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SYNERGISTIC BANANA PSEUDOSTEM COMPOST AND MKP ENHANCE ROSE TOMATO PRODUCTIVITY

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ABSTRACT

Integrating recycled organic amendments with rapidly available mineral nutrients may improve tomato productivity while valorizing agricultural residues. This study evaluated banana pseudostem compost (BPC) and monopotassium phosphate (MKP), individually and in combination, on the growth, yield, and fruit soluble solids of Mawar (rose) tomato (Solanum lycopersicum L.). A 3 x 3 factorial randomized complete block design with three replications was used. BPC was applied at 0, 1, and 2 kg plant-1 (K0, K1, K2), while MKP was applied at 0, 2, and 3 g plant-1 (M0, M1, M2). Plant height, stem diameter, branch number, flowering age, fruit number, fruit weight, and total soluble solids (degrees Brix) were analyzed by factorial ANOVA followed by Duncan's Multiple Range Test at 5%. BPC significantly improved plant height and stem diameter at 2-8 weeks after planting (WAP), branches at 4 WAP, fruit number, fruit weight, and degrees Brix. MKP significantly increased plant height at 2-8 WAP, stem diameter at 2 and 6 WAP, fruit number, fruit weight, and degrees Brix. The BPC x MKP interaction was significant for plant height at 6 WAP and fruit weight per plant. K2M2 produced the greatest 6-WAP height (54.22 cm) and fruit weight (104.56 g plant-1). These results indicate a trait-specific synergy between compost-based residue recycling and targeted P-K nutrition for rose tomato production.

Keywords: banana pseudostem compost; monopotassium phosphate; integrated nutrient management; rose tomato; soluble solids.

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INTRODUCTION

Tomato (*Solanum lycopersicum L.*) is an economically important horticultural crop whose productivity and market value depend on both yield formation and fruit quality. In North Sumatra, tomato production reached approximately 203,868 t in 2023, emphasizing the relevance of efficient nutrient management for regional production systems (Badan Pusat Statistik Provinsi Sumatera Utara, 2024). The Mawar (rose) tomato is particularly attractive for fresh-market use because of its distinctive ribbed fruit morphology. Genetic work involving Mawar-derived tomato material has also demonstrated substantial variation in plant height, branching, flowering, fruit number, fruit weight, and total production, indicating that this genetic background is responsive to agronomic management (Farid et al., 2024). Recent horticultural experiments published in ALGEBRA likewise show that crop growth and yield components can respond selectively to combinations of growth-regulating and nutrient-related inputs, including cherry tomato and beet (Azhari et al., 2025; Hasibuan et al., 2024).

Nutrient supply is a central constraint in tomato cultivation, but reliance on mineral fertilizer alone can increase production costs and does not address the accumulation of locally available organic residues. Banana cultivation generates bulky pseudostem residues after harvest. Composting converts this material into a reusable soil amendment and reduces the volume of organic waste. Meilani and Susyani (2021) showed that banana pseudostem can be converted into compost containing agronomically relevant organic matter and nutrients, although the final composition depends on the composting materials and process. La Kilo et al. (2023) further demonstrated that fertilizer derived partly from banana stem waste supplied N, P, and K and supported tomato growth. Positive crop responses to banana-stem-based organic inputs have also been reported in sweet corn and tomato production systems (Maulida et al., 2022; Rahma & Andri, 2025). These studies support the use of banana pseudostem as a circular nutrient resource, but organic amendments alone may release nutrients too gradually or inconsistently to match peak tomato demand during reproductive development.

Monopotassium phosphate (MKP) provides a highly soluble source of phosphorus and potassium, two nutrients closely associated with root function, reproductive development, assimilate transport, water regulation, and fruit quality. Potassium fertilization during tomato fruit development can alter soluble sugars, vitamin C, K uptake, and resource-use efficiency (Liu et al., 2021), while cultivar-specific responses of fruit quality to potassium management have also been documented (Vasileva & Dinev, 2021). Under Indonesian conditions, MKP has improved several tomato yield components when combined with other nutrient sources (Fabregas et al., 2025; Tinata & Astuti, 2024), and foliar MKP has affected growth and production traits in chili (Setyadi & Fanata, 2024). These findings suggest that a readily available P-K source could complement the slower nutrient release and soil-conditioning functions of compost.

The agronomic rationale for combining organic and inorganic nutrient sources is supported by a broader body of evidence. Integrated fertilizer programs have increased tomato growth and yield compared with single-source nutrient strategies in several environments (Adekiya et al., 2022; Ahmed et al., 2022; Ramesh et al., 2023; Shamita et al., 2022). A global meta-analysis found that organic-inorganic combinations generally improved tomato yield and several morphological traits relative to inorganic fertilizer alone, although responses depended on environment, soil condition, and input type (Yang et al., 2023). In Indonesia, combined organic and mineral fertilization has similarly produced trait-specific responses in tomato (Sendy et al., 2024). Thus, integration is not automatically synergistic for every parameter; the interaction must be tested experimentally.

A clear gap remains because previous studies have mostly evaluated banana-derived organic fertilizers without MKP, MKP with other organic amendments, or fertilizer responses in tomato cultivars other than Mawar. Evidence is especially limited on whether banana pseudostem compost and MKP interact to improve both vegetative growth and fruit traits, including total soluble solids. The novelty of the present study is therefore the simultaneous evaluation of a recycled banana-pseudostem amendment and a targeted soluble P-K fertilizer in a factorial design for Mawar tomato, linking circular residue use with yield and fruit-quality indicators. The study aimed to determine (1) the main effect of banana pseudostem compost, (2) the main effect of MKP, and (3) their interaction on tomato growth, flowering, yield, and degrees Brix. It was hypothesized that increasing BPC and MKP rates would improve growth and production, and that the combined treatment would generate a positive interaction for selected performance traits.

RESEARCH METHODS

The experiment was conducted from February to May 2026 at Perumnas Mandala, Percut Sei Tuan District, Deli Serdang Regency, North Sumatra, Indonesia. Mawar tomato was grown in 40 cm x 50 cm polybags filled with cleaned topsoil. The experiment used a factorial randomized complete block design (RCBD) with two treatment factors and three replications.

Factor A was banana pseudostem compost (BPC): K0 = 0 kg plant-1 (control), K1 = 1 kg plant-1, and K2 = 2 kg plant-1. Factor B was monopotassium phosphate (MKP): M0 = 0 g plant-1 (control), M1 = 2 g plant-1, and M2 = 3 g plant-1. The factorial arrangement generated nine combinations (K0M0, K0M1, K0M2, K1M0, K1M1, K1M2, K2M0, K2M1, and K2M2). There were 27 experimental plots, four plants per plot, and three sampled plants per plot, giving 108 plants in total and 81 sampled plants. Plot size was 90 cm x 100 cm, with 50 cm between plots and 100 cm between blocks.

Banana pseudostem compost was produced using the procedure described in the thesis protocol. Pseudostem material was chopped and sun-dried, mixed with manure, rice bran, and lignocellulosic bulking material, then inoculated with activated EM-4 solution containing brown sugar. The mixture was composted under a covered condition for approximately 1.5 months until it developed an earthy odor and lower moisture content. The assigned compost dose was incorporated into the planting medium one week before transplanting. MKP was dissolved in water at the treatment-specific dose and applied as a soil drench around the root zone when the plants entered the generative phase, approximately 30 days after transplanting.

Seedlings were raised in small polybags under protection from direct sunlight for approximately two weeks until they developed three to four young leaves, then transplanted in the afternoon. Plants were supported with stakes and maintained by regular irrigation, weed control, and pest management when required. Harvesting was performed progressively when fruits reached physiological maturity, indicated by the characteristic transition from green to bright red.

Plant height (cm) was measured from the stem base at the medium surface to the highest growing point at 2, 4, 6, and 8 weeks after planting (WAP). Stem diameter (mm) was measured with a caliper approximately 5 cm above the medium surface at the same observation times. Productive lateral branches were counted, and flowering age (days) was recorded when approximately 75% of plants within a plot had flowered. Fruit number per plant was the cumulative number of fruits harvested from each sample plant. Fruit weight per plant (g) was obtained by summing fruit mass across harvests. Total soluble solids were measured from tomato juice using a refractometer and reported as degrees Brix; refractometry is a widely used approach for quantifying soluble solids in fruit and food matrices (Jaywant et al., 2022).

Data were analyzed using factorial analysis of variance according to the RCBD model Yijk = mu + rhoi + alphaj + betak + (alphabeta)jk + epsilonijk, where rhoi represents block effects, alphaj represents BPC effects, betak represents MKP effects, and (alphabeta)jk represents the interaction. When the F test indicated a significant treatment effect, means were separated using Duncan's Multiple Range Test (DMRT) at alpha = 0.05. The statistical interpretation in this article follows the superscript/grouping letters in the original DMRT tables: means carrying different letters within the same factor and observation time were treated as significantly different.

RESULTS AND DISCUSSION

Banana pseudostem compost significantly affected plant height at every observation from 2 to 8 WAP (Table 1). K2 produced the greatest mean height at each observation, reaching 50.67 cm at 6 WAP and 99.96 cm at 8 WAP. MKP also significantly affected height at all observation times; M2 reached 51.19 cm at 6 WAP and 99.33 cm at 8 WAP. The BPC x MKP interaction was significant only at 6 WAP. At that stage, K2M2 produced 54.22 cm and was significantly greater than the other interaction means, including K2M1 (51.00 cm). The response demonstrates that the combined treatment accelerated mid-season canopy development, but the interaction was not sustained as a statistically detectable effect at 8 WAP.

The consistent height response to K2 is compatible with the role of compost as a source of organic matter and slowly released nutrients. Banana-stem-based amendments have previously supported tomato growth (La Kilo et al., 2023; Maulida et al., 2022), while composting can improve the reuse value of banana pseudostem residues (Meilani & Susyani, 2021). The response to MKP is also plausible because phosphorus supports energy metabolism and root activity, whereas potassium regulates water relations and assimilate movement. However, the present experiment did not quantify

soil nutrient availability or plant tissue nutrient status; therefore, these mechanisms should be regarded as agronomic interpretations rather than directly measured causal pathways.

Table 1. Main effects of banana pseudostem compost and MKP on plant height

Factor	Level	2 WAP (cm)	4 WAP (cm)	6 WAP (cm)	8 WAP (cm)
BPC	K0	11.00 b	27.93 b	48.33 b	97.81 b
	K1	11.48 b	28.30 b	49.19 b	98.26 b
	K2	12.70 a	29.67 a	50.67 a	99.96 a
MKP	M0	10.81 c	27.67 b	47.70 c	97.81 b
	M1	11.74 b	28.67 a	49.30 b	98.89 a
	M2	12.63 a	29.56 a	51.19 a	99.33 a

Within each factor and observation time, means followed by different letters differ significantly by DMRT at $p < 0.05$. BPC = banana pseudostem compost; MKP = monopotassium phosphate; WAP = weeks after planting.

Stem diameter responded more selectively than plant height (Table 2). BPC significantly increased stem diameter at 2, 4, 6, and 8 WAP, with K2 consistently producing the largest values. MKP significantly affected stem diameter at 2 and 6 WAP but not at 4 or 8 WAP. Branch number showed an even narrower response: BPC was significant at 4 WAP, when K2 produced 3.52 branches compared with 3.07 under K0, whereas MKP and the interaction were not significant. This trait specificity is consistent with reports showing that fertilizer effects can vary by developmental stage and morphological endpoint rather than producing uniform responses across all variables (Azhari et al., 2025; Kusumawati et al., 2022).

The absence of an MKP effect on late stem diameter and branch number is agronomically important. Nutrient inputs may shift carbon allocation toward reproductive sinks once fruit set begins, so a treatment that increases yield does not necessarily continue to increase all vegetative traits. Similar non-uniform responses have been reported when potassium-containing fertilizers or combined nutrient sources were applied to tomato and related horticultural crops (Setyadi & Fanata, 2024; Sihombing et al., 2023). The results therefore support evaluation of yield and quality traits alongside vegetative growth rather than using plant size alone as a proxy for productivity.

Table 2. Main effects on stem diameter and branch number

Factor	Level	Stem 2 WAP	Stem 4 WAP	Stem 6 WAP	Stem 8 WAP	Branches 4 WAP
BPC	K0	2.30 b	4.70 b	5.78 b	6.90 b	3.07 c
	K1	2.28 b	4.73 b	5.95 ab	6.94 b	3.30 b
	K2	2.70 a	4.90 a	6.07 a	7.31 a	3.52 a
MKP	M0	2.22 b	4.47	5.83 b	6.89	3.11
	M1	2.36 b	4.77	5.90 ab	7.11	3.37
	M2	2.69 a	4.82	6.07 a	7.16	3.41

Stem diameter is expressed in mm. Means with different letters within the same factor and observation time differ significantly by DMRT at $p < 0.05$. Values without letters were not significantly different for that factor/time.

Yield and fruit-quality responses were stronger than the response of flowering age (Table 3). BPC significantly increased fruit weight and fruit number. K2 produced 92.56 g fruit plant-1, 19.1% more than K0 (77.74 g), and 3.74 fruits plant-1 compared with 2.93 under K0. MKP produced a clearer dose response: M2 reached 94.78 g fruit plant-1, 27.0% above M0, and 3.93 fruits plant-1 compared with 2.70 under M0. Flowering age remained statistically unchanged by BPC, MKP, and their interaction, indicating that the yield advantage was not simply the result of earlier flowering.

The positive BPC effect on fruit production aligns with studies in which banana-derived organic inputs or compost-amended media increased tomato growth and yield components (La Kilo et al., 2023; Maulida et al., 2022). In another crop, banana stem compost also improved yield-related variables, demonstrating that the residue can function as an agronomic amendment beyond waste disposal (Rahma & Andri, 2025). The significant MKP main effect agrees with Fabregas et al. (2025), who reported improved tomato yield components after MKP application, and with Tinata and Astuti (2024), who found significant tomato growth and yield responses to MKP. Potassium-based nutrient management has also been associated with fruit yield and quality responses in tomato (Liu et al., 2021; Vasileva & Dinev, 2021).

Total soluble solids also responded to both nutrient sources. K2 produced 4.41 degrees Brix compared with 3.96 under K0, while M2 produced 4.51 degrees Brix compared with 3.67 under M0. The respective increases were approximately 11.4% and 22.9%. The BPC x MKP interaction for

degrees Brix was not significant even though K2M2 had the highest raw mean (5.00 degrees Brix). Consequently, the 5.00 value should not be interpreted as statistically superior to the other combinations. This distinction is important because fruit-quality traits often show high biological variation, and potassium effects can depend on cultivar and nutrient balance (Liu et al., 2021; Vasileva & Dinev, 2021).

Table 3. Main effects on flowering, yield, and fruit soluble solids

Factor	Level	Flowering (days)	Fruit weight (g plant-1)	Fruit number (plant-1)	Soluble solids (degrees Brix)
BPC	K0	59.00	77.74 b	2.93 b	3.96 b
	K1	59.89	81.85 b	3.11 b	3.89 b
	K2	59.11	92.56 a	3.74 a	4.41 a
MKP	M0	59.67	74.63 c	2.70 c	3.67 b
	M1	59.11	82.74 b	3.15 b	4.08 b
	M2	59.22	94.78 a	3.93 a	4.51 a

Means with different letters within the same factor and trait differ significantly by DMRT at p < 0.05. Flowering age was not significantly affected by BPC or MKP.

The most important interaction occurred for fruit weight per plant (Figure 1). K2M2 produced 104.56 g plant-1, compared with 68.00 g plant-1 under K0M0, an increase of approximately 53.8%. DMRT grouping showed that K2M2 (a) was not significantly different from K2M1 (ab), but it was significantly greater than treatments assigned only to groups b or c. This corrected interpretation is stricter than the narrative wording in the thesis and follows the actual DMRT letters. The interaction indicates that the highest compost rate combined with the highest MKP rate created a favorable nutrient context for fruit biomass accumulation, but the lack of interactions for fruit number and degrees Brix shows that the synergy was parameter-specific rather than universal.

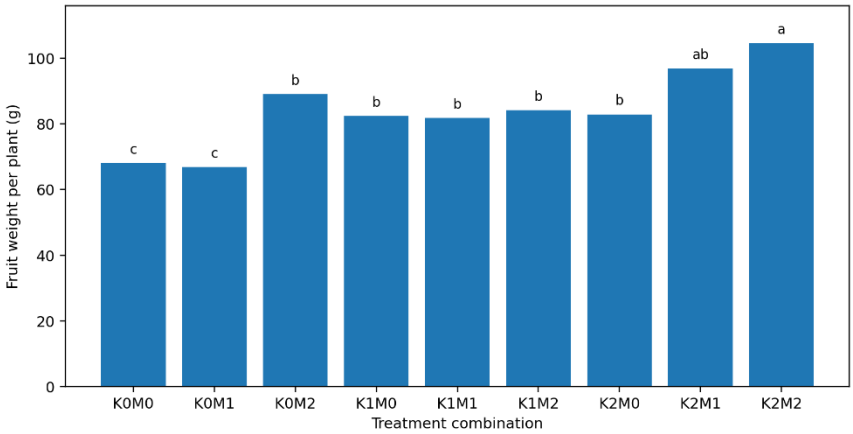


Figure 1. Fruit weight per plant across BPC x MKP treatment combinations. Different letters indicate significant differences by DMRT at p < 0.05.

This pattern is supported by the wider integrated-nutrient literature. Ahmed et al. (2022) reported improved tomato growth and fruit yield when bio-organic and chemical fertilizers were integrated. Adekiya et al. (2022) similarly found that combinations of organic and inorganic fertilizer affected tomato performance in soilless culture, and Ramesh et al. (2023) reported improvements in growth, yield, and postharvest quality under integrated nutrient management. At the global scale, Yang et al. (2023) found that organic-inorganic fertilizer combinations increased mean tomato yield and several morphological traits relative to inorganic fertilizer alone. The present study extends this concept to a locally available banana pseudostem compost and soluble P-K source in Mawar tomato.

The results also have a practical circularity implication. Banana pseudostem is normally discarded after bunch harvest, whereas composting can convert it into a soil amendment (Meilani & Susyani, 2021). Combining this recycled material with a small, targeted MKP input may reduce dependence on a single nutrient source while maintaining a rapid supply of P and K during the reproductive phase. Nevertheless, this experiment does not establish fertilizer replacement ratios or long-term soil benefits. The trial was conducted at one location and season, and the actual chemical composition and mineralization rate of the compost used in the experiment were not measured. Future work should quantify compost nutrient composition, soil P and K dynamics, leaf nutrient status, nutrient-use efficiency, and economic returns across seasons before broad fertilizer recommendations are made.

Overall, the findings show a useful distinction between main effects and interaction effects. BPC independently improved multiple growth, yield, and soluble-solids traits, while MKP independently strengthened height, yield, and degrees Brix. Their combination generated statistically demonstrable synergy for 6-WAP plant height and fruit weight per plant, not for every measured parameter. This trait-specific pattern is consistent with the principle that integrated nutrient management should be optimized for target outcomes rather than assumed to produce universal additive benefits (Shamita et al., 2022; Sendy et al., 2024; Yang et al., 2023).

CONCLUSIONS

Banana pseudostem compost and MKP improved Mawar tomato performance, but their effects differed among traits and growth stages. Applying 2 kg BPC plant-1 (K2) significantly increased plant height and stem diameter at 2-8 WAP, branch number at 4 WAP, fruit number, fruit weight, and total soluble solids. Applying 3 g MKP plant-1 (M2) significantly increased plant height at 2-8 WAP, stem diameter at 2 and 6 WAP, fruit number, fruit weight, and total soluble solids. The BPC x MKP interaction was significant for plant height at 6 WAP and fruit weight per plant. K2M2 produced the greatest 6-WAP plant height (54.22 cm) and the highest fruit weight (104.56 g plant-1). Flowering age was unaffected, and interaction effects were not significant for stem diameter, branch number, fruit number, or degrees Brix. These results support a circular nutrient-management strategy that combines recycled banana pseudostem compost with targeted P-K fertilization, while also showing that the benefit is trait-specific. Multi-season validation with soil and tissue nutrient measurements is required before defining a general fertilizer recommendation.

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