World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

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EVALUATION OF THE AGRONOMIC EFFECTIVENESS OF POLIFOL FERTILIZERS ON COTTON PRODUCTION IN COTE D'IVOIRE

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World Journal of Advanced Research and Reviews, 2026, 31(03), 1176–1187

Publication history: Received on 07 August 2026; revised on 15 September 2026; accepted on 17 September 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.31.3.2408

ABSTRACT

Soil acidification is a major constraint in cotton-based cropping systems, as it reduces both the efficiency of mineral fertilizers and cotton productivity. In this context, the present study aimed to evaluate the agronomic effectiveness of Polifol foliar fertilizers enriched with calcium and/or magnesium as an alternative or complementary approach to conventional cotton fertilization in Côte d'Ivoire. A field trial was conducted at the Centre National de Recherche Agronomique (CNRA) in Bouaké, using a randomized complete block design with five treatments and four replicates. The effects of the different fertilizer formulations were assessed on the basis of plant height, plant density, number of nodes per plant, taproot depth, and seed cotton yield, and compared with the recommended fertilization treatment (200 kg ha^{-1} of NPK 15-15-15 + 6S + 1B and 50 kg ha^{-1} of urea).

The results showed that Polifol treatments significantly improved plant height, root development, and seed cotton yield. Plant height ranged from 102.8 to 130.6 cm, taproot depth from 18.88 to 21.97 cm, and seed cotton yield from 1 061 to 1,262 kg ha^{-1}. The best performances were obtained with treatments T3 and T5, with T5 producing the tallest plants (130.6 cm) and T3 the highest seed cotton yield (1,262 kg ha^{-1}). In contrast, Polifol application did not significantly improve plant density or the number of nodes per plant. The experimental soil was strongly acidic (pH = 5.0), with a low organic matter content (2.27%) and a low exchangeable base content (1.953 cmol+ kg^{-1}). These first-year results demonstrate the agronomic potential of Polifol formulations to improve cotton productivity and offer promising prospects for more sustainable soil fertility management in cotton-based cropping systems.

Keywords: Fertilization, Polifol Fertilizers, Agronomic Effectiveness, Cotton, Côte d'Ivoire

1 INTRODUCTION

Agriculture is a strategic sector for sub-Saharan African economies, contributing substantially to employment, rural incomes, and food security (Lebret et al., 2008). In Côte d'Ivoire, it remains a pillar of the national economy and constitutes the main source of income for a large proportion of the rural population (FAO, 2009). Among the major agricultural commodities, cotton occupies a prominent place in the savannah zones of the northern part of the country, where it represents an important source of income for family farms and contributes to the economic dynamics of these territories. The cotton sector also plays a major role in agricultural trade and, together with cocoa, rubber, and cashew, constitutes one of the country's leading export sectors (Didi et al., 2018).

However, cotton productivity remains strongly constrained by the progressive degradation of soil fertility. Cropping intensification, shorter fallow periods, nutrient export through harvesting, and insufficient organic matter restitution all contribute to soil depletion. In West African cotton-based agrosystems, these processes can be exacerbated by the repeated use of mineral fertilizers, leading to a progressive decline in soil pH and exchangeable base content (Doumbia et al., 2009; Vanlauwe et al., 2015). Work conducted under the Regional Program for Integrated Cotton Production in Africa (PR-PICA) has highlighted the importance of soil fertility management and of calcium, magnesium, and potassium imbalances in West African cotton-growing basins (Hien, 2016).

Soil acidification thus constitutes a major constraint on cotton nutrition and productivity. It can reduce the availability of certain nutrients, particularly phosphorus, promote aluminum solubilization, and impair root development. Moreover, rising mineral fertilizer costs limit accessibility for smallholder farmers, reinforcing the need to improve fertilization efficiency. In this context, foliar formulations enriched with calcium and/or magnesium appear to be a complementary approach capable of improving cotton nutrition while contributing to more sustainable soil fertility management. However, the agronomic effectiveness of these formulations needs to be verified under the pedoclimatic conditions of Côte d'Ivoire.

It is within this perspective that the present study, entitled “Evaluation of the agronomic effectiveness of Polifol fertilizers on cotton production in Côte d'Ivoire,” was conducted. It aims to evaluate the effect of Polifol fertilizers applied by foliar spraying on the growth, root development, and productivity of cotton. More specifically, the study assesses their influence on plant density, the number of nodes per plant, height growth, taproot depth, and seed cotton yield.

1.1 Geographic setting of the study area

The study was conducted at the cotton research station of the Centre National de Recherche Agronomique (CNRA) in Bouaké, in the Gbêkê region, central Côte d'Ivoire. The station is located at 7°44′ N and 5°04′ W, at an altitude of approximately 376 m. The region lies in a transition zone between the savannah domains of the north and the forest formations of the south, and experiences a transitional tropical climate of the Sudanian type with Baoulean-Dahomeyan influence (Aubreville, 1949; Ouattara, 2001). Temperatures generally range from 25 to 38 °C, and annual rainfall ranges from 1,000 to 1,700 mm, with strong spatio-temporal variability. Relative humidity ranges from 70 to 80% during the rainy season and can fall to 55% during the dry season (N'Goran, 2008). Vegetation is dominated by sub-Sudanian savannah in the north and a pre-forest zone in the south, with patches of dense forest and gallery forests along watercourses. The relief is generally gentle, characterized by gently undulating plateaus, hills, and lowlands (Avenard et al., 1971). The hydrographic network is dominated by the Bandama River and its tributaries, together with watercourses of the N'Zi basin (N'Goran, 2008). The geology is dominated by metamorphic and volcano-sedimentary formations associated with Eburnean granitoids, notably granites, granodiorites, and migmatites (Ouattara et al., 2012). Soils are predominantly ferrallitic, generally shallow and light-textured on upland and intermediate positions, whereas lowland soils are hydromorphic with variable texture (N'Cho, 1991 ; Yoro, 2000). Their water-holding capacity is generally low and permeability high, with a risk of runoff associated with surface crusting (Figure 1).

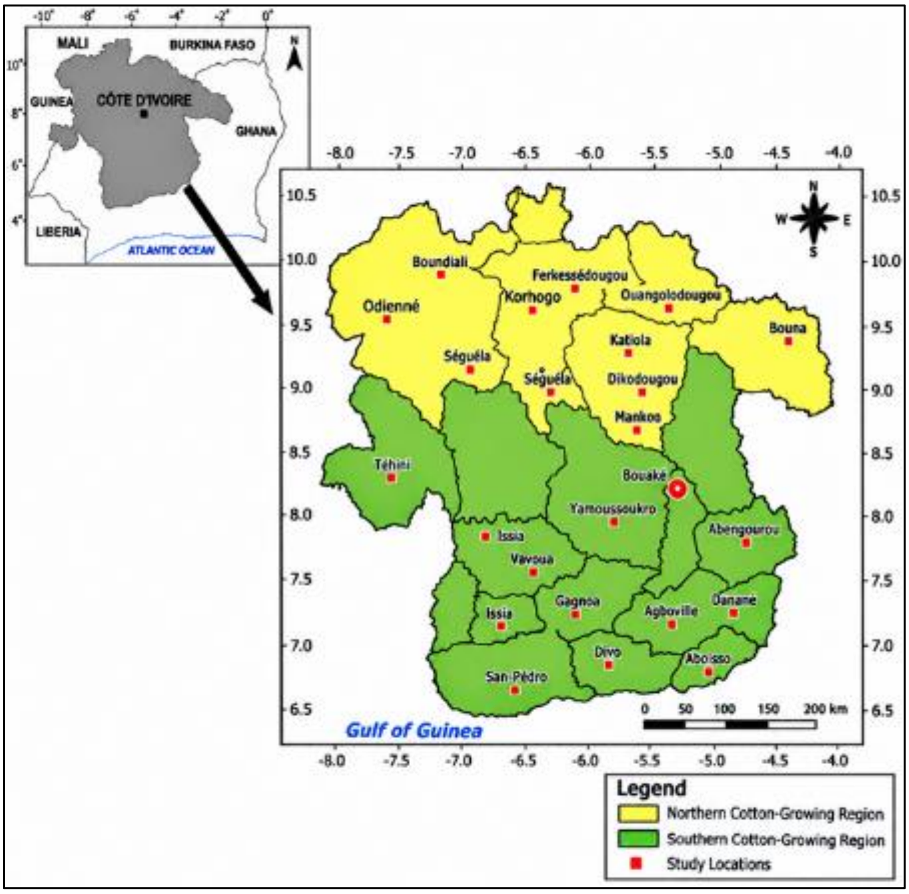

Figure 1: Map of the study area (Pitou, 2017)

2 MATERIAL

2.1 Plant material

The cotton variety Y 331 B (Gossypium hirsutum) was used. It originates from the CNRA genetic resources collection and was selected in 2000. This variety has a growth cycle of approximately 130 days and is well adapted to the climatic and edaphic conditions of Côte d'Ivoire. It is characterized by a high production potential of up to 3 t ha^{-1} of seed cotton, good fiber quality, early maturity, and a very high ginning outturn (45%).

2.2 Fertilizer material

The mineral fertilizer used comprised nitrogen (N) at 15%, phosphorus (P) at 15%, potassium (K) at 15%, sulfur (S) at 6%, boron trioxide (B_2O_3) at 1%, and urea ($[CO(NH_2)]_2$) at 46% N. These fertilizers were applied either alone or in combination with organo-mineral fertilizers, depending on the treatment. The organo-mineral fertilizers used were Polifol products, comprising Basal Active, Polinitro 30, and Mestrado Plus. These products were applied at different rates according to the trial treatments.

3 METHODS

3.1 Soil physicochemical analysis

Before establishing the trial, a composite topsoil sample (0–30 cm) was collected for laboratory physicochemical analysis to determine the initial fertility status of the plot (organic matter, phosphorus, exchange complex, pH). Owing to resource constraints, only pre-sowing soil samples were analyzed; post-harvest soil samples were not analyzed. Total carbon (C) content, total nitrogen (N), assimilable phosphorus (P-ass.), exchangeable bases (Ca^{2+}, Mg^{2+}, K^+, and Na^+), CEC, and soil water pH were determined. Organic matter (OM) content was calculated using the formula OM (%) = C (%) × 1.72. Analyses were performed on fine earth obtained after air-drying, grinding, and sieving through a 2 mm mesh for each sample. Particle-size distribution was determined by the pipette method. Carbon, nitrogen, and phosphorus contents were determined by the Walkley and Black, Kjeldahl, and Olsen methods, respectively. Exchangeable bases were determined after extraction with ammonium acetate buffered at pH 7, with quantification by atomic absorption spectrophotometry following alcohol washing. Quantification of this extract, followed by Kjeldahl distillation, was used to determine CEC. Water pH was measured electrometrically on a soil:water suspension at a ratio of 1 :2.5.

3.2 Experimental design

The trial was established using a randomized complete block design (RCBD) with five treatments and four replicates (Table I, Figure 2). Each treatment comprised 100 plants. Each elementary plot measured 6.4 m × 10 m, and blocks (replicates) were spaced 2 m apart. Cotton plants were spaced 0.80 m × 0.30 m, corresponding to a density of 41,666 plants ha^{-1}. The trial covered a total area of 1,960 m^2.

Table 1: Treatments compared

Treatment	Product	Application timing	Rate
T1	No fertilization	–	–
T2	NPKSB + Urea	15 DAE	200 kg/ha
		45 DAE	50 kg/ha
T3	Mestrado Plus	Pre-sowing and 15 DAE	200 mL/20 L water/0.25 ha
	Polinitro 30	15 DAE and 45 DAE	200 mL/20 L water/0.25 ha
	Basal Active	15-30-45-60 DAE	200 mL/20 L water/0.25 ha
T4	Mestrado Plus	Pre-sowing and 15 DAE	200 mL/20 L water/0.25 ha
	Polinitro 30	15 DAE and 45 DAE	200 mL/20 L water/0.25 ha
	Basal Active	15-30-45-60 DAE	200 mL/20 L water/0.25 ha
	NPKSB	15 DAE	200 kg/ha
	Urea	45 DAE	50 kg/ha
T5	Mestrado Plus	Pre-sowing and 15 DAE	200 mL/20 L water/0.25 ha
	Polinitro 30	15 DAE and 45 DAE	200 mL/20 L water/0.25 ha
	Basal Active	15-30-45-60 DAE	200 mL/20 L water/0.25 ha
	NPKSB	15 DAE	100 kg/ha
	Urea	45 DAE	25 kg/ha

DAE: days after emergence.

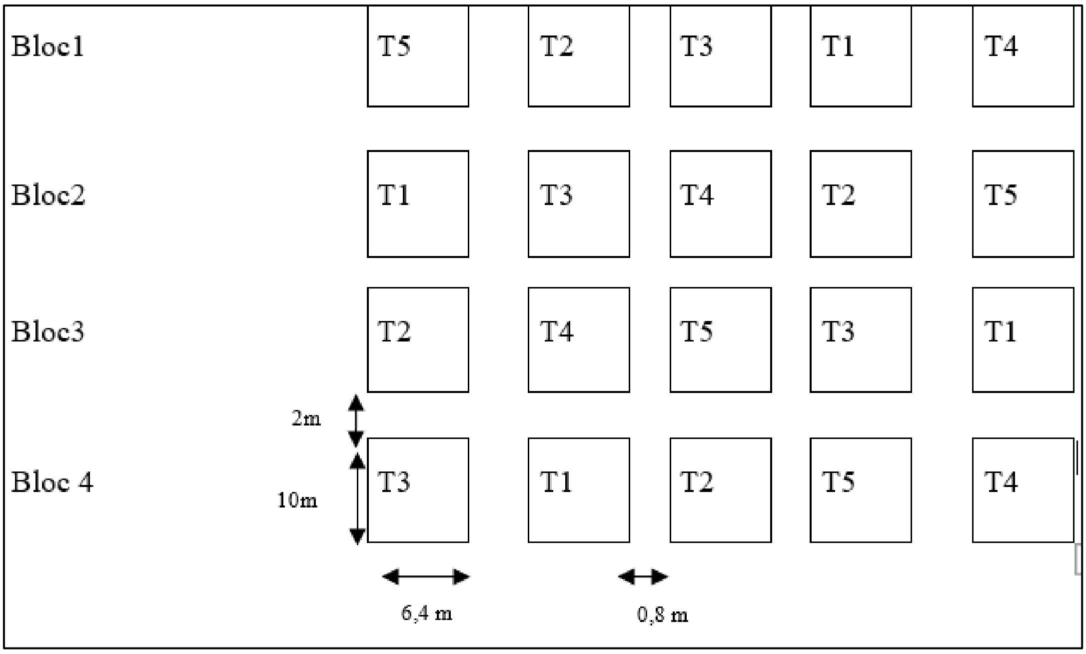

Figure 2: Layout of the experimental plot randomized block arrangement of treatments T1–T5 across four blocks

3.3 Conduct of the experimental trial

Soil preparation consisted of tractor plowing followed by harrowing. Cotton was sown at a rate of five seeds per hill, followed by thinning to two plants per hill (corresponding to a theoretical density of 83,333 plants ha^{-1}) at 15 days after sowing (DAS), with a spacing of 0.80 m × 0.30 m. Mestrado Plus was applied to the soil the day before sowing and again at 15 days after emergence. The foliar fertilizers Polinitro 30 and Basal Active were applied by foliar spraying at 15, 30, 45, and 60 days after emergence (DAE). A single cotton row was treated at each pass to ensure adequate leaf coverage. Foliar applications were preferably carried out early in the morning, before 9 :00 a.m., owing to wind direction. The number of hand-weedings depended on the level of weed infestation; two weedings were carried out during the trial, the first at 15 days after sowing (at thinning) and the second at 30 days after sowing.

A delay of 10 to 20 days relative to the optimal sowing date can result in a 10–20% yield loss. Phytosanitary treatments followed the standard three-window cotton protection program, with insecticide applications carried out two days after each foliar fertilizer application. The NPKSB basal fertilizer was applied at 15 days after emergence, and urea at 45 days after emergence, both at the recommended rates.

3.4 Observations and measurements on cotton plants

Each elementary plot contained eight rows, each 10 m long, with 32 cotton plants per row. Observations and measurements were carried out on two 8-m-long rows per elementary plot, taking border plants into account. The following parameters were recorded:

- the number of plants after thinning and at harvest, used to determine plant density;
- plant height, measured with a tape measure at 30, 45, 60, and 75 days after emergence (DAE) and
- at harvest, which also provided an indication of boll number;
- the number of nodes per plant at 30, 45, 60, and 75 DAE, corresponding to all nodes located above
- the cotyledonary node up to the last node of the plant; this parameter reflects plant development and
- allows an estimate of the number of fruiting branches and, consequently, an approximate yield
- forecast;
- taproot penetration depth in the soil at 30, 45, 60, and 75 DAE, reflecting root system development
- and used to assess the risk of plant lodging at different growth stages;
- at harvest, seed cotton weight per treatment, used to determine seed cotton yield.

3.5 Statistical analysis

Data were processed according to the study objectives. Data entry and graphical representation were performed using Excel 2016. Statistical analyses (analysis of variance and mean separation) were carried out using GENSTAT software.

The Student-Newman-Keuls (SNK) test was used for mean comparison whenever analysis of variance revealed significant differences among treatments at the 5% probability threshold.

4 RESULTS

4.1 Soil physicochemical characteristics prior to trial establishment

Soil particle-size distribution. Coarse sand was the dominant fraction (49.4%), followed by fine sand (24.6%), while the fraction below 0.05 mm (silt + clay) represented 26%. The soil exhibited a sandy clay texture (Table II).

Table 2: Soil particle-size distribution (% of fine earth)

Depth (cm)	0–30
Clay (%)	13.5
Silt (%)	12.5
Sand (%)	74
Texture	Sandy clay

Soil organic matter and phosphorus. Assimilable phosphorus content was low, below the critical threshold of 15 ppm. The C/N ratio (11) fell within the normal range (9 < C/N < 12), while organic matter content was low relative to the 2% threshold (Table III).

Table 3: Soil organic matter and phosphorus content

Depth (cm)	0–30	Threshold value
Organic matter (%)	2.27	≤ 2%
Total nitrogen (%)	0.12	< 0.2%
Total organic carbon (%)	1.32	< 4%
C/N	11	9 < C/N < 12
Assimilable phosphorus (ppm)	7	< 15 ppm

Cation exchange capacity and soil acidity. The experimental soil was acidic (pH = 5.0), below the optimal range of 6–7 for cotton cultivation. The exchange complex was characterized by a low exchangeable base content (7.68 cmol+ kg^{-1}, below the 15 cmol+ kg^{-1} threshold), resulting in a very low cation exchange capacity (CEC). The sum of exchangeable bases (S = 1.953 cmol+ kg^{-1}) was likewise below the 3 cmol+ kg^{-1} threshold, and soil organic matter content was low (Table IV).

Table 4: Cation exchange capacity and soil acidity

Depth (cm)	0–30	Threshold value
CEC (T)	7.68	< 15 cmol+/kg
Calcium	1.125	< 4 cmol+/kg
Magnesium	0.616	< 0.5 cmol+/kg
Potassium	0.081	< 0.2 cmol+/kg
Sodium	0.131	Trace in tropical soils
Sum of exchangeable bases (S)	1.953	< 3 cmol+/kg
Saturation rate (S/T) (%)	25.4	< 60%
Water pH	5.0	5.5

4.2 Effects of treatments on plant density at thinning and harvest

Changes in cotton plant density at thinning and at harvest are shown in Figure 3. At thinning, densities ranged from 55,625 to 63,906 plants ha^{-1}, with no significant treatment effect. At harvest, densities ranged from 36,406 to 42,188 plants ha^{-1}, and the treatment effect was likewise not significant.

Overall, the densities obtained were lower than the theoretical density of 83,333 plants ha^{-1}. Nonetheless, treatment T3 (Mestrado Plus + Polinitro 30 + Basal Active) produced the highest plant density at harvest (42,188 plants ha^{-1}).

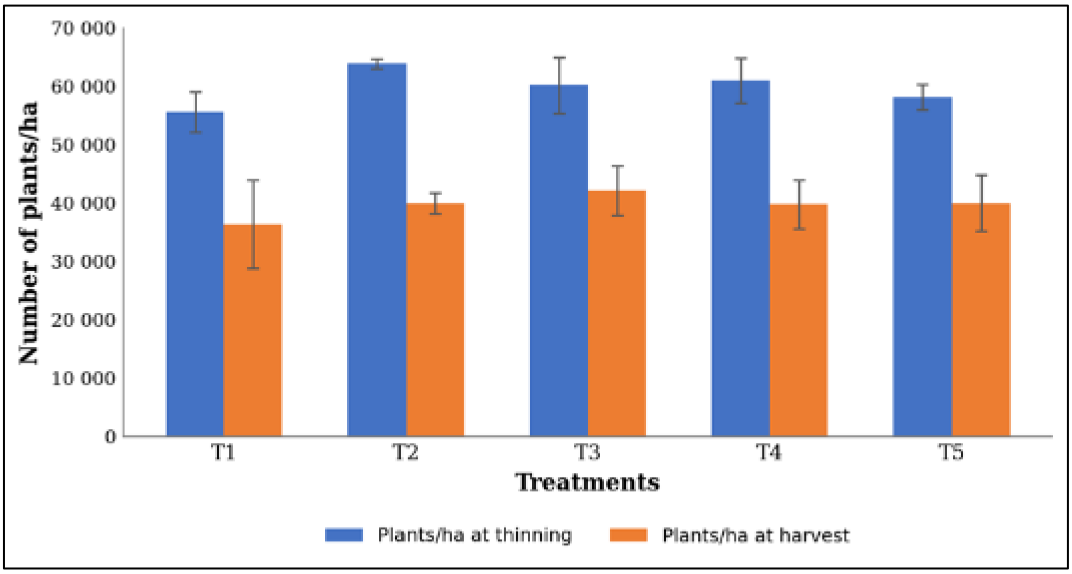

Figure 3: Plant density at thinning and at harvest

hly significant effect at 75 DAE. Overall, Polifol products combined with half the recommended fertilizer rate (100 kg NPKSB + 25 kg urea) produced greater plant growth than the full recommended rate. At harvest, treatment T5 produced the tallest plants (130.6 cm), compared with 102.8 cm under the recommended fertilization treatment (T2).

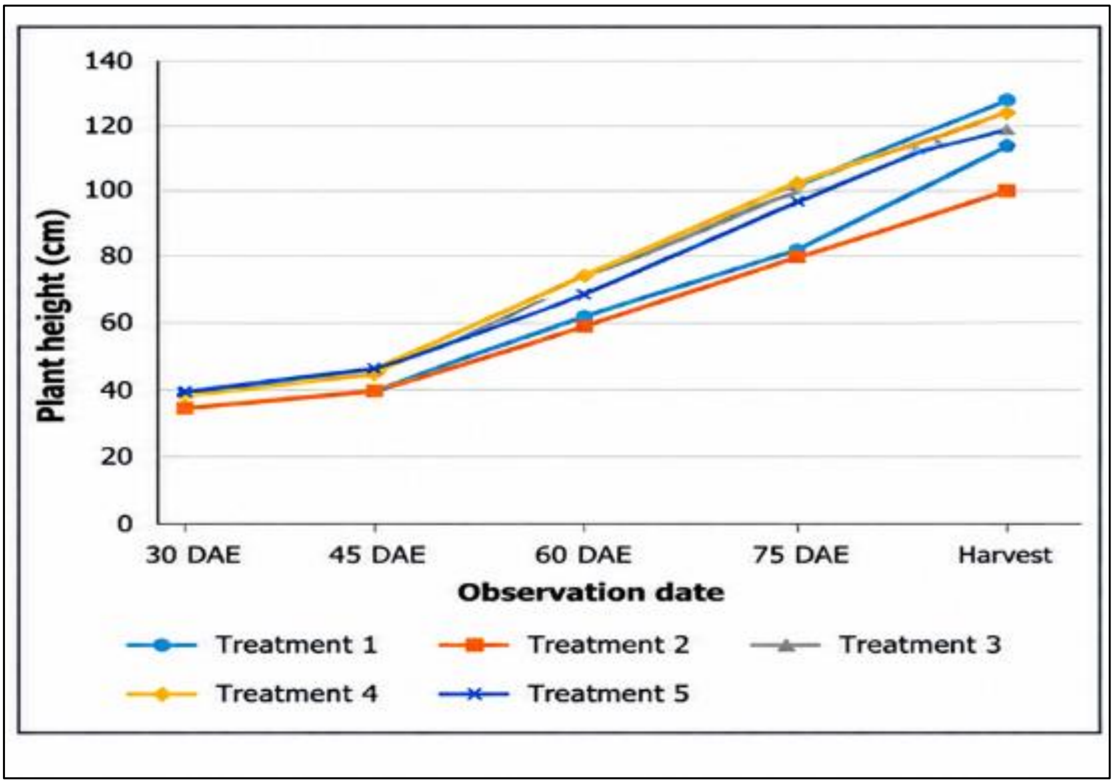

Figure 4: Cotton plant height

4.3 Effects of treatments on the number of nodes per cotton plant

Table V shows changes in the number of nodes per plant. The treatment effect was significant only at 45 DAE, with treatment T5 producing the highest number of nodes per plant (12.81 nodes/plant). At the other measurement dates (30, 60, and 75 DAE), the treatment effect was not significant. Node number was consistently higher under T5 than under the recommended fertilization treatment.

Table 5: Number of nodes per cotton plant

Treatment	30 DAE	45 DAE	60 DAE	75 DAE
T1	10.38 ± 0.260	10.81 ± 0.69 b	16.25 ± 0.57	18.12 ± 0.826
T2	10.81 ± 0.344	11.25 ± 0.51 ab	15.06 ± 0.72	18.25 ± 0.323
T3	11.19 ± 0.258	12.62 ± 0.24 a	15.19 ± 0.45	17.88 ± 0.722
T4	10.56 ± 0.120	12.00 ± 0.37 ab	15.25 ± 0.53	18.31 ± 0.710
T5	10.31 ± 0.472	12.81 ± 0.26 a	14.94 ± 0.24	17.75 ± 0.368
Mean	10.65	11.90	15.34	18.06
LSD (5%)	1.04	1.47	1.55	1.70
Significance	ns	s	ns	ns
CV (%)	6.4	8.0	6.6	6.1

4.4 Effects of treatments on taproot development

Taproot penetration depth increased progressively from 30 to 75 DAE (Figure 5). The use of Polifol products, alone or combined with the recommended fertilization, promoted good root growth. From 45 DAE onward, the effects of treatments T3, T4, and T5 became more pronounced, and statistical analysis showed a significant treatment effect on taproot length, particularly at 60 DAE. At 75 DAE, taproot development under treatment T5 (21.97 cm) exceeded that of the recommended fertilization treatment.

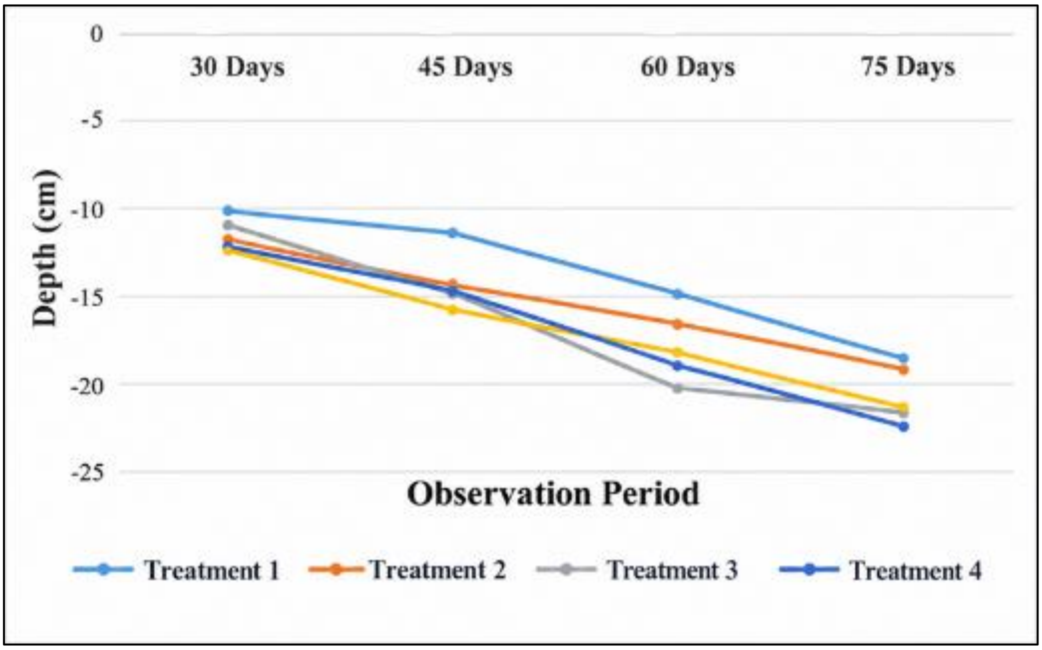

Figure 5: Taproot development of cotton plants at 30, 45, 60, and 75 days after emergence

4.5 Effects of treatments on seed cotton yield

Seed cotton yield ranged from 848 to 1,262 kg ha^{-1} (Figure 6), with a significant treatment effect. Treatment T3 produced the highest yield (1,262 kg ha^{-1}), compared with the standard recommended fertilizer rate used in Côte d'Ivoire (T2). The Polifol combinations (T3, T4, T5) resulted in yield gains of 18 to 201 kg ha^{-1} relative to the recommended fertilization.

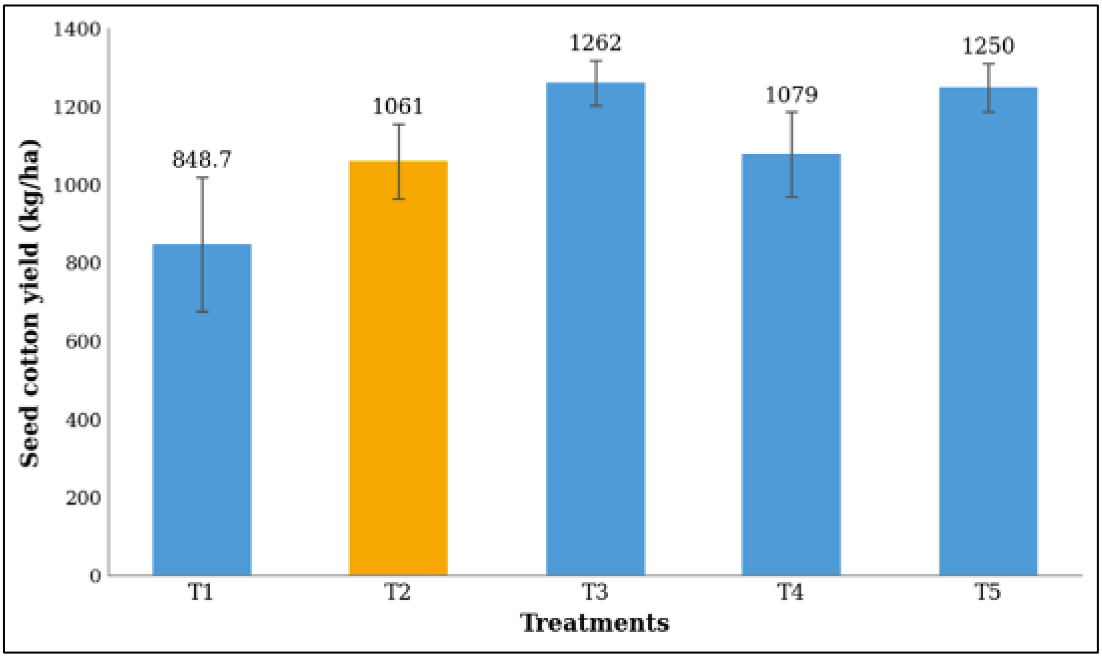

Figure 6: Effects of treatments on seed cotton yield

5 DISCUSSION

5.1 Cotton plant density

The different treatments had no significant effect on cotton plant density. The greater stem growth observed under the highest density (treatment T3) four weeks after sowing coincides with the flowering period, when photosynthetic rates increase to meet the plant's demand for assimilates required for floral initiation (Heller, 1995). Under high density, competition for light among plants drives faster growth (Dajoz, 1985). This effect may also be attributed to supplementary calcium and magnesium supply, since Polifol contains calcium-magnesium ions typically used for liming; these ions raise soil pH, increase cation exchange capacity, and enhance calcium and magnesium nutrition (Bado et al., 1993), thereby favoring a higher plant density relative to the recommended fertilization.

5.2 Vegetative growth of cotton plants

Treatment effects on plant height were significant, with a continuous and gradual increase in height throughout the growth cycle. Polifol products combined with half the recommended fertilizer rate produced greater growth than the recommended fertilization alone. Potassium plays a key role in improving photosynthesis and growth in cotton (Cassman et al., 1989); although complex mineral fertilization (N, P, K, S, B) supplies approximately 15 kg ha^{-1} of potassium, the annual potassium balance in cotton systems remains negative, at approximately −16 kg ha^{-1} (Sheldrick et al., 2002 ; FAO, 2006). The full recommended rate (200 kg ha^{-1} NPKSB + 50 kg urea) therefore proved comparatively less efficient for growth than Polifol combined with half the recommended rate. This may be explained by nutrient leaching linked to the low cation exchange capacity and low clay content of ferrallitic soils, which limits their ability to retain nutrients from mineral fertilization (Olina et al., 2008 ; Dakuo, 2012). The substantial trace-element content (zinc, magnesium, calcium) of Polifol products appears to limit such leaching, thereby supporting better growth.

The higher urea input may also explain this trend, since nitrogen directly promotes plant height, and phosphorus is a key determinant of growth and vegetative development (FAO, 2013) ; the latter was present in adequate proportion under treatment T5. The below-threshold assimilable phosphorus content (< 15 ppm) reflects a soil phosphorus deficiency that was corrected under treatment T5. These findings contrast with those of Sekloka et al. (2015), who reported that cotton plants sown at very high density are shorter and develop fewer nodes on the main stem than those grown at lower densities.

5.3 Taproot development

Polifol products, whether applied alone or combined with the recommended fertilization, promoted good root growth. Potassium, owing to its high mobility within the plant, plays a central role in root development (FAO, 2005). Improving root growth in these acidic, Fe- and Al-dominated soils requires elements capable of neutralizing acidity. Polifol fertilizers, through their content of trace elements — notably magnesium and calcium — can neutralize soil acidity and thereby support substantial root development. Beyond their role in nutrient storage and retention, soil amendments exert a threefold effect on the physical, chemical, and biological properties of the soil, and their trace-element content contributes to yield components, including vegetative and root growth (Soltner, 2003 ; FAO, 2003 ; Zougmoré et al., 2004).

This finding is consistent with Soltner (1992), who showed that calcium and magnesium inputs regulate soil pH and promote the ion exchange required for adequate plant mineral nutrition. Cotton is particularly sensitive to soil acidity, which explains the marked efficacy of Polifol fertilizers on taproot length. Furthermore, potassium absorbed as the K^+ cation binds to the soil exchange complex, reducing its loss through leaching and increasing its availability for root elongation.

5.4 Number of nodes per cotton plant

The treatment effect on node number was significant only at 45 DAE. A correlation exists between nitrogen and potassium nutrition: a plant well supplied with nitrogen requires proportionally more potassium to maintain the turgor of its leaves, roots, and nodes. The potassium supplied under treatment T5 accordingly increased node number (12.81 nodes/plant) at 45 DAE, a stage at which the plant completes its vegetative development.

5.5 Seed cotton yield

Seed cotton yields were relatively acceptable overall, ranging from 848 to 1,262 kg ha^{-1}, with a significant treatment effect. The absence of fertilization negatively affected plant growth and, consequently, cotton production, partly explaining the low yield of the unfertilized control. Mineral fertilizer application appeared to have a stronger effect on boll number, likely reflecting the high solubility and rapid action of mineral fertilizers, which provide an immediate nutrient supply (T3 yield = 1,262 kg ha^{-1}). These results are consistent with Traoré et al. (2007), Ouattara (2011), and Pouya et al. (2013), who reported yield increases in cotton following mineral fertilizer application.

The efficiency of mineral fertilizer rates on yield was further enhanced by Polifol products, owing to their high trace-element content, although the combination with half the recommended rate still produced a relatively acceptable yield (1,250 kg ha^{-1}). Yields tended to decline as fertilizer rates increased, possibly reflecting greater soil acidification under higher nitrogen inputs (Olina, 2008). Similarly, the half-rate applied under treatment T5 allowed the plant to absorb the nutrients required for its nutrition with less leaching loss. The combination of 100 kg ha^{-1} cotton fertilizer plus 25 kg ha^{-1} urea (T5) with Polifol fertilizer could therefore be recommended, both for its effectiveness on yield and for the resulting 100 kg ha^{-1} saving in recommended fertilizer, since this combination still supplies the trace elements required for adequate cotton nutrition. This suggests that yield can be improved through the use of Polifol alone or combined with split doses of the recommended fertilization, consistent with Koulibaly et al. (2009), who reported that the lowest mineral fertilizer rate tested (75 kg ha^{-1} NPKSB + 25 kg ha^{-1} urea) in cotton and maize systems in Burkina Faso produced yield gains of 205–318 kg ha^{-1} of seed cotton and 219 kg ha^{-1} of maize grain.

Cotton cultivation remained most productive under Polifol fertilization relative to the other treatments, likely because Polifol products help correct soil acidity, to which cotton is particularly sensitive. This is consistent with Berger et al. (1987), Sama (1989), and Bado et al. (1993), who showed that combining NPK with dolomite corrects soil acidity while improving cotton yield, and with Sedogo (1993) and Gnankambary (2007), who demonstrated the benefit of combining manure or compost with mineral fertilizers. These authors reported that continuous mineral fertilizer application can, over the long term, contribute to soil degradation, with risks of acidification and subsequent aluminum toxicity.

Combining Polifol products with the recommended fertilization produced yield gains of 18 to 201 kg ha^{-1}. These gains were not strictly proportional to the quantity of mineral fertilizer applied, indicating that reducing the fertilizer rate does not necessarily result in a proportionally greater yield loss.

6 CONCLUSION AND PROSPECTS

Soil acidification in cotton-based cropping systems is one of the major challenges for sustainable soil fertility management in the cotton-growing areas of Côte d'Ivoire. This study aimed to evaluate the agronomic effect of the combination of Basal Active, Mestrado Plus, and Polinitro 30, applied by foliar spraying, on cotton production in Côte d'Ivoire.

The main findings were as follows:

- the application of Polifol products to the soil (Mestrado Plus) and to the foliage (Polinitro 30 and Basal Active) had no notable effect on plant density (at thinning or harvest) or on node number per plant, and thus did not support Hypothesis 1 (H1), which postulated that Polifol fertilizers would improve cotton plant density;

- the use of Polifol products had significant effects on plant height growth, taproot development, and seed cotton yield, confirming Hypothesis 2 (H2), which postulated that Polifol fertilizers would improve height growth, taproot anchorage, and the number of nodes per plant (the site of fruiting-branch insertion) ;
- yield gains of 18 to 201 kg ha^{-1} were obtained relative to the recommended fertilization, with the highest yield achieved when Polifol products were used alone, confirming Hypothesis 3 (H3), which postulated that Polifol fertilizers would improve seed cotton yield.

The use of Polifol products enriched with calcium and/or magnesium is recommended given their potential to mitigate soil acidification and to enhance both yield and the sustainability of cotton-based cropping systems.

Looking ahead, this trial should be repeated in subsequent seasons to confirm or refine the trends observed during this first year of experimentation. An economic profitability analysis of Polifol fertilizers would also be valuable to assess their potential impact on producer income. Finally, further work is needed to characterize the residual effect of Polifol fertilizers on soil physicochemical properties, in order to refine application rates for the different elements.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

This paper is prepared as part of the PhD research work for the corresponding author. The study was fully funded by WASCAL (West African Science Center for Climate Change and Adapted Land Use) through the German Federal Ministry of Education and Research (BMBF). We are grateful to West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL) for providing all the support needed during fieldwork. Our thanks go to CNRA for their support during my fieldwork.

Disclosure of conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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