

Growth and Yield Responses of Pepper (*Capsicum annuum*) to *Klebsiella oxytoca* Biofertilizer and NPK Fertilizer

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ABSTRACT

The over-reliance on inorganic fertilizers in crop cultivation poses environmental concerns, necessitating the search for sustainable alternatives. This study evaluated the effect of soil amendment with *Klebsiella oxytoca* on the growth, yield, and soil properties of *Capsicum annuum*. Soil samples were collected from the Botany Garden of Rivers State University, while seedlings were obtained from the Teaching and Research Farm of Rivers State University, Port Harcourt, Nigeria. *Klebsiella oxytoca* were isolated from soil, and identified through phenotypic and genotypic characterization. Broth cultures of the bacterium were prepared and standardized. Seedlings were divided into three treatments: control (water only), *Klebsiella oxytoca*-amended (alternating water and broth culture), and NPK fertilizer (water plus fertilizer), and transplanted into sandy loam soil in polythene bags. Growth results showed that *Klebsiella oxytoca* significantly increased plant height (39.76 ± 16.42 cm) compared to NPK (38.72 ± 2.13 cm) and control (18.82 ± 1.71 cm) ($p < 0.05$). NPK significantly enhanced number of leaves (55.40 ± 22.51) and leaf breadth (44.15 ± 10.51 cm²) relative to *Klebsiella oxytoca* (49.80 ± 3.63 leaves; 25.86 ± 7.80 cm²) and control (16.60 ± 4.98 leaves; 19.26 ± 5.04 cm²) ($p < 0.05$). Stem caliper showed no significant difference ($p > 0.05$), though NPK plants recorded the thickest stems (2.24 ± 0.59 cm) compared to *Klebsiella oxytoca* (1.68 ± 0.23 cm) and control (1.28 ± 0.11 cm). Fruit production was limited to NPK (0.60 ± 1.34 fruits), with no significant differences ($p > 0.05$). Total Heterotrophic Bacteria increased from 5.63×10^6 to 8.02×10^6 CFU/g in control soil, while higher counts were recorded in *Klebsiella*-amended (9.30×10^6 CFU/g) and NPK-treated soils (9.50×10^6 CFU/g) after cultivation. *Klebsiella* spp. counts remained relatively stable in the control soil (5.51×10^4 – 5.53×10^4 CFU/g) but increased in *Klebsiella*-amended (6.55×10^4 CFU/g) and NPK-treated soils (8.05×10^4 CFU/g). Fungi counts decreased in the control (5.54×10^4 to 2.98×10^4 CFU/g) and *Klebsiella*-amended soils (3.60×10^4 CFU/g), while remaining relatively unchanged in NPK-treated soil (5.54×10^4 to 5.56×10^4 CFU/g). In conclusion, soil amendment with *Klebsiella oxytoca* showed promising potential as a sustainable biofertilizer by enhancing vegetative growth of *Capsicum annuum*; however, it does not improve fruit yield.

Keywords: *Klebsiella oxytoca*; *Capsicum annuum*; soil amendment; biofertilizer; plant growth; NPK fertilizer.

Introduction

Capsicum annuum L. is one of the most widely cultivated vegetable crops worldwide and is valued for its nutritional, economic, and medicinal importance (Bosland & Votava, 2012). The fruits are rich sources of vitamins A, C, and E, antioxidants, and bioactive compounds such as capsaicin, which contribute significantly to dietary quality and human health (Howard et al., 2000; Simonne et al., 1997; Gupta et al., 2011).

In many developing countries, including Nigeria, *Capsicum annuum* plays a crucial role in food security, income generation, and culinary practices, making its sustainable production an important agricultural goal.

The cultivation of *Capsicum annuum* commonly depends on the application of inorganic fertilizers, particularly nitrogen–phosphorus–potassium (NPK) formulations, to promote vegetative growth and enhance fruit yield (Singh et al., 2021).

Although chemical fertilizers improve crop productivity, their continuous and excessive use has been associated with soil nutrient imbalance, reduction in beneficial soil microorganisms, environmental pollution, and increased greenhouse gas emissions (Tilman *et al.*, 2002; Chen *et al.* 2018). These negative impacts have raised concerns over the long-term sustainability of conventional fertilizer-based farming systems and have necessitated the search for environmentally friendly alternatives.

Biofertilizers, especially plant growth-promoting rhizobacteria (PGPR), have emerged as sustainable inputs capable of improving plant growth while maintaining soil health (Glick, 2012; Compant *et al.*, 2019). PGPR promote plant development through mechanisms such as biological nitrogen fixation, phosphate solubilization, production of phytohormones, and enhancement of soil microbial activity (Rajkumar *et al.*, 2006; Gupta *et al.*, 2020). These attributes make microbial inoculants attractive substitutes or supplements to inorganic fertilizers in sustainable agriculture.

Klebsiella oxytoca is a Gram-negative bacterium naturally present in soil and plant-associated environments and belongs to the family *Enterobacteriaceae* (Navon-Venezia . *et al.*, 2022). Beyond its clinical relevance, environmental strains of *Klebsiella* species have been reported to exhibit plant growth-promoting traits, including nitrogen fixation and phytohormone production, which contribute to improved plant vigor and biomass accumulation (Rajkumar *et al.*, 2006; Compant *et al.*, 2019).

However, information on the effectiveness of *Klebsiella oxytoca* as a biofertilizer for *Capsicum annuum*, particularly in comparison with conventional NPK fertilizer under local agro-ecological conditions, remains limited.

Therefore, this study was undertaken to evaluate the effect of soil amendment with *Klebsiella oxytoca* on the growth, yield, and soil microbial population associated with *Capsicum annuum*. The performance of *Klebsiella oxytoca* was compared with that of NPK fertilizer and an unfertilized control to assess its potential as a sustainable biofertilizer alternative for pepper cultivation.

Materials and Methods

Study Area

The experiment was conducted in perforated black polythene bags containing well- drained loamy soil in an open field in front of Microbiology Green House, Rivers State University, Port Harcourt, Rivers State, Nigeria (Latitude 4.803802 and Longitude 6.978905) with an annual temperature range of 22°C-32°C, annual rainfall of 350-400mm and relative humidity 93-95%.

Sample Collection

Soil samples were aseptically collected from three distinct points within the Botany Garden of Rivers State University (RSU), Port Harcourt, Nigeria. The samples were obtained from the rhizosphere of healthy plants using a sterile garden hand trowel. Approximately 10-20 grams of soil was collected from each point at a depth of 5-15 cm and transferred immediately into sterile labelled polythene bags. Seedlings of *Capsicum annuum* were obtained from the Teaching and Research Farm of Rivers State University, Port Harcourt, Nigeria. The collected soil samples and *Capsicum annuum* seedlings were immediately transported to the Microbiology Laboratory, Rivers State University for isolation of *Klebsiella oxytoca*

Isolation and Identification of *Klebsiella oxytoca*

Ten grams of the soil sample was suspended in 100ml of sterile physiological saline in a conical flask and shaken thoroughly to create a soil suspension. The suspension was subjected to ten-fold serial dilution, to a dilution of 10^{-5} . A volume of 0.1ml of the 10^{-3} , 10^{-4} , and 10^{-5} dilution were inoculated on freshly prepared Eosine Methylene Blue (EMB) agar in triplicates, using the spread plate technique. Inoculated EMB plates were incubated at 37°C for 48 hours. After incubation, EMB plates were observed for coloured colonies. Pure cultures of these colonies were prepared and subjected to Gram staining and microscopy, and to the following biochemical and physiological tests: motility, catalase production, citrate utilization, Indole production, Methyl Red-Vogues Proskauer (MRVP), and fermentation tests using glucose, lactose, maltose, mannitol, sucrose, xylose, and glycerol.

The procedures used for these tests are as described in Peekate (2022). The results of the tests on the pure cultures were filled into the online platform of Advanced Bacteria Identification Software (ABIS) located at https://www.tgw1916.net/bacteria_logare_desktop.html, (2007) so as to identify the isolates that belong to *Klebsiella* species.

Preparation of standardized broth culture of identified *Klebsiella oxytoca*

Broth cultures of the identified *Klebsiella oxytoca* were prepared by inoculating its colonies into 500 ml sterile nutrient broth. The inoculated broth was incubated at 35 °C for 24 hours. After incubation, the absorbance of the broth culture was measured and compared with the absorbance of a freshly prepared 0.5 McFarland standard (prepared as outlined in the Clinical and Laboratory Standards Institute manual; CLSI, 2012).

Sterile normal saline was added to the broth culture so as to adjust its absorbance to the absorbance of the McFarland standard. Absorbance measurements were achieved with the aid of a spectrophotometer set at 600 nm.

Cultivation and Treatment of *Capsicum annuum*

Seedlings of *Capsicum annuum* (Scotch Bonnet pepper) were divided into three groups of five seedlings each and transplanted on 7 April 2025 into perforated polythene bags containing sandy-loamy soil.

Seedlings were spaced 20 cm apart, with 2 m separation between treatment groups. The control group received only water weekly for 12 weeks. The *Klebsiella* treatment group received alternating applications of water and 100 ml of standardized *Klebsiella oxytoca* broth at two-week intervals from weeks 2 to 12 (Ogunlela et al., 2018).

The NPK group (positive control) received granular NPK fertilizer (15:15:15) at 3 g weekly (weeks 1–2), 5 g biweekly (weeks 2–6), and then finally once in 4 weeks at 7 g from weeks 6–12 (Table 1), alongside weekly watering (Ayeni, et al., 2010). Fertilizer was applied using the ring method, followed by immediate watering. All treatments were conducted in the morning.

Table 1: Treatment and application schedule for *Capsicum annuum* seedlings

Week	Treatment schedule for <i>Capsicum annuum</i>			
	Negative Control (Water)	<i>Klebsiella oxytoca</i> (SBK)	Positive Control (Water)	NPK Fertilizer (NF)
1	W	-	W	3g
2	W	100ml	W	3g
3	W	-	W	-
4	W	100ml	W	5g
5	W	-	W	-
6	W	100ml	W	5g
7	W	-	W	-
8	W	100ml	W	-
9	W	-	W	-
10	W	100ml	W	7g
11	W	-	W	-
12	W	100ml	W	-

Note: All bags contain L.S = Loamy soil (15kg), Cap. S = *Capsicum annuum* seedlings; W = water, SBK = Standardized broth-culture of *Klebsiella oxytoca* (100ml); NF = NPK fertilizer (15: 15: 15).

Results

In this study, at week 0, plant heights (cm) of *Capsicum annuum* (SBP) from week 0 to week 12 were similar across treatments (Control: 7.38 ± 0.13 cm, *Klebsiella oxytoca*-amended: 7.56 ± 0.55 cm, NPK: 7.18 ± 0.15 cm). At week 2, *Klebsiella oxytoca*-amended (9.68 ± 1.78 cm) had a slight advantage over NPK (8.78 ± 0.54 cm) and control (8.68 ± 0.59 cm). At week 4, differences became clearer: *Klebsiella oxytoca*-amended grew to 14.94 ± 3.34 cm, NPK 12.56 ± 1.37 cm, and control 10.84 ± 1.32 cm. At week 6, *Klebsiella oxytoca*-amended seedlings grew taller (20.58 ± 4.49 cm), followed by NPK (18.52 ± 3.64 cm), and control (12.94 ± 1.69 cm). At week 8, a sharp growth increase was observed: *Klebsiella oxytoca*-amended (33.56 ± 13.88 cm) and NPK (28.74 ± 3.16 cm) far outgrew control (16.78 ± 1.87 cm). The same trend held at week 10, with *Klebsiella oxytoca*-amended (33.56 ± 13.88 cm), NPK (28.74 ± 3.16 cm) and control (16.78 ± 1.87 cm). Finally, at week 12, *Klebsiella oxytoca*-amended plants attained the tallest mean height (39.76 ± 16.42 cm), followed by NPK (38.72 ± 2.13 cm), and control plants (18.82 ± 1.71 cm), as shown in Fig. 1.

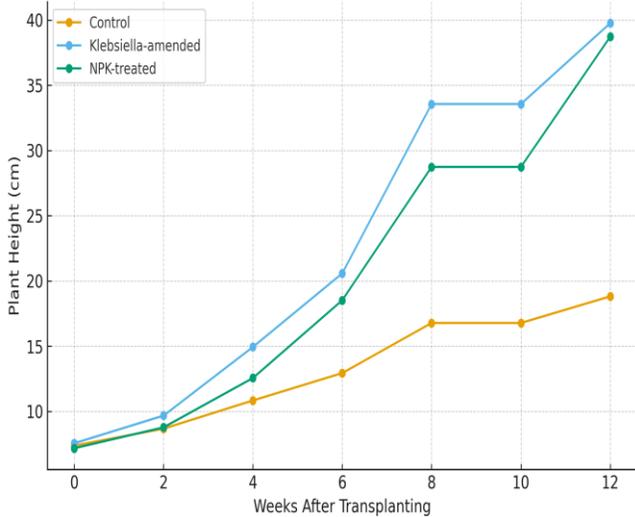


Fig. 1: Plant Height of *Capsicum annuum* (SBP) from week 0 - 12

The number of leaves of *Capsicum annuum* (SBP) from week 0 to week 12 is as presented in Fig. 2.

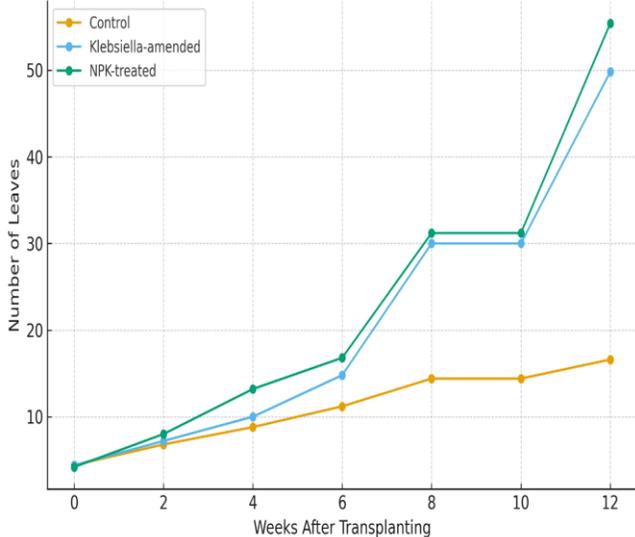


Fig. 2: Number of Leaves of *Capsicum annuum* (SBP) from week 0-12

At week 0, all treatments started with about 4 leaves per plant (Control: 4.40 ± 0.55 , *Klebsiella oxytoca*-amended: 4.40 ± 0.55 , NPK: 4.20 ± 0.45). By week 2, leaf production had increased slightly, with Control at 6.80 ± 1.10 , *Klebsiella oxytoca*-amended at 7.20 ± 1.10 , and NPK slightly ahead at 8.00 ± 2.28 . At Week 4, the difference widened: Control plants had 8.80 ± 2.69 leaves, *Klebsiella oxytoca*-amended 10.00 ± 1.41 , and NPK markedly higher at 13.20 ± 3.03 .

By week 6, Control grew to 11.20 ± 3.03 , *Klebsiella oxytoca*-amended increased to 14.80 ± 2.28 , and NPK led with 16.80 ± 4.38 leaves. At week 8, rapid leaf development occurred in *Klebsiella oxytoca*-amended (30.00 ± 2.00) and NPK (31.20 ± 8.12) compared to Control (14.40 ± 4.10). The same trend persisted at week 10, with Control stable at 14.40 ± 4.10 , while *Klebsiella oxytoca*-amended and NPK maintained high counts at 30.00 ± 2.00 and 31.20 ± 8.12 , respectively. By Week 12, maximum leaf numbers were reached, with NPK producing the highest (55.40 ± 22.51), *Klebsiella oxytoca*-amended following (49.80 ± 3.63), and Control 16.60 ± 4.98 .

The result of Leaf Breadth (cm^2) of *Capsicum annuum* (SBP) measured from week 0 to week 12 is presented in Figure 3.

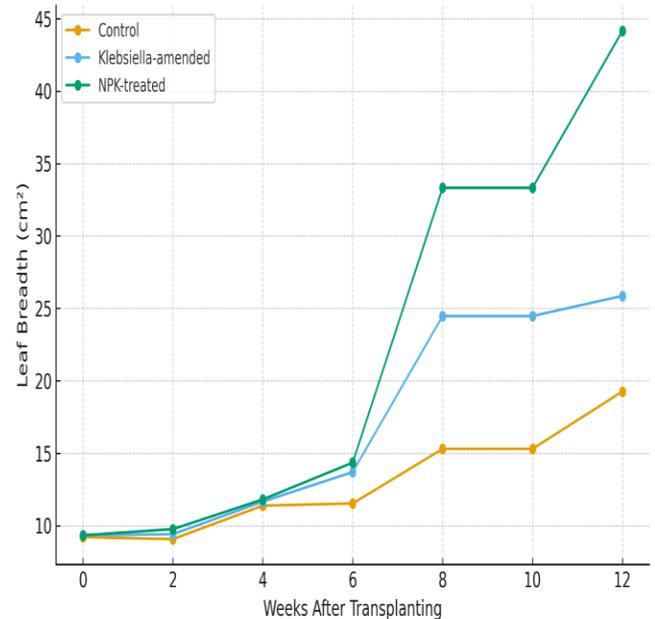


Fig. 3: Leaf breadth of *Capsicum annuum* (SBP) from week 0-12

Result showed that, at week 0, the leaf breadths were almost identical across treatments, with Control plants recording $9.20 \pm 0.18 \text{ cm}^2$, *Klebsiella oxytoca*-amended plants $9.33 \pm 0.51 \text{ cm}^2$, and NPK-treated plants $9.33 \pm 0.51 \text{ cm}^2$, by week 2, leaf expansion was slight across treatments, with Control at $9.07 \pm 0.18 \text{ cm}^2$, *Klebsiella* at $9.41 \pm 0.28 \text{ cm}^2$, and NPK at $9.76 \pm 0.46 \text{ cm}^2$, showing a small advantage in NPK. At week 4, further increases were observed:

Control reached $11.38 \pm 0.19 \text{ cm}^2$, *Klebsiella oxytoca*-amended $11.66 \pm 0.42 \text{ cm}^2$, and NPK $11.81 \pm 0.43 \text{ cm}^2$, with treatments still closely matched. By week 6, treatment effects became more pronounced. Control plants had $11.53 \pm 0.47 \text{ cm}^2$, while *Klebsiella oxytoca*-amended plants expanded to $13.70 \pm 0.61 \text{ cm}^2$, and NPK-treated plants to $14.35 \pm 1.15 \text{ cm}^2$, clearly surpassing the control. At week 8, sharp differences emerged, NPK produced the widest leaves at $33.32 \pm 8.11 \text{ cm}^2$, followed by *Klebsiella oxytoca*-amended at $24.47 \pm 3.46 \text{ cm}^2$, while Control remained much smaller at $15.30 \pm 1.81 \text{ cm}^2$. This same pattern persisted at week 10, with Control at $15.30 \pm 1.81 \text{ cm}^2$, *Klebsiella oxytoca*-amended $24.47 \pm 3.46 \text{ cm}^2$, and NPK still dominant at $33.32 \pm 8.11 \text{ cm}^2$. By week 12, NPK reached $44.15 \pm 10.51 \text{ cm}^2$, *Klebsiella oxytoca*-amended $25.86 \pm 7.80 \text{ cm}^2$, and Control $19.26 \pm 5.04 \text{ cm}^2$, showing the superiority of NPK, as seen in Fig.3.

The Stem Caliper (cm) of *Capsicum annuum* (SBP) after cultivation at week 12 and measured at week 12, showed that the control plants had the smallest stem caliper ($1.28 \pm 0.11 \text{ cm}$), *Klebsiella oxytoca*-amended plants recorded an intermediate value ($1.68 \pm 0.23 \text{ cm}$), compared to the control. The NPK-treated plants exhibited the largest stem caliper ($2.24 \pm 0.59 \text{ cm}$), almost twice that of the control, as seen in Fig. 4.

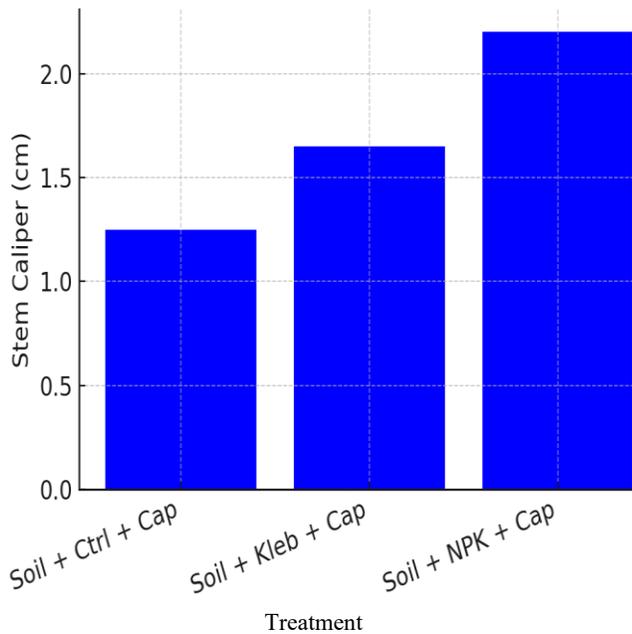


Fig. 4: Stem Caliper of *Capsicum annuum* (SBP) week at 12

With regards to the number of fruits of *Capsicum annuum* (SBP) at 12 weeks and 9 days, both the control and *Klebsiella oxytoca*-amended plants produced no fruits (0.00 ± 0.00), indicating an absence of reproductive output. However, the NPK-treated plants recorded a mean fruit number of 0.60 ± 1.34 , showing that fruiting was initiated only in the NPK group as seen in Fig. 5.

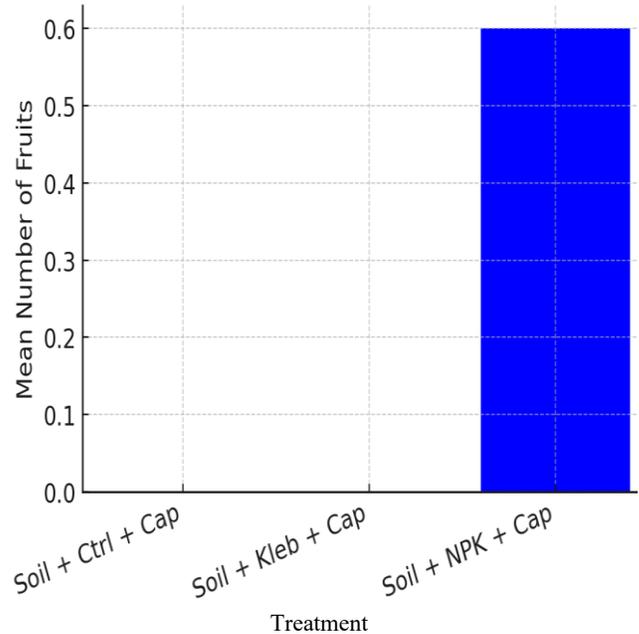


Fig. 5: Number of Fruits of *Capsicum annuum* (SBP) at 12 weeks and 9 days

The vegetative and reproductive growth progressions of *Capsicum annuum* (SBP) under different treatments are presented in Plates 1, 2 and 3.



Plate: 1: *Capsicum annuum* under different Treatments at six weeks

Results showed that, at six weeks (Plate 1), growth differences became more pronounced as NPK-treated plants developed larger foliage with extensive leaf formation, while *Klebsiella oxytoca*-amended plants exhibited significant height advantage compared to both NPK and control, and the control group lagged behind. At eight weeks (Plate 2), NPK-treated plants began bearing immature green fruits, showing an accelerated shift into the reproductive stage, a feature not observed in the other treatments. By twelve weeks (Plate 3), the NPK group had progressed to producing mature ripened fruits.



Plate 2: *C. annuum* Plant bearing Immature Green Fruits (NPK plant 4) at eight weeks



Plate 3: Mature *C. annuum* plant with ripened fruits in Polybags at twelve weeks

The population of Total Heterotrophic Bacteria (THB) in the soil before and after cultivation is presented in Fig. 6. The result shows that control soil had an increase in THB from 5.63×10^6 CFU/g before cultivation to 8.02×10^6 CFU/g after cultivation. The *Klebsiella*-amended soil recorded 9.30×10^6 CFU/g after cultivation, while the NPK-treated soil recorded 9.50×10^6 CFU/g.

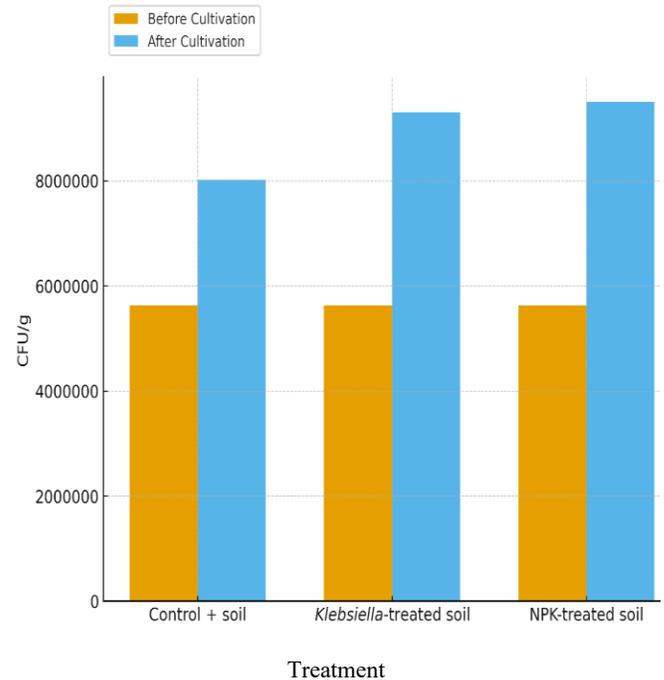


Fig. 6: Population of THB in the Soil before and after cultivation

The population of *Klebsiella* spp. in the soil before and after cultivation is presented in Fig. 7.

In the control soil, the population remained stable, increasing only slightly from 5.51×10^4 to 5.53×10^4 CFU/g. The *Klebsiella*-amended soil recorded 6.55×10^4 CFU/g after cultivation, while the NPK-treated soil recorded 8.05×10^4 CFU/g.

The population of Total Fungi (TF) in the soil before and after cultivation is presented in Fig.8.

The control soil reduced from 5.54×10^4 to 2.98×10^4 CFU/g after cultivation. In the *Klebsiella*-amended soil, fungal counts reduced to 3.60×10^4 CFU/g, while in the NPK-treated soil, fungal counts remained almost the same, from 5.54×10^4 to 5.56×10^4 CFU/g.

Discussion

In this study, the results clearly demonstrated that *Klebsiella oxytoca* significantly enhanced plant height in *Capsicum annuum* at the 95% confidence interval ($p < 0.05$). By Week 12, plants amended with *Klebsiella oxytoca* attained 39.76 ± 16.42 cm, which was higher than NPK (38.72 ± 2.13 cm) and more than twice the height of control (18.82 ± 1.71 cm). This suggests that *Klebsiella oxytoca* inoculation promoted vegetative vigor comparable to inorganic fertilization. Previous reports confirm this effect, as *Klebsiella oxytoca* are known to produce indole-3-acetic acid (IAA), fix atmospheric nitrogen, and solubilize phosphate, thereby stimulating cell elongation and shoot growth (Rajkumar et al., 2006; Glick, 2012). Similar positive effects on plant growth have been reported in maize and tomato when inoculated with *Klebsiella* strains (Compant et al., 2019).

Leaf number was significantly different at 95% CI ($p < 0.05$). NPK produced the highest leaf count at Week 12 (55.40 ± 22.51), while *Klebsiella oxytoca* produced slightly fewer (49.80 ± 3.63) than the control (16.60 ± 4.98). This indicates that NPK maximized leaf proliferation (Bosland & Votava, 2012) emphasized that leaf number in pepper directly correlates with photosynthetic potential and yield potential, highlighting the importance of nutrient availability. Similar findings were reported in chili pepper where Ashrafuzzaman et al (2009) found that inorganic fertilizer treatments significantly boosted leaf count relative to control. Leaf breadth also showed significant differences among treatments at the 95% CI ($p < 0.05$). NPK plants had the widest leaves (44.15 ± 10.51 cm²), followed by *Klebsiella oxytoca*-amended (25.86 ± 7.80 cm²) and the control (19.26 ± 5.04 cm²). However, wide leaves increase the photosynthetic surface area, thereby supporting carbohydrate accumulation and reproductive success. This agrees with (Greenleaf, 1986) who demonstrated that potassium fertilization directly contributes to leaf expansion in pepper. More so, stem caliper was not statistically significant ($p > 0.05$) across treatments. NPK recorded the thickest stems (2.24 ± 0.59 cm), followed by *Klebsiella oxytoca*-amended (1.68 ± 0.23 cm) and control (1.28 ± 0.11 cm). This trend is in line with Singh & Prasad (2014) who emphasized that stem girth in vegetables responds to macronutrient supply, particularly nitrogen and potassium.

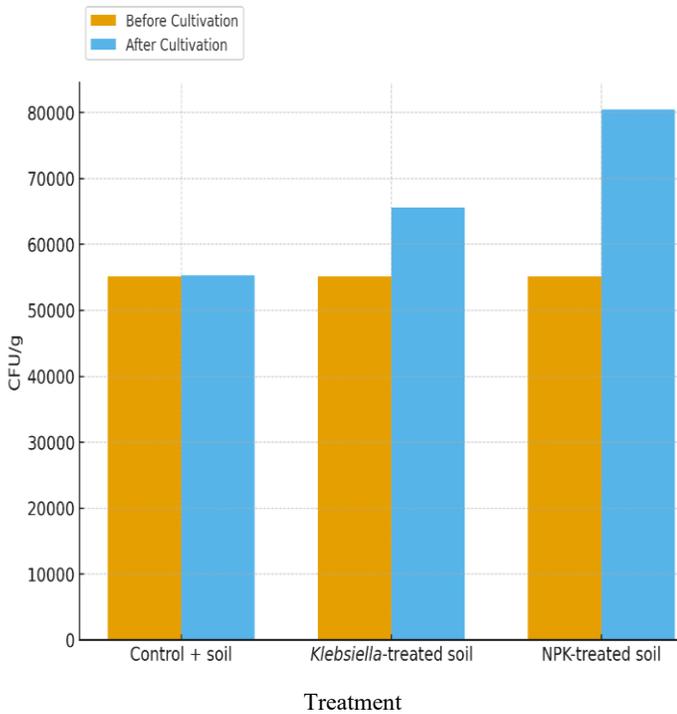


Fig. 7: Population of *Klebsiella* spp in the soil before and after cultivation

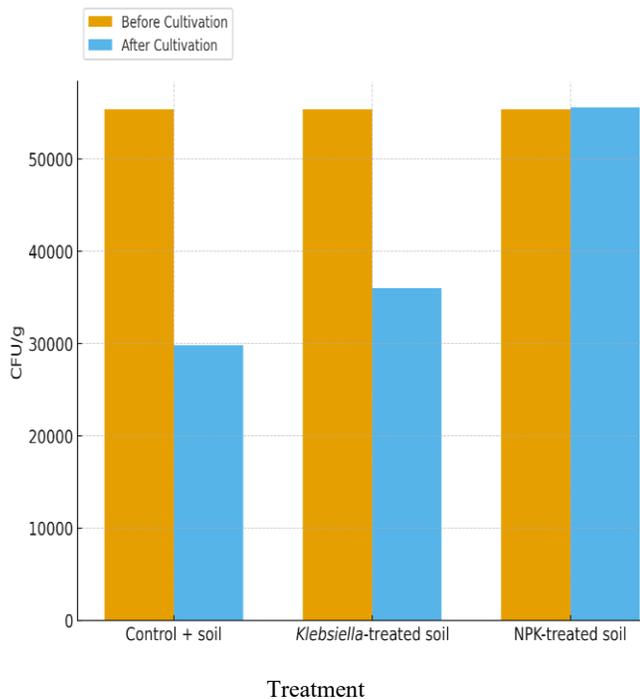


Fig. 8: Population of Fungi in the Soil before and after cultivation

Other studies in bell pepper have shown that fertilization increases stem thickness, but microbial inoculation alone may not produce statistically significant changes over short periods (Brazier *et al.*, 2018).

Fruit production was observed on NPK-treated plants, which produced an average of 0.60 ± 1.34 fruits per plant at Week 12 and entered harvest at 12 weeks and 9 days. Neither the control nor *Klebsiella oxytoca*-amended treatments produced fruits within the experimental period. ANOVA revealed no significant differences ($p > 0.05$). This implies that NPK supplied the nutrients necessary to accelerate transition to reproductive growth, *Klebsiella oxytoca*-amended was more effective in supporting vegetative traits but not reproductive output within the timeframe. Bosland & Votava (2012) similarly reported that fruit initiation in *Capsicum annuum* is highly nutrient-demanding, requiring large pools of nitrogen, phosphorus, and potassium. Moreover, Akintoye *et al* (2016) demonstrated that inorganic fertilization significantly increased fruit number in hot pepper compared to biofertilizers, supporting the present study's outcome.

Microbial population analysis under control, *Klebsiella oxytoca*-amended, and NPK-treated soils revealed significant shifts in THB, *Klebsiella oxytoca*, and fungal populations. THB increased in all treatments, from $5.63 \pm 0.39 \times 10^6$ to $8.0 \pm 0.52 \times 10^6$ CFU/g in the control, $9.30 \pm 0.56 \times 10^6$ in *Klebsiella*-amended, and $9.50 \pm 0.36 \times 10^6$ in NPK-treated soils, indicating that both microbial inoculation and inorganic fertilization enhanced bacterial proliferation (Choudhary & Johri, 2009). *Klebsiella oxytoca* counts remained stable in the control but increased in amended and NPK soils ($8.05 \pm 0.36 \times 10^4$), confirming successful colonization and nutrient-mediated growth (Compant *et al.*, 2010). Fungal populations declined in the control ($2.98 \pm 0.12 \times 10^4$), remained stable in *Klebsiella*-amended soils ($3.60 \pm 0.37 \times 10^4$), and were highest in NPK soils ($5.56 \pm 0.30 \times 10^4$), reflecting differences in competition and nutrient availability (Tilman *et al.*, 2002; Sharma *et al.*, 2011; Vessey, 2003). One-way ANOVA indicated these differences were statistically significant ($p < 0.05$), demonstrating that while both *Klebsiella oxytoca* amendment and NPK fertilizer enhanced microbial populations, their ecological impacts on the *Capsicum annuum* rhizosphere differed.

Conclusion

In this study, the effect of soil amendment with *Klebsiella oxytoca* on the growth and yield of *Capsicum annuum* was evaluated in comparison with NPK fertilizer and an untreated control. *Klebsiella oxytoca* was successfully isolated from soil using selective medium. The growth of *Capsicum annuum* on soil amended with *Klebsiella oxytoca* was enhanced compared to controls and the plants grown on NPK amended soil. However, yield was not improved. The total heterotrophic bacteria populations in soils amended with *Klebsiella oxytoca* increased after cultivation of *Capsicum annuum*. However, the population of fungi reduced.

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