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Studies on effect of bio-inoculants on shoot growth and survival of guava (*Psidium guajava* L.) air layers

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Abstract

The present investigation entitled “Studies on effect of bio-inoculants on shoot growth and survival of guava (*Psidium guajava* L.) air layers” was conducted during 2025–26 at the Horticulture Nursery, Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The experiment was laid out in a Completely Randomized Design (CRD) with 11 treatments and three replications to evaluate the effect of different bio-inoculants on the shoot growth and survivability of guava air layers. The treatments comprised different concentrations of Azotobacter, Azospirillum, Phosphate Solubilizing Bacteria (PSB), Trichoderma and vermicompost along with a control. The results revealed significant differences among the treatments. Trichoderma @ 10 ml/kg of growing media (T₈) produced the highest number of sprouts (4.33 at 30 days after planting), plant height (29.83, 30.96, 32.27 and 33.04 cm), stem thickness (8.43, 9.87, 10.11 and 10.76 mm), number of shoots, 3.84 and 4.54), number of leaves (11.95, 12.63 and 15.27), fresh shoot weight (14.57 g), dry shoot weight (5.63 g) and survival percentage (80.00%) at 120 days after planting. Therefore, application of Trichoderma @ 10 ml/kg of growing media is effective for improving growth and survival of guava air layers.

Keywords: Bio-inoculants, Guava, Growth, Survival, Trichoderma

Introduction

Guava (*Psidium guajava* L.), belonging to the family Myrtaceae, is one of the most important tropical and subtropical fruit crops cultivated worldwide. Most commercially cultivated varieties are diploid with a chromosome number of $2n = 22$, whereas seedless types are triploid. Guava is a hardy, drought-tolerant crop with high yield potential and regular bearing habit. It originated in Tropical America and is commonly referred to as the “apple of the tropics” or “poor man’s apple.” In India, it is popularly known as Bihi, Jaam and Amrud etc. (Khunte *et al.*, 2023) [6]. Guava is considered the third richest fruit in vitamin C content (260 mg/100g) following Barbados cherry and Aonla. In addition to vitamin C, guava contains several essential nutrients including thiamine (0.03-0.07 mg), riboflavin (0.02-0.04 mg), phosphorus (22.5-40 mg/100 g), calcium (10.0-30.0 mg/100 g), iron (20-35 mg/100 g) and pectin (0.5-1.8% per 100 g pulp) contributing to its high nutritional value (Shukla *et al.*, 2009) [11].

Among the various methods of guava propagation air layering is a widely used vegetative propagation technique for guava because it is relatively simple, inexpensive and capable of producing rooted plants within a comparatively short period. The rooting and establishment of air layers are governed by a combination of environmental, physiological and management factors such as the health and maturity of the mother plant, season of layering, rainfall, atmospheric humidity, temperature, rooting environment, composition of growing medium, use of plant growth regulators and the accuracy of girdling during the layering process (Maurya *et al.*, 2012) [8]. After detachment from the mother plant, air layered propagules often face difficulty in obtaining adequate nutrients from the rooting medium, which may adversely affect root establishment and subsequent survival. The application of bio-inoculants can improve nutrient availability to newly established air layers by fixing atmospheric nitrogen, solubilizing essential nutrients, and enhancing their uptake.

Bio-inoculants such as Azospirillum, Azotobacter, Phosphate Solubilizing Bacteria (PSB) and Trichoderma produce plant growth promoting substances, including indole-3-acetic acid (IAA) and other auxins, which stimulate root growth and overall plant development (Doni *et al.*, 2014) [3]. Bio-inoculants improve the chemical and biological properties of the growing medium, thereby enhancing plant growth, establishment and overall agricultural productivity (El- Habbasha *et al.*, 2007) [4].

Materials and Methods

The experiment was conducted at Horticulture Nursery, Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur during the year 2025–26. Air layers were transplanted into poly bags containing the respective treatment media and maintained under uniform nursery conditions following recommended cultural practices. The treatments comprised T₀: FYM + Sand + Soil, T₁: FYM + Sand + Soil + Azotobacter @ 5 ml/kg of growing media, T₂: FYM + Sand + Soil + Azotobacter @ 10 ml/kg of growing media, T₃: FYM + Sand + Soil + Azospirillum @ 5 ml/kg of growing media, T₄: FYM + Sand + Soil + Azospirillum @ 10 ml/kg of growing media, T₅: FYM + Sand + Soil + PSB @ 5 ml/kg of growing media, T₆: FYM + Sand + Soil + PSB @ 10 ml/kg of growing media, T₇: FYM + Sand + Soil + Trichoderma @ 5 ml/kg of growing media, T₈: FYM + Sand + Soil + Trichoderma @ 10 ml/kg of growing media, T₉: FYM + Sand + Soil + Vermicompost (1:1:1:1), T₁₀: FYM + Sand + Soil + Vermicompost (1:1:1:2). Observations were recorded on growth parameters including number of sprouts, plant height, stem thickness, number of shoots, number of leaves, fresh and dry weight of shoots and survival percentage were determined at the appropriate stages of plant growth.

Results and Discussion

Number of Sprouts

The number of sprouts per air layer was recorded at 30 days after planting. Treatment T₈ (FYM + Sand + Soil + Trichoderma @ 10 ml/kg of growing media) recorded the highest number of sprouts (4.33). It was followed by T₆ (FYM + Sand + Soil + PSB @ 10 ml/kg of growing media) with 4.07 sprouts. The lowest number of sprouts (2.33) was observed in T₀ (FYM + Sand + Soil). The enhanced sprouting under Trichoderma treatment may be attributed to its ability to produce growth-promoting substances, enhance nutrient availability, stimulate root growth and suppress soil borne pathogens. These effects improve plant vigor and promote early bud break resulting in a higher number of sprouts. Similar findings have been reported by Rathore *et al.* (2020) [10] and Harman *et al.* (2004) [5].

Plant height (cm)

The maximum plant height 29.83 cm, 30.96 cm, 32.27 cm and 33.70 cm were recorded in treatment T₈ (FYM + Sand + Soil + Trichoderma @ 10 ml/kg of growing media) at 30, 60, 90 and 120 respectively, followed by T₂ (FYM + Sand + Soil + Azotobacter @ 10 ml/kg of growing media) recording 29.65 cm, 30.84 cm, 31.77 cm and 32.86 cm. Treatment T₀ (FYM + Sand + Soil) recorded minimum plant height (26.74 cm, 27.43 cm, 27.93 cm and 29.65 cm). The increased plant height in Trichoderma treated plant may be due to increased availability of essential nutrients and production of plant growth promoting substances such as auxins, which stimulate cell division and elongation. The present results

are in same line with the findings of Rathore *et al.* (2020) [10].

Stem thickness (mm)

The data related to stem thickness (mm) recorded at 30, 60, 90 and 120 days after planting. Treatment T₈ (FYM + Sand + Soil + Trichoderma @ 10 ml/kg of growing media) recorded the maximum stem thickness (8.43 mm, 9.87 mm, 10.11 mm and 10.16 mm) followed by T₆ (FYM + Sand + Soil + PSB @ 10 ml/kg of growing media) recording 8.21 mm, 9.74 mm, 9.94 mm and 10.52 mm. Treatment T₀ (FYM + Sand + Soil) recorded minimum stem thickness (5.64 mm, 6.43 mm, 6.86 mm and 7.84 mm). The increased stem thickness under Trichoderma treatment may be attributed to its ability to enhance rhizosphere microbial activity, improve mineral solubilization and promote efficient translocation of water and nutrients. Similar findings were reported by Maindad *et al.* (2022) [7].

Number of shoots per plant

The data on number of shoots per plant recorded at 60, 90 and 120 days after planting. The maximum number of shoots per plant (3.02, 3.84, 4.54) recorded in treatment T₈ (FYM + Sand + Soil + Trichoderma @ 10 ml/kg of growing media) followed by T₆ (FYM + Sand + Soil + PSB @ 10 ml/kg of growing media) recorded 2.86, 3.53, 4.21 number of shoots. The minimum number of shoots per plant (1.25, 1.94, 2.26) recorded in T₀ (FYM + Sand + Soil). Trichoderma spp. stimulates shoot growth and overall plant development through the production of auxins like compounds. Similar results were also reported by Contreras-Cornejo *et al.* (2009) [1].

Number of leaves per plant

The number of leaves per plant was significantly influenced by the application of different bio-inoculants at 60, 90 and 120 days after planting. The highest number of leaves (11.95, 12.63 and 15.27) were recorded in treatment T₈ (FYM + Sand + Soil + Trichoderma @ 10 ml/kg of growing media) followed by T₆ (FYM + Sand + Soil + PSB @ 10 ml/kg of growing media) recorded 11.84, 12.51 and 14.24 number of leaves. T₀ (FYM + Sand + Soil) recorded the lowest number of leaves (7.64, 8.52 and 9.94). The increased leaf production under Trichoderma treatment may be due to improved nutrient uptake, enhanced root growth, and the production of plant growth-promoting substances, which stimulate vegetative growth and photosynthetic activity. Similar findings have been reported by Rathore *et al.* (2020).

Fresh weight of shoots (g)

The fresh weight of shoots was recorded 120 days after planting of the air layers. Treatment T₈ (FYM + Sand + Soil + Trichoderma @ 10 ml/kg of growing media) recorded the highest fresh weight of shoot per air layer (14.57 g) followed by T₆ (FYM + Sand + Soil + PSB @ 10 ml/kg of growing media) recorded 14.32 g fresh shoot weight. The lowest fresh shoot weight (10.00 g) was recorded in T₀ (FYM + Sand + Soil). The increase in fresh shoot weight may be attributed to beneficial effects of Trichoderma in improving nutrient availability, promoting root growth and producing plant growth promoting substances. These factors enhance water and nutrient absorption resulting in vigorous shoot growth and increased accumulation of fresh biomass. Similar findings have been reported by Thakur *et al.* (2023) [12] in guava air layers.

Dry weight of shoots (g)

The dry weight of shoots was recorded 120 days after planting of the air layers. Treatment T₈ (FYM + Sand + Soil

+ Trichoderma @ 10 ml/kg of growing media) recorded the highest dry shoot weight (5.63 g) followed by T₆ (FYM + Sand + Soil + PSB @ 10 ml/kg of growing media) recorded 5.47 g dry shoot weight. The lowest dry shoot weight (3.50 g) was recorded in T₀ (FYM + Sand + Soil). The highest dry shoot weight under Trichoderma treatment may be attributed to increased dry matter accumulation resulting from improved photosynthate production and efficient nutrient utilization leading to greater biomass production. The present findings are in agreement with those reported by Dawar *et al.* (2020) [2].

Survival percentage

The observations on plant survival percentage were recorded at 120 days after planting of the air layers. The maximum survival percentage of air layers (80.00%) was observed under T₈ (FYM + Sand + Soil + Trichoderma @ 10 ml/kg of growing media) followed by T₆ (FYM + Sand + Soil + PSB @ 10 ml/kg of growing media) recorded 70.00% survival. The minimum survival percentage (53.33%) was recorded under T₀ (FYM + Sand + Soil). The higher survival under Trichoderma treatment may be attributed to its ability to suppress soil-borne pathogens, enhance root establishment and improve plant health, thereby increasing survival. These findings are in agreement with the results reported by Patil *et al.* (2001) [9] and Thakur *et al.* (2023) [12].

Table 1: Effect of bio-inoculants on number of sprouts and plant height (cm) of guava air layers

Notations	Treatment	Number of sprouts	Plant height (cm)			
			30 DAP	60 DAP	90 DAP	120 DAP
T ₀	FYM + Sand + Soil	2.33	26.74	27.43	27.93	29.65
T ₁	FYM + Sand + Soil + Azotobacter @ 5 ml/kg of growing media	3.07	28.24	29.41	30.25	31.48
T ₂	FYM + Sand + Soil + Azotobacter @ 10 ml/kg of growing media	3.73	29.65	30.84	31.77	32.86
T ₃	FYM + Sand + Soil + Azospirillum @ 5 ml/kg of growing media	2.67	27.51	28.32	29.52	30.73
T ₄	FYM + Sand + Soil + Azospirillum @ 10 ml/kg of growing media	3.60	29.44	30.67	31.02	32.42
T ₅	FYM + Sand + Soil + PSB @ 5 ml/kg of growing media	2.93	28.03	29.14	29.94	31.24
T ₆	FYM + Sand + Soil + PSB @ 10 ml/kg of growing media	4.07	29.31	29.83	30.12	32.11
T ₇	FYM + Sand + Soil + Trichoderma @ 5 ml/kg of growing media	3.27	28.84	29.54	30.56	31.87
T ₈	FYM + Sand + Soil + Trichoderma @ 10 ml/kg of growing media	4.33	29.83	30.96	32.27	33.70
T ₉	FYM + Sand + Soil + Vermicompost (1:1:1:1)	2.53	27.42	28.21	28.87	30.06
T ₁₀	FYM + Sand + Soil + Vermicompost (1:1:1:2)	2.73	27.94	28.64	29.73	30.78
	S.E(m) ±	0.08	0.43	0.40	0.45	0.43
	CD (5%)	0.25	1.27	1.17	1.34	1.26

DAP: Days After Planting

Table 2: Effect of bio-inoculants on stem thickness and number of shoots of guava air layers

Notations	Treatment	Stem thickness (mm)				Number of shoots		
		30 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP
T ₀	FYM + Sand + Soil	5.64	6.43	6.86	7.84	1.25	1.94	2.26
T ₁	FYM + Sand + Soil + Azotobacter @ 5 ml/kg of growing media	7.16	8.03	8.45	9.33	1.58	2.43	3.37
T ₂	FYM + Sand + Soil + Azotobacter @ 10 ml/kg of growing media	8.03	9.42	9.85	10.41	2.43	3.34	4.06
T ₃	FYM + Sand + Soil + Azospirillum @ 5 ml/kg of growing media	6.64	7.32	8.04	8.91	1.50	2.33	3.30
T ₄	FYM + Sand + Soil + Azospirillum @ 10 ml/kg of growing media	7.52	8.52	8.83	9.64	1.94	2.52	3.61
T ₅	FYM + Sand + Soil + PSB @ 5 ml/kg of growing media	7.34	8.16	8.64	9.41	1.64	2.71	3.48
T ₆	FYM + Sand + Soil + PSB @ 10 ml/kg of growing media	8.21	9.74	9.94	10.52	2.86	3.53	4.21
T ₇	FYM + Sand + Soil + Trichoderma @ 5 ml/kg of growing media	7.43	8.41	8.74	9.53	1.77	2.77	3.52
T ₈	FYM + Sand + Soil + Trichoderma @ 10 ml/kg of growing media	8.43	9.87	10.11	10.76	3.02	3.84	4.54
T ₉	FYM + Sand + Soil + Vermicompost (1:1:1:1)	6.45	7.15	7.92	8.42	1.31	2.20	2.26
T ₁₀	FYM + Sand + Soil + Vermicompost (1:1:1:2)	6.85	7.73	8.32	9.12	1.38	2.28	2.84
	S.E(m) ±	0.10	0.12	0.14	0.14	0.10	0.04	0.06
	CD (5%)	0.29	0.36	0.41	0.41	0.30	0.12	0.20

DAP: Days After Planting

Table 3: Effect of bio-inoculants on number of leaves, Shoot fresh weight (g), Shoot dry weight (g) and Survival% of guava air layers

Notations	Treatment	Number of leaves			Shoot fresh weight (g)	Shoot dry weight (g)	Survival %
		30 DAP	60 DAP	90 DAP			
T ₀	FYM + Sand + Soil	7.64	8.52	9.94	10.00	3.50	53.33
T ₁	FYM + Sand + Soil + Azotobacter @ 5 ml/kg of growing media	9.88	10.84	11.83	12.87	4.83	66.67
T ₂	FYM + Sand + Soil + Azotobacter @ 10 ml/kg of growing media	10.86	11.86	13.96	14.21	5.26	73.33
T ₃	FYM + Sand + Soil + Azospirillum @ 5 ml/kg of growing media	9.34	10.37	11.31	12.56	4.52	63.33
T ₄	FYM + Sand + Soil + Azospirillum @ 10 ml/kg of growing media	10.74	11.58	12.64	13.50	5.11	70.00
T ₅	FYM + Sand + Soil + PSB @ 5 ml/kg of growing media	9.46	10.42	11.52	13.23	4.92	66.67
T ₆	FYM + Sand + Soil + PSB @ 10 ml/kg of growing media	11.84	12.51	14.24	14.32	5.47	76.67
T ₇	FYM + Sand + Soil + Trichoderma @ 5 ml/kg of growing media	10.43	11.54	12.45	13.86	5.03	70.00
T ₈	FYM + Sand + Soil + Trichoderma @ 10 ml/kg of growing media	11.95	12.63	15.27	14.57	5.63	80.00
T ₉	FYM + Sand + Soil + Vermicompost (1:1:1:1)	8.32	9.54	10.84	11.24	3.95	56.66
T ₁₀	FYM + Sand + Soil + Vermicompost (1:1:1:2)	8.61	9.82	11.03	11.82	4.23	60.00
	S.E(m) ±	0.13	0.14	0.61	0.21	0.06	0.88
	CD (5%)	0.39	0.43	1.79	0.64	0.18	2.58

DAP: Days After Planting

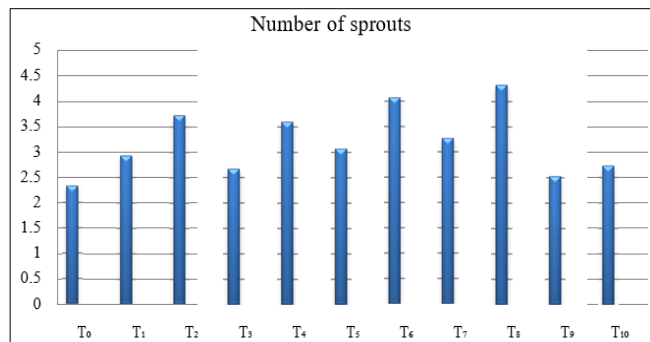


Fig 1: Effect of Bio-inoculants on number of sprouts of guava air layers

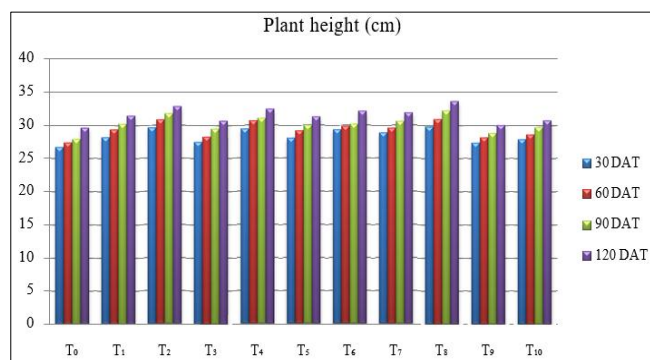


Fig 2: Effect of Bio-inoculants on plant height (cm) of guava air layers

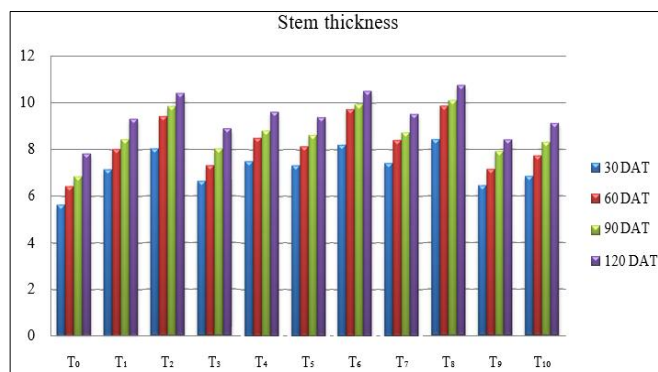


Fig 3: Effect of Bio-inoculants on stem thickness (mm) of guava air layers

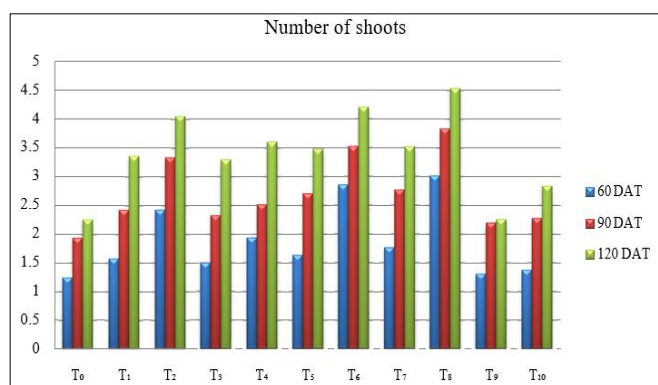


Fig 4: Effect of Bio-inoculants on numbers of shoots per plant of guava air layers

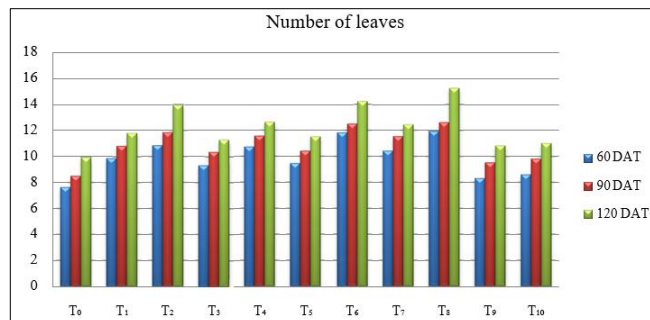


Fig 5: Effect of Bio-inoculants on numbers of leaves per plant of guava air layers

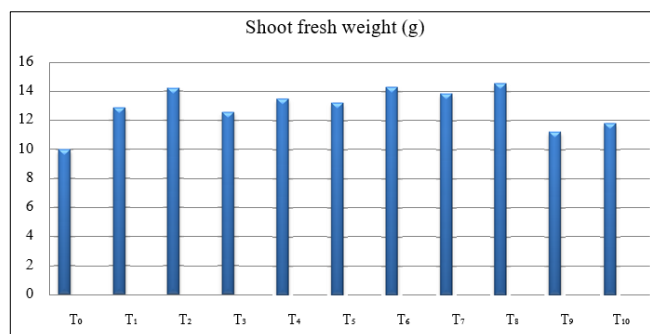


Fig 6: Effect of Bio-inoculants on fresh weight of shoots (g) of guava air layers

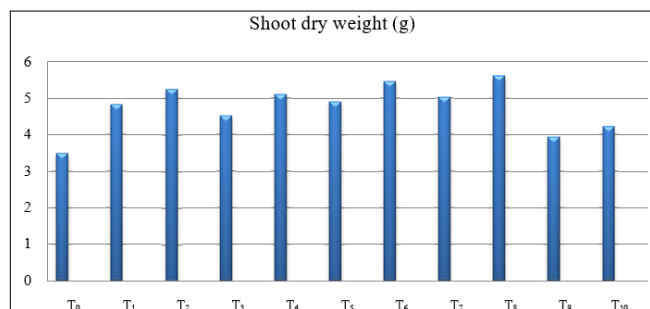


Fig 7: Effect of Bio-inoculants on dry weight of shoots (g) of guava air layers

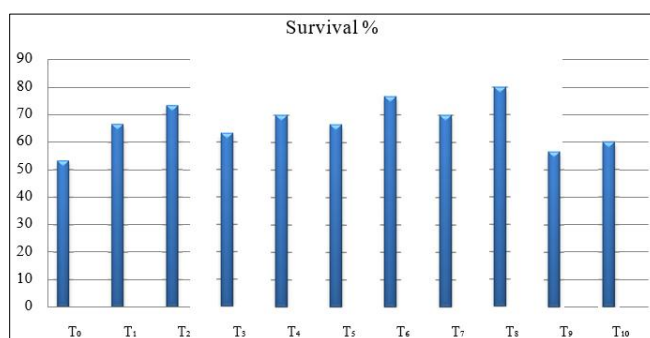


Fig 8: Effect of Bio-inoculants on survival percentage of guava air layers

Conclusion

The present investigation demonstrated that bio-inoculants significantly influenced the shoot growth and survivability of guava air layers. The results indicate that the application of *Trichoderma* @ 10 ml/kg of growing media consistently recorded the highest values for shoot growth parameters including number of sprouts, plant height, stem thickness, number of shoots, number of leaves and survival percentage.

Therefore, this treatment is effective for enhancing shoot growth and survivability of transplanted guava air layers.

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