



## Effects of Humic Fertilizer on the Growth, Yield, and Quality of Lemongrass in Tan Phu Dong, Dong Thap Province, Vietnam

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**ABSTRACT:** Lemongrass (*Cymbopogon citratus*) is an important aromatic crop with high economic value, but information on the use of humic fertilizers to improve its productivity under coastal conditions of the Mekong Delta is still limited. This study evaluated the effects of different fertilizer regimes combined with humic substances on the growth, yield, and soil properties of lemongrass in Tan Phu Dong, Dong Thap Province, Vietnam. The experiment was conducted from July to December 2025 using a randomized complete block design with nine treatments and three replications. All treatments received 2,000 kg ha<sup>-1</sup> of microbial organic fertilizer, while inorganic fertilizer rates and humic inputs varied among treatments. Plant height, tiller number, yield components, harvested yield, pest and disease incidence, and soil physicochemical properties were recorded. The results showed that fertilizer regimes did not significantly affect early growth, but significant differences were observed at later stages. Treatment 7, consisting of 240 kg urea + 240 kg phosphate fertilizer + 80 kg KCl + 6 kg Super Humic + 14 kg K-Humate-Silic ha<sup>-1</sup>, produced the highest plant height (147.19 cm), tiller number (27.40 tillers clump<sup>-1</sup>), stem diameter (22.55 mm), theoretical yield (62.99 t ha<sup>-1</sup>), and harvested yield (29.43 t ha<sup>-1</sup>). Soil nutrient availability also improved after the experiment. These findings indicate that combining reduced inorganic fertilizer with humic substances can enhance lemongrass growth, yield, and soil fertility under local field conditions.

**Keywords:** Lemongrass, Humic Fertilizer, K-Humate-Silic, lemongrass yield, nutrient management, soil fertility.

### INTRODUCTION

Lemongrass (*Cymbopogon citratus*) is a perennial aromatic plant widely cultivated in tropical and subtropical regions, including Vietnam. It is highly valued for its diverse applications in the food, pharmaceutical, and cosmetic industries due to its characteristic lemon-like aroma and high essential oil content (Adhikary *et al.*, 2024; Ekpenyong *et al.*, 2015). The essential oil of lemongrass, rich in citral, has been reported to possess strong antimicrobial, antioxidant, and anti-inflammatory activities, making it an important resource for both traditional and modern medicine (Yusuk *et al.*, 2014; Bassolé & Juliani 2012).

In Vietnam, lemongrass plays an important role in agricultural production, particularly in coastal and rural areas where it contributes to farmers' income and land-use diversification. The crop shows good adaptability to a wide range of environmental conditions; however, its growth, biomass yield, and essential oil quality are strongly influenced by soil fertility and nutrient management practices (Dukchuk *et al.*, 2025). In recent

years, excessive use of inorganic fertilizers has led to soil degradation and reduced sustainability in crop production systems, highlighting the need for alternative and environmentally friendly fertilization strategies.

Humic substances, particularly humic fertilizers, have gained increasing attention due to their ability to improve soil structure, enhance nutrient availability, stimulate root development, and promote plant growth. Previous studies have shown that humic fertilizers can significantly enhance crop productivity and quality by improving nutrient uptake efficiency and physiological processes in plants (Singh *et al.*, 2014). However, information regarding the effects of humic fertilizer on lemongrass, especially under specific ecological conditions such as coastal areas of the Mekong Delta, remains limited.

Therefore, this study, entitled "Effects of Humic Fertilizer on the Growth, Yield, and Quality of Lemongrass in Tan Phu Dong, Dong Thap Province, Vietnam", aims to evaluate the influence of humic

fertilizer on the growth performance, yield, and quality attributes of lemongrass under local field conditions.

## MATERIALS AND METHODS

### Experimental site and duration

The experiment was conducted from July to December 2025 in Ba Tien 1 hamlet, Phu Dong commune, Tan Phu Dong district, Tien Giang Province (currently Tan Phu Dong commune, Dong Thap Province), Vietnam.

### Plant material

The local lemongrass cultivar (*Cymbopogon citratus*) was used.

**Experimental design.** The experiment was arranged in a randomized complete block design with nine fertilizer treatments and three replications. Each plot covered 20 m<sup>2</sup>, with a total experimental area of 540 m<sup>2</sup>. Planting density was 40,000 plants ha<sup>-1</sup>. All treatments received a basal application of microbial organic fertilizer at 2,000 kg ha<sup>-1</sup>.

### Fertilizer treatments

| Treatment No. | N - P <sub>2</sub> O <sub>5</sub> - K <sub>2</sub> O (kg/ha) | Equivalent fertilizer rates (138 - 48 – 60)                                                                      |
|---------------|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| 1             | 100%                                                         | 300 kg ure + 300 kg phosphate fertilizer +100 kg potassium chloride ha <sup>-1</sup>                             |
| 2             | 90%                                                          | 270 kg urea+ 270 kg phosphate fertilizer + 90 kg KCl + 6 kg Super Humic ha <sup>-1</sup>                         |
| 3             | 80%                                                          | 240 kg urea+ 240 kg phosphate fertilizer + 80 kg KCl + 6 kg Super Humic ha <sup>-1</sup>                         |
| 4             | 70%                                                          | 210 kg urea + 210 kg phosphate fertilizer + 70 kg KCl + 6 kg Super Humic ha <sup>-1</sup>                        |
| 5             | 100%                                                         | 300 kg urea+ 300 kg phosphate fertilizer + 100 kg KCl + K-Humate-Silic 14 ha <sup>-1</sup>                       |
| 6             | 90%                                                          | 270 kg urea+ 270 kg phosphate fertilizer + 90 kg KCl + 6 kg Super Humic + 14 kg K-Humate-Silic ha <sup>-1</sup>  |
| 7             | 80%                                                          | 240 kg urea + 240 kg phosphate fertilizer + 80 kg KCl + 6 kg Super Humic + 14 kg K-Humate-Silic ha <sup>-1</sup> |
| 8             | 70%                                                          | 210 kg urea+ 210 kg lân + 70 kg KCl + 6 kg Super Humic + 14 kg K-Humate-Silic ha <sup>-1</sup>                   |
| 9             | 161 – 56 – 72                                                | 350 kg urea+ 350 kg phosphate fertilizer+120 kg potassium chloride ha <sup>-1</sup>                              |

### Fertilizer application schedule

Basal: all organic fertilizer and phosphorus

20–25 DAT: 25% urea

50–55 DAT: 50% urea + 50% KCl

80–85 DAT: remaining 25% urea + 50% KCl

**Data collection.** Growth parameters were recorded following QCVN 01-189:2019/BNNPTNT. Ten clumps per plot were randomly selected and tagged to measure plant height and tiller number at 40, 80, 120 DAT and at first harvest.

Yield components included stem length, stem diameter, fresh biomass per clump, and stem weight after leaf removal.

Theoretical stem yield (t ha<sup>-1</sup>) was calculated based on stem weight per clump and planting density. Harvested yield was determined from the total stem weight per plot and converted to t ha<sup>-1</sup>.

Pest and disease incidence (mealybugs, leaf spot, root rot) was monitored following the standard field pest survey procedure of the Plant Protection Department.

**Statistical analysis.** Data were analyzed using SPSS software. Treatment means were compared using Duncan's multiple range test.

## RESULTS AND DISCUSSION

**Plant height.** Plant height of lemongrass (*Cymbopogon citratus*) was influenced by different humic fertilizer treatments at later growth stages, while no significant differences were observed during the early stages (Table 1). At 40 and 80 days after transplanting (DAT), plant height ranged from 72.09 to 75.67 cm and 100.29 to

109.41 cm, respectively, with no statistically significant differences among treatments ( $p > 0.05$ ). This suggests that the immediate effect of humic fertilizer on early vegetative growth was limited, likely due to the time required for soil amendments to modify soil properties and nutrient dynamics (Canellas & Olivares 2014). Significant differences ( $p < 0.05$ ) in plant height were observed at 120 and 160 DAT. At 120 DAT, Treatment 7 recorded the highest plant height (136.37 cm), which was significantly greater than the other treatments, while the remaining treatments showed no significant differences among them (122.83–128.74 cm). Similarly, at 160 DAT, Treatment 7 maintained the highest plant height (147.19 cm), followed by Treatments 5, 6, and 9 (139.77–141.81 cm), which were statistically comparable but significantly higher than the other treatments. The coefficient of variation (CV) remained low across all observation times (3.02–3.46%), indicating high experimental precision and reliability. The delayed response of plant height to humic fertilizer application may be explained by the gradual improvement of soil structure, increased microbial activity, and enhanced nutrient availability over time (Nardi *et al.*, 2002; Trevisan *et al.*, 2010). The superior performance of Treatment 7 could be attributed to the role of humic substances in stimulating root growth and nutrient uptake. Humic acids have been reported to exhibit hormone-like activity, particularly similar to auxins, which promote cell elongation and division, thereby enhancing plant height (Samanta *et al.*, 2024; Calvo *et al.*, 2014). In addition, humic substances

improve cation exchange capacity and nutrient retention in soils, leading to better nutrient use efficiency and sustained plant growth (Rose *et al.*, 2014). These results are consistent with previous studies showing that humic fertilizer significantly increases plant height and biomass accumulation in aromatic and medicinal crops through improved physiological and biochemical processes

(Singh *et al.*, 2014; Calvo *et al.*, 2014). Overall, the findings demonstrate that appropriate application of humic fertilizer can significantly enhance plant height of lemongrass, particularly at later growth stages, contributing to improved crop performance under field conditions.

**Table 1: Effect of fertilizer regimes on plant height of lemongrass.**

| Treatment | Plant height |        |         |          |
|-----------|--------------|--------|---------|----------|
|           | 40 DAT       | 80 DAT | 120 DAT | 160 DAT  |
| 1         | 74.34        | 103.04 | 126.09b | 137.16b  |
| 2         | 72.09        | 100.29 | 123.63b | 135.57b  |
| 3         | 72.71        | 100.52 | 122.83b | 136.03b  |
| 4         | 74.08        | 103.37 | 125.72b | 136.69b  |
| 5         | 74.55        | 104.14 | 126.57b | 139.77ab |
| 6         | 74.93        | 104.89 | 128.74b | 141.67ab |
| 7         | 75.67        | 109.41 | 136.37a | 147.19a  |
| 8         | 73.76        | 102.49 | 127.37b | 138.64b  |
| 9         | 75.24        | 104.05 | 127.21b | 141.81ab |
| Mean      | ns           | ns     | *       | *        |
| CV (%)    | 3.02         | 3.46   | 3.25    | 3.28     |

Within the same column, values followed by the same letter are not significantly different. ns = not significant; \* = significant at  $p \leq 0.05$ ; \*\* = significant at  $p \leq 0.01$ . DAT = days after transplanting.

**Number of tillers.** The number of tillers per clump of lemongrass (*Cymbopogon citratus*) increased progressively from 40 to 180 days after transplanting (DAT) across all humic fertilizer treatments (Table 2), indicating strong vegetative propagation under field conditions. At early stages (40–80 DAT), tiller numbers ranged from 5.67–7.13 to 12.87–14.60 tillers clump<sup>-1</sup>, with no significant differences among treatments ( $p > 0.05$ ), suggesting that initial tiller formation was mainly influenced by plant establishment rather than fertilizer input (Kumar *et al.*, 2017). However, significant differences ( $p < 0.05$ ) were observed from 120 DAT onward, where Treatment 7 produced the highest number of tillers (22.13 and 27.40 tillers clump<sup>-1</sup> at 120 and 180

DAT, respectively), followed by Treatment 8, while lower values were recorded in Treatments 1, 2, and 4. This increasing divergence indicates that nutrient availability became more critical during active tillering stages. The positive effect of humic fertilizer can be attributed to improved soil properties, enhanced nutrient uptake, and hormone-like activity that stimulates root growth and lateral shoot formation (Nardi *et al.*, 2002; Canellas & Olivares 2014; Calvo *et al.*, 2014). These findings are consistent with previous studies showing that improved nutrient supply enhances tiller production and biomass accumulation in aromatic crops (Pandey *et al.*, 2018; Choudhary *et al.*, 2020).

**Table 2: Effect of fertilizer regimes on Number of tillers.**

| Treatment | Number of tillers |        |         |         |
|-----------|-------------------|--------|---------|---------|
|           | 40 DAT            | 80 DAT | 120 DAT | 160 DAT |
| 1         | 5.87              | 12.87  | 18.40c  | 23.53c  |
| 2         | 5.80              | 13.67  | 19.53bc | 24.27c  |
| 3         | 6.07a             | 14.20  | 20.93ab | 25.07bc |
| 4         | 5.67              | 13.47  | 20.40ab | 24.27c  |
| 5         | 6.33a             | 14.47  | 20.93ab | 24.73bc |
| 6         | 7.07              | 13.40  | 21.13ab | 24.93bc |
| 7         | 7.13              | 14.60  | 22.13a  | 27.40a  |
| 8         | 6.73              | 14.13  | 21.47a  | 26.47ab |
| 9         | 5.73              | 12.93  | 21.13ab | 25.40bc |
| Mean      | ns                | ns     | *       | *       |
| CV (%)    | 8.99              | 10.64  | 4.98    | 4.33    |

Within the same column, values followed by the same letter are not significantly different. ns = not significant; \* = significant at  $p \leq 0.05$ ; \*\* = significant at  $p \leq 0.01$ . DAT = days after transplanting.

**Effect of fertilizer regimes on yield components of lemongrass.** Yield components of lemongrass (*Cymbopogon citratus*) were markedly influenced by different fertilizer regimes (Table 3). Significant differences ( $p < 0.05$ ) were observed in mean leaf–stem biomass, stem diameter, theoretical yield, and harvested stem yield, whereas mean stem weight and commercial plant height were not significantly affected. Mean leaf–stem biomass ranged from 2.21 to 2.61 kg clump<sup>-1</sup>, with Treatment 7 producing the highest value (2.61 kg clump<sup>-1</sup>), significantly higher than Treatment 1 (2.21 kg clump<sup>-1</sup>). Treatments with improved nutrient supply generally resulted in greater biomass accumulation, indicating enhanced vegetative growth capacity and nutrient use efficiency. Although mean stem weight (45.98–48.22 kg) did not differ significantly, higher

values were observed in Treatments 7, 6, and 9, suggesting better assimilate accumulation and pseudo-stem development. Biomass production is widely recognized as a key indicator of nutrient conversion efficiency in aromatic crops (du Jardin, 2015). Commercial plant height ranged from 49.69 to 51.89 cm and showed no significant variation among treatments, indicating its relative stability under different fertilization regimes. In contrast, stem diameter varied significantly (19.83–22.55 mm), with Treatment 7 recording the highest value. Increased stem diameter reflects improved structural development and assimilate partitioning, which are essential for enhancing commercial quality and yield potential (Taiz & Zeiger 2015).

**Table 3: Effect of fertilizer regimes on yield components of lemongrass.**

| Treatment | Mean leaf–stem biomass (kg) | Mean stem weight (kg) | Commercial plant height (cm) | Stem diameter (mm) | Theoretical yield (t ha <sup>-1</sup> ) | Harvested stem yield (t ha <sup>-1</sup> ) |
|-----------|-----------------------------|-----------------------|------------------------------|--------------------|-----------------------------------------|--------------------------------------------|
| 1         | 2.21c                       | 45.98                 | 50.84                        | 19.83b             | 56.73b                                  | 22.58b                                     |
| 2         | 2.30bc                      | 46.09                 | 50.49                        | 20.69b             | 57.80b                                  | 23.30b                                     |
| 3         | 2.44ab                      | 46.87                 | 50.09                        | 20.67b             | 56.91b                                  | 23.65b                                     |
| 4         | 2.42abc                     | 46.38                 | 49.93                        | 20.54b             | 58.44b                                  | 23.83b                                     |
| 5         | 2.42abc                     | 46.73                 | 50.50                        | 20.15b             | 58.00b                                  | 23.97b                                     |
| 6         | 2.31bc                      | 46.97                 | 50.27                        | 20.63b             | 56.20b                                  | 25.85ab                                    |
| 7         | 2.61a                       | 48.22                 | 51.89                        | 22.55a             | 62.99a                                  | 29.43a                                     |
| 8         | 2.38bc                      | 46.99                 | 50.42                        | 20.33b             | 56.63b                                  | 24.58b                                     |
| 9         | 2.48ab                      | 47.02                 | 49.69                        | 20.87b             | 59.92ab                                 | 25.90ab                                    |
| Mean      | *                           | ns                    | ns                           | *                  | *                                       | *                                          |
| CV (%)    | 4.76                        | 2.90                  | 1.84                         | 2.99               | 4.05                                    | 9.30                                       |

Within the same column, values followed by the same letter are not significantly different. ns = not significant; \* = significant at  $p \leq 0.05$ ; \*\* = significant at  $p \leq 0.01$ . DAT = days after transplanting.

Fertilizer regimes also significantly affected both theoretical and harvested stem yield ( $p < 0.05$ ). Theoretical yield ranged from 56.20 to 62.99 t ha<sup>-1</sup>, while harvested yield varied from 22.58 to 29.43 t ha<sup>-1</sup>. Treatment 7 achieved the highest yields (62.99 and 29.43 t ha<sup>-1</sup>, respectively), significantly outperforming Treatment 1. Treatments 6 and 9 showed intermediate performance, indicating partial improvement under these regimes. The superior yield under Treatment 7 suggests enhanced nutrient availability, leading to increased photosynthetic efficiency, assimilate translocation, and biomass accumulation. Similar trends have been reported in studies on nutrient management and plant biostimulants, where improved nutrient uptake and root activity significantly enhanced crop productivity (Rouphael & Colla 2020; Yakhin *et al.*, 2017). Collectively, these results highlight the importance of optimized fertilization strategies in improving critical yield components, particularly biomass production, stem development, and yield output, ultimately contributing to greater productivity and cultivation efficiency.

**Effect of fertilizer regimes on pest and disease incidence.** Throughout the study period, the occurrence of major pests and diseases, including mealybugs, leaf

spot, and root rot, was regularly evaluated following standard monitoring protocols recommended by the Plant Protection Department. In general, no considerable pest or disease infestations were detected among the fertilizer treatments. Although slight symptoms were sporadically observed, their severity was minimal and showed no statistically significant variation across treatments. The low level of pest and disease incidence observed in this study could be related to favorable agro-environmental conditions and effective crop management practices, which may have suppressed the proliferation of harmful organisms. Moreover, balanced nutrient supply might have enhanced plant physiological status and resilience, thereby increasing tolerance to potential biotic stresses.

**Soil analysis.** Soil physicochemical properties before and after the experiment are presented in Table 4. Overall, noticeable changes in several soil parameters were observed following the application of fertilizer regimes in lemongrass (*Cymbopogon citratus*) cultivation. Soil pH showed only slight variation, increasing from 6.42 to 6.47 (H<sub>2</sub>O) and from 6.01 to 6.04 (KCl), indicating that the applied fertilizer regimes had minimal impact on soil acidity. These values suggest that

the soil remained within a favorable pH range for nutrient availability and crop growth, as most essential nutrients are optimally available in slightly acidic to neutral soils (Brady & Weil 2016). In contrast, electrical conductivity (EC) increased markedly from 0.16 to 1.04 mS cm<sup>-1</sup>, reflecting higher soluble salt concentrations due to fertilizer inputs. However, the EC level remained within an acceptable range for crop production and did not indicate salinity stress. Total organic matter decreased from 3.37% to 2.78%, which may be attributed to enhanced microbial decomposition and mineralization processes during the cropping period. Similar reductions in organic matter have been reported under intensive cultivation systems, where increased microbial activity accelerates organic matter turnover (Brady & Weil 2016). In contrast, soil nutrient status improved after the experiment. Total nitrogen increased from 0.15% to 0.22%, while total phosphorus (P<sub>2</sub>O<sub>5</sub>) slightly increased from 0.15% to 0.16%. Notably, available phosphorus rose from 0.012% to 0.017%,

indicating enhanced nutrient availability for plant uptake. Similarly, total potassium increased from 0.27% to 0.32%, and available potassium showed a substantial increase from 0.037% to 0.10%. These improvements suggest that fertilizer application, particularly with humic substances, enhanced nutrient retention and availability in the soil. Exchangeable cations also increased, with calcium rising from 239.6 to 265.7 mg kg<sup>-1</sup> and magnesium from 5,199 to 5,376 mg kg<sup>-1</sup>. The increase in these base cations may be associated with improved soil cation exchange capacity and nutrient retention, which are commonly enhanced by organic amendments and humic substances (Gricel *et al.*, 2021; Feng *et al.*, 2022). Overall, the results indicate that fertilizer regimes, particularly those involving humic substances, contributed to improving soil fertility by increasing nutrient availability and exchangeable cations, despite a slight decline in organic matter content. These changes are beneficial for sustaining soil productivity and supporting long-term crop growth.

**Table 4: Soil physicochemical properties before and after the experiment.**

| Sr. No. | Soil parameter                                        | Unit                           | Before experiment | After experiment |
|---------|-------------------------------------------------------|--------------------------------|-------------------|------------------|
| 1.      | pH (H <sub>2</sub> O)                                 | –                              | 6,42              | 6,47             |
| 2.      | pH (KCl)                                              | –                              | 6,01              | 6,04             |
| 3.      | Electrical conductivity (EC)                          | mS cm <sup>-1</sup>            | 0,16              | 1,04             |
| 4.      | Total organic matter                                  | % (dry soil)                   | 3,37              | 2,78             |
| 5.      | Total nitrogen                                        | % (dry soil)                   | 0,15              | 0,22             |
| 6.      | Total phosphorus (P <sub>2</sub> O <sub>5</sub> )     | % (dry soil)                   | 0,15              | 0,16             |
| 7.      | Available phosphorus (P <sub>2</sub> O <sub>5</sub> ) | % (dry soil)                   | 0,012             | 0,017            |
| 8.      | Total potassium (K <sub>2</sub> O)                    | % (dry soil)                   | 0,27              | 0,32             |
| 9.      | Available potassium (K <sub>2</sub> O)                | % (dry soil)                   | 0,037             | 0,1              |
| 10.     | Calcium                                               | mg kg <sup>-1</sup> (dry soil) | 239,6             | 265,7            |
| 11.     | Magnesium                                             | mg kg <sup>-1</sup> (dry soil) | 5.199             | 5.376            |

## CONCLUSION

Fertilizer regimes exerted a significant effect on the growth, yield components, final yield, and soil properties of lemongrass (*Cymbopogon citratus*) under field conditions in Tan Phu Dong. The influence of fertilization became increasingly apparent at later growth stages, particularly in terms of plant height and tiller formation. Among the evaluated treatments, Treatment 7 consistently demonstrated superior performance, achieving the highest harvested stem yield (29.43 t ha<sup>-1</sup>), theoretical yield (62.99 t ha<sup>-1</sup>), and tiller number (27.40 tillers clump<sup>-1</sup>).

This treatment corresponded to the fertilizer regime of 240 kg urea + 240 kg phosphate fertilizer + 80 kg KCl combined with 6 kg Super Humic and 14 kg K-Humate-Silic ha<sup>-1</sup>, which provided a balanced supply of macro- and micro-nutrients. Such optimized fertilizer management improved nutrient availability and promoted active vegetative growth, thereby resulting in higher productivity and greater production efficiency under local agro-ecological conditions. This fertilizer regime is therefore recommended for lemongrass

cultivation in Tan Phu Dong and similar agro-ecological regions to achieve optimal yield and production efficiency.

## FUTURE SCOPE

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