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EFFECT OF BIODEPOSIT ELIXIR ORGANIC FERTILIZER ON THE AGRONOMIC AND ECONOMIC PERFORMANCE OF TWO TOMATO VARIETIES (*SOLANUM LYCOPERSICUM* L.) GROWN UNDER FIELD CONDITIONS

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ABSTRACT

Tomato (*Solanum lycopersicum* L.) production requires sustainable fertilization practices to improve productivity while reducing dependence on synthetic fertilizers. This study evaluated the effects of different BioDeposit Elixir organic fertilizer application rates on the agronomic and economic performance of two tomato varieties under field conditions in Côte d'Ivoire. A field experiment was conducted during the 2024-2025 cropping season using a randomized complete block design with a factorial arrangement of two varieties (Petomech+ and Cobra 26 F1) and five application rates (0, 12, 15, 20, and 25 mL per 10 m^2), with three replications. Morphological, phenological, yield, fruit quality, postharvest, and economic traits were evaluated. Data were analyzed using two-way analysis of variance followed by the Newman–Keuls multiple range test at P < 0.05. BioDeposit Elixir significantly affected most traits. Significant variety × BioDeposit Elixir dose interactions were observed for stem collar diameter, plant height, flowering time, fruit diameter, fruit fresh weight, gross yield, and shelf life. The 25 mL rate generally produced the highest values. Cobra 26 F1 showed superior performance for several traits, including plant height, fruit diameter, gross yield, and shelf life. The number of leaves, number of flowers, fruit appearance, harvest timing, and blossom-end rot incidence were mainly affected by the variety and/or BioDeposit Elixir dose without significant interaction. The 25 mL rate also resulted in the highest net economic value under both selling price scenarios (700 and 900 XOF kg^{-1}). Overall, BioDeposit Elixir improved several agronomic, postharvest, and economic traits, with responses depending on the trait and variety. The 25 mL rate provided the best overall performance under the experimental conditions.

Keywords: Biofertilizer; Organic Fertilizer; Tomato; BioDeposit Elixir dose; Yield; Economic Value.

1 INTRODUCTION

Tomato (*Solanum lycopersicum* L.), a member of the family Solanaceae, is one of the world's major vegetable crops because of its nutritional, economic, and food value [1]. It is widely cultivated worldwide and ranks among the leading vegetable crops in terms of production. According to FAO data, tomato is cultivated in more than 170 countries, with global production reaching approximately 192 million tonnes in 2024 [2]. Tomato is grown both under open-field and soilless production systems [3] and represents an important source of income for vegetable growers [4]. Nutritionally, tomato fruits are rich in vitamins (B, C, E, and K), minerals, dietary fiber, amino acids, and antioxidant compounds, particularly lycopene and β-carotene, which are recognized for their beneficial effects on human health [5-7].

In Côte d'Ivoire, tomato plays an important role in the diet of the population and contributes substantially to the income of vegetable growers, with an estimated average consumption of 12 kg per capita per year. However, tomato production remains severely constrained by biotic and abiotic stresses, which can cause substantial yield losses, reaching up to 90% under certain conditions [8]. To improve productivity, growers widely rely on mineral fertilizers, whose effectiveness in promoting crop growth is well established [9]. Nevertheless, their intensive and repeated use can progressively degrade the physical, chemical, and biological properties of soils, promote soil acidification, and increase the risk of pollution of natural resources [10,11]. Such dependence on synthetic fertilizers therefore raises environmental and economic concerns regarding the sustainability of vegetable production systems.

In response to these constraints, the development of more sustainable fertilization practices is essential to maintain crop productivity while conserving natural resources. Organic fertilizers represent a promising alternative because of their ability to improve soil fertility, structure, biological activity, and nutrient availability to plants [12]. Several studies have shown that organic fertilizers can enhance tomato growth and productivity and improve certain fruit quality attributes [13].

However, the agronomic effectiveness of an organic fertilizer depends on its composition, application rate, agroecological conditions, and crop genotype. Determining an appropriate application rate is therefore important for achieving a balance between agronomic performance and production profitability. In this context, BioDeposit Elixir, a liquid organic fertilizer rich in organic matter, humic acids, and mineral nutrients, could represent a promising option for tomato production. However, scientific evidence regarding its effectiveness and the responses of different tomato varieties to increasing application rates remains limited, particularly under field conditions in Côte d'Ivoire. This knowledge gap raises the following question: what application rate of BioDeposit Elixir can effectively improve the agronomic and economic performance of tomato, and does the response to this fertilizer vary among cultivated varieties?

The present study aimed to evaluate the effects of different BioDeposit Elixir dose on the agronomic performance of two tomato varieties (*Solanum lycopersicum* L.) grown under field conditions. Specifically, the objectives were to (i) evaluate the effects of BioDeposit Elixir on the vegetative growth and phenological development of Petomech+ and Cobra 26 F1, (ii) assess its effects on yield components and postharvest fruit quality, and (iii) determine the effects of the different BioDeposit Elixir doses on the economic value of tomato production.

2 MATERIAL AND METHODS

2.1 Study site

The study was conducted during the 2024-2025 cropping season in Gokra village, located approximately 27 km southwest of Daloa, in the Haut-Sassandra region of west-central Côte d'Ivoire. The experimental site was located at 6°40′29″ N latitude and 6°35′20″ W longitude. Mean annual rainfall is estimated at 1,835 mm, while the mean annual temperature ranges from 24.7 to 27.8 °C.

2.2 Plant material

The plant material consisted of certified seeds of two commercial tomato varieties (*Solanum lycopersicum* L.), Petomech+ and Cobra 26 F1, supplied by Technisem. Petomech+ has a relatively short production cycle, with the first harvests generally occurring 70-75 days after sowing. In contrast, Cobra 26 F1 has a production cycle ranging from 75 to 80 days after sowing.

2.3 Experimental design

The experiment was conducted under field conditions using a randomized complete block design (RCBD) with a factorial arrangement involving two factors: tomato variety and BioDeposit Elixir dose. The first factor consisted of two tomato varieties (Petomech+ and Cobra 26 F1), while the second comprised five BioDeposit Elixir dose: 0 mL (D0, control), 12 mL (D1), 15 mL (D2), 20 mL (D3), and 25 mL (D4), corresponding to the manufacturer's recommendations for an area of 10 m^2. The combination of the two factors resulted in 10 treatments, each replicated three times, giving a total of 30 experimental units.

The experiment was established on a 272.8 m^2 plot (31 m × 8.8 m). The experimental plot was divided into three blocks, each containing the ten treatments randomly assigned. The blocks and experimental plots were separated by 1-m-wide alleys to facilitate crop management, observations, and harvesting. Each experimental unit measured 2.0 m × 1.6 m, corresponding to an area of 3.2 m^2, and contained 15 plants arranged in three rows, with 0.80 m between rows and 0.50 m between plants within a row. A total of 450 plants were transplanted across the entire experimental layout. To minimize border effects, only the nine central plants of each experimental unit were used for measurements of growth, phenology, and yield.

2.4 Fertilization treatments

Fertilization was carried out using the liquid organic fertilizer BioDeposit Elixir. The main physicochemical characteristics of the product are presented in Table 1. Five fertilization treatments were evaluated: an untreated control (0 mL) and four BioDeposit Elixir dose of 12, 15, 20, and 25 mL. The actual volumes applied were 3.84, 4.80, 6.40, and 8.00 mL, respectively, each diluted in 6.4 L of water. The fertilizer was applied by soil drenching at the base of the plants immediately after transplanting, followed by soil application and foliar spraying during the vegetative growth, flowering, fruit set, and fruit enlargement stages. Applications were made every seven days after transplanting and subsequently every two weeks until the end of the crop cycle.

Table 1: Physicochemical composition of the BioDeposit Elixir organic fertilizer

Parameter	Value	Unit
Humic acids	123	$g\ L^{-1}$
Total nitrogen (N)	0.26	%
Total phosphorus (P)	0.009	%
Total potassium (K)	0.70	%
Organic matter	8.3	%
Moisture content	78.2	%
Calcium (Ca)	16.3	$mg\ kg^{-1}$
pH (20 °C)	10.0	-
Water-soluble sodium	0.45	%
Sodium chloride (NaCl)	< 0.1	%
C/N ratio	16:1	-
Electrical conductivity (20 °C)	2.64	$mS\ cm^{-1}$

Source: adapted from Nord Agri Ltd. [14]

2.5 Crop management

Seeds were sown in a nursery on 4 m × 1 m seedbeds for 21 days. Irrigation was provided using borehole water according to crop water requirements. After transplanting, each plant received approximately 300 mL of water every two days during the first week, followed by 500 mL per plant during the second and third weeks. From the fourth week onward, irrigation volumes ranged from 1 to 1.5 L per plant every two to three days, depending on climatic conditions and soil moisture. Preventive plant protection treatments against insect pests were applied immediately after transplanting and subsequently at 7-day intervals throughout the crop cycle. Plants were also staked three weeks after transplanting to prevent stem breakage caused by wind and fruit weight.

Fruits were harvested manually in several picking rounds as they reached commercial maturity. After each harvest, fruits were sorted to remove those showing symptoms of blossom-end rot. Healthy fruits were subsequently stored at room temperature (20 °C) on clean trays without any preservative treatment.

2.6 Traits evaluated

2.6.1 Morphological traits

The morphological traits evaluated were stem collar diameter, plant height, number of leaves, and number of flowers per plant. Stem collar diameter was measured using a digital caliper from the third week after transplanting and subsequently at two-week intervals. Plant height was measured using a measuring tape, from the stem collar to the apical tip of the main stem. The numbers of leaves and flowers were determined by direct counting.

2.6.2 Phenological traits

The phenological traits assessed were days to first flowering, days to 50% flowering, days to 100% flowering, days to first fruit appearance, and days to first and last harvest. Observations were conducted every two days from the appearance of the first flowers until the end of the harvesting period.

2.6.3 Yield and fruit quality traits

The yield and fruit quality traits evaluated were fruit diameter, fruit fresh weight, gross yield, percentage of fruits affected by blossom-end rot, and fruit shelf life. Fruit diameter was measured on five randomly selected fruits per plant using a digital caliper. Fruit fresh weight was determined using an electronic balance at each harvest. Gross yield was calculated by extrapolating the total fruit weight harvested from each experimental unit to a hectare basis.

The percentage of fruits affected by blossom-end rot was determined at each harvest by counting fruits showing blossom-end rot symptoms and expressing this number as a percentage of the total number of harvested fruits. Fruit shelf life was assessed at room temperature (20 °C) by recording the number of days between harvest and the appearance of the first visible signs of deterioration, including loss of firmness, wilting, mold growth, or abnormal odors.

2.6.4 Economic analysis of BioDeposit Elixir application

An economic analysis was conducted to assess the effect of BioDeposit Elixir dose on the economic value of tomato production. Two fruit selling price scenarios, 700 and 900 West African CFA francs (XOF) kg^{-1}, were considered to account for fluctuations in tomato market prices. The purchase price of BioDeposit Elixir was set at 2,000 XOF L^{-1}, equivalent to 2 XOF mL^{-1}. For each BioDeposit Elixir dose, fertilizer cost was calculated based on the amount of BioDeposit Elixir applied per hectare. Application rates of 12, 15, 20, and 25 mL per 10 m^2 corresponded to 12, 15, 20, and 25 L ha^{-1}, respectively, resulting in fertilizer costs of 24,000, 30,000, 40,000, and 50,000 XOF ha^{-1}, respectively.

Gross revenue from fruit sales was calculated for each treatment using the following equation:

$$GR = Y \times P$$

where GR represents gross revenue (XOF ha^{-1}), Y represents tomato gross yield (kg ha^{-1}), and P represents the tomato selling price (XOF kg^{-1}).

The net value after accounting for the cost of BioDeposit Elixir was then estimated using the following equation:

$$NV = GR - FC$$

where NV represents the net value after fertilizer cost (XOF ha^{-1}), GR represents gross revenue (XOF ha^{-1}), and FC represents the cost of BioDeposit Elixir (XOF ha^{-1}).

For each variety and BioDeposit Elixir dose, the resulting values were compared with those of the untreated control and the 12 mL per 10 m^2 application rate, corresponding to the manufacturer's recommended rate. This comparison was used to estimate the economic gain associated with increasing the fertilizer application rate.

2.7 Statistical analysis

Data were analyzed using STATISTICA version 7.1. A two-way analysis of variance (ANOVA) was performed to assess the effects of tomato variety, BioDeposit Elixir dose, and their interaction on growth, phenological, and yield-related traits. When the ANOVA revealed significant differences ($P < 0.05$), means were compared using the Newman–Keuls multiple range test at the 5% significance level.

3 RESULTS

3.1 Effect of BioDeposit Elixir on the morphological traits of Petomech+ and Cobra 26 F1

Table 2 presents the combined effects of tomato variety and BioDeposit Elixir dose on stem collar diameter and plant height. The interaction between variety and BioDeposit Elixir dose was highly significant for both traits (P < 0.001). Stem collar diameter increased with increasing application rate in both varieties, from 8.04 to 10.22 mm in Cobra 26 F1 and from 7.59 to 9.78 mm in Petomech+ between the untreated control and 25 mL, respectively. Cobra 26 F1 consistently showed a greater stem collar diameter than Petomech+. A similar response was observed for plant height, which increased from 50.40 to 93.56 cm in Cobra 26 F1 and from 50.34 to 85.40 cm in Petomech+. From 12 mL onward, Cobra 26 F1 was significantly taller than Petomech+.

Table 2: Interactive effects of tomato variety and BioDeposit Elixir dose on stem collar diameter and plant height.

Tomato variety	BioDeposit Elixir dose (mL)	Stem collar diameter (mm)	Plant height (cm)
Cobra 26 F1	0	8.04± 0.13*^{i}	50.40 ± 0.52^{i}
	12	8.82 ± 0.10^{f}	70.16 ± 1.43^{g}
	15	9.39 ± 0.07^{d}	84.49 ± 1.74^{d}
	20	9.84 ± 0.06^{b}	89.43 ± 1.45^{b}
	25	10.22± 0.09^{a}	93.56 ± 0.89^{a}
Petomech+	0	7.59 ± 0.09^{j}	50.34 ± 1.26^{i}
	12	8.14 ± 0.09^{h}	64.40 ± 1.26^{h}
	15	8.62 ± 0.08^{g}	70.40 ± 1.26^{f}
	20	9.16 ± 0.09^{e}	79.40 ± 1.26^{e}
	25	9.78 ± 0.08^{c}	85.40 ± 1.26^{c}
P-value Variety x Dose		*P < 0.001*	*P < 0.001*

*Values are expressed as mean ± SE. Means followed by the same lowercase letter within a column are not significantly different according to the Newman-Keuls multiple range test at P < 0.05.

Table 3: Main effects of tomato variety and BioDeposit Elixir dose on numbers of leaves and flowers

Factor	Number of leaves	Number of flowers
Tomato variety		
Cobra 26 F1	39.24 ± 2.83*^{a}	32.43 ± 2.44*^{a}
Petomech+	31.84 ± 3.75^{b}	31.05 ± 2.44^{b}
BioDeposit Elixir dose (mL)		
0	19.27 ± 0.15^{e}	7.97 ±1.09^{e}
12	23.81 ± 0.13^{d}	16.10 ± 1.20^{d}
15	27.77 ± 0.12^{c}	25.11 ± 1.20^{c}
20	31.84 ± 0.13^{b}	30.10 ± 1.20^{b}
25	35.81 ± 0.13^{a}	50.13 ± 1.20^{a}
P-value		
Variety	*P < 0.001*	*P < 0.001*
Dose	*P < 0.001*	*P < 0.001*
Variety x Dose	*0.56^{ns}*	*1^{ns}*

*Values are presented as mean ± SE. Means followed by different lowercase letters within each factor are significantly different according to the Newman–Keuls multiple range test (P < 0.05). ns: not significant.

Regarding the number of leaves and flowers per plant, the analysis of variance revealed significant effects of both tomato variety and BioDeposit Elixir dose on these two traits ($P < 0.001$). However, the interaction between variety and BioDeposit Elixir dose was not significant for either the number of leaves or the number of flowers (Table 3). Cobra 26 F1 had significantly higher mean numbers of leaves and flowers than Petomech+. The numbers of leaves and flowers per plant increased progressively with increasing BioDeposit Elixir dose. The number of leaves ranged from 19.27 leaves per plant in the untreated control to 35.81 leaves per plant at 25 mL. Similarly, the number of flowers increased from 7.97 flowers per plant in the untreated control to 50.13 flowers per plant at 25 mL. Thus, the highest values for both traits were recorded at the 25 mL BioDeposit Elixir dose, whereas the lowest values were observed in the absence of BioDeposit Elixir application.

3.2 Effect of BioDeposit Elixir on the phenological traits of Petomech+ and Cobra 26 F1

The analysis of variance revealed a highly significant interaction between tomato variety and BioDeposit Elixir dose for days to first flowering, 50% flowering, and full flowering ($P < 0.001$). Days to first flowering decreased with increasing BioDeposit Elixir dose in both varieties (Table 4). The shortest period was recorded for Cobra 26 F1 at 25 mL (25.27 days), whereas the longest was observed for Petomech+ in the untreated control (33.27 days). At 25 mL, the two varieties showed significantly different times to first flowering, with Cobra 26 F1 flowering earlier than Petomech+. A similar trend was observed for 50% flowering, with the shortest period recorded for Cobra 26 F1 at 25 mL (31.67 days). For full flowering, the time required also progressively decreased with increasing BioDeposit Elixir dose in both varieties. The two varieties showed statistically similar values at 25 mL.

The traits related to fruiting and harvesting are presented in Table 5. Unlike the flowering traits, no significant interaction between tomato variety and BioDeposit Elixir dose was observed for days to first fruit appearance, days to first harvest, or days to last harvest ($P > 0.05$). However, both variety and BioDeposit Elixir dose had significant effects on these traits ($P < 0.001$). Cobra 26 F1 recorded 54.06 days to first fruit appearance, compared with 55.06 days for Petomech+. The time to first harvest was 71.47 and 72.46 days, respectively. Conversely, the time to last harvest was 118.47 days for Cobra 26 F1 and 117.48 days for Petomech+. Regarding BioDeposit Elixir dose, days to first fruit appearance decreased from 59.17 days in the untreated control to 50.17 days at 25 mL. Similarly, days to first harvest decreased from 75.97 to 67.97 days, while days to last harvest decreased from 121.99 to 113.97 days over the same range of application rates.

Table 4: Interactive effects of tomato variety and BioDeposit Elixir dose on flowering phenological traits.

Tomato variety	BioDeposit Elixir dose (mL)	Day to first flowering (Day)	Day to 50% flowering (Day)	Day to full flowering (Day)
Cobra 26 F1	0	$32.27 \pm 1.45^{*b}$	37.66 ± 1.09^{a}	45.67 ± 1.09^{a}
	12	30.27 ± 1.45^{d}	35.67 ± 1.09^{c}	43.67 ± 1.09^{c}
	15	28.27 ± 1.45^{f}	33.67 ± 1.09^{d}	41.67 ± 1.45^{e}
	20	26.27 ± 1.45^{g}	32.67 ± 1.09^{e}	40.67 ± 1.45^{f}
	25	25.27 ± 1.45^{h}	31.67 ± 1.09^{f}	39.67 ± 1.45^{h}
Petomech+	0	33.27 ± 1.45^{a}	37.27 ± 1.45^{a}	44.27 ± 1.09^{b}
	12	31.27 ± 1.45^{c}	36.27 ± 1.45^{b}	43.27 ± 1.09^{c}
	15	29.27 ± 1.45^{e}	35.27 ± 1.45^{c}	42.27 ± 1.09^{d}
	20	29.27 ± 1.45^{e}	33.27 ± 1.45^{d}	40.27 ± 1.45^{f}
	25	26.27 ± 1.45^{g}	32.27 ± 1.45^{e}	39.27 ± 1.45^{h}
P-value Variety x Dose		*P < 0.001*	*P < 0.001*	*P < 0.001*

*Values are presented as mean ± SE. Means followed by the same lowercase letter within a column are not significantly different according to the Newman-Keuls multiple range test ($P < 0.05$).

Table 5: Main effects of tomato variety and BioDeposit Elixir dose on days to first fruit set, first harvest, and final harvest.

Factor	Day to first fruit set	Day to first harvest	Day to final harvest
Tomato variety			
Cobra 26 F1	54.06 ± 2.75*[b]	71.47 ± 2.99[b]	118.47 ± 2.99[a]
Petomech+	55.06 ± 2.94[a]	72.46 ± 2.99[a]	117.48 ± 3.00[b]
BioDeposit Elixir dose (mL)			
0	59.17 ± 1.53[a]	75.97 ± 1.09[a]	121.99 ± 1.05[a]
12	57.17 ± 2.09[b]	73.97 ± 1.09[b]	119.97 ± 1.09[b]
15	54.16 ± 1.53[c]	71.97 ± 1.09[c]	117.97 ± 1.09[c]
20	52.17 ± 1.53[d]	69.97 ± 1.09[d]	115.97 ±1.09[d]
25	50.17 ± 1.53[e]	67.97 ± 1.09[e]	113.97 ± 1.09[e]
P-value			
Variety	*P < 0.001*	*P < 0.001*	*P < 0.001*
Dose	*P < 0.001*	*P < 0.001*	*P < 0.001*
Variety x Dose	*1[ns]*	*1[ns]*	*0.99[ns]*

*Values are presented as mean ± SE. Means followed by different lowercase letters within each factor are significantly different according to the Newman–Keuls multiple range test (P < 0.05). ns: not significant.

3.3 Effects of tomato variety and BioDeposit Elixir dose on yield and fruit quality

Table 6 presents the effects of tomato variety and BioDeposit Elixir dose on fruit diameter, fruit fresh weight, gross yield, and shelf life. The analysis revealed a significant interaction between variety and dose for all these traits (P < 0.001). Fruit diameter increased with increasing BioDeposit Elixir dose in both varieties. In Cobra 26 F1, the values ranged from 46.73 mm in the untreated control to 65.73 mm at 25 mL, whereas in Petomech+, they ranged from 42.73 to 58.73 mm.

Table 6: Interactive effects of tomato variety and BioDeposit Elixir dose on fruit characteristics, yield and shelf life

Tomato variety	BioDeposit Elixir dose (mL)	Fruit diameter (mm)	Fresh fruit weight (kg)	Gross yield (kg ha^{-1})	Fruit shelf life (Days)
Cobra 26 F1	0	46.73 ± 1.07*[e]	8.11 ± 0.18[i]	8.45 ± 0.12[i]	13.51 ± 0.17[g]
	12	50.73 ± 1.07[d]	10.20 ± 0.23[g]	10.63 ± 0.21[g]	14.87 ± 0.13[f]
	15	57.73 ± 1.07[c]	10.95 ± 0.25[e]	11.41 ± 0.21[e]	17.00 ± 0.12[d]
	20	60.73 ± 1.07[b]	11.55 ± 0.21[c]	12.03 ± 0.25[c]	20.00 ± 0.12[b]
	25	65.73 ± 1.07[a]	12.15 ± 0.26[a]	12.65 ± 0.26[a]	23.00 ± 0.12[a]
Petomech+	0	42.73 ± 1.07[h]	8.02 ± 0.18[i]	8.35 ± 0.18[i]	8.13 ± 0.12[j]
	12	44.73 ± 1.07[g]	9.88 ± 0.20[h]	10.29 ± 0.23[h]	10.85 ± 0.14[i]
	15	48.73 ± 1.07[f]	10.40 ± 0.23f	10.83 ± 0.20[f]	12.89 ± 0.14[h]
	20	54.73 ± 1.07[d]	11.10 ± 0.21[d]	11.56 ± 0.24[d]	15.02 ± 0.17[e]
	25	58.73 ± 1.07[c]	11.80 ± 0.25[b]	12.29 ± 0.23[b]	18.80 ± 0.14[c]
P-value Variety x Dose		*P < 0.001*	*P < 0.001*	*P < 0.001*	*P < 0.001*

*Values are presented as mean ± SE. Means followed by the same lowercase letter within a column are not significantly different according to the Newman-Keuls multiple range test (P < 0.05).

At all BioDeposit Elixir doses, Cobra 26 F1 produced fruits with a greater diameter than Petomech+. Similarly, fruit fresh weight was affected by the variety × BioDeposit Elixir dose interaction. In Cobra 26 F1, values increased from 8.11 kg in the untreated control to 12.15 kg at 25 mL, while in Petomech+ they increased from 8.02 to 11.80 kg. Gross yield showed a similar pattern, increasing from 8.45 to 12.65 t ha^{-1} in Cobra 26 F1 and from 8.35 to 12.29 t ha^{-1} in Petomech+ between the untreated control and 25 mL, respectively. The highest gross yield was therefore recorded for Cobra 26 F1 at 25 mL, whereas the lowest values for both varieties were observed in the untreated controls.

Fruit shelf life was also significantly affected by the variety × BioDeposit Elixir dose interaction. In Cobra 26 F1, shelf life increased from 13.51 days in the untreated control to 23.00 days at 25 mL, whereas in Petomech+ it increased from 8.13 to 18.80 days. The longest shelf life was recorded for Cobra 26 F1 at 25 mL, while the shortest was observed for Petomech+ in the untreated control.

Regarding the incidence of blossom-end rot, the analysis of variance revealed no significant interaction between tomato variety and BioDeposit Elixir dose ($P > 0.05$). However, the main effects of both variety and BioDeposit Elixir dose were significant ($P < 0.001$). As shown in Figure 1, Petomech+ recorded a higher incidence of blossom-end rot (10.57%) than Cobra 26 F1 (8.87%). Moreover, blossom-end rot incidence significantly decreased with increasing BioDeposit Elixir dose (Figure 2). The highest incidence was recorded in the untreated control (17.54%), whereas the lowest incidence was observed at 25 mL (3.39%).

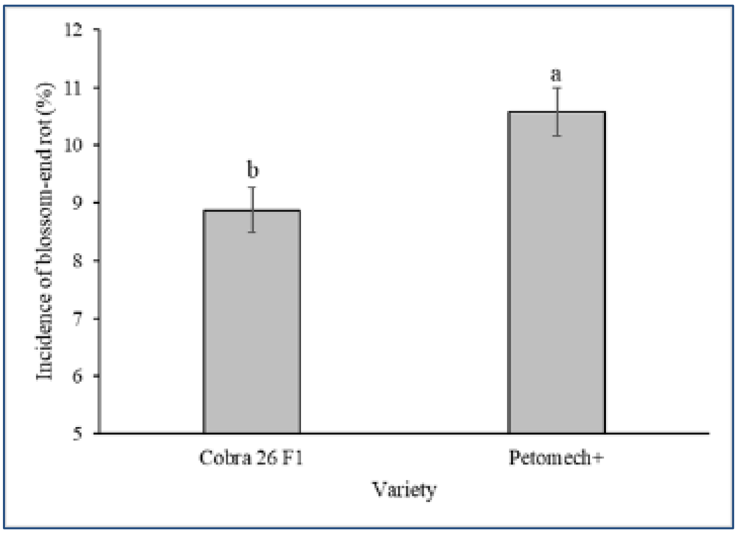

Figure 1: Main effect of tomato variety on the incidence of blossom-end rot.

Bars represent means ± SE. Bars with different lowercase letters indicate significant differences according to the Newman–Keuls multiple range test ($P < 0.05$).

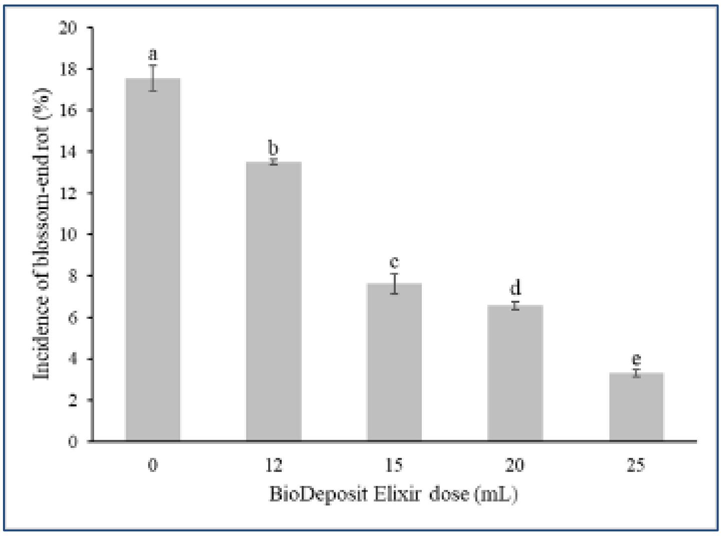

Figure 2: Main effect of BioDeposit Elixir dose on the incidence of blossom-end rot.

Bars represent means ± SE. Bars with different lowercase letters indicate significant differences according to the Newman–Keuls multiple range test ($P < 0.05$).

3.4 Effect of BioDeposit Elixir dose on the economic value of tomato production

The gross revenue and net value of tomato production are presented in Table 7. Under both selling price scenarios (700 and 900 XOF kg^{-1}), net value after deduction of the BioDeposit Elixir cost increased with the application rate in both varieties. For Cobra 26 F1, at a selling price of 700 XOF kg^{-1}, net value was 5,915,000 XOF ha^{-1} in the untreated control, compared with 7,417,000, 7,957,000, 8,381,000, and 8,805,000 XOF ha^{-1} at application rates of 12, 15, 20, and 25 mL 10 m^{-2}, respectively. At 900 XOF kg^{-1}, the corresponding values were 7,605,000, 9,543,000, 10,239,000, 10,787,000, and 11,335,000 XOF ha^{-1}.

For Petomech+, net value at 700 XOF kg^{-1} was 5,845,000 XOF ha^{-1} in the untreated control, followed by 7,179,000, 7,551,000, 8,052,000, and 8,553,000 XOF ha^{-1} at 12, 15, 20, and 25 mL 10 m^{-2}, respectively. At a selling price of 900 XOF kg^{-1}, the corresponding values were 7,515,000; 9,237,000; 9,717,000; 10,364,000, and 11,011,000 XOF ha^{-1}, respectively.

Under both selling price scenarios, the highest net value was obtained at 25 mL 10 m^{-2} for both varieties. At this application rate, Cobra 26 F1 recorded net values of 8,805,000 XOF ha^{-1} at 700 XOF kg^{-1} and 11,335,000 XOF ha^{-1} at 900 XOF kg^{-1}. The corresponding values for Petomech+ were 8,553,000 and 11,011,000 XOF ha^{-1}, respectively.

Table 7: Gross revenue and net value of tomato production according to tomato variety, BioDeposit Elixir dose, and selling price

Tomato variety	BioDeposit Elixir dose (mL)	BioDeposit cost (XOF ha^{-1})	Gross revenue at 700 XOF kg^{-1}	Net value at 700 XOF kg^{-1}	Gross revenue at 900 XOF kg^{-1}	Net value at 900 XOF kg^{-1}
Cobra 26 F1	0	0	5,915,000	5,915,000	7,605,000	7,605,000
	12	24,000	7,441,000	7,417,000	9,567,000	9,543,000
	15	30,000	7,987,000	7,957,000	10,269,000	10,239,000
	20	40,000	8,421,000	8,381,000	10,827,000	10,787,000
	25	50,000	8,855,000	8,805,000	11,385,000	11,335,000
Petomech+	0	0	5,845,000	5,845,000	7,515,000	7,515,000
	12	24,000	7,203,000	7,179,000	9,261,000	9,237,000
	15	30,000	7,581,000	7,551,000	9,747,000	9,717,000
	20	40,000	8,092,000	8,052,000	10,404,000	10,364,000
	25	50,000	8,603,000	8,553,000	11,061,000	11,011,000

4 DISCUSSION

This study showed that BioDeposit Elixir application improved several components of plant growth, phenological development, yield, postharvest quality, and economic value in the two tomato varieties. However, the magnitude of the response depended on the trait considered and, for several traits, on the interaction between variety and fertilizer dose.

Morphological traits generally responded positively to increasing BioDeposit Elixir doses. Stem collar diameter and plant height showed significant variety × BioDeposit Elixir dose interactions, whereas the numbers of leaves and flowers were affected by the main effects of both factors without significant interaction. The best performances were generally recorded at 25 mL, with higher values observed in Cobra 26 F1 for several traits. This response could be related to improved nutrient availability resulting from the fertilizer application, as BioDeposit Elixir contains 8.3% organic matter, 123 g L^{-1} humic acids, 0.70% potassium, and 0.26% nitrogen. A meta-analysis of 124 studies showed that organic fertilizers can improve soil chemical properties and nutrient availability, with positive effects on tomato performance [12]. Similarly, Traoré et al. [15] reported improved tomato growth and productivity under different combinations of organic and mineral fertilizers. The findings of Sawadogo et al. [16] also support a positive response of tomato to organic fertilization. The increase in leaf and flower numbers with increasing BioDeposit Elixir doses could consequently contribute to greater photosynthetic surface and reproductive potential, respectively.

Phenological traits also responded to BioDeposit Elixir application, although the response differed among traits. Days to first flowering and to 50% and 100% flowering showed significant variety × BioDeposit Elixir dose interactions, whereas days to first fruit appearance and harvest timing showed no significant interaction. Nevertheless, increasing dose generally shortened the reproductive development period, indicating earlier flowering and fruit production. This response could be associated with improved plant nutritional status, thereby favoring the transition to the reproductive phase. Konan [17] also highlighted the importance of fertilizer management in organic tomato production, while Traoré et al. [15] showed that improved mineral and organic nutrition can promote crop development and productivity.

Yield and fruit quality traits showed significant variety × BioDeposit Elixir dose interactions. The Cobra 26 F1 × 25 mL combination produced the highest values for fruit diameter, fresh weight, gross yield, and shelf life. The improvement in yield and fruit characteristics with increasing dose could be associated with more favorable plant nutrition. Similar results were reported by Traoré et al. [15], while the meta-analysis by Fan et al. [12] confirmed the positive effects of organic fertilizers on tomato yield and several fruit quality attribute. The overall superiority of Cobra 26 F1 may also reflect its genetic potential. Bhandari et al. [18] showed that genetic variation contributes substantially to differences in yield and fruit characteristics in tomato.

Fruit shelf life increased with BioDeposit Elixir dose, with the highest value recorded for Cobra 26 F1 at 25 mL. This improvement could be related to better physiological and structural fruit quality. The presence of 0.70% potassium, 16.3 mg kg^{-1} calcium, 123 g L^{-1} humic acids, and 8.3% organic matter in BioDeposit Elixir provides a plausible basis for this response. Wicaksana et al. [19] specifically highlighted the importance of potassium and calcium in tomato fruit quality and storage. However, because fruit mineral concentrations were not determined in the present study, the improvement in shelf life cannot be directly attributed to any particular mineral element.

Blossom-end rot incidence decreased with increasing BioDeposit Elixir dose, with no significant variety × BioDeposit Elixir dose interaction, and Petomech+ showed a higher incidence than Cobra 26 F1. Blossom-end rot is a physiological disorder associated mainly with calcium homeostasis and various environmental factors. De Freitas et al. [20] showed that its development is related to disturbances in fruit calcium status and several physiological factors. Topcu et al. [21] also emphasized the importance of calcium homeostasis and water availability in the development of this disorder. In the present study, the observed reduction with increasing application rate could therefore be associated with an overall improvement in plant nutritional conditions, although a direct effect of calcium supplied by BioDeposit Elixir cannot be demonstrated.

Finally, the economic analysis confirmed the advantage of the higher BioDeposit Elixir dose under the conditions of the study. Net value increased with application rate under both price scenarios, and 25 mL 10 m^{-2} generated the highest net value for both varieties. Increasing the rate from 12 to 25 mL resulted in an additional net gain of 1.388 and 1.792 million XOF ha^{-1} for Cobra 26 F1 at selling prices of 700 and 900 XOF kg^{-1}, respectively, compared with 1.374 and 1.774 million XOF ha^{-1} for Petomech+. This response was mainly attributable to the increase in yield, which offset the additional fertilizer cost. These findings suggest that, under the conditions of this experiment, application rates above the manufacturer's recommended rate of 12 mL 10 m^{-2} provided greater economic value. This approach is consistent with the growing interest in jointly evaluating the agronomic and economic performance of organic fertilizers [12].

5 CONCLUSION

This study evaluated the effects of different BioDeposit Elixir doses on the agronomic, phenological, yield, postharvest, and economic performance of two tomato varieties, Cobra 26 F1 and Petomech+. The results showed that plant responses to BioDeposit Elixir depended on the dose applied and, for several traits, on the tomato variety. Overall, Cobra 26 F1 exhibited better performance, particularly in terms of plant growth, fruit diameter, yield, and shelf life. Among the doses evaluated, 25 mL 10 m^{-2} produced the best performance for most of the traits assessed. This dose also generated the highest economic value for both varieties under both selling price scenarios, 700 and 900 XOF kg^{-1}. These findings indicate that, under the conditions of this experiment, doses higher than the manufacturer's recommended dose of 12 mL 10 m^{-2} resulted in greater agronomic and economic performance. However, 25 mL 10 m^{-2} cannot yet be considered a general optimum dose, as the study included only five doses and a limited range of experimental conditions. Further trials involving a wider range of doses, multiple growing seasons and experimental sites, together with an economic analysis incorporating all production costs, are required to determine the optimal agronomic and economic dose of BioDeposit Elixir for tomato production.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare that they have no financial or non-financial conflicts of interest.

Statement of ethical approval

Ethical approval was not required for this study because it involved only plant material and did not involve human participants or animals.

REFERENCES

[1] Shankara N, Joep VLJ, De Goffau M, Hilmi M, Van Dam B. La culture de la tomate : production, transformation et commercialisation. Wageningen: Agromisa Foundation; 2005. 105 p.

[2] FAOSTAT. Base de données FAO des statistiques agricoles [Internet]. Rome: Food and Agriculture Organization of the United Nations; 2024 Available from: https://www.fao.org/newsroom/detail/fao-statistical-yearbook-2024-reveals-critical-insights-on-the-sustainability-of-agriculture-food-security-and-the-importance-of-agrifood-in-employment

[3] Yéo MA, Koblai KH, Koffi KE, Coulibaly L. Evaluation de l'influence du substrat sur des paramètres agromorphologiques et biochimiques de la tomate (*Solanum lycopersicum esculentum*) en culture hydroponique. J Anim Plant Sci. 2022; 52(2): 9452-9463.

[4] Hanson P, Chen JT, Kuo CG, Morris R, Opeña RT. Suggested cultural practices for tomato. International Cooperators' Guide. Shanhua, Taiwan: Asian Vegetable Research and Development Center (AVRDC); 2000. 8 p.

[5] Blancard D, Laterrot H, Marchoux G, Candresse T. Les maladies de la tomate: identifier, connaître, maîtriser. Versailles : Éditions Quæ; 2009. 690 p.

[6] Abidi L, Snousi SAB, Stadea MS. Variation du taux du Brix sous l'effet d'un biofertilisant. UPB Sci Bull Ser B. 2017; 79(1): 135-144.

[7] Akpo AF. Mise en place d'une méthode de conservation de la tomate (*Solanum lycopersicum*) par l'application du froid et d'extraits végétaux aux effets anti-mûrissement et antifongique [doctoral thesis]. Avignon (France): Avignon Université; Abidjan (Côte d'Ivoire): Université Nangui Abrogoua; 2022. 168 p.

[8] Fondio L, Djidji HA, N'gbesso FPM, Kone D. Evaluation de neuf variétés de tomate (*Solanum lycopersicum* L.) par rapport au flétrissement bactérien et à la productivité dans le Sud de la Côte d'Ivoire. Int J Biol Chem Sci. 2013; 7(3): 1078-1086.

[9] Bernados LC, Joven PE, Julieta AA, Nelly SA. Increasing tomato productivity through integrated nutrient sources and inoculation with arbuscular mycorrhizal fungi and *Azospirillum* spp. Horticulturae. 2024; 10(10): 1-12.

[10] Deng M, Ma H, Sadeghpour A, Yang G, Hu Y, Yang D. Responses of crop production and soil health to chemical nitrogen fertilization in a maize-wheat rotation system. Front Environ Sci. 2023; 11:1108288. doi:10.3389/fenvs.2023.1108288

[11] Adouane T, Barrached A, Bezziche H. Les impacts négatifs des engrais chimiques sur l'environnement et la santé publique [licence thesis]. Ouargla : Université de Kasdi Merbah Ouargla ; 2023. 62 p.

[12] Fan H, Zhang Y, Li J, Jiang J, Waheed A, Wang S, et al. Effects of organic fertilizer supply on soil properties, tomato yield, and fruit quality: a global meta-analysis. Sustainability. 2023; 15(3): 2556.

[13] Murmu K, Ghosh BC, Swain DK. Yield and quality of tomato grown under organic and conventional nutrient management. Arch Agron Soil Sci. 2013;59(10):1311-1321. doi:10.1080/03650340.2012.711472.

[14] Nord Agri Ltd. Nord Agri Elixir+ technical analysis certificate and safety data sheet [Internet]. Riga: Nord Agri Ltd.; 2014. Available from: https://anyflip.com/adrh/ypsl/

[15] Traoré A, Bandaogo AA, Savadogo OM, Saba F, Ouédraogo AL, Sako Y, et al. Optimizing tomato (*Solanum lycopersicum* L.) growth with different combinations of organo-mineral fertilizers. Front Sustain Food Syst. 2022; 5: 694628. doi:10.3389/fsufs.2021.694628.

[16] Sawadogo J, Coulibaly PJD'A, Traore B, Bassole MSD, Savadogo CA, Legma JB. Effets des fertilisants biologiques sur la productivité de la tomate en zone semi-aride du Burkina Faso. J Appl Biosci. 2021; 167: 17375-17390. doi:10.35759/JABs.167.8.

[17] Konan YA. Implication de différents paramètres dans la production biologique de la tomate [thesis]. Daloa: Université Jean Lorougnon Guédé; 2020. 49 p.

[18] Bhandari P, Kim J, Lee TG. Genetic architecture of fresh-market tomato yield. BMC Plant Biol. 2023; 23:18. doi:10.1186/s12870-022-04018-5.

[19] Wicaksana PC, Wijaya KA, Soeparjono J. The role of potassium and calcium in improving the quality and shelf life of tomato (*Lycopersicum esculentum* var. servo). El-Hayah J Biol. 2019; 7(2): 98-110.

[20] De Freitas ST, Padda M, Wu Q, Park S, Mitcham EJ. Dynamic alterations in cellular and molecular components during blossom-end rot development in tomatoes expressing sCAX1, a constitutively active Ca^{2+}/H^{+} antiporter from Arabidopsis. Plant Physiol. 2011; 156(2): 844-855. doi:10.1104/pp.111.175208.

[21] Topcu Y, Nambeesan SU, van der Knaap E. Blossom-end rot: a century-old problem in tomato (*Solanum lycopersicum* L.) and other vegetables. Mol Hortic. 2022; 2:1. doi:10.1186/s43897-021-00022-9.