Magna Scientia Advanced Biology and Pharmacy

eISSN: 2582-8363

Cross Ref DOI: 10.30574/msabp

Journal homepage: https://magnascientiapub.com/journals/msabp/

Magna Scientia
Open access publication

(Research Article)

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# Efforts to increase yield and quality of off-season crystal guava fruit through application of shoot dormancy breaking substances and shoot pruning

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Magna Scientia Advanced Biology and Pharmacy, 2025, 15(01), 071-078

Publication history: Received on 05 May 2025; revised on 18 June 2025; accepted on 20 June 2025

Article DOI: https://doi.org/10.30574/msabp.2025.15.1.0045

## Abstract

Research with the aim of analyzing the effect of bud dormancy breaker application and shoot pruning to increase yield and quality of crystal guava fruit outside the season was designed, using a factorial randomized group design with two factors. The first factor was potassium nitrate (K) application in four levels: K0 (0 g/tree), K1 (30 g/tree), K2 (60 g/tree), and K3 (90 g/tree). The second factor involves shoot pruning (P) with three levels: P0 (no pruning), P1 (pruning 2 internodes from the shoot tip), and P2 (pruning 3 internodes from the shoot tip). The combination of 12 treatments was repeated three times, using 36 crystal guava trees. Results showed that the interaction of pruning and potassium nitrate had no significant effect on most variables, except weight per fruit (very significant effect) and fruit diameter (significant effect). Individually, pruning had significant to very significant effects on all variables except KAR leaves, while potassium nitrate had significant to very significant effects on all parameters. The highest weight per fruit (240.33 g) and largest fruit diameter (8.05 cm) were achieved in the interaction P1K2 (pruning 2 internodes + potassium nitrate 60 g/tree), an increase of 22.48% and 16.50% over the untreated control (196.22 g; 6.91 cm). This finding proves that the combination of precision pruning and optimal doses of dormancy-breaking agents synergistically improve the quality attributes of off-season crystal guava fruits, especially in terms of fruit weight and size.

**Keywords:** Dosage; Yield; Crystal Guava; Quality; Pruning

## 1. Introduction

Crystal guava (*Psidium guajava* L.) is a horticultural commodity with high economic value and is favored by consumers because of the uniqueness of its fruit. However, its production is often unstable due to dependence on seasonality and weather anomalies that cause fluctuations in yield and price [1]. Efforts to increase off-season production are crucial to sustainably meet market demand. One promising strategy is to manipulate the bud dormancy phase through the application of dormancy-breaking agents combined with shoot pruning techniques, in order to stimulate flowering and fruiting in a controlled manner. This approach is supported by recent findings on the effectiveness of manipulating plant physiology for off-season fruiting in tropical fruit crops [2], [3], [4].

Crystal guava (Psidium guajava L.), a superior variety released through Minister of Agriculture Decree No. 540/Kpts/SR.120/9/2007, has become a priority commodity due to its agronomic advantages and high economic value [1], [5] This variety has a compact plant habitus, allowing high populations of up to 1,600-2,000 trees per hectare, as well as the ability to bear fruit quickly (1-2 years after planting) [1], [6]. Its special fruit characteristics include large size (100-500 g/fruit), thick flesh with a crunchy texture like an apple or pear, sweet taste (11-12°Brix), and minimal seed content (<3%) which provides a consumption portion of up to 90% [5], [7], [8], [9]. The visual uniqueness of the fruit with its asymmetrical, squiggly shape and whitish translucent flesh strengthens its market appeal [10], [7]. The potential for substitution of imported fruits (especially apples and pears) is supported by similarities in texture and

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good storability [11], [5]. The Ministry of Agriculture actively encourages its cultivation given its ease of maintenance, year-round fruiting ability, and stable selling price over local varieties [5], [7].

National guava production shows significant fluctuations: 422,491 tons (2021), increased to 472,686 tons (2022), then dropped dramatically to 404,654 tons (2023) [12]. A similar pattern is seen in Bali with crystal guava production of 36,372.46 kw (2021), a decline to 32,162.51 kw (2022), then a jump to 60,580.53 kw (2023) [13]. This instability reinforces the urgency of regulating off-season production. In the last five years, intensive cultivation of crystal guava in Bali expanded to production centers such as Gerokgak (Buleleng), Petang (Badung), and Susut (Bangli) Market demand continues to increase not only for fresh consumption, but also to fulfill the needs of Balinese traditional rituals, inter-island trade, export potential, and the tourism industry [14]. The combination of multifunctional demand and production volatility makes the development of sustainable production techniques including off-season flowering manipulation one of the strategic solutions.

Crystal guava cultivation in Tiga Village showed a significant decline in quality: fruit weight dropped from 350 g (first year) to 200 g (second year) due to technical errors [field observation]. Farmers do not apply proper cultivation, such as balanced fertilization (relying only on manure), pest control, or adjustment of planting distance (only 2 m causing competition for light and space) [farmer group interview]. As a result, there is a long harvest lag after production because the plants run out of energy, even though guavas are naturally able to bear fruit throughout the year [observation]. Solving this problem requires physiological interventions, one of which is shoot pruning. Scientifically, pruning stops apical dominance by diverting auxin accumulation from shoots to lateral buds, stimulating new branching as flowering sites [15]. Research [16] proved that pruning 10-30 cm from the shoot tip significantly increased the number of buds, flowers, and fruits in the rainy and cold seasons. Recent findings by [17], on the guava 'Allahabad Safeda' confirmed that pruning 25% of the length of the branches increased fruit yield by 37% through optimization of photosynthesis and photo assimilate distribution.

The complexity of the problem requires an integrative approach with the application of shoot dormancy breaking agents. Substances such as gibberellin (GA) and potassium nitrate ($KNO_3$) function to break the postharvest dormancy phase by stimulating meristematic cell division [20]. This mechanism is supported by a study [18] that showed the application of 100 ppm $GA_3$+ $KNO_3$ 2% on mango increased off-season flowering by 68% through regulation of flower-forming gene expression. In guava, recent research by [19] proved that the combination of pruning (30% of branch length) and spraying $KNO_3$ 3% shortened the vegetative phase by 21 days and increased synchronous flowering. This strategy specifically addresses the postharvest "energy drain" by regulating plant resource allocation through hormonal manipulation. The integration of these two techniques not only overcomes the decline in fruit quality, but also ensures the continuity of off-season production according to the needs of Bali's multi-target market (ritual, tourism, export) [14].

Potassium Nitrate ($KNO_3$) doubles as a bud dormancy breaker and a source of essential nutrients for crystal guava. It provides nitrogen (N) for vegetative growth (canopy expansion and chlorophyll synthesis) as well as potassium (K) which improves fruit quality through increased sugar content, biotic/abiotic stress resistance, and reduction of flower-fruit shedding [20], [21].

Its dormancy-breaking mechanism works by disrupting the ABA/gibberellin balance and inducing the expression of shoot-forming genes (e.g. FT, SOC1), as evidenced in a recent study [22] that showed 3% $KNO_3$ application increased the awakening of dormant guava shoots by 78% through activation of calcium signaling pathways. Its effectiveness is reinforced by its balanced nutrient content (46% $K_2O$, 13% N) which prevents excess nitrogen while optimizing flowering [21].

The application dose of 50 g/tree can be applied by leaking (soil injection in the root zone) or foliar spraying, with the foliar method showing 40% faster uptake based on research [23] on tropical guava. Their research also proved that the combination of foliar $KNO_3$ (2%) with pruning increased fruit weight by 22% and soluble solids content by 15°Brix due to flowering synchronization and improved photosynthesizing efficiency.

## 2. Materials and methods

### 2.1. Materials

Materials used included crystal guava plants, dolomite as a source of calcium (Ca), potassium nitrate, water and chemical solutions for laboratory analysis. While the tools used are nylon rope, zinc (plate), permanent marker, paper, hoe, pruning shears, stationery scales, oven, spray sprayer, camera, plastic, 40-watt fluorescent light lamp, cup, small ice thermos (coolbox), aluminum foil. scissors, ice mold, scissors, ice mold.

### 2.2. Methods

The research was conducted in Tiga Village, Susut District, Bangli Regency from December to May 2024. The research location is at an altitude of 650 - 800 m above sea level. The topography of the research site is sloping to hilly, slope 10-30%, temperature between $^{15-30o}$ C and high rainfall between 2,500-3,500 mm.

This study used a Randomized Group Design (RAK) arranged factorially with 2 factors. The first factor is shooting pruning (P) which consists of 3 levels, namely P0 (No pruning (control)), P1 (Shoot pruning 2 internodes from the shoot tip), P2 (Shoot pruning 3 internodes from the shoot tip). While the second factor is a dormancy breaking agent, namely potassium nitrate, which consists of 4 dose levels, namely K0 (0 g/tree), K1 (20 g/tree), K2 (40 g/tree), K3 (60 g/tree). Thus, there were 12 treatment combinations, each of which was repeated 3 times so that 36 crystal guava trees were needed.

The plant materials used in this study were crystal guava plants that were approximately 2-3 years old after planting in the field, with a planting distance of 3 x 4 meters. The plants selected were 36 plants that were uniform based on plant age, plant height, and healthy plant conditions, after which they were randomly labeled for treatment. Prior to the fertilization treatment, weeds were cleared and holes were made around the plants in a circular manner with a depth of 20 cm, width of 20 cm, at a distance of 30 cm from the main stem near the roots for potassium nitrate application.

Fertilization treatment was carried out in the morning by placing dolomite fertilizer as a source of calcium (Ca) in the prepared circle at a dose of 500 g/tree which was given evenly to each plant once in the study. Two weeks after the application of dolomite, potassium nitrate was applied according to the dose levels of 0, 20, 40, and 60 g/tree. Potassium nitrate was given twice, half of which was given 2 weeks after dolomite application and the other half was given during the enlargement of the fruit. While the pruning treatment was carried out simultaneously when giving dolomite according to the treatment, namely without pruning the shoots, pruning 2 internodes from the tip of the shoot, and pruning 3 internodes from the tip of the shoot. Also pruned leaves, shaded branches and disease on all plants.

## 3. Results and discussion

**Table 1** Significant effect of shoot pruning treatment and potassium nitrate dosage and their interaction on the observed variables

| No | Variable | Treatment | | |
|---|---|---|---|---|
| | | P | K | P x K |
| 1 | Number of flowers formed per tree (florets) | * | * | ns |
| 2 | Percentage of flowers becoming young fruit/fruit set (%) | * | ** | ns |
| 3 | Number of fruit set per tree (fruit) | * | * | ns |
| 4 | Percentage of young fruit fall per tree (%) | * | * | ns |
| 5 | Relative water content (KAR) of leaves (%) | ns | * | ns |
| 6 | Number of harvested fruits per tree (fruit) | * | * | ns |
| 7 | Weight per fruit (g) | ** | * | ** |
| 8 | Harvested fruit weight per tree (kg) | * | * | ns |
| 9 | Diameter per harvest fruit (cm) | * | ** | * |

Description: ns = Not significantly affected ($P>0.05$); * = Significantly affected ($P<0.05$); ** Very significant effect ($P<0.01$)

Table 1 shows that the interaction between shoot pruning and potassium nitrate fertilizer had no significant effect on all variables observed, except for the variable weight per fruit which had a very significant effect and the diameter per harvest fruit which had a significant effect. The treatment of shoot pruning had a very real effect on the variable weight per fruit and a real effect on other variables except for the relative water content (KAR) of the leaves which had no real effect. While potassium nitrate had a real to very real effect on all variables observed.

The interaction of shoot pruning 2 internodes from the tip (P2) and potassium nitrate application 60 g/tree (K3) produced the highest weight per fruit (240.33 g), an increase of 22.48% compared to the control/no treatment (P0K0: 196.22 g) (Table 2). This increase was strongly positively correlated with fruit diameter (r = 0.793*) and relative water content (KAR) of leaves (r = 0.766*), where fruit diameter in P2K3 reached 8.05 cm (up 16.50% vs. P0K0: 6.91 cm) (Table 3). [25] stated that KAR >85% optimizes stomatal opening and Rubisco activity, thus increasing photosynthetic efficiency by 35%. This is in line with the finding that high KAR promotes an increase in the number of flowers (r= 0.779*) *fruit-set* percentage (r= 0.763*), and number of fruits per tree (r= 0.931*), while suppressing fruit

drop (r = -0.584ns) (Table 4). This relationship was seen in the highly significant correlation between the number of harvested fruits and harvested weight per tree (r = 0.995** and 0.964**). The P2 treatment alone produced a KAR of 86.12% which was not significantly different from P1: 81.81% or P0: 81.63%), while K3 gave the highest KAR (85.28% vs K0: 78.47%). [26] explained that KAR >85% triggers the expression of the *PIP2;1* gene which accelerates intercellular water transport, supporting 40% higher photo assimilate synthesis. The P2K3 combination also optimizes auxin redistribution post- pruning, as observed [27] that pruning increases gibberellin translocation to reproductive shoots by 2.3 times. This synergy explains the increase in plant metabolism through the increased role of potassium nitrate in maintaining cell turgor for optimal photosynthesis (water as a key substrate of light reactions) and shoot pruning reduces sink-source competition so that photosynthate is allocated to the fruit.

Pruning can stimulate the formation of new shoots (production shoots) that produce flowers, because it reduces assimilate competition between plant organs due to the cessation of apical dominance. This encourages the formation of productive shoots in the leaf axils below the pruning marks, which are immediately followed by flower growth. In line with this, [15] states that the cessation of apical dominance increases the growth of lateral buds due to the redistribution of auxin from the apical meristem. [28] stated that shoot pruning increases flowering gene expression and photosynthate accumulation in lateral shoots. At the pruned part, cell division and enlargement activities increase significantly, thus stimulating auxin translocation around the cut area. This mechanism promotes the formation of new production branches that produce more flowers, which directly increases the potential for fruit formation.

**Table 2** Effect of interaction between shoot pruning treatment and potassium nitrate fertilizer dose (PxK) on average weight per fruit

| **Treatment** | **Potassium nitrate** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | K0 | | K1 | | K2 | | K3 | |
| **Pruning shoots.** | | | | | | | | |
| P0 | 196,22 | B | 211,85 | A | 214,66 | A | 214,88 | A |
| | a | | b | | b | | b | |
| P1 | 211,97 | B | 215,35 | B | 227,55 | A | 228,10 | A |
| | a | | b | | a | | a | |
| P2 | 213,43 | C | 222,60 | C | 231,81 | B | 240,23 | A |
| | a | | a | | a | | a | |
| BNT 0.05 | 7,20 | | | | | | | |

Notes: - Numbers followed by the same lowercase letter in the same column, are not significantly different at the 5% BNT test level.
- Numbers followed by the same uppercase letter in the s a m e row, are not significantly different at the 5% BNT test level.

**Table 3** Effect of interaction between shoot pruning treatment and potassium nitrate fertilizer dose (PxK) on average fruit diameter

| Treatment | Potassium Nitrate | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | K0 | | K1 | | K2 | | K3 | |
| **Pruning shoots** | | | | | | | | |
| P0 | 6,91 | C | 7,47 | B | 7,65 | A | 7,75 | A |
| | b | | a | | a | | b | |
| P1 | 7,56 | A | 7,63 | A | 7,72 | A | 7,77 | A |
| | a | | a | | a | | b | |
| P2 | 7,70 | B | 7,71 | B | 7,74 | B | 8,05 | A |
| | a | | a | | a | | a | |
| BNT 0.05 | 0,27 | | | | | | | |

Notes: - Numbers followed by the same lowercase letter in the same column, are not significantly different at the 5% BNT test level.
- Numbers followed by the same uppercase letter in the same row, are not significantly different at the 5% BNT test level.

**Table 4** Effect of shoot pruning treatment and potassium nitrate dosage on the average of all observed plant variables

| Treatment | Number of flowers formed per tree (florets) | Percentage of flowers into young *fruit* (*fruit- set*) (%) | Number of fruits formed per tree (fruit) | Percentage of fallen fruit per tree (%) | Relative water content of leaves (%) | Number of harvested fruits per tree (fruit) | Harves t weight per tree (kg) |
|---|---|---|---|---|---|---|---|
| **Pruning** | | | | | | | |
| $P_0$ | 66,75 b | 53,68 c | 35,83 c | 16,92 a | 81,63 a | 23,00 c | 4.51 b |
| $P_1$ | 75,08 a | 64,82 b | 48,67 b | 14,38 b | 81,81 a | 41,67 b | 8.74 ab |
| $P_2$ | 79,08 a | 70,08 a | 55,42 a | 9,42 c | 86,12 a | 50,20 a | 11,29 a |
| BNT 0.05 | 5,57 | 4,81 | 5,57 | 5,69 | 6,68 | 6,50 | 7,67 |
| **Potassium Nitrate** | | | | | | | |
| $K_0$ | 68,56 b | 57,21 b | 39,22 c | 28,60 a | 78.47 b | 28,00 c | 6.90 b |
| $K_1$ | 76,11 a | 58,01 b | 44,22 b | 25,62 a | 83.60 ab | 32,89 b | 8.24 a |
| $K_2$ | 78,78 a | 62,34 a | 49,11 a | 17,18 b | 84.40 a | 40,67 b | 10,02 a |
| $K_3$ | 79.78 a | 62,68 a | 50,01 a | 9.36 c | 85,28 a | 45,33 a | 11,61 a |
| BNT 0.05 | 4,47 | 3,98 | 4,88 | 4,93 | 5,79 | 4,93 | 6,64 |

Notes: Mean values followed by the same letter in the same treatment means not significantly different at 5% BNT test.

Potassium nitrate is an effective generative bud dormancy breaker, demonstrated by its ability to encourage the development of induced flower buds into flowers. [21] explains that this compound contains 13% nitrogen (N) and 46% potassium (K) in the form of $K_2O$, functioning to balance plant physiology when excess nitrogen.

The essential functions of potassium in fruit plants according to [29] include: (1) supporting the development of the root system, (2) strengthening the stem structure so that plants do not easily fall over, (3) increasing resistance to pest and disease pressure, and (4) significantly improving fruit quality. In addition, potassium plays a crucial role in the initiation of flowering and fruiting, while minimizing the loss of reproductive organs. In the context of off-season crystal guava cultivation, this combination of dormancy breaking and potassium application creates a synergy that optimizes flower formation and improves productivity and fruit quality.

The results showed that the shoot pruning treatment of 2 internodes from the shoot tip (P2) resulted in a significant increase in the number of flowers (79.08 florets), number of fruits formed per tree (55.42 fruits), and fruit-set percentage (70.08%) compared to no pruning (P0: 66.75 florets; 35.88 fruits; 53.68%). This finding is in line with [30] that shoot pruning increases photosynthate flow to reproductive buds. In the potassium nitrate treatment, the dose of 60 g/tree (K3) produced the highest number of flowers (79.78 florets), number of fruits (50.01 fruits), and fruit-set (62.68%) (Table 4). The highest percentage of fallen flowers occurred in P0 (16.92%) and K0 (28.607%), while the lowest in P2 (9.42%) and K3 (9.36%). These results are in accordance with [31] who reported that potassium nitrate suppresses the synthesis of ethylene that triggers miscarriage. The synergy of P2 and K3 increased fruit-set and suppressed young fruit drop, which was strongly positively associated with the number of harvested fruits per tree (r = 0.762*; r = 0.995) and negatively with miscarriage (r = - 0.700ns). Consequently, P2 produced 50.20 fruits and 11.29 kg/tree (79.28% and 65.84% higher than P0: 23.00 fruits; 5.51 kg). On potassium nitrate, K3 produced 45.33 fruits and

11.61 kg/tree, much higher than the untreated control (28 fruits; 5.90 kg) (Table 2). The strong correlation between fruit number and harvest weight (r = 0.967) confirmed that this productivity increases directly boosted yield. This mechanism is reinforced by the interaction of shoot pruning that optimizes photosynthate distribution and potassium nitrate that modulates hormonal balance for fruit stabilization.

## 4. Conclusion

Based on the results of the study, it was concluded that the interaction of shoot pruning and potassium nitrate dosage had no significant effect on most variables, except weight per fruit (very significant effect) and fruit diameter (significant effect). The highest weight per fruit was achieved in the combination of shoot pruning 2 internodes with potassium nitrate 60 g/tree (P2K3) at 240.23 g or an increase of 22.43% compared to no pruning (196.22 g).

Similarly, the highest fruit diameter was obtained in P2K3 (8.05 cm), showing an increase of 16.50% from the control/no pruning (6.91 cm). These findings confirm that the synergy of pruning 2 internodes from the tip and the application of potassium nitrate at a dose of 60 g/tree specifically improves the quality attributes of crystal guava fruit, especially in the aspects of fruit weight and size, which are key indicators of off-season yield increases.

## Compliance with ethical standards

### *Acknowledgments*

The authors would like to thank the Research Institute of Warmadewa University for providing research funding through the 2024 Institutional Grant Fund.

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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