Original Research article
Effect of Seaweed extract and Humic acid treatment on the phenological and yield characteristics of guava (*Psidium guajava* L.)

ABSTRACT

Aim

The main aim of this study was to evaluate the impact of seaweed and humic acid treatment at different doses on the phenological characteristics and yield of guava.

Study Design: Randomized Block Design

Place and Duration of Study

A field experiment was conducted from December 2023 to July 2024 to assess the impact of bio-stimulants on the phenological and yield traits of guava (var. Arka Kiran) in the Poongunam village, Chengalpattu Dist, Tamil Nadu, India.

Methodology

The experiment followed a Randomized Block Design with eight treatments: T_1 - Absolute control, T_2 - Water Spray, T_3 - 1% Seaweed Extract, T_4 - 1.5% Seaweed Extract, T_5 - 2% Seaweed Extract, T_6 - 1% Humic Acid, T_7 - 1.5% Humic Acid, and T_8 - 2% Humic Acid, each replicated three times.

Results

Results showed that 2% Seaweed Extract (T_5) significantly improved flower retention (7.55 flowers per shoot), reduced the duration from flowering to fruit set (12.47 days), and shortened the time from fruit set to harvest (121.56 days). T_5 also led to the highest fruit set (68.65%), lowest fruit drop (48.72%), largest fruit weight (150.02 g), and greatest yield (13.35 kg/tree). Humic Acid at 2% (T_8) also improved fruit set (64.32%), fruit drop (49.54%), and yield (12.34 kg/tree), but was less effective than Seaweed Extract.

Conclusion

This study demonstrates the potential of Seaweed Extract as a powerful bio-stimulant to enhance guava production, offering a sustainable alternative to traditional chemical treatments.

Keywords: Sustainable agriculture, Arka Kiran, Seaweed extract, Humic acid, Yield attributes

1. INTRODUCTION

Guava (*Psidium guajava* L.), one of the most highly regarded tropical fruit crops, is native to Tropical America and belongs to the Myrtle family which is known worldwide for its nutritional benefits particularly its high protein and fiber content and being naturally cholesterol-free guava is a popular choice among consumers (Kareem et al., 2024). Botanically, guava is an evergreen tree that can grow up to 6 meters in height. Its leaves are arranged in an opposite phyllotaxy, with white, bisexual flowers emerging at the leaf axils on current-season shoots. The guava fruit, classified as a berry, can vary in shape round, ovoid, or pear-shaped depending on the variety. It is a highly perishable, climacteric fruit, with a shelf life of about 2–3 days at ambient temperatures (Vasugi et al., 2024). It thrives well as a commercial crop across tropical and subtropical regions, including the Indian subcontinent. In India, major guava-producing states include Uttar Pradesh, Maharashtra, Gujarat, Rajasthan, Bihar, Karnataka Andhra Pradesh and Tamil Nadu. Tamil Nadu, in particular, has significant production areas around the districts of Madurai, Dindigul and Salem. Nationally, India dedicates approximately 351.90 thousand hectares to guava cultivation, with an average productivity of 15.24 metric tons per hectare. In Tamil Nadu, the area under cultivation is approximately 14.63 hectares, with a productivity of around 25.28 metric tons per hectare (Indiastat, 2023). Guava is known for its sweet taste and distinctive aroma and is valued for its nutritional composition, including carotenoids, polyphenols and pectin (0.60 percent). It is also rich in dietary fiber, ascorbic acid (210 mg 100 g^{-1}) and essential minerals such as phosphorus (24–37 mg 100 g^{-1}), calcium (14–30 mg 100 g^{-1}) and iron (0.6–1.4 mg 100 g^{-1}). These nutrients contribute to its benefits in managing blood pressure and type 2 diabetes (Kumar et al., 2021). The appealing white or pink flesh of guava is popular for fresh consumption and is also widely used in commercial processing to create various food products such as jelly, jam, puree, juice, wine, ice cream and nectar (Lakshmi et al., 2022).

A major challenge in commercial guava cultivation is the premature dropping of flowers and fruits, which can lead to a 45-65% loss in yield and affect fruit quality (Gomasta et al., 2024). The use of inorganic chemicals, though common, has detrimental effects on the ecosystem. A promising alternative for sustainable yield enhancement is the use of bio-stimulants, which are organic materials that can improve nutrient absorption, productivity and fruit quality (Du Jardin, 2015). Foliar application of bio-stimulants has been shown to enhance yield-related traits in guava, such as average fruit weight, quantity and overall fruit quality (Al-Saif et al., 2023). Among various bio-stimulants, seaweed extract and humic acid play crucial roles in improving plant yield and quality. Seaweed extract contains growth-promoting substances such as IAA, IBA, cytokinins and gibberellins, as well as essential micronutrients that enhance pollination, fertilization and fruit set (Farouk, 2023). Humic acid provides a comprehensive positive impact on plant physiology by boosting vital biological processes, including respiration, photosynthesis and enzymatic activities. Together, these enhancements significantly contribute to the plant's overall growth and developmental performance (Canellas et al., 2015). Bio-stimulants have a substantial impact on the farming community by providing an affordable way to enhance crop productivity. However, further trials are necessary to establish optimal dosage standards. Considering these factors, this field experiment was conducted to assess the effectiveness of bio-stimulants on phenological and yield characteristics in guava.

2. MATERIAL AND METHODS

2.1. Field Location

The field experiment was performed at farmer’s field in Cheyyur Taluk, Tamil Nadu from December 2023 to July 2024. The location is situated between 12°21'North latitude and 79°52'East longitude, with an average elevation of 49 m (160 ft. 9.13 inches) and a relative humidity of 72 percent. The average rainfall in the region is 995 mm. The average temperature in the area ranged from 26°C to 36°C. The soil in the experimental field was sandy loam, with low to medium levels of nitrogen (N) (125.52 kg ha^{-1}), phosphorus (P) (26 kg ha^{-1}), potassium (K 190 kg ha^{-1}) and organic carbon (0.74%). The soil pH was 7.2 and the electrical conductivity (EC) was 0.15 ds/m

2.2. Experimental site and Design

The field experiment was executed to examine the effects of seaweed extract (geo life plus) and humic acid (humi drop) on floral and yield performance of five-year-old guava trees with 2x1 m spacing. For the experiment, guava variety Arka Kiran which is released from IIHR, Bangalore is carefully selected. The statistical design of experiment was laid out in Randomized Block Design (RBD) with eight treatments viz. T_1 - Absolute control, T_2 - Water Spray, T_3 - Seaweed extract 1%, T_4 - Seaweed extract 1.5%, T_5 -Seaweed extract 2%, T_6 - Humic acid 1%, T_7 - Humic acid 1.5%, T_8 - Humic acid 2% and each treatment were replicated thrice (72 trees).

The trees were thoroughly drenched with the spray solution in two phases at bud break and after fruit set, to ensure optimal plant absorption by battery-operated knapsack sprayer, while the Absolute control trees were sprayed with distilled water.

After the development of new shoots, 25 randomly chosen shoots from each tree were tagged in all the direction. From the tagged shoots, observations were made on the percentage of fruit set. Observations on number of flowers retained per shoot, duration of flowering to fruit set, duration of fruit set to harvest, fruit set (%), fruit drop (%), fruit weight (g), number of fruits per tree and yield were recorded in both treated and untreated trees.

2.3. Number of flowers retained per shoot

25 randomly chosen shoots were tagged in all the direction. The number of flowers retained per shoot was randomly recorded during the peak flowering period after the 1st spray (At bud break) and the average value was expressed in numbers.

2.4. Duration from flowering to fruit set (Days)

The duration of time that flowers were retained after anthesis until fruit set was observed during the month of April after the 1st spray (At bud break) and recorded in days.

2.5. Duration of fruit set to harvest (days)

The total number of days taken from fruit set to harvest was observed and recorded in days.

2.6. Fruit set (%)

The fruit set was assessed by enumerating the number of flowers on each designated branch. The fruit set percentage was calculated at pea size stage after the 1st spray (At bud break) during the month of April and expressed as a percent.

$$\text{Percentage of fruit set} = \frac{Number\ of\ fruits\ set}{Total\ number\ of\ flowers}\ X\ 100$$

2.7. Fruit drop (%)

The fruit drop was determined by considering the number of fruits dropped during harvest in relation to the total fruit set and expressed in per cent.

2.8. Fruit weight (g)

At harvest, fruit weight of ten randomly selected samples of variable sizes were collected to find out the mean weight of fruits during the month of July and expressed in gram (g).

2.9. Number of fruits per tree

The number of fruits harvested was counted for each treatment and replication during the month of July. It was added up and the average number of fruits per tree was calculated.

2.10. Yield (kg tree^{-1})

The guava fruit yield from each tree was determined by weighing the harvested fruits at mature green stage (color change from dark to light green) individually during the month of July and then expressed as kilograms per tree.

2.11. Statistical analysis

The data underwent statistical analysis using the R software (R version 4.3.1). A Randomized Block Design was utilized to assess the effects of treatments on the guava trees. Mean comparisons were conducted after computing analysis of variance (ANOVA), standard deviation SE(d) and least significant difference (LSD) values, with the critical difference set at a significance level of five percent.

3. RESULTS AND DISCUSSION

3.1. Effect of bio stimulant application on phenological characters of guava

3.1.1. Number of flowers retained per shoot

The treatments had a noticeable impact on the number of flowers retained per shoot, with values ranging from 5.27 in the absolute control (T_1) to 7.55 in the seaweed extract treatment (T_5). Following the bud break stage, T_5 demonstrated the highest flower retention per shoot at 7.55, followed by T_8 at 7.16 and T_4 at 7.04. In contrast, the lowest retention was seen in the absolute control (T_1) at 5.27, with T_2 retaining only slightly more at 5.64 (Table 1).

Table 1. Effect of bio stimulant application on phenological characters of guava

Treatments	Number of flowers retained per shoot	Duration of flowering to fruit set (days)	Duration of fruit set to harvest (days)
T_1	5.27	15.31	130.88
T_2	5.64	15.10	129.74
T_3	6.43	14.23	127.51
T_4	7.04	13.35	126.32
T_5	7.55	12.47	121.56
T_6	6.17	14.51	127.12
T_7	6.78	13.78	128.23
T_8	7.16	12.05	125.04
SE(m)	0.07	0.17	0.44
SE (d)	0.09	0.24	0.63
CD (5 %)	0.20	0.51	1.35
CV (%)	1.38	0.94	0.39

The use of bio stimulants, especially seaweed extract at 2% (T_5), has proven to significantly enhance several key yield traits in guava, making it a promising option for improving fruit production. One of the most notable benefits of seaweed extract application is its ability to increase the number of flowers retained per shoot, reaching an impressive 7.55 flowers. This improvement can be attributed to the cytokinin and auxin content in the extract. Cytokinins encourage lateral shoot growth and floral development, while auxins work to prevent the formation of the abscission layer, effectively improving flower retention. These findings align with studies on guava (Mathukiya, 2022) and strawberry (Al-Shatri et al., 2020), highlighting the positive impact of seaweed extract on floral development.

3.1.2. Duration from flowering to fruit set (Days)

The duration from flowering to fruit set was notably influenced by the different treatments applied. This period ranged from 12.05 days with treatment T_8 to 15.31 days in the absolute control (T_1). The application of 2 percent humic acid (T_8) significantly shortened the time from flowering to fruit set to 12.05 days, closely followed by the 2 percent seaweed extract treatment (T_5) at 12.47 days. In contrast, the absolute control (T_1) showed a longer duration of 15.31 days, which was comparable to the water spray treatment (T_2) at 15.10 days (Table 1).

Beyond flower retention, seaweed extract (T_5) also shortened the time between flowering and fruit set by 12.47 days. This accelerated transition is likely due to better nutrient absorption and the hormonal effects of auxins and cytokinins, which help speed up the flower-to-fruit transformation. The results observed in guava (Ashwini et al., 2023) and pomegranate (Khattab et al., 2012) further confirm this benefit of seaweed extract in shortening key developmental periods.

3.1.3. Duration of fruit set to harvest (days)

Significant differences were observed in the duration from fruit set to harvest across the various treatments. This duration ranged from 121.56 days for the seaweed extract treatment at 2 percent (T_5) to 130.88 days in the absolute control (T_1). Among the treatments, the shortest period from fruit set to harvest was recorded for T_5 (121.56 days), followed by T_8 (125.05 days) and T_4 (126.32 days). In contrast, the absolute control (T_1) exhibited the longest duration of 130.88 days, with delays also observed in T_2 (129.74 days) and T_3 (127.51 days) (Table 1) (Fig 1).

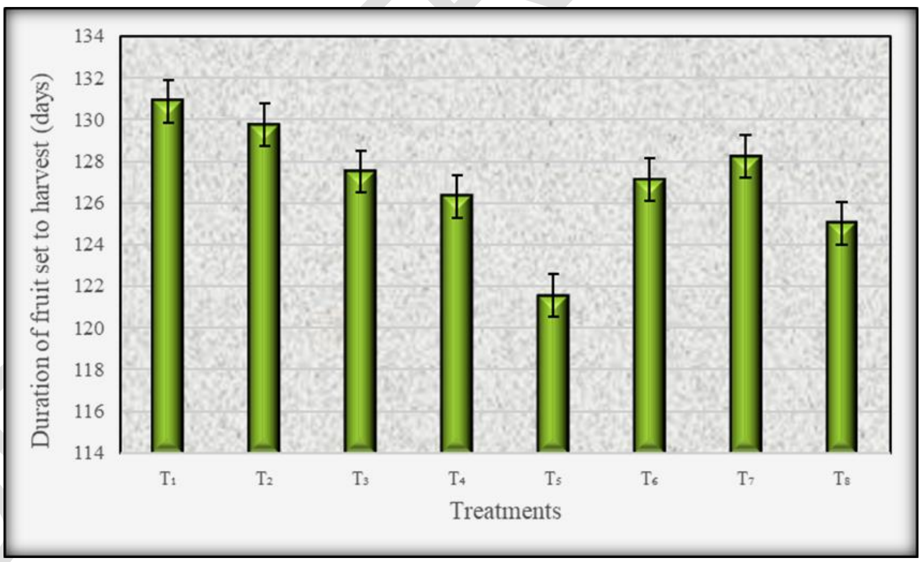

Fig 1. Effect of bio stimulants on duration of fruit set to harvest

The impact of seaweed extract extends to the duration from fruit set to harvest, which was significantly reduced to 121.56 days. This rapid fruit development is likely the result of enhanced nutrient uptake and mobilization, essential for early fruit maturation. This effect is consistent with findings in strawberry (Rishitha et al., 2023), further supporting the beneficial role of seaweed extract in promoting early fruit development.

3.2. Effect of bio stimulant application on yield attributing characters of guava

3.2.1. Fruit set (%)

Fruit set exhibited significant variation among the treatments, as presented in Table 2. The percentage of fruit set ranged from 52.14 per cent in the absolute control (T_1) to 68.65 per cent in the seaweed extract treatment at 2 per cent (T_5). Treatment with seaweed extract (T_5) led to a significantly higher fruit set (68.65 per cent), followed by T_8 (64.32 per cent) and T_4 (64.11 per cent). In contrast, the lowest fruit set (52.14 per cent) was observed in the absolute control (T_1), which was comparable to T_2 (53.56 per cent) (Table 2) (Fig 2).

Another remarkable outcome of applying seaweed extract (T_5) was a notable increase in fruit set, which reached 68.65%, compared to the Absolute control's 52.14%. This improved fruit set can be explained by better cell division, enlargement, and overall photosynthetic efficiency, thanks to the auxins in the extract. These compounds help boost photosynthesis, thereby ensuring more fruit retention. Research in guava (Mathukiya, 2022), litchi (Nayak et al., 2024), and strawberry (Chakraborty et al., 2023) has similarly demonstrated the positive effects of seaweed extract on fruit set.

3.2.2. Fruit drop (%)

Significant differences in fruit drop were also observed among the treatments. The fruit drop ranged from 48.72 percent for the seaweed extract at 2 percent (T_5) to 58.99 percent in the absolute control (T_1). The lowest fruit drop (48.72 percent) was recorded in T_5, followed closely by humic acid at 2 percent (T_8) with 49.54 percent. In contrast, the highest fruit drop (58.99 percent) was recorded in the absolute control (T_1), followed by the water spray treatment (T_2) at 57.33 percent (Table 2) (Fig 2).

Table 2. Effect of bio stimulant application on yield-attributing characteristics and yield of guava

Treatments	Fruit set (%)	Fruit drop (%)	Fruit weight (g)	Number of fruits/ Tree	Yield (kg tree^{-1})
T_1	52.14	58.99	133.99	75.97	10.18
T_2	53.56	57.33	135.45	77.58	10.51
T_3	59.36	53.75	139.27	83.98	11.70
T_4	64.11	51.29	142.29	84.63	12.04
T_5	68.65	48.72	150.02	88.96	13.35
T_6	57.67	54.94	137.73	83.39	11.49
T_7	61.67	52.55	140.51	84.13	11.82
T_8	64.32	49.54	145.15	85.02	12.34
SE(m)	0.82	0.16	1.55	1.12	0.15

SE (d)	1.16	0.22	2.19	1.59	0.22
CD (5 %)	2.50	0.48	4.71	3.40	0.47
CV (%)	1.93	0.41	1.56	1.92	1.88

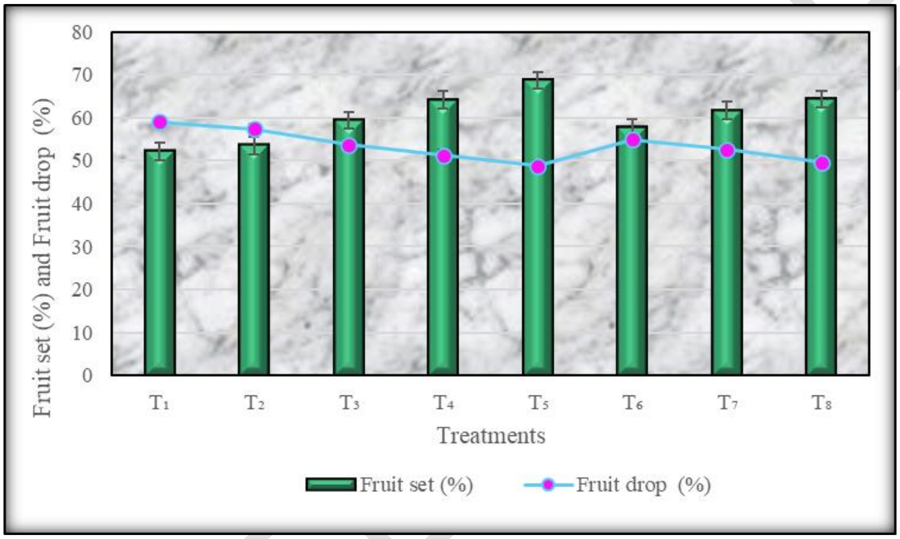

Fig 2. Effect of bio stimulants on duration of fruit set (%) and fruit drop (%)

Moreover, fruit drop was significantly reduced in trees treated with seaweed extract, with a decrease to 48.72% compared to the untreated Absolute control (58.99%). This reduction is likely due to the bioactive compounds in the seaweed extract, particularly auxins, which inhibit the formation of the abscission layer and help retain more fruit. These results align with studies in mango (El-Motty et al., 2010), litchi (Nayak et al., 2024), and pomegranate (Anbhu et al., 2022), further supporting the extract's role in improving fruit retention

3.2.3. Fruit Weight (g)

Fruit weight ranged from 133.99 g in the absolute control (T_1) to 150.02 g in the seaweed extract treatment at 2 percent (T_5). The highest fruit weight was observed in T_5 (150.02 g), followed by T_8 (145.15 g) and T_7 (140.51 g). In contrast, the absolute control (T_1) recorded the lowest fruit weight (133.99 g), which was comparable to T_2 (135.45 g) (Table 2).

The positive impact of seaweed extract on fruit weight was also evident, with the highest weight of 150.02 g recorded in T_5. This increase in fruit weight can be attributed to the seaweed extract's ability to alter the source-sink relationship by reducing vegetative growth and directing more resources toward fruit development. The extract's growth hormones, micronutrients, and vitamins enhanced chlorophyll production and photosynthetic efficiency, contributing to the increased weight. Similar improvements in fruit weight have been reported in guava (Mosa et al., 2021), mango (El-Motty et al., 2010), and banana (Ravi et al., 2018).

3.2.4. Number of Fruits per Tree

The number of fruits per tree varied from 75.97 in the absolute control (T_1) to 88.96 in the seaweed extract treatment at 2 percent (T_5). Treatment T_5 produced the highest number of fruits (88.96), followed by T_8 (85.02) with humic acid at 2 per cent and T4 (84.63) with seaweed extract at 1.5 per cent. The lowest fruit count was recorded in the absolute control (T_1) at 75.97, which was similar to T_2 (77.58) (Table 2).

Furthermore, the number of fruits per tree was highest in T_5 (88.96), likely due to improved photosynthetic efficiency and altered carbohydrate allocation. With reduced vegetative growth, more resources were available for fruit production, leading to a greater number of fruits per tree. These findings align with those in guava (Ali et al., 2021), strawberry (Al-Shatri et al., 2020), and litchi (Nayak et al., 2024), further confirming the benefits of seaweed extract in increasing fruit number.

3.2.5. Yield (kg tree^{-1})

The yield per tree at harvest was significantly influenced by the different treatments. Yield per tree ranged from 10.18 kg in the absolute control (T_1) to 13.35 kg tree^{-1} in the seaweed extract treatment at 2 per cent (T_5). Treatment T_5 achieved the highest yield of 13.35 kg tree^{-1} season^{-1}, followed by T_8 (12.34 kg tree^{-1} and T_4 (12.04 kg tree^{-1}). In contrast, the lowest yield was recorded in the absolute control (T_1) at 10.18 kg tree^{-1}, which was comparable to T_2 (10.51 kg tree^{-1}) (Table 2) (Fig 3).

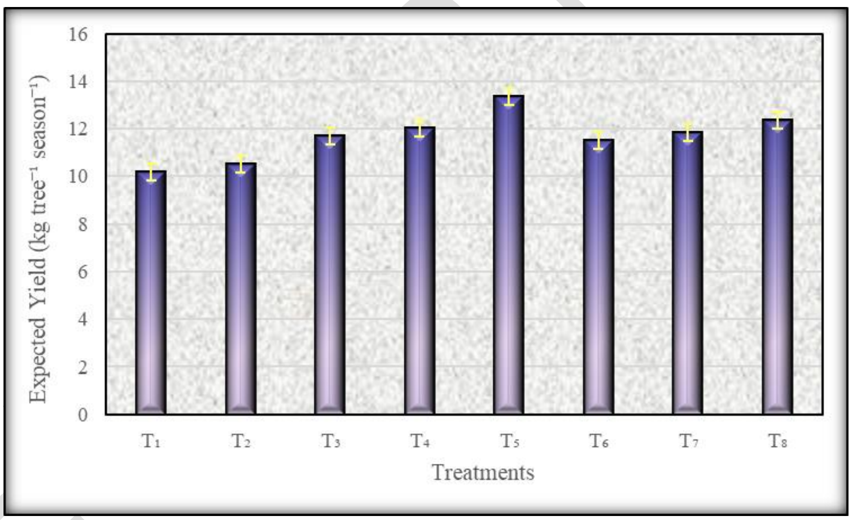

Fig 3. Effect of bio stimulants on duration of expected Yield (kg tree^{-1})

Finally, the yield per tree was significantly higher in T_5 (13.35 kg tree^{-1}) compared to the untreated Absolute control (10.18 kg tree^{-1}). This increase in yield is attributed to the enhanced availability of essential nutrients in seaweed extract, which supports better flower retention, fruit set, and growth. The extract's rich supply of macro and micronutrients, such as nitrogen, phosphorus, potassium, and trace elements, likely facilitated the transition from vegetative growth to reproductive growth, resulting in higher fruit yield. These findings are consistent with previous research in guava (Ali et al., 2021), mango (El-Motty et al., 2010), and strawberry (El-Miniawy et al., 2014).

4. CONCLUSION

This study highlights the positive impact of bio-stimulants, particularly seaweed extract, on guava productivity. Seaweed extract at 2% improved flower retention, reduced the time between flowering and fruit set, increased fruit set, and reduced fruit drop. It also enhanced fruit weight and overall yield, making it a promising eco-friendly alternative to chemical fertilizers. Humic acid showed some benefits but was less effective than seaweed extract. The use of biostimulants is the best option for sustainable guava cultivation, with the potential for better crop yield and quality without environmental harm. Further research is needed to refine application methods and assess long-term effects.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that generative AI technologies such as Large Language Models (ChatGPT, GPT-4, OpenAI) were not used in the writing or editing of this manuscript.

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