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*Research Article*

# Combined application of broiler chicken manure and PGPR on growth, yield, and amylopectin content of waxy corn "Kumala F1"

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## Abstract

*Glutinous corn or waxy corn is often used as a raw material for flour, while sweet glutinous corn is preferred when fresh harvest. Broiler manure is one of the organic fertilizers that can be used in the organic cultivation of sweet glutinous corn, and it needs to be optimized. The addition of plant growth-promoting rhizobacteria (PGPR) can be used to stimulate plant growth and increase fertilization efficiency. The experiment was conducted from March to August 2025 at IPB Experimental Field in Cikarawang B, Dramaga, Bogor. The experiment used s a randomized complete block design with doses of broiler manure and PGPR as treatment factors with 3 replications. The manure doses were 0, 10, 20, and 30 t ha$^{-1,}$ while 2 levels of PGPR were with and without PGPR. The concentration of PGPR was 20 g L$^{-1}$ and was applied by soaking the seeds for about 30 minutes. The results showed that the average leaf numbers did not differ significantly at 8 weeks after planting. The highest leaf area index was recorded without PGPR application, while PGPR application increased root length. Amylopectin content showed a significant response at the lowest manure dose of 0 t ha$^{-1}$.*

**Keywords:** amylopectin; C:N ratio; nutrient immobilization; sweet waxy corn.

## Introduction

Sweet waxy corn has unique characteristics, including a delicious taste, soft texture, and stickier consistency compared to regular sweet corn. Waxy corn is often utilized by local communities as a traditional food ingredient in products such as corn porridge, corn rice, and corn-based glutinous dishes. In addition to its distinctive flavor, waxy corn also serves as a functional food due to its sufficient fiber, protein, and sugar content, making it suitable for diet foods such as soups or porridges (Parhusip et al., 2024). The potential yield of waxy corn can reach 10-12 t ha$^{-1}$; however, the average field yield is only about 2-4 t ha$^{-1}$ (Alnasir, 2023). Therefore, agronomic efforts are needed to increase production, one of which is by applying biofertilizer to increase nutrient use efficiency.

Chicken manure is one of the inputs that can be utilized in organic farming. The use of organic fertilizers in cultivation aims to preserve soil conditions. The benefits of using organic fertilizers in crop cultivation include improving soil structure by promoting soil granulation or stabilizing soil aggregates, which facilitates root development (Zhang et al., 2012). The application of manure can also enhance soil fertility and increase organic matter content (Wang et al., 2017). Furthermore, organic fertilizers can improve soil health by enhancing soil aggregation and increasing soil biodiversity (Lin et al., 2019).

This study uses broiler chicken manure as one of the main inputs. Broiler chicken manure functions as a soil conditioner or ameliorant, which will improve soil fertility and physical properties. In addition, the roles of broiler chicken manure are not only as an ameliorant, but also as a source of nutrient content. It was reported that this manure consisted of 2.79 % N, 0.52 % $P_2O_5$, and 2.29% $K_2O$ (Purba et al., 2019). Therefore, it is expected that the broiler chicken manure can also supply the plant nutrients of waxy corn.

Although manure is highly beneficial for both the environment and crops, the use of organic fertilizers also has several drawbacks, including the need for high application rates and a long decomposition process if not supported by adequate soil moisture and temperature (Sharma, 2017). One approach to overcome these limitations is the use of biological fertilizers, for example, plant growth-promoting rhizobia (PGPR) to enhance fertilizer efficiency (Jannah et al., 2022). PGPR can improve fertilizer efficiency, both organic and inorganic. The role of PGPR in enhancing cultivation efficiency involves several mechanisms, such as producing organic acids that solubilize phosphorus in the soil and transforming nitrogen into forms that can be directly utilized by plants (Vejan et al., 2016). The proper dose of broiler chicken manure and PGPR to produce sweet waxy corn has not been reported yet. Therefore, it is necessary to evaluate the effect of the combination of broiler chicken manure and PGPR on the growth and yield of sweet waxy corn.

## Materials and methods

### *Study site and materials*

The field experiment was carried out at the IPB Experimental Field in Cikarawang B, Dramaga District, Bogor Regency, West Java, Indonesia. Post-harvest observation was carried out at the Post-harvest Laboratory, Department of Agronomy and Horticulture, IPB University, Bogor. The study was conducted from March to August 2025.

The study used the "Kumala F1" variety for sweet waxy corn seeds, half-ripe broiler chicken manure, PGPR (a consortium of *Rhizobium* sp., *Bacillus* sp., and *Pseudomonas fluorescens*) (Information on inoculum density (CFU $g^{-1}$) was not specified by the manufacturer), dolomite, fungicides, and insecticides. The instrument used for amylopectin content analysis was a UV-Vis spectrophotometer.

### *Experimental design and procedures*

The experiment was arranged in a two-factor randomized complete block design (RCBD) with three replications. The first factor was the dosage of broiler chicken manure, consisting of 0, 10, 20, and 30 t $ha^{-1}$, and the second factor was PGPR application (without PGPR and with PGPR at 20 g $L^{-1}$).

Each experimental plot measured 4.2 m × 2.8 m and consisted of 84 plants planted at a spacing of 70 cm × 20 cm. A total of 24 experimental units were established. Ten plants per plot were randomly selected as sample plants for growth and quality observations. Yield data were calculated based on these sampled plants (0.70 $m^2$ harvested area) and extrapolated to a hectare basis.

Land preparation was conducted two weeks before planting. Half of the manure dose was incorporated into the soil prior to planting, while the remaining half was applied at 3 weeks after planting (WAP) using furrow and drenching methods. Soil samples were collected from the top 20 cm of the soil layer and composited for chemical analysis, including pH, N, P, K, organic C, and CEC, while broiler chicken manure was analyzed for N, P, K, organic C, moisture content, pH, Zn, and Mg (Table 1).

Table 1. Chemical properties of chicken manure

| Parameter | Result | Standard | Status* |
|---|---|---|---|
| Moisture Content (%) | 29.98 | >20% | Appropriate |
| C-organic (%) | 41.27 | Minimum 15 % | Appropriate |
| pH | 7.53 | 4–9 | Appropriate |
| Total N (%) | 0.95 | | Appropriate |
| Total $P_2O_5$ (%) | 0.37 | N+P+K ≥ 2% | Appropriate |
| Total $K_2O$ (%) | 0.69 | | Appropriate |
| Total Zn (ppm) | 55.3 | <5000 | Appropriate |
| $Mg^+$(%) | 0.15 | | Appropriate |
| C:N | 43.4 | 25 | Inappropriate |

*Note:* *Criteria based on Evianti et al. (2023)

PGPR application was conducted only once through seed soaking (product recommendation) at a concentration of 20 g $L^{-1}$ for 30 minutes prior to planting, following common farmer practice. No soil or foliar re-inoculation was applied during the growing period. Broiler chicken manure was also applied by foliar spraying at 6 WAP. Manure was applied as an aqueous suspension at concentrations of 10%, 20%, and 30% (w/v; kg $L^{-1}$ water), filtered using a fine mesh cloth, and applied to the plant canopy and soil surface. Manure solution was applied three times per week until 8 WAP (grain filling phase). Foliar application is used to increase nitrogen sufficiency according to Kumar et al. (2022). No visible phytotoxic symptoms were observed. Pest and disease control were done with fungicides (Mancozeb, Propineb) and insecticides (Cypermethrin).

### Trait observations and data analysis

Plant characteristics were observed weekly, at the maximum vegetative stage, and at harvest. During the vegetative and maximum vegetative stages, observations included plant height, leaf number, stem diameter, leaf area, fresh and dry biomass, leaf nitrogen index, leaf nutrient content (N, P, K) (6th leaf from top), and root length. At harvest, observations included ear length and diameter, ear weight (with and without husk), number of kernel rows, number of kernels per row, yield productivity, and amylopectin content. Sweet waxy corn was harvested 70 days after planting (DAP).

Data were analyzed according to a two-factor randomized complete block design (RCBD) linear model. Analysis of variance (ANOVA) was performed at a 5% significance level. When significant differences were detected, mean separation was conducted using Duncan's multiple range test (DMRT). All data are presented as mean ± standard deviation (SD). Statistical assumptions of normality and homogeneity of variance were tested prior to analysis.

## Results and discussion

### *Soil properties*

The results of the soil analysis before the application of chicken manure indicated a low cation exchange capacity (CEC) (Table 2). Low CEC will affect cation storage in the soil and nutrient supply for plants. The P content in the land was 134.4 ppm, which is very high. This is also supported by a pH of 6.57, which is classified as neutral, and under these conditions, P is most available (Penn & Camberato, 2019). Soil analysis results show a soil pH of 6.57, which is optimal for corn. The organic carbon content in the soil is 2.03%, which is classified as low.

Table 2. Results of soil chemical properties analysis before the application of broiler chicken manure

| Parameter | Value | Unit | Status* |
|---|---|---|---|
| pH ($H_2O$) | 6.57 | - | Neutral |
| C-organic | 2.03 | % | Moderate |
| N-total | 0.24 | % | Moderate |
| P-available | 134.4 | ppm $P_2O_5$ | Very High |
| Cation exchange capacity (CEC) | 12.70 | cmol $kg^{-1}$ | Low |
| K-potential | 0.29 | cmol K $kg^{-1}$ | Low |

*Note:* *Criteria based on Evianti et al. (2023)

### *Vegetative growth*

Interaction effects between manure dosage and PGPR application were tested for all observed variables. However, no significant manure × PGPR interaction was observed for most growth, yield, and quality parameters, indicating that the effects of each factor were largely independent under the conditions of this study.

Different doses of broiler chicken manure and PGPR did not result in significant differences in vegetative growth parameters (plant height, leaf number, and stem diameter) (Table 3). The manure dosage treatments did not enhance vegetative growth, likely due to the slow-release nature of broiler chicken manure (Chandran et al., 2021). The vegetative characteristics observed in this study were considerably lower compared to the description of the "Kumala F1" variety. This condition is associated with the slow-release nature of chicken manure and its high C:N ratio (43.4), which limits the plant's ability to meet its nutrient requirements. Consequently, the plants were unable to reach their maximum vegetative growth potential.

Although organic fertilizers can improve soil aggregation and microbial diversity over time (Lin et al., 2019), these benefits require repeated applications and sufficient decomposition. In this study, the high C:N ratio of broiler chicken manure likely delayed decomposition and caused nitrogen immobilization, thereby limiting short-term nutrient availability and suppressing early vegetative growth.

Table 4 shows that the use of PGPR causes a 22% reduction in leaf area compared to the use without PGPR addition (Table 4). PGPR application causes a significant reduction in leaf area. The reduction in leaf area is due to the C:N ratio being outside the maximum limit. A high C:N ratio causes nutrient immobilization, which results in N not being available in a short period of time (Hobbie, 2015).

Table 3. Effect of broiler chicken manure on plant height, leaf number, and stem diameter

| Treatment | Plant age (week after planting) | | | |
|---|---|---|---|---|
| | 4 | 6 | 8 | 10 |
| Manure dosage (t ha$^{-1}$) | Plant height (cm) | | | |
| 0 | 101.50±7.3 | 133.89±11.9 | 132.29±4.3 | 132.23±1.7 |
| 10 | 97.17±12.5 | 125.43±12.7 | 133.59±0.5 | 127.59±10.7 |
| 20 | 97.67±9.7 | 125.79±10.1 | 126.83±3.7 | 128.75±2.3 |
| 30 | 105.50±12.7 | 135.14±18.8 | 133.70±6.9 | 133.13±5.0 |
| Pr > F | 0.232 | 0.637 | 0.782 | 0.385 |
| PGPR | | | | |
| PGPR | 95.56±8.1 | 124.81±11.9 | 130.39±4.9 | 127.55±5.6 |
| Without PGPR | 105.36±7.4 | 135.31±9.6 | 132.82±4.4 | 133.30±3.1 |
| Pr > F | 0.291 | 0.669 | 0.293 | 0.570 |
| Manure dosage (t ha$^{-1}$) | Leaf number | | | |
| 0 | 7±0.7 | 7±0.1 | 7±0.2 | 6±0.5 |
| 10 | 7±0.8 | 7±0.4 | 7±0.1 | 6±0.3 |
| 20 | 7±0.4 | 7±0.4 | 7±0.1 | 6±0.1 |
| 30 | 7±0.6 | 8±0.3 | 8±0.3 | 6±0.1 |
| Pr > F | 0.747 | 0.992 | 0.154 | 0.185 |
| PGPR | | | | |
| PGPR | 7±0.5 | 7±0.4 | 7±0.4 | 6±0.4 |
| Without PGPR | 7±0.4 | 8±0.4 | 7±0.3 | 6±0.5 |
| Pr > F | 0.326 | 0.070 | 0.070 | 0.136 |
| Manure dosage (t ha$^{-1}$) | Stem diameter(mm) | | | |
| 0 | 13.17±1.2 | 14.86±1.1 | 13.41±1.2 | 14.31±0.6 |
| 10 | 13.02±1.5 | 14.28±0.4 | 13.72±0.7 | 14.02±0.2 |
| 20 | 12.68±1.3 | 14.09±1.5 | 13.22±0.5 | 14.13±0.7 |
| 30 | 14.19±2.1 | 15.79±1.1 | 13.82±1.6 | 14.46±0.6 |
| Pr > F | 0.139 | 0.752 | 0.665 | 0.586 |
| PGPR | | | | |
| PGPR | 12.61±1.0 | 14.42±1.1 | 13.27±0.7 | 14.09±0.5 |
| Without PGPR | 13.92±1.4 | 15.09±1.1 | 13.82±1.0 | 14.37±0.4 |
| Pr > F | 0.152 | 0.308 | 0.348 | 0.437 |

The addition of PGPR causes competition for N use between the host and microbes, leading to N immobilization. Immobilization causes N in the soil to be used to decompose the fertilizer used, resulting in fewer nutrients available for the plants (Kaleem et al., 2015). The lack of N in growth causes the leaf area in the PGPR treatment to be smaller than without PGPR treatment (Afrida et al., 2024). Leaf area is a morphological characteristic of plants that can indicate the nutritional status of plants, especially nitrogen. The leaf area of sweet corn plants that grow optimally is 200–400 cm$^2$ (Rasool et al., 2023). In addition to the low decomposition rate of broiler manure, a high level of downy mildew infestation is also a factor that can cause a decrease in leaf area through damage to leaf tissue (Crouch et al., 2022).

The effect of chicken manure fertilizer application rate did not have a significant effect on root length (Table 4). A significant effect was shown through the application of PGPR, with root length increasing by 21% compared to without PGPR. This indicates that PGPR inoculation occurred in the corn roots.

PGPR can increase root length in corn plants, as also proven by Hartono et al. (2024). The increase in root length occurs because the exudate is very useful as a source of nutrients for microorganisms, which then triggers root growth. The adaptive response of plants to N deficiency conditions can also increase root length

(Amoah et al., 2025). After exuding exudates, microorganisms present around the plant roots are attracted, causing the root zone to expand and facilitating nutrient uptake by the plant (Nazir et al., 2019).

Table 4. Leaf area and root length of waxy corn plant at 6 weeks after planting (WAP)

| Treatment | Leaf area ($cm^2$) | Root length (cm) |
|---|---|---|
| Manure dosage ($t\ ha^{-1}$) | | |
| 0 | 73.28±0.8 | 20±3.5 |
| 10 | 76.74±0.8 | 22±4.9 |
| 20 | 73.03±1.1 | 20±6.1 |
| 30 | 73.74±0.1 | 22±4.0 |
| Pr > F | 0.99 | 0.59 |
| PGPR | | |
| PGPR | 64.91±0.3b | 23±4.0a |
| Without PGPR | 83.49±0.3a | 19±2.2b |
| Pr > F | 0.04* | 0.02* |

*Note*: * = Significant based on ANOVA at 5% level; different letters indicate significantly different means according to the DMRT at 5% level

The dosage of manure, PGPR, or their interaction did not affect the N and P content of the leaves, but PGPR caused lower K content compared to the treatment without PGPR (Table 5). Referring to Vitosh et al. (1995), the nutrient adequacy levels in corn plants during the maximum vegetative phase range as follows: N: 2.90–3.50%; P: 0.30–0.50%; K: 1.91–2.50%. The N, P, and K levels in the leaves indicate insufficient nutrient uptake for the vegetative phase. This could indicate suboptimal vegetative growth. It is possible that during the vegetative phase, the nutrients provided in the form of chicken manure were not yet available due to a high C:N ratio, even though the nutrient content requirements were met (Parhusip et al., 2024). This condition is evidenced by N and P content that is not within the adequate nutrient range. Several studies show that nitrogen stress alters potassium uptake and translocation, thereby reducing K concentration in leaves, altering transpiration flow, and redistributing K to prioritized organs (roots) (Feng et al., 2024; Hou et al., 2019).

Table 5. Leaf nutrient content at the maximum vegetative stage of waxy corn plants

| Treatment | Total-N (%) | P (%) | K (%) |
|---|---|---|---|
| Manure dosage ($t\ ha^{-1}$) | | | |
| 0 | 2.59±0.02 | 0.26±0.04 | 1.43±0.30 |
| 10 | 2.51±0.25 | 0.29±0.01 | 1.50±0.32 |
| 20 | 2.43±0.17 | 0.31±0.04 | 1.80±0.34 |
| 30 | 2.44±0.10 | 0.28±0.01 | 1.46±0.40 |
| Pr > F | 0.476 | 0.241 | 0.516 |
| PGPR | | | |
| PGPR | 2.55±0.13 | 0.30±0.01 | 1.31±0.34b |
| Without PGPR | 2.44±0.14 | 0.27±0.03 | 1.79±0.18a |
| Pr > F | 0.199 | 0.109 | 0.02* |

*Note*: * = Significant based on ANOVA at 5% level; different letters indicate significantly different means according to the DMRT at 5% level

The dosage of broiler chicken manure and PGPR had no significant effect on the fresh and dry weight of the plant biomass (Table 6). In general, under optimal conditions, the combination of PGPR and broiler chicken manure can increase the weight of the vegetative part of plants (Silalahi et al., 2018). However, the results of this experiment did not reach a total wet weight of 200 g. The very low N content in the fertilizer, 0.95%, was insufficient for the plants to achieve high wet weight. The high C:N ratio also caused the nutrients in the chicken manure fertilizer to be retained.

The role of PGPR in this study was not very apparent. The high C:N ratio is thought to have caused competition between the host and microorganisms. Thus, the initial role of PGPR in helping plants improve growth performance instead became competition for nitrogen nutrients. Gannett et al. (2024) stated that for every 23 carbon atoms, microorganisms require 1 nitrogen atom. The C:N ratio in the study was 43.4:1, which means that microorganisms lacked 0.5 nitrogen atoms to decompose the fertilizer. Therefore, PGPR and plants competed for limited nitrogen nutrients in the soil.

Table 6. Fresh and dry weight of waxy corn plant at 6 WAP

| Treatment | Plant parts | | | |
|---|---|---|---|---|
| | Root | Leaf | Stem | Total |
| Manure dosage (t ha$^{-1}$) | Fresh weight of plant(g) | | | |
| 0 | 16.00±0.47 | 57.83±11.0 | 36.50±0.71 | 110.33±11.3 |
| 10 | 20.33±4.71 | 62.17±7.78 | 38.33±8.01 | 120.83±11.1 |
| 20 | 19.83±1.65 | 53.83±6.36 | 39.33±0.64 | 113.00±8.01 |
| 30 | 29.50±2.12 | 86.50±7.73 | 53.17±1.65 | 169.17±7.31 |
| Pr > F | 0.192 | 0.158 | 0.156 | 0.120 |
| PGPR | | | | |
| PGPR | 22.25±4.88 | 64.25±18.84 | 40.58±9.56 | 127.08±32.2 |
| Without PGPR | 20.58±3.53 | 65.92±19.93 | 43.08±11.0 | 129.58±33.8 |
| Pr > F | 0.704 | 0.874 | 0.648 | 0.892 |
| Manure dosage (t ha$^{-1}$) | Dry weight of plant (g) | | | |
| 0 | 3.83±0.24 | 8.33±0.47 | 9.33±3.30 | 17.67±2.83 |
| 10 | 4.33±0.94 | 10.17±1.65 | 12.00±0.54 | 22.17±1.65 |
| 20 | 4.00±0.84 | 10.17±2.59 | 9.50±2.59 | 19.67±5.19 |
| 30 | 5.67±0.91 | 12.83±0.71 | 14.00±0.47 | 26.83±1.42 |
| Pr > F | 0.467 | 0.147 | 0.350 | 0.208 |
| PGPR | | | | |
| PGPR | 4.83±0.69 | 10.75±2.28 | 11.00±2.84 | 21.75±4.74 |
| Without PGPR | 5.11±0.51 | 11.44±2.21 | 12.33±1.21 | 23.78±3.02 |
| Pr > F | 0.407 | 0.567 | 0.841 | 0.913 |

## *Harvest characteristics and quality*

Table 7 presents the effect of manure dosage and PGPR application on harvest characteristics. Cob length and diameter are among the important production traits of corn that influence its market appeal, and these traits are affected by the nitrogen supply provided (Sutihati, 2003). Under field conditions, a high C:N ratio likely caused nitrogen to be insufficiently available during the vegetative stage. Corn plants at the maximum vegetative stage require high nitrogen availability to optimize kernel filling. Corn plants that do not receive adequate nitrogen during the VT stage may experience a yield reduction of up to 71–95% (Mueller & Vyn, 2018). In relation to leaf nutrient content during the maximum vegetative stage, the plants were found to be nitrogen-deficient, which significantly affected yield production. Furthermore, the high C:N ratio also limited the effectiveness of PGPR, preventing it from enhancing the plant's harvest characteristics.

Table 7. Waxy corn production characteristics

| Treatment | Cob weight (g) | | Cob size (cm) | | Number | |
|---|---|---|---|---|---|---|
| | With husk | Without husk | Diameter | Length | Kernel rows | Kernels per row |
| Manure dosage (t ha$^{-1}$) | | | | | | |
| 0 | 115.5±2.80 | 83.54±3.3 | 3.4±0.8 | 14.8±1.3 | 8.7±0.1 | 16.6±1.1 |
| 10 | 103.8±10.1 | 70.14±7.2 | 3.1±2.2 | 14.0±0.4 | 7.6±1.3 | 13.1±3.7 |
| 20 | 92.1±20.45 | 57.74±7.5 | 3.1±1.2 | 12.6±0.6 | 7.4±1.3 | 12.5±2.0 |
| 30 | 112.3±4.62 | 82.80±1.5 | 3.3±0.5 | 14.8±0.6 | 8.7±0.6 | 14.9±0.3 |
| Pr > F | 0.387 | 0.067 | 0.487 | 0.204 | 0.315 | 0.193 |
| PGPR | | | | | | |
| PGPR | 106.4±7.1 | 73.2±10.7 | 3.2±1.7 | 14.0±1.5 | 7.9±0.8 | 13.8±2.3 |
| Without PGPR | 105.4±18.7 | 73.8±14.9 | 3.3±2.0 | 14.1±0.9 | 8.2±1.2 | 14.7±2.6 |
| Pr > F | 0.924 | 0.937 | 0.646 | 0.743 | 0.633 | 0.527 |

The application of broiler chicken manure and PGPR did not show a significant effect at the 5% level (Table 8). Correlating with the corn yield characteristics, when nutrients are unavailable during the maximum vegetative phase, production can decrease by 71–95%. Compared to the Kumala F1 variety description, which can reach a productivity of 10–12 t ha$^{-1}$, this study only achieved a maximum productivity of 3.7 t ha$^{-1}$ far below its potential yield. The productivity obtained in this study (2.66–3.79 t ha$^{-1}$) is consistent with the field-level yield of waxy corn reported by Alnasir (2023), who documented average yields of 2–4 t ha$^{-1}$ despite a potential yield of 10–12 t ha$^{-1}$. This indicates that the present results represent typical farmer-level conditions rather than the potential performance of the variety.

The low productivity observed in the field may be associated with several factors, including the high C:N ratio of the applied broiler chicken manure and the occurrence of downy mildew. A high C:N ratio can potentially promote nitrogen immobilization during manure decomposition, which may limit nitrogen availability for plant uptake. Under such conditions, microbial competition for nitrogen may occur, and the addition of PGPR alone may not be sufficient to overcome this limitation. In addition, downy mildew infection may have further disrupted plant growth from the vegetative stage until harvest.

Table 8. Productivity of waxy corn

| Treatment | Productivity (t ha$^{-1}$) |
|---|---|
| Manure dosage (t ha$^{-1}$) | |
| 0 | 3.79±0.80 |
| 10 | 3.35±1.85 |
| 20 | 2.66±0.83 |
| 30 | 3.51±1.19 |
| Pr > F | 0.08 |
| PGPR | |
| PGPR | 3.23±1.47 |
| Without PGPR | 3.42±1.28 |
| Pr > F | 0.51 |

Improvement in soil physical and biological properties due to organic amendments is often gradual and cumulative. In this study, the short experimental duration and limited decomposition of broiler chicken manure likely prevented these benefits from being fully realized. Consequently, nitrogen availability during the maximum vegetative stage remained insufficient, leading to reduced cob development and yield.

The broiler chicken manure used in this study had a high C:N ratio (≈43.4) and low total nitrogen content (0.95%), indicating that the manure was not fully composted. Such manure characteristics may promote microbial immobilization of nitrogen during decomposition, thereby reducing nitrogen availability for plants. The absence of soil mineral nitrogen measurements during the crop cycle (e.g., pre-planting, V6, and VT stages) represents a limitation of this study. Future research should incorporate these measurements to better elucidate nutrient dynamics associated with high C:N organic inputs.

The dosage of broiler chicken manure showed a highly significant effect on amylopectin content (Table 9). Waxy corn typically has a higher amylopectin-to-amylose ratio, as photosynthetic products are predominantly converted into amylopectin (Feng et al., 2024). As shown in Table 9, amylopectin content increased with decreasing manure dosage.

Generally, higher nitrogen application rates have been reported to increase amylopectin content in some waxy corn varieties (Wang et al., 2017). However, the results of this study showed an opposite trend. This response may be associated with the high C:N ratio of the applied broiler chicken manure, which can promote microbial nitrogen immobilization and reduce nitrate ($NO_3^-$) availability in the soil (Cheng et al., 2017).

Under nitrogen-limited conditions, carbon allocation may be redirected toward starch synthesis, particularly amylopectin, rather than biomass production. Therefore, the higher amylopectin content observed in the treatment without manure application likely reflects changes in carbohydrate partitioning rather than improved overall productivity.

Table 9. Amylopectin content of waxy corn in treatments without PGPR

| Manure dosage (t ha$^{-1}$) | Amylopectin content (g 100 g$^{-1}$) |
|---|---|
| 0 | 69.97±0.10a |
| 10 | 68.89±0.07b |
| 20 | 68.86±0.13b |
| 30 | 68.15±0.35c |
| Pr > F | 0.002** |

*Note:* **= Significant based on ANOVA at 1% level; different letters indicate significant differences based on the DMRT at 5% level.

## Conclusions

Broiler chicken manure and PGPR application did not significantly enhance the growth or yield of sweet waxy corn under the conditions of this study. The high C:N ratio of half-ripe manure likely limited nutrient availability through nitrogen immobilization. PGPR application increased root length but did not translate into higher productivity. The use of half-ripe broiler chicken manure is therefore not recommended for sweet waxy corn production unless further processed. Future studies should evaluate composted manure, improved foliar formulations, and soil nitrogen dynamics to optimize organic fertilization strategies. Additionally, a variety of waxy corn that is more resistant to leaf rust needs to be developed.

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