERIZ working document (excel file) base de données l'étude. 2020, 52p.



© The Author(s) 2024. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).