DINAMIKA PERTANIAN
p-ISSN : 0215-2525, e-ISSN: 2549-7960
Accredited: Sinta 4
Publisher: Uir Press, Website: https://journal.uir.ac.id/index.php/dinamikapertanian
Vol. 42, No.2 (2026)

Respons Pertumbuhan Sambung Pucuk Mangga (*Mangifera indica* L.) terhadap Kombinasi Pupuk NPK 16-16-16 dan ZPT Atonik

Growth Response of Top-Grafted Mango (*Mangifera indica* L.) Seedlings to Combined NPK 16-16-16 Fertilizer and Atonik Plant Growth Regulator

M. Fikri, Sulhaswardi*, Putri Lukmanasari, Siti Yuli Meilanda Sormin

Department of Agrotechnology, Faculty of Agriculture, Universitas Islam Riau, Pekanbaru, 28284, Indonesia
*Email : sulhaswardi@agr.uir.ac.id

Received: 09 July 2026 | Revised: 31 July 2026 | Accepted: 30 August 2026

ABSTRACT

Background: Top grafting is an effective method for producing uniform and vigorous mango (*Mangifera indica* L.) seedlings, but successful graft establishment and subsequent growth depend on adequate nutrient and hormonal support. NPK 16-16-16 provides essential macronutrients for vegetative growth, while Atonik plant growth regulator (PGR) may stimulate physiological processes involved in graft establishment and shoot development. **Objective:** This study evaluated the interaction and individual effects of NPK 16-16-16 fertilizer and Atonik plant growth regulator (PGR) on the growth of top-grafted mango seedlings. **Methods:** The experiment used a 4 x 4 factorial Completely Randomized Design with three replications, comprising NPK 16-16-16 at 0, 2.5, 5, and 7.5 g polybag^{-1} and Atonik PGR at 0, 50, 100, and 150 ppm. Grafting success rate, days to bud break, scion height, scion diameter, leaf number, shoot number, and shoot height were analyzed using ANOVA followed by Tukey's HSD test at the 5% significance level. **Results:** NPK 16-16-16 x Atonik interaction significantly affected days to bud break, scion height, scion diameter, leaf number, and shoot height, but not grafting success rate or shoot number. The N3A3 combination (7.5 g polybag^{-1} NPK 16-16-16 + 150 ppm Atonik) produced the fastest bud break (28.00 days) and the greatest scion height (33.17 cm), scion diameter (6.27 mm), leaf number (16.67), and shoot height (27.17 cm). **Conclusions:** The combination of 7.5 g polybag^{-1} NPK 16-16-16 and 150 ppm Atonik is recommended to enhance the growth of top-grafted mango seedlings.

***Keywords*:** *Atonik PGR; mango seedlings; NPK 16-16-16; top grafting*

ABSTRAK

Pendahuluan: Sambung pucuk merupakan metode efektif untuk menghasilkan bibit mangga (*Mangifera indica* L.) yang seragam dan vigor, tetapi keberhasilan penyambungan dan pertumbuhan selanjutnya dipengaruhi oleh kecukupan nutrisi dan dukungan hormonal. Pupuk NPK 16-16-16 menyediakan unsur hara makro yang diperlukan untuk pertumbuhan vegetatif, sedangkan ZPT Atonik dapat merangsang proses fisiologis yang mendukung keberhasilan penyambungan dan perkembangan tunas. **Tujuan**: Penelitian ini bertujuan mengevaluasi pengaruh interaksi dan pengaruh utama pupuk NPK 16-16-16 dan ZPT Atonik terhadap pertumbuhan bibit sambung pucuk mangga. **Metode**: Penelitian menggunakan Rancangan Acak Lengkap faktorial 4 × 4 dengan tiga ulangan, terdiri atas dosis NPK 16-16-16 sebesar 0; 2,5; 5; dan 7,5 g/polybag serta konsentrasi ZPT Atonik sebesar 0; 50; 100; dan 150 ppm. Parameter meliputi persentase tumbuh, umur pecah tunas, tinggi batang atas, diameter entres, jumlah daun, jumlah tunas, dan tinggi tunas, yang dianalisis menggunakan ANOVA dan uji BNJ 5%. **Hasil**: Interaksi NPK 16-16-16 dan ZPT Atonik berpengaruh nyata terhadap umur pecah tunas, tinggi batang atas, diameter entres, jumlah daun, dan tinggi tunas, tetapi tidak terhadap persentase tumbuh dan jumlah tunas. Kombinasi N3A3 (7,5 g/polybag NPK 16-16-16 + 150 ppm Atonik) menghasilkan pecah tunas tercepat (28,00 hari) serta tinggi batang atas (33,17 cm), diameter entres (6,27 mm), jumlah daun (16,67 helai), dan tinggi tunas (27,17 cm) tertinggi. **Kesimpulan**: Kombinasi NPK 16-16-16 7,5 g/polybag dan ZPT Atonik 150 ppm direkomendasikan untuk meningkatkan pertumbuhan bibit sambung pucuk mangga.

Kata kunci: *Bibit mangga; NPK 16-16-16; sambung pucuk; ZPT Atonik*

BACKGROUND

Mango (*Mangifera indica* L.) is a tropical fruit tree native to South Asia that has long been cultivated throughout Indonesia and is valued both for fresh consumption and processing (Syamsul et al., 2018). The fruit is nutritionally rich, providing carbohydrates, dietary fiber, vitamin A, vitamin C, and several essential minerals (Novia et al., 2015), and Indonesian mango orchards produce a wide range of varieties differing in shape, color, and fruit weight (Auditira, 2019).

National mango production reached 3,308.8 thousand tons in 2022 before declining to 3,302.6 thousand tons in 2023, a trend attributed to climatic variation, pest and disease pressure, and shifts in cultivation practice (Badan Pusat Statistik, 2023). A similar decline has occurred in Riau Province, where mango production fell from 19,737 tons in 2021 to 15,241 tons in 2022 and 14,093 tons in 2023 (Badan Pusat Statistik, 2023). Part of this decline is attributed to the continued use of seedlings that are not high-yielding or well adapted to local conditions, together with propagation methods that fail to consistently produce vigorous planting material (Badan Pusat Statistik, 2021).

Top grafting is a vegetative propagation technique performed while the rootstock is still young, joining a rootstock with strong, well-established roots to a scion (entres) taken from a superior mother plant (Ardana et al., 2022). Compared with propagation from seed, grafted seedlings retain the desirable characteristics of the mother plant and typically begin bearing fruit sooner (Jufran & Muhardi, 2019). The vigor of the rootstock strongly influences grafting success and subsequent seedling growth (Wahyudi et al., 2017), while the quality of the scion bud, taken from a healthy, pest-free branch, determines the uniformity and vigor of the resulting shoot (Maulana, 2023). Graft compatibility, along with hormonal factors, is also a major determinant of grafting success (Thalib, 2019).

Because grafted seedlings depend entirely on stored reserves and newly supplied nutrients until the graft union and new shoot are established, balanced fertilization is essential to support this process. NPK 16-16-16 is a compound fertilizer supplying nitrogen, phosphorus, and potassium in equal proportions together with small amounts of calcium and magnesium (Gumelar, 2017); nitrogen supports vegetative growth and chlorophyll formation, phosphorus promotes root development, and potassium activates enzymatic processes within the plant (Triastuti et al., 2016). In cacao seedlings, NPK 16-16-16 applied at 5 g polybag^{-1} has been reported to significantly improve seedling height, stem diameter, leaf area, and root growth (Nasrullah et al., 2015).

In addition to fertilization, plant growth regulators (PGRs) are commonly applied to support graft establishment. Auxin, the principal hormone involved in cell elongation, division, and differentiation, plays a central role in root initiation and shoot development following grafting (Khairuna, 2019). Atonik is a synthetic PGR containing sodium nitrophenolate compounds that act similarly to auxin at low concentrations, stimulating protoplasmic streaming within cells and accelerating germination and rooting (Cokrowati & Diniarti, 2019). Siregar (2018) reported that application of Atonik at 100 ppm gave the best graft success and growth of durian seedlings, while Jalaluddin (2023) found that Atonik at 3.0 mL L^{-1} significantly hastened bud emergence in cacao grafts, and Riswandi (2024) reported that a concentration of 150 ppm gave the best overall growth response in avocado top grafting.

Although the individual effects of NPK 16-16-16 and Atonik PGR on vegetative propagation have been documented for several crops, information on their combined, interactive effect on top-grafted mango seedlings remains limited. This study therefore evaluated the interaction and individual effects of NPK 16-16-16 fertilizer and Atonik PGR on the growth of top-grafted mango (*Mangifera indica* L.) seedlings.

METHODS

Study Site and Time

The experiment was conducted at the Air Dingin Experimental Garden, Faculty of Agriculture, Universitas Islam Riau, Pekanbaru, over six months from May to October 2025.

Materials and Equipment

The materials used were mango seeds (rootstock), scion wood (entres) of the Arum Manis variety, NPK 16-16-16 fertilizer, Atonik PGR, mineral soil, polybags, polyethylene (PE) plastic, plastic sungkup (grafting hoods), rice husk, distilled water, filter paper, zinc labels, paint, and a research banner. The equipment

used included a hoe, grafting shears, a grafting knife, a hand sprayer, a measuring cylinder, wooden stakes, nails, shade netting, wire, a scale, a watering can, and stationery.

Experimental Design

The experiment was arranged in a 4 x 4 factorial Completely Randomized Design (CRD) with three replications, giving 48 experimental units. The first factor was NPK 16-16-16 fertilizer (N), consisting of four dose levels: N0 = 0, N1 = 2.5, N2 = 5, and N3 = 7.5 g polybag^{-1}. The second factor was Atonik PGR (A), consisting of four concentration levels: A0 = 0, A1 = 50, A2 = 100, and A3 = 150 ppm. Sixteen treatment combinations resulted from crossing the two factors. Each experimental unit consisted of four plants, of which two were selected as observation samples, giving a total of 192 plants. Data from the two sample plants per experimental unit were averaged before statistical analysis, so that each experimental unit contributed one single value for each variable.

Rootstock and Scion Preparation

A plot measuring 4 x 8 m was cleared of weeds and debris and leveled before polybags were arranged, and a 50%-density shade net was installed at a height of 2 m over the plot. Two hundred fifty rootstock seedlings, raised from seed and ready for grafting at three months after sowing, were used, together with 250 scions of the Arum Manis mango variety obtained from Kuok, Kampar Regency, Riau. NPK 16-16-16 fertilizer and Atonik PGR were obtained from a local agricultural supply store on Jl. Kaharudin Nasution, Pekanbaru. Polybags (25 × 30 cm) were filled with a 2:1 mixture of mineral soil and burnt rice husk, arranged in rows with 30 × 30 cm spacing between polybags following the experimental layout, and labeled with painted zinc tags after the rootstocks were ready for grafting.

Grafting and Fertilizer Application

Top grafting was carried out between 07:00 and 09:00 local time. The rootstock was cut 25 cm above the growing point and split vertically to a depth of 2 cm. A 13 cm scion was wedge-cut on both sides of its base, inserted into the rootstock split, and secured with polyethylene wrapping tape from the bottom upward and back down. Grafted seedlings were covered with a plastic hood for 21-28 days and uncovered once the scion appeared green and fresh, marked by the emergence of new buds.

NPK 16-16-16 fertilizer was applied twice, in two equal half-doses: once before grafting, when the rootstock was 60 days old, and once one month after grafting, by broadcasting the fertilizer around the base of the plant. Atonik PGR was applied once, one week before grafting, by spraying the leaves and stem of the rootstock seedlings until wet.

Maintenance

Watering was carried out every morning and afternoon using a watering can, except on rainy days when the polybag substrate remained sufficiently moist. Weeding was performed manually at 14-day intervals throughout the study. Pest and disease control combined preventive sanitation with curative chemical spraying; root rot caused by *Phytophthora* sp., observed as wilting at 60 days after grafting (DAG), was controlled using Antracol 70 WP fungicide at 2 g L^{-1} applied every two weeks. The plastic hood was removed once new shoots emerged from the scion, at 28 DAG, followed by regular removal of water sprouts from the rootstock.

Observation Variables

Grafting success rate (%) was assessed once, at 28 DAG, as the proportion of grafts showing new bud emergence; grafts with browning stems and leaves were scored as dead. Days to bud break were recorded from 28 DAG at 14-day intervals until 90 DAG, a graft being scored as having broken bud once the emerging shoot showed young, not-yet-fully-expanded leaves. Scion height was measured from the graft union to the growing point using a ruler at 14-day intervals from 28 to 90 DAG. Scion diameter was measured 2 mm above the graft union using a digital caliper at 90 DAG. Leaf number was counted as the number of fully expanded leaves on the scion at 90 DAG. Shoot number was counted as the total number of shoots emerging from leaf axils, recorded at 14-day intervals from 28 to 90 DAG. Shoot height was measured from the leaf axil to the growing point using a ruler at 14-day intervals from 28 to 90 DAG.

Statistical Analysis

Data were analyzed using analysis of variance (ANOVA). When the calculated F value exceeded the table F value, means were

compared using Tukey's Honestly Significant Difference (HSD) test at the 5% significance level.

RESULTS AND DISCUSSION

Grafting Success Rate

Analysis of variance showed that the interaction between NPK 16-16-16 and Atonik PGR did not significantly affect grafting success rate. However, the individual effects of both NPK 16-16-16 and Atonik PGR were significant (Table 1).

The main effect of NPK 16-16-16 at 7.5 g polybag-1 (N3) gave the highest mean grafting success rate (97.92%), not significantly different from N2 and N1 but significantly higher than the unfertilized control. Fertilization with a balanced supply of N, P, and K supports graft survival by ensuring the scion and rootstock have adequate nutrients to sustain the healing process during union formation, in line with the roles of nitrogen, phosphorus, and potassium in supporting vegetative growth and enzymatic activity in newly grafted tissue (Hardjowigeno, 2025; Ulpah, 2025).

Table 1. Mean grafting success rate of mango seedlings under NPK 16-16-16 and Atonik PGR treatments (%).

NPK 16-16-16 (g polybag^{-1})	A0 (0)	A1 (50)	A2 (100)	A3 (150)	Mean
N0 (0)	66.67	75.00	83.33	91.67	79.17b
N1 (2.5)	75.00	100.00	100.00	100.00	93.75a
N2 (5)	83.33	100.00	100.00	100.00	95.83a
N3 (7.5)	91.67	100.00	100.00	100.00	97.92a
Mean	79.17b	93.75a	95.83a	97.92a	

* Values in the Mean row and Mean column followed by the same lowercase letter are not significantly different at the 5% HSD level

The main effect of Atonik PGR at 150 ppm (A3) also produced the highest mean grafting success rate (97.92%), significantly higher than the unfertilized control but not significantly different from A2 and A1. This success rate was higher than the 93.33% reported by Supriyanto and Yulianto (2022) for avocado top grafting treated with auxin PGR, and is consistent with Pakpahan et al. (2018), who reported that Atonik, as an auxin-type PGR, induces cell elongation, apical dominance, and rooting initiation, thereby improving graft survival. Environmental factors such as temperature and humidity also influence graft survival; excessively low humidity causes desiccation and death of the graft, while excessively high humidity favors fungal and bacterial infection (Noval et al., 2014).

Atonik contains sodium nitrophenolate compounds which act as a biostimulant, influencing cell membrane permeability and enhancing the plant's physiological efficiency, rather than directly substituting potassium in stomatal regulation (Alfira, 2020). Root development, which is essential for nutrient uptake and overall graft survival, is also promoted by auxin-type PGRs (Derlina & Hafnati, 2016). In addition to hormonal and nutrient effects, compatibility between scion and rootstock strongly determines graft survival and subsequent growth; in compatible grafts, cambial lignification helps unite adjoining cells beyond the graft interface itself (Pardede, 2017).

Days to Bud Break

Analysis of variance showed that both the interaction between NPK 16-16-16 and Atonik PGR, and the individual effects of each treatment, significantly affected days to bud break. Mean values are presented in Table 2.

The fastest bud break was obtained from the combination of 7.5 g polybag^{-1} NPK 16-16-16 and 150 ppm Atonik PGR (N3A3), at 28.00 days, not significantly different from N3A2, N3A1, N3A0, N2A3, N2A2, N2A0, N1A2, and N1A1, but significantly faster than the remaining treatments. The slowest bud break occurred in the unfertilized control (N0A0), at 32.33 days.

The faster bud break under N3A3 reflects the combined contribution of Atonik PGR and NPK 16-16-16 to scion establishment. Growth regulators and endogenous plant hormones are produced naturally within plant tissue and mainly influence developmental timing rather than nutrient supply, whereas NPK

16-16-16 supplies the macronutrients required to support the metabolic activity underlying bud emergence. Atonik is a synthetic biostimulant containing sodium nitrophenolate, which at low concentrations exhibits auxin-like activity. This activity promotes cell elongation and division, thereby supporting graft growth when combined with endogenous plant hormones (Siregar, 2018).

Table 2. Mean days to bud break of mango seedlings under NPK 16-16-16 and Atonik PGR treatments (days).

NPK 16-16-16 (g polybag^{-1})	A0 (0)	A1 (50)	A2 (100)	A3 (150)	Mean
N0 (0)	32.33g	31.66fg	31.00efg	30.33def	31.33c
N1 (2.5)	30.00cde	29.33a-d	29.00a-d	29.67b-e	29.50b
N2 (5)	29.00a-d	29.67b-e	29.00a-d	28.33ab	29.00b
N3 (7.5)	28.67abc	28.67abc	28.33ab	28.00a	28.41a
Mean	30.00c	29.83bc	29.33ab	29.08a	

*Values followed by the same lowercase letter are not significantly different at the 5% HSD level

Application of Atonik PGR at 150 ppm is presumed to have accelerated scion establishment, consistent with Khadijah (2021), who reported that PGR application at an appropriate concentration promotes plant growth, whereas excessive concentrations can inhibit or even kill the plant; PGR application is generally most beneficial during the first two months of active growth. NPK 16-16-16 fertilization also contributed to faster bud break when combined with Atonik PGR, because the compound fertilizer supplies both macronutrients (N, P, K) and smaller amounts of secondary nutrients (Ca, Mg) that help maintain balanced nutrient uptake during early graft establishment (Intan, 2025). Phosphorus specifically stimulates root development and supports the plant's transition toward reproductive and vegetative growth stages, while potassium contributes to protein and carbohydrate formation and strengthens the plant against pest and disease pressure (Sihombing, 2021).

Scion Height

Analysis of variance showed that both the interaction between NPK 16-16-16 and Atonik PGR, and the individual effects of each treatment, significantly affected scion height at 90 days after grafting (DAG). Mean values are presented in Table 3

Table 3. Mean scion height of mango seedlings at 90 DAG under NPK 16-16-16 and Atonik PGR treatments (cm).

NPK 16-16-16 (g polybag^{-1})	A0 (0)	A1 (50)	A2 (100)	A3 (150)	Mean
N0 (0)	13.05g	14.80fg	18.87ef	25.75bcd	18.12d
N1 (2.5)	20.78de	24.82cd	24.97cd	28.40abc	24.74c
N2 (5)	22.75de	25.58bcd	28.83abc	30.62ab	26.95b
N3 (7.5)	25.57bcd	28.67abc	31.55a	33.17a	29.74a
Mean	20.54d	23.46c	26.05b	29.48a	

Values followed by the same lowercase letter are not significantly different at the 5% HSD level

The tallest scions were obtained from the combination of 7.5 g polybag^{-1} NPK 16-16-16 and 150 ppm Atonik PGR (N3A3), at 33.17 cm, not significantly different from N3A2, N3A1, N2A3, N2A2, and N1A3, but significantly taller than the remaining treatments. The shortest scions occurred in the unfertilized control (N0A0), at 13.05 cm. The variation in scion height across the 28-90 DAG observation period is likely related to the fact that early scion growth was still influenced by the recovery process from grafting wounds, so the response to added nutrients such as NPK 16-16-16 and Atonik PGR was particularly sensitive during this stage; nitrogen in particular promotes shoot elongation.

Figure 1. Comparison of scion height of top-grafted mango seedlings at 90 DAG under (a) N0A0, (b) N1A1, (c) N2A2, and (d) N3A3.

Height increment reflects cell division activity in the apical meristem, beginning with shoot elongation followed by leaf and stem development. Shoot growth proceeds through cell division, elongation, and differentiation; the cell-division phase requires carbohydrate, whose principal structural component (glucose) depends on the supply of photosynthate, itself dependent on chlorophyll, which is in turn supported by nitrogen. Suseno (1974), as reviewed in Rosman *et al.* (2024), noted that photosynthate is preferentially allocated to new shoot growth rather than to stem thickening or root development, because active growth is concentrated at the shoot apex.

Scion Diameter

Analysis of variance showed that both the interaction between NPK 16-16-16 and Atonik PGR, and the individual effects of each treatment, significantly affected scion diameter at 90 DAG. Mean values are presented in Table 4.

Table 4. Mean scion diameter of mango seedlings at 90 DAG under NPK 16-16-16 and Atonik PGR treatments (mm).

NPK 16-16-16 (g polybag^{-1})	A0 (0)	A1 (50)	A2 (100)	A3 (150)	Mean
N0 (0)	5.52e	5.69de	5.77cd	5.83cd	5.70c
N1 (2.5)	5.78cd	5.79cd	5.81cd	5.92bcd	5.82b
N2 (5)	5.78cd	5.81cd	5.82cd	5.97bc	5.84b
N3 (7.5)	5.85cd	5.88cd	6.15ab	6.27a	6.04a
Mean	5.73c	5.79c	5.89b	5.99a	

Values followed by the same lowercase letter are not significantly different at the 5% HSD level.

The largest scion diameter was obtained from N3A3 (6.27 mm), not significantly different from N3A2, but significantly larger than the remaining treatments, while the smallest diameter occurred in the unfertilized control (N0A0), at 5.52 mm.

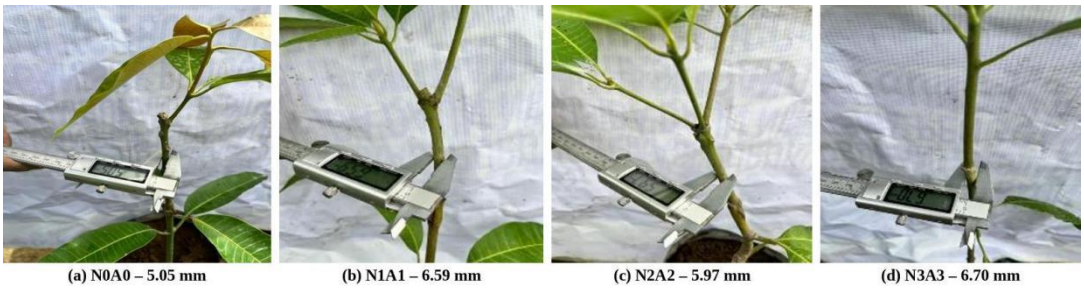

Figure 2. Comparison of scion diameter of top-grafted mango seedlings at 90 DAG under (a) N0A0, (b) N1A1, (c) N2A2, and (d) N3A3.

The larger diameter obtained under N3A3 is presumed to result from the nitrogen, phosphorus, and potassium supplied by NPK 16-16-16 promoting root elongation and expansion, thereby increasing the plant's capacity to absorb water and nutrients from the growing medium,

while Atonik PGR contains 2,4-dinitrophenolate, historically used as an herbicide at high concentration but functioning as an auxin-like compound at low concentration (Wiraatmaja, 2017). Auxin supports stem diameter growth, root development, and cell division (Rajiman, 2018).

The smallest scion diameter, recorded under the unfertilized control, reflects growth constrained to baseline physiological capacity in the absence of supplementary nutrients or PGR. Cytokinin, one of the active compounds attributed to Atonik, promotes cambial cell division and wound healing, thereby supporting shoot growth when applied at an appropriate dose (Perdanawan, 2022). Nitrogen supplied by NPK 16-16-16 additionally supports protein and chlorophyll synthesis, both of which underlie leaf and shoot development and, by extension, cambial activity driving diameter growth (Khadijah, 2021). Similarly, in cacao seedlings, balanced N, P, and K fertilization has been shown to support shoot diameter growth by promoting protein and carbohydrate synthesis and enhancing root development, which improves nutrient and water uptake (Jekinda, 2023).

Leaf Number

Analysis of variance showed that both the interaction between NPK 16-16-16 and Atonik PGR, and the individual effects of each treatment, significantly affected leaf number at 90 DAG. Mean values are presented in Table 5.

Table 5. Mean leaf number of mango seedlings at 90 DAG under NPK 16-16-16 and Atonik PGR treatments (leaves).

NPK 16-16-16 (g polybag^{-1})	A0 (0)	A1 (50)	A2 (100)	A3 (150)	Mean
N0 (0)	7.00e	7.83de	8.17cde	10.67b-e	8.42c
N1 (2.5)	7.50de	7.67de	9.17cde	11.33bcd	8.92bc
N2 (5)	9.33cde	10.67b-e	11.33bcd	13.00b	11.08b
N3 (7.5)	10.17b-e	10.83bc	13.33ab	16.67a	12.75a
Mean	8.50c	9.25c	10.50b	12.92a	

Values followed by the same lowercase letter are not significantly different at the 5% HSD level..

The greatest leaf number was obtained from N3A3 (16.67 leaves), not significantly different from N3A2, but significantly higher than the remaining treatments, while the lowest leaf number occurred in the unfertilized control (N0A0), at 7.00 leaves.

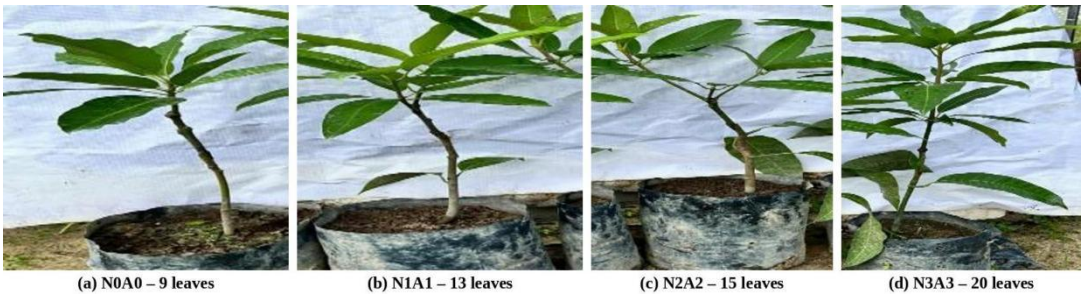

Figure 3. Comparison of leaf number of top-grafted mango seedlings at 90 DAG under (a) N0A0, (b) N1A1, (c) N2A2, and (d) N3A3.

The combination of NPK 16-16-16 and Atonik PGR appears to have accelerated the reorientation of the scion toward active shoot and leaf production. Musrini *et al.* (2020) noted that N, P, and K are essential nutrients strongly involved in vegetative growth, and that inappropriate fertilizer type, dose, timing, or application method can prevent plants from reaching their expected growth. Increasing shoot number tends to translate into a greater leaf number, since shoot formation is regulated primarily by auxin and cytokinin activity; when endogenous levels of these hormones are already favorable, they promote both cell division and differentiation, driving the formation of new shoots and leaves (Perdanawan, 2022).

The auxin supplied through Atonik PGR is understood to influence leaf number, growth rate,

and root differentiation and branching, and its most characteristic effect is promoting cell enlargement (Perdanawan, 2022). At an appropriate dose and concentration, PGR application supports plant growth, whereas excessive application can instead suppress it.

Shoot Number

Analysis of variance showed that the interaction between NPK 16-16-16 and Atonik PGR did not significantly affect shoot number. However, the individual effects of both NPK 16-16-16 and Atonik PGR were significant. Mean values are presented in Table 6.

Table 6. Mean shoot number (shoots) of mango seedlings under NPK 16-16-16 and Atonik PGR treatments.

NPK 16-16-16 (g polybag^{-1})	A0 (0)	A1 (50)	A2 (100)	A3 (150)	Mean
N0 (0)	0.50	0.66	1.00	1.50	0.92c
N1 (2.5)	1.16	1.50	1.50	2.16	1.58b
N2 (5)	1.50	1.83	2.16	2.66	2.04b
N3 (7.5)	1.83	2.16	3.00	3.33	2.58a
Mean	1.25c	1.54bc	1.92ab	2.42a	

*Values in the Mean row and Mean column followed by the same lowercase letter are not significantly different at the 5% HSD

The main effect of NPK 16-16-16 at 7.5 g polybag^{-1} (N3) gave the highest mean shoot number (2.58), significantly higher than the other NPK levels. Shoot formation depends on auxin to stimulate cell division and expansion, allowing the plant to generate new leaves; this auxin can be supplied through Atonik PGR application, while nitrogen from NPK 16-16-16 supports the accompanying vegetative growth.

Figure 4. Comparison of shoot number of top-grafted mango seedlings under (a) N0A0, (b) N1A1, (c) N2A2, and (d) N3A3

Atonik PGR contains both auxin and cytokinin, which together promote cell division and thereby increase shoot number. A greater shoot number generally translates into a correspondingly greater leaf number, consistent with Perdanawan (2022), who reported that shoot formation is influenced more strongly by auxin and cytokinin activity than by gibberellin; when endogenous auxin and cytokinin reach an optimal level, they accelerate cell division and differentiation, driving the formation of new shoots and leaves.

The main effect of Atonik PGR at 150 ppm (A3) gave the highest mean shoot number (2.42), not significantly different from A2 but significantly higher than the remaining concentrations, consistent with the role of nitrogen from NPK 16-16-16 in supporting shoot formation. Increasing the NPK 16-16-16 dose was accompanied by an increase in shoot number, reflecting the greater nutrient availability under higher fertilizer rates, in line with Benardi (2022), who noted that favorable growth requires the interacting factors influencing plant development to be balanced and within a concentration range the plant can tolerate.

Vegetative growth strongly determines a plant's subsequent development, making nitrogen supply a key factor for shoot growth and development. Kadekoh and Made (2024) reported that adequate nitrogen improves

vegetative growth, producing greener foliage through enhanced chlorophyll formation and promoting the emergence of new shoots, additional leaves, and stem elongation. Phosphorus and potassium likewise play essential supporting roles: phosphorus contributes to cell nucleus formation, cell division, and meristematic tissue development, and also influences nitrogen availability, while potassium supports flowering, helps prevent flower drop, strengthens the root system, and improves resistance to pests and diseases (Khadijah, 2021).

Shoot Height

Analysis of variance showed that both the interaction between NPK 16-16-16 and Atonik PGR, and the individual effects of each treatment, significantly affected shoot height at 90 DAG. Mean values are presented in Table 7.

Table 7. Mean shoot height of mango seedlings at 90 DAG under NPK 16-16-16 and Atonik PGR treatments (cm).

NPK 16-16-16 (g polybag^{-1})	A0 (0)	A1 (50)	A2 (100)	A3 (150)	Mean
N0 (0)	7.75g	8.80fg	12.87ef	19.75bcd	12.29d
N1 (2.5)	14.78de	18.98cd	18.97cd	22.40abc	18.78c
N2 (5)	16.75de	19.58bcd	22.83abc	24.62ab	20.95b
N3 (7.5)	19.57bcd	22.67abc	25.55a	27.17a	23.74a
Mean	14.71d	17.51c	20.05b	23.48a	

Values followed by the same lowercase letter are not significantly different at the 5% HSD level

The tallest shoots were obtained from N3A3 (27.17 cm), not significantly different from N3A2, N3A1, N2A3, and N2A2, but significantly taller than the remaining treatments, while the shortest shoots occurred in the unfertilized control (N0A0), at 7.75 cm.

Figure 5. Comparison of shoot height of top-grafted mango seedlings at 90 DAG under (a) N0A0, (b) N1A1, (c) N2A2, and (d) N3A3.

The hormones supplied through Atonik PGR are considered the main driver of the observed increase in shoot height, complemented by NPK 16-16-16 supporting overall seedling growth. Auxin, in particular, plays a role in the growth of meristematic tissue; increased cell-division activity in young shoot tissue promotes shoot elongation, and Atonik PGR also contains cytokinin and gibberellin, both of which benefit plant growth and development, so that its addition to grafted mango seedlings can improve their growth and development (Supriyanto & Yulianto, 2022).

Growth results from the combined processes of cell division and cell elongation, both of which require a substantial nutrient supply (Utami & Fahmi, 2025). A healthy rootstock that meets grafting criteria can more effectively transport water and nutrients absorbed by the roots to the leaves, supporting efficient photosynthesis and the return transfer of photosynthate throughout the rootstock; differences in shoot elongation rate are one indicator of how well the grafting process has proceeded, alongside the genetic capacity of the plant to form the parenchyma tissue needed for successful union (Fioneri, 2021).

Atonik PGR contains active ingredients including sodium orthonitrophenolate, sodium paranitrophenolate, sodium 2,4-dinitrophenolate, indole-3-butyric acid (IBA, 0.057%), and sodium 5-nitroguaiacolate, which together

promote plant growth; Atonik is rapidly absorbed by the plant and stimulates protoplasmic streaming within cells, thereby accelerating germination and rooting (Lailiyah et al., 2022).

CONCLUSION

The interaction between NPK 16-16-16 and Atonik PGR significantly affected days to bud break, scion height, scion diameter, leaf number, and shoot height of top-grafted mango seedlings, but not grafting success rate or shoot number, which responded only to the individual effects of each treatment. NPK 16-16-16 significantly affected grafting success rate, with the best dose obtained at 7.5 g polybag^{-1}, while Atonik PGR significantly affected grafting success rate and days to bud break, with the best concentration obtained at 150 ppm. The combination of NPK 16-16-16 at 7.5 g polybag^{-1} and Atonik PGR at 150 ppm (N3A3) consistently produced the best overall growth performance and is recommended for practical use in mango top-grafting nurseries. However, as this experiment was conducted in polybags under a shaded nursery over a single growing season, further evaluation under different environmental conditions, mango varieties, and field conditions is necessary before large-scale adoption.

REFERENCES

Alfira, S. N. 2020. Kadar Kalsium dan Fosfor pada Tanaman Sorgum (Sorghum bicolor L. Moench) dengan Pemberian Tepung Cangkang Telur. Skripsi. Universitas Hasanuddin.

Ardana, I. G. M. K., N. L. M. Pradnyawathi, dan Y. Hestin. 2022. Studi waktu penyambungan terhadap keberhasilan sambung pucuk pada wani ngumpen Bali (*Mangifera caesia* Jack var Ngumpen Bali). Jurnal Agriekoteknologi Tropika, 11(1): 20-29.

Auditira, F. 2019. Respon Tingkat Penaungan dan Lama Penyungkupan terhadap Pertumbuhan Tanaman Mangga Garifta Merah. Skripsi. Universitas Muhammadiyah Sumatera Utara.

Badan Pusat Statistik. 2021. Statistik Produksi Hortikultura Tahun 2021. Jakarta: Badan Pusat Statistik.

Badan Pusat Statistik. 2023. Statistik Produksi Hortikultura Tahun 2023. Jakarta: Badan Pusat Statistik.

Benardi, E. 2022. Pengaruh POC Kulit Jengkol dan Pupuk NPK 16-16-16 terhadap Pertumbuhan serta Produksi Tanaman Okra Merah (*Abelmoschus esculentus* L.). Skripsi. Universitas Islam Riau.

Cokrowati, N., dan N. Diniarti. 2019. Komponen Sargassum aquifolium sebagai hormon pemicu tumbuh untuk *Eucheuma cottonii*. Jurnal Biologi Tropis, 19(2): 316-321.

Derlina, H., dan R. Hafnati. 2016. Pengaruh penyiraman air kelapa (*Cocos nucifera* L.) terhadap pertumbuhan vegetatif lada (*Piper nigrum* L.). Jurnal Ilmiah Mahasiswa Pendidikan Biologi, 1(1): 20-28.

Fioneri, F. 2021. Pengaruh Dosis Multi KP dan Diameter Batang terhadap Tingkat Persentase Keberhasilan Sambung Susu pada Tanaman Lengkeng Varietas Itoh (*Dimocarpus longan*). Skripsi. Universitas Islam Riau.

Gumelar, A. I. 2017. Pengaruh dosis pupuk NPK 16-16-16 Mutiara terhadap pertumbuhan dan hasil tanaman mentimun (*Cucumis sativus* L.) varietas Bandana F1. Jurnal Agrorektan, 4(2).

Hardjowigeno, S. 2025. Ilmu Tanah. Jakarta: Media Sarana Perkasa.

Intan, A. 2025. Pengaruh Penggunaan Asap Cair dan Flower Inducer terhadap Pembungaan dan Pembuahan Tanaman Kakao (*Theobroma cacao* L.). Skripsi. Universitas Islam Riau.

Jalaluddin, J. 2023. Pengaruh konsentrasi zat pengatur tumbuh Atonik dan takaran kotoran kelelawar terhadap pertumbuhan sambung pucuk bibit kakao klon 45 (*Theobroma cacao* L.). Agrotekmas: Jurnal Ilmu Pertanian, 4(2): 192-199.

Jekinda, A. 2023. Pengaruh Bokashi Eceng Gondok (*Eichhornia crassipes*) dan Legin terhadap Pertumbuhan dan Produksi Kedelai (*Glycine max* L.). Skripsi. Universitas Islam Riau.

Jufran, L. S., dan Muhardi. 2019. Tingkat keberhasilan sambung pucuk mangga (*Mangifera indica* L.) pada berbagai panjang dan posisi penyisipan entres. Jurnal Agrotekhis, 7(3): 313-321.

Kadekoh, I., dan U. Made. 2024. Pengaruh pupuk NPK dan pupuk organik cair terhadap pertumbuhan dan hasil kacang

hijau (*Vigna radiata* L.). Agrotekbis: Jurnal Ilmu Pertanian (e-Journal), 12(5): 1235-1246.

Khadijah, S. 2021. Pengaruh ZPT Dekamon dan Pupuk NPK 16-16-16 terhadap Pertumbuhan Okulasi Tanaman Jeruk Kasturi (*Citrofortunella microcarpa*). Skripsi. Universitas Islam Riau.

Khairuna. 2019. Diktat Fisiologi Tumbuhan. Medan: Program Studi Pendidikan Biologi, Fakultas Tarbiyah dan Keguruan, Universitas Islam Negeri Sumatera Utara.

Lailiyah, W. N., R. Jumadi, dan S. Suhaili. 2022. Sosialisasi perbanyakan bibit tebu (*Saccharum officinarum* L.) klon ROC-01 dengan bibit asal bagal 1 mata tunas di Desa Gintungan, Kecamatan Kembangbahu, Lamongan. DedikasiMU: Journal of Community Service, 4(2): 174-179.

Maulana, R. 2023. Efektivitas Aplikasi Ekstrak Bawang Merah (*Allium cepa* L.) dan Varietas Batang Bawah terhadap Keberhasilan Sambung Pucuk Tanaman Mangga (*Mangifera indica* L.) Var. Arum Manis. Disertasi. Universitas Medan Area.

Musrini, E., A. Muin, dan B. Burhanuddin. 2020. Pertumbuhan tanaman ketapang (*Terminalia catappa* L.) dengan penambahan pupuk organik dan NPK pada tailing di persemaian. Jurnal Hutan Lestari, 8(1).

Nasrullah, N., N. Nurhayati, dan A. Marliah. 2015. Pengaruh dosis pupuk NPK (16-16-16) dan mikoriza terhadap pertumbuhan bibit kakao (*Theobroma cacao* L.) pada media tumbuh subsoil. Jurnal Agrium, 12(2).

Noval, D. S., Sobarna, dan Sumad. 2014. Budidaya Bunga Potong. Jakarta: Penebar Swadaya.

Novia, C., S. Syaiful, dan D. Utomo. 2015. Diversifikasi mangga off grade menjadi selai dan dodol. Teknologi Pangan: Media Informasi dan Komunikasi Ilmiah Teknologi Pertanian, 6(2): 1-12.

Pakpahan, F. E., N. Azizah, dan Sudiarso. 2018. Pengaruh berbagai konsentrasi ZPT Atonik pada pertumbuhan berbagai asal batang stek sirih merah (*Piper crocatum* Ruiz and Pav.). Jurnal Produksi Tanaman, 6(2): 1080-1086.

Pardede, C. 2017. Pengaruh Pemberian Benzyl Amino Purin (BAP) terhadap Keberhasilan Sambung Pucuk Tanaman Durian (Durio zibethinus Murr.). Skripsi. Universitas Jambi.

Perdanawan, A. 2022. Aplikasi Berbagai Jenis dan Konsentrasi ZPT terhadap Pertumbuhan Stum Okulasi Mata Tidur Tanaman Karet (*Hevea brasiliensis*). Skripsi. Universitas Islam Riau.

Rajiman. 2018. Pengaruh zat pengatur tumbuh (ZPT) alami terhadap hasil dan kualitas bawang merah. Jurnal Universitas Sebelas Maret, 2(1): 327-335.

Riswandi. 2024. Pengaruh ZPT Atonik dan Ekstrak Bawang Merah pada Sambung Pucuk Tanaman Alpukat (*Persea americana*). Skripsi. Universitas Islam Riau.

Rosman, R., S. Soemono, dan Suhendra. 2024. Pengaruh konsentrasi dan frekuensi pemberian pupuk daun terhadap pertumbuhan panili di pembibitan. Buletin TRO, 15(2).

Sihombing, A. R. 2021. Pengaruh Jenis Mulsa dan Pupuk Kalium Nitrat (KNO3) terhadap Pertumbuhan serta Produksi Tanaman Tomat (*Lycopersicum esculentum* Mill). Skripsi. Universitas Islam Riau.

Siregar, A. D. 2018. Pemanfaatan Auksin Sintetik dan Ekstrak Bawang Merah untuk Meningkatkan Keberhasilan Sambung Pucuk Tanaman Durian (*Durio zibethinus* Murr.). Skripsi. Universitas Medan Area.

Supriyanto, E. A., dan Y. W. 2022. Pengaruh konsentrasi ZPT auksin dan panjang entres terhadap pertumbuhan bibit tanaman alpukat. Innofarm: Jurnal Inovasi Pertanian, 24(1): 75-86.

Syamsul, B., A. Amin, dan M. A. Ash'ari. 2018. Keberhasilan sambung pucuk mangga (*Mangifera indica* L.) akibat perlakuan lamanya penyimpanan dan tinggi tunas. Prosiding Seminar Nasional Pertanian, 1(1): 182-193.

Thalib, S. 2019. Pengaruh sumber dan lama simpan batang atas terhadap pertumbuhan hasil grafting tanaman durian. Jurnal Agro, 6(2): 196-205.

Triastuti, F., Wardati, dan A. E. Yulia. 2016. Pengaruh pupuk kascing dan pupuk NPK terhadap pertumbuhan bibit tanaman kakao (*Theobroma cacao* L.). Jurnal Agroteknologi, 3(1): 8-13.

Ulpah, S. 2025. Pengaruh bokashi kulit pisang dan NPK 16-16-16 terhadap pertumbuhan serta hasil tanaman okra hijau (*Abelmoschus esculentus* L.) pada media campuran sekam padi dengan tanah PMK.

Jurnal Agroteknologi, Agribisnis, dan Akuakultur, 5(2): 168-180.

Utami, A. I., dan K. Fahmi. 2025. Pengaruh komposisi media tanam pada pertumbuhan dan hasil tanaman kangkung (*Ipomoea aquatica*). Jurnal Ilmu dan Teknologi Pertanian, 1(1): 59-74.

Wahyudi, E., I. Permanasari, dan E. Aryanti. 2017. Perbedaan batang bawah dan masa penyimpanan entres terhadap pertumbuhan okulasi bibit jeruk siam madu (*Citrus nobilis*). Jurnal Agroteknologi, 8(1): 35-40.

Wiraatmaja, W. I. 2017. Zat Pengatur Tumbuh Auksin dan Cara Penggunaannya dalam Bidang Pertanian. Buku Ajar. Fakultas Pertanian, Universitas Udayana.

How to Cite This Article:

Fikri, M., Sulhaswardi. Putri, L., Siti, Y. M S. 2026. Respons Pertumbuhan Sambung Pucuk Mangga (*Mangifera indica* L.) terhadap Kombinasi Pupuk NPK 16-16-16 dan ZPT Atonik. Dinamika Pertanian, 42(2): 71-82