EFFECTS OF AN ORGANIC BIOSTIMULANT ON THE AGRONOMIC AND ECONOMIC PERFORMANCE OF GROUNDNUT CULTIVATION IN REAL-WORLD CONDITIONS IN THE NAKAMBE REGION OF BURKINA FASO

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Abstract

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In Burkina Faso, climatic hazards and soil degradation negatively affect groundnut (Arachis hypogaea L.) productivity. This study evaluates the effects of a biostimulant on the productivity and profitability of groundnuts grown in a real-world setting. It was conducted at the Tenkodogo University Center in the Nakambé region. The groundnut variety used was TE3, cultivated according to a completely randomized Fischer block design with four replications and four treatments: T0 (control without fertilizer); T1 (1 liter/ha of biostimulant), T2 (2 liters/ha of biostimulant), and T3 (3 liters/ha of biostimulant).

Data were collected on physiological, agronomic, and economic parameters. An analysis of variance using the Newman-Keuls test and gross margin calculations were performed. The physiological parameters (start date and 50% flowering, start date and 50% maturity) of the different treatments showed highly significant differences ($p<0.0001$). For the agronomic parameters, the treatments had a highly significant effect ($p<0.0001$) on the number of pods (NG), pod dry weight (PSG), number of seeds (NGr), and foliage dry weight (DWF).

The highest seed yield was obtained with the 1 liter/ha treatment, at 1145 kg/ha, and the highest gross margin (776,750 CFA francs/ha). Conversely, the 3 liters/ha treatment resulted in the highest haulm yield (2430 kg/ha). Therefore, the 1 liter/ha treatment could be recommended to producers aiming to improve Groundnut grain yield, and the 3 liter/ha treatment for haulm production.

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Introduction

The groundnut (Arachis hypogaea L.) is an annual oilseed legume cultivated for its seeds, leaves, and beneficial effects on soil fertility worldwide (Schilling et al., 1996). It is a crop generally grown in tropical areas and is highly valued for its nutritional and economic worth (Kouadio, 2007; FAO, 2003). According to the Statistics Division of the Food and Agriculture Organization of the United Nations (FAOSTAT, 2023), global groundnut production in 2022-2023 exceeded 50 million tons. The largest Groundnut-producing countries are China (18,357,437 tonnes), India (10,244,000 tonnes), Nigeria (4,607,669.46 tonnes), the United States (2,898,140 tonnes), and Sudan (2,355,000 tonnes). In Burkina Faso, Groundnuts were the primary cash crop before cotton until the early 1990s (Dyemkouma, 2009). They are cultivated throughout the country, but the spatial distribution of production shows significant regional disparities.The groundnut sector is structured with an interprofessional organization called the "Interprofessional Groundnut Sector of Burkina Faso (IFA-BF)". Average national production between 2005 and 2023 is estimated at 381,648 tonnes, with an average national cultivated area of 455,960 ha and an average annual national yield of 0.8 t/ha. Five regions stand out with higher average production volumes, exhibiting significant variability over the past five years (2019-2023): these are the Nando region (representing 12% of total production), Bankui (15%), Nakambé (13%), Gulmu (13%), and Guiriko (10%), according to data from the Ministry of Agriculture, Animal Resources and Fisheries (DGESS/MARAH, 2024). Consequently, production increased from 396,129 tonnes in 2019 to 630,526 tonnes in 2020, followed by a sharp decline to 447,254 tonnes in 2021. However, after this drop, production increased steadily in 2022 and 2023, reaching 559,064 and 683,183 tonnes respectively (DGESS/MARAH, 2024), compared to an estimated production of 825,732 tonnes in 2025 (allAfrica, 2025). groundnut derivatives are numerous and offer a wide range of benefits. Groundnuts are consumed as oil, Groundnut paste, and whole kernels (roasted or boiled), and are used in the production of soaps, infant formula, and animal feed (leaves and oilseed cake). Groundnut paste is a staple in many diets, particularly as a sauce in the southwest of the country (Nikiema, 1993). It also provides income for producers (Traoré *et al.*, 2021). The marketing of Groundnuts, Groundnut paste, oil, and oilseed cake is a key activity for women in production areas. Groundnut oilseed cake and Groundnut hay, which are rich in protein, are used in animal feed (Fonceka, 2010). Groundnut exports from Burkina Faso totaled 27,000 tons between 2019 and 2023 (MICA, 2023). Exports are mainly destined for Senegal, Togo and Ghana, which account for 75% of exports (APEX-BF, 2023). Despite the numerous benefits of Groundnuts for the national economy and population, their production in Burkina Faso remains insufficient and below the country's potential due to several limiting factors (Lankoandé, 2023). Drought, diseases and pests, poor soil quality, heat stress, and flooding are all environmental constraints that can subject plants to certain forms of abiotic stress. Faced with numerous daily challenges, plants may require additional support to survive and continue their development. At a time when farmers are confronted with increasing challenges such as climate change, soil degradation, and the growing demand for higher yields, as well as the high cost of chemical fertilizers and their harmful consequences for the environment and human and animal health, biostimulants appear as an innovative solution.These natural or synthetic substances positively influence plant growth, resistance to abiotic stress, and yield stability. Biostimulants play several key roles within the plant. They are substances that amplify plant biological processes. For example, they stimulate plant physiology, activate ion transporters, modulate enzymatic activities, reduce the impact of abiotic stress, improve organic matter degradation, regulate microflora, and enhance water use by the plant (Futureco Bioscience, 2025). This study aimed to evaluate the effect of a biostimulant on the growth, productivity, and profitability of Groundnuts grown in a real-world environment.

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Material and methods

Presentation of the study site

The study was conducted at the Tenkodogo University Center site, located in Sector 6 of the Tenkodogo municipality. This municipality is situated in the northern part of the Boulgou province in the Nakambé region (Figure 1). It is approximately 185 km from Ouagadougou, the capital. The site's geographic coordinates are:

latitude 11°48’37’’N, longitude 0°22’19’’W, and altitude 321 m. The surrounding topography is almost flat with an average slope of approximately 1 to 2%. The site has a dry soil composition, with approximately 5% ferruginous gravel as coarse surface material. Its phytogeographic vegetation is of the North Sudanian type, characterized by a wooded savanna (SDAU, 2012).

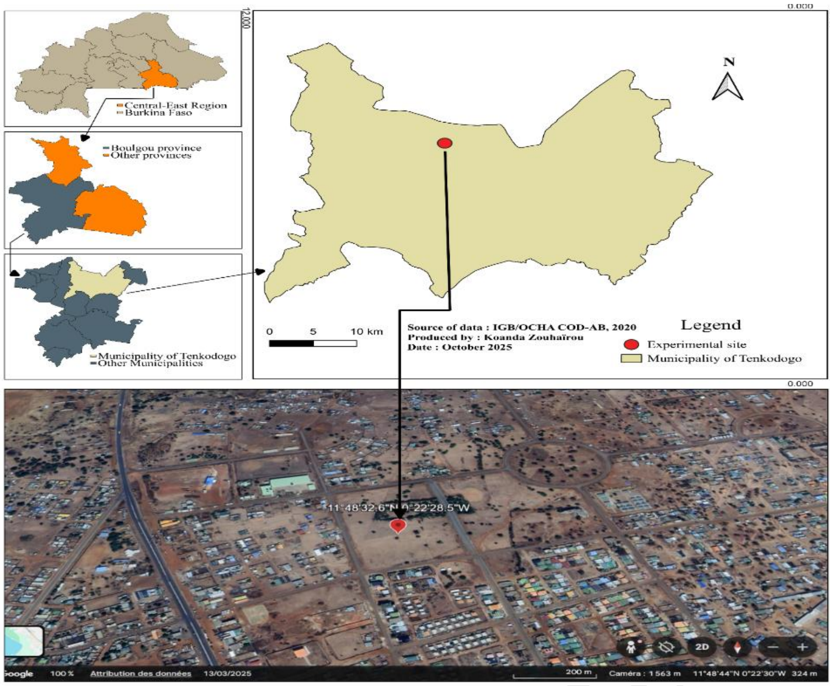

Figure 1: Geolocation map of the study site

The climate of the commune of Tenkodogo is of the Sudanian-Sahelian type, falling between the 600 mm and 900 mm isohyets. This climate is characterized by two seasons: the dry season, extending from November to May, during which the Harmattan wind blows, bringing cold and dry conditions, followed by a rainy season, or wintering period, from June to October, characterized by a humid pseudo-monsoon. The average monthly temperature observed during certain periods is 33°C, and maximum temperatures can reach 41°C (SDAU, 2012). The soils of the region are characterized by their homogeneous structure and texture: sandy, clayey, and gravelly. The following soil groups have been identified in the commune of Tenkodogo (WRB, 2015). These soils are mostly poor in mineral elements such as calcium, potassium, and phosphorus, with a low water retention capacity. They are relatively suitable for cereal and legume crops, such as millet, sorghum, groundnuts, and cowpeas. Vertic or gley soils, on the other hand, are generally used for rice cultivation and fruit tree farming (WRB, 2015).

Plant material

The plant material used for this study is the Groundnut (Arachis hypogaea L.) variety called TE3 (variety code SCHV 392). It was chosen for its short growing cycle (90 days) and high oil content (72%). The seed coat is light pink (Figure 2). It is a drought-tolerant and drought-resistant variety. Its potential yield is 1.5 to 2 t/ha (Apex Burkina, 2024).

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Figure 2: Seeds (a) and pods (b) of the TE3 Groundnut variety

Fertilizer

During the experiment, the fertilizer used was a non-microbial liquid organic biostimulant called BIORGA, obtained from the company Nakosem (Table I). The recommended dose is 1 to 5 liters/ha for Groundnuts. It was applied 10 days after sowing to the emerged seedlings. The organic amendment was applied weekly at precise doses until the flowering stage. The fertilizer doses applied per plot were as follows: T0: control treatment (no fertilizer); T1: fertilization at a dose of 1 liter/ha; T2: fertilization at a dose of 2 liters/ha; T3: fertilization at a dose of 3 liters/ha.

Table I: Chemical composition of the BIORGA biostimulant

Chemical components	**Content (%)**
Fulvic acids	31
Total amino acids	16
Free amino acids	9
Nitrogen (N)	7
Potassium (K_20)	1
Magnesium (Mg0)	0,3
Sulfur (SO_3)	7.7

Experimental device

The experimental design used was a completely randomized Fisher block design (Figure 3). It consisted of four replicates, each comprising four elementary plots. Each elementary plot had six rows of plants spaced 0.4 m apart, with 0.4 m between rows and 0.4 m between planting holes. Each planting hole contained one or two seeds. The elementary plot was 2 m long and 2 m wide, for a total area of 4 m². The spacing between two elementary plots was 0.8 m, and between blocks was 1.2 m. The total field area was 120.64 m² (10.4 m × 11.6 m).

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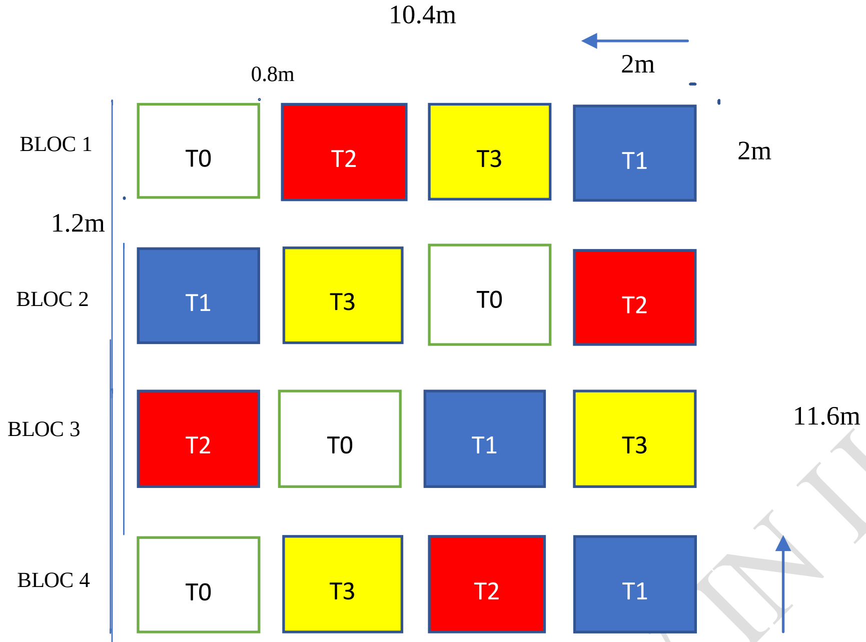

Figure 3 : Diagram of the experimental setup

Legend: T0: Control treatment without fertilization; T1: Fertilization at a dose of 1 liter/ha; T2: Fertilization at a dose of 2 liters/ha; T3: Fertilization at a dose of 3 liters/ha.

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Agricultural works

The plots were plowed with a tractor followed by manual leveling on July 10, 2025. Sowing took place on July 15, 2025, with one to two seeds per planting hole. Following these operations, organic fertilizer (compost) was broadcast over all the individual plots. To eliminate weeds, hoeing was carried out 15 days after sowing (DAS). To reduce competition between the crop and weeds, manual weeding was performed as needed, depending on the level of weed infestation. However, some plants were attacked, and we resorted to biological control, namely the use of neem leaf extract, to limit the damage caused by pests.

Observed parameters and measurement methods

To determine soil fertility and the effect of the biostimulant on the soil, soil analyses were conducted before and after sowing in the laboratory. Soil samples were collected from 4 m² plots using an auger to a depth of 0-30 cm. Three (3) individual samples per plot were mixed to form a composite sample in each plot. The analyses were performed by CID (Engineering Firm for Development). Each composite sample was first dried and then sieved through 2 mm and 0.5 mm meshes. The 2 mm fraction was used for particle size analysis, and the 0.5 mm fraction was used to determine the total nitrogen (Nt), total phosphorus (Pt), total carbon (Ct), and total organic matter (TOM) content. The analytical methods used to determine the different parameters were:

- Particle size distribution of three fractions (clay, total silt, and total sand) was determined by special hydrometer calibrated at 20°C. This involved stirring 5 g of the 2 mm fraction of the sample with a sodium hexamethaphosphate solution for 2 hours. The suspension was then stirred by hand for one minute, and the density was measured first after 40 seconds of rest, and then after 3 hours of rest, using a special hydrometer calibrated at 20°C (Bouyoucos, 1962).
- Total nitrogen and total phosphorus were determined by mineralization with sulfuric, selenium, and salicylic acid. This involved mineralizing 1 g of the 0.5 mm fraction of the sample with a sulfuric, selenium, and salicylic acid mixture by gradually heating it (100 to 340°C) until complete mineralization was achieved. The determination of total nitrogen in the mineralized material was done using an auto-analyzer with Nessler's reagent as an indicator and total phosphorus using ammonium molybdate.

- Organic matter/carbon (Walkley & Black method modified by Graham, 1948). 0.5 g of the 0.5 mm fraction of the sample was oxidized with potassium dichromate in sulfuric acid. The excess dichromate was measured by spectrophotometry at 650 nm (Graham, 1948).

Physiological parameters were measured starting from flowering. These are:

- Emergence date (ED), which corresponds to the number of days between the sowing date and the date on which the plants in each plot emerged.
- Flowering start date (FSD), which corresponds to the number of days between the sowing date and the date on which the plants in each plot began to flower.
- 50% flowering date (50%FD), which corresponds to the number of days between the sowing date and the date on which half of the plants in the plot flowered.

Maturity start date (MSD), which corresponds to the number of days between the sowing date and the date on which the leaves began to yellow.

- 50% maturity date (MD), which corresponds to the number of days between the sowing date and the date on which half of the leaves of the plants in the plot turned yellow.

The agronomic parameters were determined by weighing the samples (grains, haulms) after harvest and drying. They consist of:

- Number of Pods (NG): This is the average number of pods counted on four plants in each plot.
- Number of Seeds (NGr): This is the average number of seeds counted on four plants in each plot.
- Dry Weight of Seeds (PSGr): This is the weight of the seeds harvested per plant, measured using an electronic balance.
- Weight of 100 Seeds (P100G): This is the weight of 100 seeds randomly selected per plot, measured using an electronic balance.
- Dry Weight of Pods (PSG): This is the weight of the pods harvested per plant, measured using an electronic balance.
- Dry weight of foliage (DWF): This is the weight of the dry biomass per plant, measured using an electronic scale.
- Seed and haulm yield:

A 4 m² (2 m x 2 m) plot served as the experimental unit where all plants were harvested to determine seed and foliage yield. The results obtained were extrapolated to the hectare level.

Seed yield was calculated using the following formula:

$$\text{Grain yield(kg/ha)} = \frac{\text{Weight of seeds in the plot (kg)*10000 m}^2}{\text{Area of the plot (4 m}^2\text{)}} \qquad (1)$$

$$\text{Haulm yield(kg/ha)} = \frac{\text{Weight of the haulm in the plot(kg)*10000 m}^2}{\text{Area of the plot (4 m}^2\text{)}} \qquad (2)$$

The economic parameters were calculated taking into account the gross product (GP) and the variable costs (VC) of each treatment

$$\text{Gross margin} = \text{Gross product} - \text{Variable costs} \qquad (3)$$

Statistical analysis of data

Data entry and graph creation were performed using Excel. XLSTAT 2025 software was used to conduct an analysis of variance (ANOVA) to separate the means of the different treatments. When significant differences were observed, means were compared using the Newman-Keuls test at a significance level of 5%.

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Results

The physicochemical analysis of the soil before sowing and after harvest yielded the results presented in Table II. These results show an increase in all chemical components except for total potassium, which decreased. Regarding the physical components, there was an increase in sand content and a decrease in clay and silt content.

Table II : Physico-chemical composition of the soil in the study area

Soil Components		Before sowing	After the harvest
Physical	Clay (%)	7.84	3.92
	Silt (%)	9.81	7.84
	Sand (%)	82.35	88.24
	Organic Matter (%)	0.848	1.086
Chemicals	Calcium (%)	0.492	0.63
	Total Nitrogen (%)	0.044	0.061
	Total Phosphorus (mg/kg)	144.65	727.14
	Total Potassium (mg/kg)	1000.79	922.8
	Assimilable phosphorus (mg/kg)	4.55	10.22
	Potassium available (mg/kg)	92.74	100.82
	waterpH	5.55	5.71

(Source : CID-Engineering, 2025)

Physiological parameters

Table III presents the results for the physiological parameters. Analysis of variance (ANOVA) at the 5% significance level shows no significant difference ($p > 0.05$) between treatments for emergence (ED). However, highly significant differences ($p < 0.0001$) were observed at the beginning of flowering, at 50% flowering, at the beginning of maturity, and at 50% maturity. The beginning of flowering ranged from 22.5 ± 1.15 days under treatment T2 to 24 ± 0.81 days under T0. The date of 50% flowering ranged from 31 ± 1 days under T3 to 33 ± 1 days under T0. The beginning of maturity ranged from 57 ± 1 days under T2 and T3 to 59 ± 1 days under T0. The date of 50% maturity ranged from 71 ± 1 days under T2 and T3 to 74 ± 1 days under T0. The probability values (Pr>F) indicate that the treatments significantly influenced the parameters related to flowering and maturity, unlike the start of emergence, which remained similar between treatments.

Table III: Physiological parameters of Groundnuts as a function of treatments

Treatments	ED (DAS)	FSD (DAS)	50%FD (DAS)	MSD(DAS)	50%MD (DAS)
T0	9±1	24±0.81	33±1	59±1	74±1
T1	10±1	23±0.75	32±1	58±1	72±1
T2	9±1	23±1.15	32±1	57±1	71±1
T3	9±1	22±0.51	31±1	57±1	71±1
Pr>F	0.765	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

Legend: ED: Emergence date, FSD: Flowering start date; 50%FD: 50% flowering date, MSD: Maturity start date; 50% MD: 50% maturity date; T0: control treatment without fertilizer application; T1: dose of 1 liter/ha of biostimulant; T2: dose of 2 liters/ha of biostimulant; T3: dose of 3 liters/ha of biostimulant; DAS: Days after sowing.

Agronomic parameters

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Table IV presents the results for the agronomic parameters studied. Analysis of variance (ANOVA) performed at the 5% significance level shows that the treatments had a highly significant effect ($p<0.0001$) on the number of pods (NG), the dry weight of pods (PSG), the number of seeds (NGr), and the dry weight of foliage (DWF). However, no significant difference ($p>0.05$) was observed for the dry weight of seeds (PSGr) and the weight of 100 seeds (P100G). The average number of pods per plant ranged from 43.43 ± 20.51 (T0) to 66.06 ± 17.87 (T1). The weight of pods per plant ranged from 34.31 ± 10.49 g (T3) to 49.68 ± 7.26 g (T1). The number of seeds per plant ranged from 76.50 ± 23.37 (T2) to 116.87 ± 26.83 (T1). Finally, the dry weight of the foliage ranged from 50.25 ± 17.74 g (T0) to 67.18 ± 14.58 g (T1). The treatment at a dose of 1 liter/ha (T1) showed the highest values for all agronomic parameters.

Table IV: Agronomic parameters of Groundnuts according to treatments

Treatments	**NG**	**PSG (g)**	**NGr**	**PSGr (g)**	**P100G (g)**	**DWF (g)**
T0	43.43±20.51	34.93±7.90	96.18±26.63	23.75±7.86	27.13±6.30	50.25±17.74
T1	66.06±17.87	49.68±7.26	116.87±26.83	30.43±5.22	31.88±13.07	67.18±14.58
T2	62.43±3.28	43.68±13.42	76.5±23.37	26.5±10.07	30.01±7.37	55.43±14.97
T3	51.37±14.37	34.31±10.49	83.18±21.22	25.87±10.17	29.97±6.64	59.37±12.29
Pr>F	**0.000**	**<0.0001**	**0.000**	0.178	0.502	**0.018**

Legend: NG: number of pods; PSG: dry weight of pods; NGr: number of seeds; PSGr: dry weight of seeds; P100G: weight of 100 seeds; DWF: dry weight of foliage; T0: control treatment without fertilizer application; T1: dose of 1 liter/ha of biostimulant; T2: dose of 2 liters/ha of biostimulant; T3: dose of 3 liters/ha of biostimulant.

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Groundnut seed and leaf yield

- **Seed yield**

The results shown in Figure 4 indicate that the highest seed yield was obtained in treatment T1 (fertilization at a dose of 1 l/ha) with 1145 kg/ha, followed by T2 (fertilization at a dose of 2 l/ha) with 1070 kg/ha and T3 (fertilization at a dose of 3 l/ha) with 1085 kg/ha. The lowest seed yield was obtained in treatment T0 (unfertilized control) with 817.5 kg/ha.

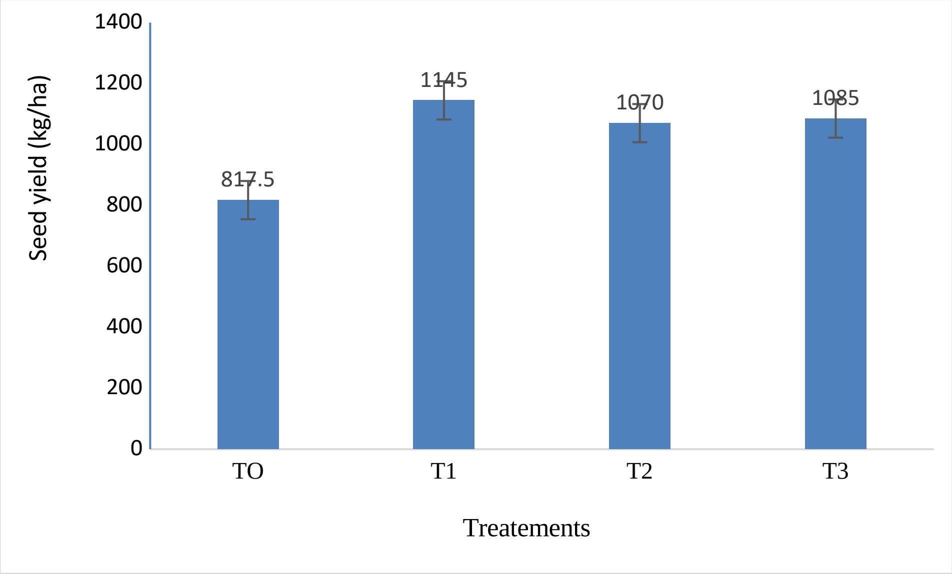

Figure 4: Groundnut seed yield of the TE3 variety as a function of treatments

Legend: T0: control treatment without fertilizer application; T1: dose of 1 liter/ha of biostimulant; T2: dose of 2 liters/ha of biostimulant; T3: dose of 3 liters/ha of biostimulant.

- **Haulm yield**

The results shown in Figure 5 demonstrate that haulm yield increases with increasing biostimulant doses. Treatment T0 (Control) resulted in the lowest yield (1977.5 kg/ha), followed by T1 (fertilization at a dose of 1 liter/ha): 2240 kg/ha, T2 (fertilization at a dose of 2 liters/ha): 2280 kg/ha. Treatment T3 (fertilization at a dose of 3 liters/ha) yielded the highest haulm yield, at 2430 kg/ha.

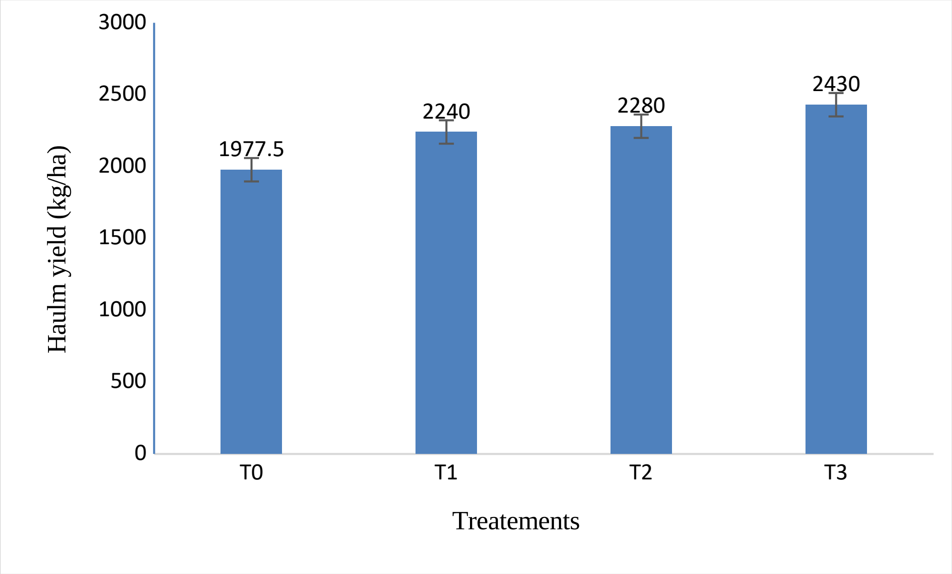

Figure 5: Haulm yield of the TE3 Groundnut variety as a function of treatments

Legend: T0: control treatment without fertilizer application; T1: dose of 1 liter/ha of biostimulant; T2: dose of 2 liters/ha of biostimulant; T3: dose of 3 liters/ha of biostimulant.

Analysis of the economic profitability of treatments

Figure 6 shows the gross margins according to the treatments. Treatment T1 (fertilization at a dose of 1 liter/ha) has the highest gross margin (776,750 CFA francs/ha) followed by treatment T3 (fertilization at a dose of 3 liters/ha) with 729;750 CFA francs/ha and treatment T2 (fertilization at a dose of 2 liters/ha) with 717,500 CFA francs/ha.

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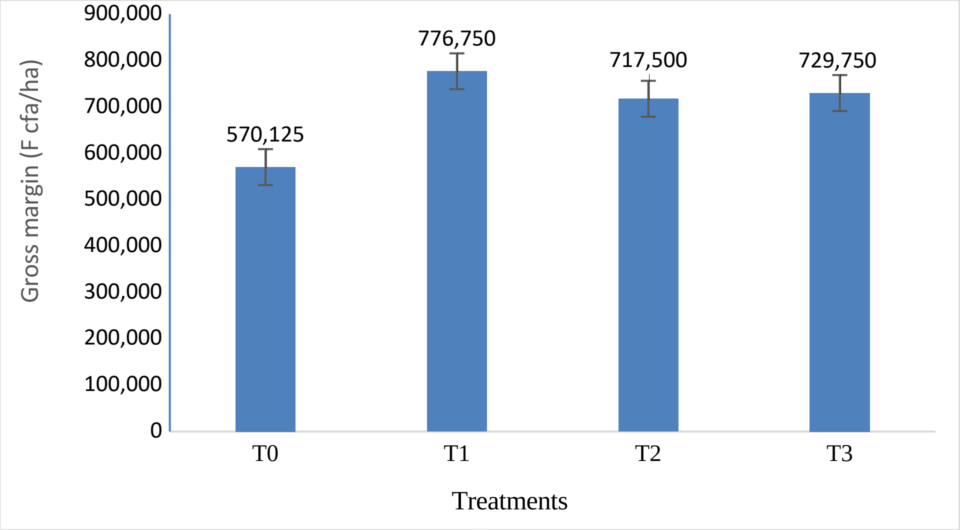

Figure 6: Gross margin of the TE3 Groundnut variety as a function of treatments

Legend: T0: control treatment without fertilizer application; T1: dose of 1 liter/ha of biostimulant; T2: dose of 2 liters/ha of biostimulant; T3: dose of 3 liters/ha of biostimulant.

Discussion

The aim of this study was to evaluate the effect of biostimulant on the productivity of field-grown Groundnuts with four treatments: T0 (control without fertilizer); T1 (dose of 1 liter/ha of biostimulant), T2 (dose of 2 liters/ha of biostimulant), T3 (dose of 3 liters/ha of biostimulant).

The physicochemical analysis of the soil showed that after the application of the biostimulant, an improvement in the soil's chemical properties was observed, notably through an increase in the availability of organic matter, nitrogen, phosphorus, and potassium. This reflects a stimulation of soil biological activity. According to Vessey (2003), biostimulants and beneficial microorganisms can improve nutrient availability through mineralization and nutrient mobilization. The increase in available phosphorus confirms this hypothesis, as some microorganisms are capable of solubilizing phosphorus fixed in the soil (Richardson *et al.*, 2009). Similarly, the increase in available potassium suggests improved nutrient dynamics in the soil solution. These results confirm the importance of organic amendments and biostimulants in the sustainable management of low-fertility tropical soils.

Regarding the physiological parameters of Groundnuts, the treatments had no influence on plant emergence date. This lack of significant effect suggests that germination and emergence are primarily determined by the intrinsic quality of the seeds and soil conditions rather than by the action of the biostimulant applied after sowing. Similar observations were reported by Calvo *et al.* (2014), who indicated that the effect of biostimulants on germination is variable and strongly depends on the application method. Significant variations were observed for flowering date and 50% flowering. Unfertilized control plants flowered later (24 days), while those treated with fertilizers flowered earlier. This earlier flowering can be explained by hormonal stimulation (auxins, gibberellins, cytokinins) induced by the biostimulant, accelerating the vegetative-reproductive transition. According to Rouphael and Colla (2020), biostimulants improve plant metabolism and accelerate the development process. The date of 50% flowering was also significantly influenced by the treatments ($p<0.0001$). Treated plants reached the stage where 50% of the plants were flowering more quickly.

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This confirms the effect of the biostimulant on the uniformity and synchronization of flowering. Du Jardin (2015) emphasizes that biostimulants improve internal hormonal balance, promoting better coordination of developmental stages. The dates of maturity and 50% maturity also varied between treatments. The control treatment, which did not receive a biostimulant, reached maturity late (59 days), while the treatments that received the biostimulant showed early maturity (57 to 58 days). The biostimulant treatments appear to slightly shorten the cycle. This reduction in the cycle can be interpreted as an improvement in the physiological and metabolic efficiency of the plants, allowing for faster pod filling. Work by Reddy *et al.* (2003) showed that improving mineral nutrition and physiological status can accelerate maturation in Groundnuts. Furthermore, Rouphael & Colla (2020) indicate that biostimulants increase enzymatic activity and photosynthetic efficiency, which can reduce the duration of the crop cycle.

Regarding agronomic parameters, the higher number of pods and seeds per plant in treatments receiving 1 liter/ha of biostimulant, compared to other treatments and the control treatment without fertilization, is explained by improved mineral nutrition, which promotes flowering, fruit set, and the transformation of fertilized flowers into pods. According to Singh *et al.* (2004), better availability of essential nutrients, particularly phosphorus and calcium, improves pod formation and development in Groundnuts. Nutrient availability is thought to be linked to an improvement in the physical and chemical properties of the soil following biostimulant application. Similar results were reported by Ntare *et al.* (2001), who emphasized that improved growing conditions lead to an increased number of seeds per plant in improved Groundnut varieties. The dry weight of the seeds varied between treatments, with higher values observed in treated plants. This is explained by a better accumulation of dry matter in the seeds, reflecting increased efficiency in the assimilation and redistribution of nutrients. According to Rouphael & Colla (2020), biostimulants improve nutrient (N, P, K) use efficiency and stimulate carbon metabolism, resulting in increased reproductive biomass. The 100-seed weight showed relatively little variation between treatments. This observation suggests that this parameter is primarily controlled by the genetic potential of the TE3 variety and is less sensitive to cultivation practices than other yield components. Similar conclusions were reported by ICRISAT (2016), which indicated that seed weight in Groundnuts is generally stable within a given variety. The haulm dry weight (HDW) was higher in plants fertilized with the biostimulant than in unfertilized control plants, thus reflecting improved vegetative growth. Treatment T1 (fertilization at a rate of 1 liter/ha) resulted in the highest seed yield, at 2430 kg/ha, and the best gross margin (776,750 CFA francs/ha), while treatment T3 (fertilization at a rate of 3 liters/ha) resulted in the highest haulm yield, also at 2430 kg/ha, with a gross margin of 729,750 CFA francs/ha. This indicates that a low dose of biofertilizer promotes pod and seed formation, and a high dose of biostimulant promotes vegetative growth, hence the high aboveground dry biomass obtained with the 3-liter/ha dose. However, according to Bationo *et al.* (2018), a good balance between vegetative and reproductive growth is essential to avoid excessive competition between haulm and pods. These results show that the applied treatments allowed for a better expression of the agronomic potential of the TE3 variety by improving the main yield components without altering essential varietal characteristics. This performance demonstrates the adaptability of the TE3 variety to local agro-climatic conditions and the importance of improved cultivation practices for optimizing Groundnut production. The treatment at a dose of 1 liter/ha showed the highest values for all agronomic and economic parameters compared to the other treatments. This could be explained by optimized nutrient uptake, resulting in better yield and income. This improvement would be linked to an appropriate dose of the biostimulant, thus promoting photosynthesis, cell division, and stress tolerance. These results corroborate those of Calvo *et al.* (2014) and Rouphael *et al.* (2015), who demonstrated that the optimal application of biostimulants significantly improves the agronomic performance of crops. Thus, these results show that biostimulants are effective at low doses, with doses of 2 liters/ha and 3 liters/ha giving lower values for all agronomic parameters.

Conclusion

This study allowed us to highlight the effect of a biostimulant on various parameters of field-grown Groundnut plants. The results showed that applying the biostimulant at different doses significantly improved agro-physiological parameters. These results indicate that the effect of the treatments varies according to their dosage on

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the parameters studied. Indeed, fertilization with the biostimulant at a dose of 1 liter/ha yielded the best performance, with a notable improvement in pod and seed yield compared to the other treatments, while the dose of 3 liters/ha resulted in the highest haulm yield. Economically, the dose of 1 liter/ha provided the best gross margin. Biostimulants, when used at the correct dose, can therefore constitute an alternative for reducing the use of chemical fertilizers, leading to sustainable, healthy, and environmentally friendly agriculture that provides substantial income for producers.

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