INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN APPLIED SCIENCE (IJRIAS)
ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue XV May 2026
Special Issue on Next-Generation Approaches in Plant Sciences and Agriculture

Effects of Organic Amendments on Growth and Disease Resistance of Green Chili (*Capsicum annuum*)

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DOI: https://doi.org/10.51584/IJRIAS.2026.111500014

Received: 04 May 2026; Accepted: 10 May 2026; Published: 29 May 2026

ABSTRACT

This study evaluated the effects of baking soda (sodium bicarbonate), brown sugar, and white vinegar—individually and in combination—on the growth performance and disease resistance of green chili (Capsicum annuum). A Completely Randomized Design (CRD) with seven treatments and three replications was employed. Data on plant height, number of fruits per plant, fruit weight, total yield, and disease incidence were analyzed using ANOVA and Tukey's HSD. Results showed that T5 (15g baking soda + 15g brown sugar + recommended rate of fertilizer) produced the tallest plants (78.57 cm) and the highest number of fruits per plant (56.22), representing a 37.8% increase over the control (32.22 fruits). Disease incidence was significantly lowest in T5 at 0.67%, an 89% reduction relative to the control (6.25%). Fruit weight and total yield showed no statistically significant differences among treatments, though T5 recorded the highest numerical values (0.36 g and 0.69 kg, respectively). These findings demonstrate that the synergistic combination of baking soda and brown sugar offers a practical, cost-effective, and environmentally sustainable strategy for improving green chili productivity and disease management, with implications for smallholder farmers seeking to reduce reliance on synthetic agrochemicals.

Keywords: organic amendments, baking soda, brown sugar, white vinegar, *Capsicum annuum*, disease incidence, sustainable agriculture

INTRODUCTION

Green chili (Capsicum annuum) is a globally significant vegetable crop valued for its culinary versatility and medicinal properties, including antimicrobial and anti-inflammatory effects attributable to its high capsaicin content (Sarma et al., 2021). In the Philippines, it serves as an important income source for smallholder farmers, particularly in regions like South Cotabato, where tropical growing conditions are generally favorable. However, persistent challenges—including fungal and bacterial disease pressure, high input costs, and limited access to improved varieties—continue to constrain yields and compromise crop quality (Philippine Statistics Authority, 2024; Dela Cruz et al., 2023).

Conventional disease management in chili production has long relied on synthetic pesticides and fungicides. While effective, these inputs contribute to environmental degradation, development of pathogen resistance, and adverse health effects in farm workers and consumers (Patel et al., 2020). The growing imperative for sustainable agriculture has prompted investigation into organic, low-cost alternatives that can maintain or improve productivity while reducing chemical dependency.

Baking soda (sodium bicarbonate), brown sugar, and white vinegar are readily available household substances with documented agronomic potential. Baking soda has been reported to suppress fungal pathogens by raising leaf surface pH and disrupting fungal cell wall integrity (Liu et al., 2021; Lee et al., 2022). Brown sugar functions as a bio-stimulant by providing carbon substrates that invigorate beneficial soil microbiota, thereby improving nutrient availability and plant vigor (Shah et al., 2022). White vinegar, through its acetic acid content, exhibits direct antimicrobial activity and can induce systemic resistance in treated plants (Williams, 2017; Lopez et al., 2021).

Although each amendment has been studied individually, their synergistic effects—particularly in the Philippine context for green chili—remain largely unexplored. Abdelaziz and Al-Khayri (2023) demonstrated that combined applications of sodium bicarbonate and acetic acid reduced bell pepper fruit rot by 85%, while Singh and Yadav (2024) reported a 31% yield increase in chili using multi-ingredient organic mixtures. These findings suggest that integrated organic amendment strategies may outperform single-compound applications through complementary modes of action.

The present study therefore aimed to evaluate the effects of baking soda, brown sugar, and white vinegar—applied singly and in binary combinations—on the agronomic performance and disease response of green chili grown in polyethylene bags. Specifically, it sought to: (1) determine the effect of these amendments on plant height, fruit number, fruit weight, and total yield; (2) evaluate their efficacy in disease prevention and pest control; and (3) determine disease incidence and severity using a standardized scoring scale.

MATERIALS AND METHODS

Study Site and Duration

The study was conducted at Alamada's Compound, Purok Rizal, Barangay Lamba, Banga, South Cotabato, Philippines, from November 14, 2025, to March 20, 2026 (approximately 18 weeks). The site provided uniform exposure to sunlight and consistent microclimatic conditions across all experimental units.

Plant Material and Experimental Treatments

Green chili (Capsicum annuum) seeds were obtained from a reputable local supplier. Seeds were pre-soaked for 12–24 hours and germinated in seedling trays containing a sterile soil medium. Seedlings (four to six weeks old with at least four to six true leaves) were transplanted individually into 6×6×12-inch polyethylene bags filled with well-draining loamy soil (pH 6.0–7.0).

Seven treatments were evaluated under a Completely Randomized Design (CRD) with three replications per treatment (n = 21 experimental units):

T1 – Control: water only + recommended rate of fertilizer (RRF)

T2 – 15g baking soda + RRF

T3 – 15g brown sugar + RRF

T4 – 15g white vinegar + RRF

T5 – 15g baking soda + 15g brown sugar + RRF

T6 – 15g baking soda + 15g white vinegar + RRF

T7 – 15g brown sugar + 15g white vinegar + RRF

Each amendment was dissolved in one gallon of water and applied as a foliar spray at a concentration of 15 grams per gallon. The first application was administered two to four weeks after transplanting (WAT), and subsequent applications were made every 10 days during the vegetative stage.

Data Collection

Ten representative plants per experimental unit were tagged and monitored throughout the crop cycle. Plant height (cm) was measured from the base to the tip of the tallest leaf. The number of fruits per plant was counted at each harvest. Individual fruit weight (g) was recorded using a calibrated digital weighing scale. Total fruit yield per treatment (kg) was determined by weighing all harvested fruits across three replications combined. Three harvesting events were conducted between 60 and 90 days after transplanting.

Disease Assessment

Disease incidence was calculated as the percentage of plants exhibiting visible disease symptoms (leaf spots, curling, wilting, or discoloration) relative to the total number of plants assessed per experimental unit, using the formula:

Disease Incidence (%) = (Number of Infected Plants / Total Plants Assessed) × 100

Disease severity was rated on a 0–5 scale adapted from Massimi (2024): 0 = no symptoms; 1 = 1–10% leaf area affected; 2 = 11–25%; 3 = 26–50%; 4 = 51–75%; 5 = 76–100% or plant dead.

Statistical Analysis

Data were subjected to one-way Analysis of Variance (ANOVA) under a CRD using the Statistical Tool for Agricultural Research (STAR). Where significant treatment effects were detected, Tukey's Honest Significant Difference (HSD) test was applied to determine pairwise differences among means at the 5% level of significance.

RESULTS AND DISCUSSION

Plant Height

Treatment significantly influenced plant height ($F(6,14) = 8.64$, $p = 0.0005$; CV = 8.42%). Table 1 presents the mean plant heights for all treatments.

Table 1. Mean Plant Height (cm) of Green Chili as Influenced by Different Organic Amendments

Treatment	Mean Height (cm)	Grouping
T1 – Control (Water Only + RRF)	57.05	bc
T2 – 15g Baking Soda + RRF	58.15	bc
T3 – 15g Brown Sugar + RRF	71.25	ab
T4 – 15g White Vinegar + RRF	59.39	bc
T5 – 15g Baking Soda + 15g Brown Sugar + RRF	78.57	a
T6 – 15g Baking Soda + 15g White Vinegar + RRF	61.48	bc
T7 – 15g Brown Sugar + 15g White Vinegar + RRF	53.13	c
Over-all Mean	62.72	

Means followed by a common letter are not significantly different at 5% level (Tukey's HSD). CV = 8.42%.T5 (baking soda + brown sugar + RRF) produced the tallest plants at 78.57 cm, significantly outperforming all other treatments except T3 (71.25 cm; group ab). The control and T2, T4, T6 recorded intermediate heights (57.05–61.48 cm; group bc), while T7 (brown sugar + white vinegar) produced the shortest plants at 53.13 cm (group c). The superior growth performance of T5 is consistent with the bio-stimulant role of sugar-based amendments, which provide readily available carbon sources that stimulate beneficial rhizosphere microorganisms, enhance nutrient cycling, and improve soil nutrient bioavailability (Shah et al., 2022; Hasan et al., 2021). The concurrent application of baking soda may have further contributed to plant vigor by maintaining healthy foliar surfaces free from early fungal infections that would otherwise divert photosynthate toward defense responses (Lee et al., 2022). The unexpectedly low height in T7 may reflect an inhibitory interaction between acetic acid and brown sugar under the specific soil and container conditions of this experiment, warranting further mechanistic investigation.

Number of Fruits per Plant

Highly significant differences in fruit number were observed among treatments ($F(6,14) = 50.81$, $p < 0.0001$; CV = 4.75%; Table 2).

Table 2. Mean Number of Fruits per Plant of Green Chili as Influenced by Different Organic Amendments

Treatment	Mean No. of Fruits	Grouping
T1 – Control (Water Only + RRF)	32.22	d
T2 – 15g Baking Soda + RRF	38.11	d
T3 – 15g Brown Sugar + RRF	38.78	bc
T4 – 15g White Vinegar + RRF	33.78	cd
T5 – 15g Baking Soda + 15g Brown Sugar + RRF	56.22	a
T6 – 15g Baking Soda + 15g White Vinegar + RRF	40.22	b
T7 – 15g Brown Sugar + 15g White Vinegar + RRF	41.33	b
Over-all Mean	40.10	

Means followed by a common letter are not significantly different at 5% level (Tukey's HSD). CV = 4.75%.

T5 produced the highest mean fruit count (56.22 fruits/plant), a statistically significant 74% increase over the control (32.22 fruits/plant; group d). Treatments T6 and T7 yielded moderate fruit counts (40.22 and 41.33, respectively; group b), followed by T3 and T2 (group bc), and T4 at 33.78 (group cd). The marked superiority of T5 is attributable to the complementary roles of its two active components: brown sugar's bio-stimulant activity promotes flowering and fruit set by enhancing microbial nutrient mobilization during the reproductive stage (Alcantara & Reyes, 2022), while baking soda preserves photosynthetically active leaf area by suppressing fungal disease, thereby sustaining carbon assimilation and resource allocation toward fruiting (Shah et al., 2022).

Fruit Weight

No statistically significant treatment effect was observed on individual fruit weight ($F(6,14) = 2.20$, $p = 0.1046$, ns; CV = 18.39%; Table 3), indicating that all treatments were statistically comparable for this variable.

Table 3. Mean Fruit Weight (g) of Green Chili as Influenced by Different Organic Amendments

Treatment	Mean Fruit Weight (g)	Grouping
T1 – Control (Water Only + RRF)	0.2300	a
T2 – 15g Baking Soda + RRF	0.2733	a
T3 – 15g Brown Sugar + RRF	0.2800	a
T4 – 15g White Vinegar + RRF	0.2633	a
T5 – 15g Baking Soda + 15g Brown Sugar + RRF	0.3600	a
T6 – 15g Baking Soda + 15g White Vinegar + RRF	0.2800	a
T7 – 15g Brown Sugar + 15g White Vinegar + RRF	0.3433	a
Over-all Mean	0.2900	

ns = not significant. CV = 18.39%. Means within a column sharing the same letter are not significantly different.

Numerically, T5 recorded the heaviest fruits (0.36 g) and T1 the lightest (0.23 g). The absence of significant differences suggests that the tested amendments influenced yield predominantly through fruit number rather than individual fruit size, possibly due to high environmental variability within the containerized system (CV = 18.39%). The high coefficient of variation reflects inherent variability in containerized production, where localized differences in root volume, moisture distribution, and nutrient concentration can substantially affect fruit development independently of amendment effects (Lebaka, 2023). These numerical trends nonetheless align with reports that sugar-based bio-stimulants can improve fruit filling through enhanced source–sink relationships (Hasan et al., 2021), and should be investigated in larger, more controlled trials.

Total Fruit Yield

Total fruit yield per treatment showed no statistically significant differences ($F(6,14) = 0.47$, $p = 0.8217$, ns; CV = 63.87%; Table 4).

Table 4. Mean Total Yield (kg) of Green Chili as Influenced by Different Organic Amendments

Treatment	Mean Total Yield (kg)	Grouping
T1 – Control (Water Only + RRF)	0.3267	a
T2 – 15g Baking Soda + RRF	0.4233	a
T3 – 15g Brown Sugar + RRF	0.4333	a
T4 – 15g White Vinegar + RRF	0.3933	a
T5 – 15g Baking Soda + 15g Brown Sugar + RRF	0.6867	a
T6 – 15g Baking Soda + 15g White Vinegar + RRF	0.4433	a
T7 – 15g Brown Sugar + 15g White Vinegar + RRF	0.5367	a
Over-all Mean	0.4900	

ns = not significant. CV = 63.87%. Means within a column sharing the same letter are not significantly different.

Despite the lack of statistical significance, T5 produced the highest numerical yield (0.6867 kg), which was 110% higher than the control (0.3267 kg)—a practically meaningful difference for smallholder farmers. The extremely high CV (63.87%) reflects substantial yield variability across replications, which reduced statistical power and obscured true treatment differences. This pattern of high variability is common in small-scale containerized chili trials and underscores the need for larger sample sizes and more uniform experimental conditions in future studies (Gomez & Gomez, 1984). The consistent numerical superiority of combination treatments (T5, T7) suggests real agronomic potential that warrants validation in field-scale or replicated greenhouse experiments.

Disease Incidence

Treatment significantly affected disease incidence ($F(6,14) = 4.80$, $p = 0.0074$; CV = 44.99%; Table 5).

Table 5. Mean Disease Incidence (%) of Green Chili as Influenced by Different Organic Amendments

Treatment	Mean Disease Incidence (%)	Grouping
T1 – Control (Water Only + RRF)	6.25	c
T2 – 15g Baking Soda + RRF	3.33	b
T3 – 15g Brown Sugar + RRF	7.00	d
T4 – 15g White Vinegar + RRF	4.42	b
T5 – 15g Baking Soda + 15g Brown Sugar + RRF	0.67	a
T6 – 15g Baking Soda + 15g White Vinegar + RRF	2.92	b
T7 – 15g Brown Sugar + 15g White Vinegar + RRF	2.50	b
Over-all Mean	3.87	

Means followed by a common letter are not significantly different at 5% level (Tukey's HSD). CV = 44.99%.

T5 recorded the lowest disease incidence (0.67%; group a), representing an 89% reduction relative to the control (6.25%). Treatments T2, T4, T6, and T7 exhibited intermediate incidence (2.50–4.42%; group b). Notably, T3 (brown sugar alone, 7.00%; group d) exhibited the highest incidence, significantly exceeding even the control. This result indicates that brown sugar applied without a disease-suppressive co-amendment can inadvertently promote pathogen proliferation by stimulating microbial activity broadly, including pathogenic microorganisms, under the warm, humid conditions of the study site (Shah et al., 2022).

The superior disease suppression of T5 reflects the synergistic interaction between baking soda's antifungal mechanism—elevation of leaf surface pH inhibiting spore germination and disrupting fungal cell walls (Liu et al., 2021; Guo et al., 2019)—and brown sugar's capacity to stimulate beneficial microbiota that compete with and suppress soil-borne pathogens (Shah et al., 2022). This synergism parallels findings by Abdelaziz and Al-Khayri (2023) and Singh and Yadav (2024), who reported similarly enhanced disease suppression with combined organic applications in pepper and chili, respectively. The moderate disease reduction observed in vinegar-containing treatments (T4, T6, T7) is consistent with the antimicrobial properties of acetic acid at low concentrations (Radwan & Salama, 2006; Lopez et al., 2021), though efficacy appears limited without a complementary antifungal agent.

CONCLUSION

This study demonstrates that the foliar application of a combination of 15g baking soda and 15g brown sugar per gallon of water, alongside the recommended fertilizer rate, is the most effective organic amendment strategy for green chili production among the treatments evaluated. T5 significantly improved plant height (78.57 cm) and fruit number (56.22 fruits/plant), and achieved the strongest disease suppression (0.67% incidence; 89% reduction over the control). While fruit weight and total yield did not reach statistical significance—likely due to high environmental variability in containerized conditions—T5 consistently produced the highest numerical values, representing a practical 110% yield advantage over the untreated control.

These results highlight a critical management implication: brown sugar should not be used as a sole amendment, as it can exacerbate disease incidence. Its application must be paired with an antifungal agent such as baking soda to realize growth-promoting benefits without increasing disease risk. The synergistic combination of baking soda (antifungal, pH modulator) and brown sugar (bio-stimulant, microbial promoter) constitutes a low-cost, environmentally friendly, and practically accessible strategy for sustainable chili production, with particular relevance for smallholder farmers in the Philippines seeking to reduce reliance on synthetic agrochemicals.

Future research should investigate optimum application rates and frequencies for baking soda and brown sugar combinations, evaluate long-term effects on soil health and pathogen resistance development, and validate these findings under field-scale conditions and across diverse agroecological zones.

ACKNOWLEDGMENTS

The author expresses sincere gratitude to Dr. Jesusa D. Ortuoste, thesis adviser, for scholarly guidance and mentorship; to the members of the Advisory Committee, Dr. Junito P. Marcelino and Dr. Marissa C. Hitalia, for their insightful recommendations; and to Dr. Allan Jay S. Cajandig, statistician, for assistance with data analysis. The author also thanks Dr. Adrian V. Protacio for editorial review and Sultan Kudarat State University Graduate School for institutional support.

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