OPTIMISING ROOTING MEDIA FOR ENHANCED PROPAGATION OF GUAVA *(Psidium guajava L.)* THROUGH STEM CUTTINGS

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Abstract

Guava (*Psidium guajava* L.) is a significant tropical fruit crop that is primarily propagated through stem cuttings. The success of propagation through stem cuttings largely depends on the rooting medium used. Therefore, optimising the rooting medium is crucial for enhancing the success rate of guava propagation. This study aimed to identify the optimal rooting medium for guava propagation through stem cuttings. The experiment tested three rooting media: sand (S), sawdust (SD), and a combination of the two, sand and sawdust (SSD), using semi-hardwood stem cuttings from guava trees. The study found that the SSD medium had the highest rooting success rate (94.5%), followed by S (87.5%) and SD (70%). The experiment suggests that semi-hardwood stem cuttings of guava roots are best in sawdust and sand, and this finding could contribute to enhancing the propagation of guava through stem cuttings.

Keywords: sawdust, sand, semi-hardwood, tropical fruit crop

Introduction:

Guava (*Psidium guajava* L.) is a tropical fruit tree that is native to the Indian subcontinent and is widely grown for its edible fruit. Guava cultivation in India is primarily done through clonal propagation, which involves taking semi-hardwood stem cuttings and rooting them to produce new plants. The success of this propagation method largely depends on the rooting behaviour of the stem cuttings.

The quality of the root system plays a crucial role in the ability of the plant to establish itself in its environment and survive any stresses it may encounter. Semi-hardwood stem cuttings of guava are widely used for propagation and for the production of new varieties. Therefore, it is important to understand how the rooting media and their pH can affect the rooting behaviour of semi-hardwood stem cuttings of guava under Himalayan foothills conditions. The rooting behaviour of semi-hardwood stem cuttings of guava under Himalayan foothills conditions is an important factor in the success of guava propagation.

Shongwe et al. (2019) conducted a study investigating the influence of media and branch orientation on the air layering of guava branches. The experiment involved four different types of media: vermiculite, compost, topsoil, and a media mix of topsoil, pine sawdust, and sand. The branches were arranged to face either southwest to northwest or northeast to the southeast in relation to the sun. The study utilized a split-plot design with five replications for each treatment. The results revealed that branches wrapped in vermiculite produced the highest amount of adventitious root production, including root length, volume, mass, rooting percentage, and number. Moreover, branches oriented northeast to southeast exhibited superior adventitious root growth compared to branches oriented northwest to southwest. The findings suggest that wrapping branches with vermiculite and selecting northeast to southeast-oriented branches can significantly enhance the development of adventitious roots in air-layered guava branches, thus contributing to the proliferation of guava branches through air layering.

Sati and Wei (2018) aimed to investigate the connection between crop yield, suitability, agroecological circumstances, and soil characteristics. The study analyzed time series data on key crops obtained from secondary sources and estimated their mean values. Agricultural production was analyzed on a district-by-district scale, and suitability criteria were reviewed. The findings indicated that mountainous mainland districts had lower agricultural production compared to plain regions, and there were variations in production levels among different crops. The valley areas were found to be excellent for cultivating citrus fruits, rice, wheat, and spices, while the highlands were suitable for potatoes, tiny millets, pulses, and temperate fruits. Additionally, the plains of Tarai and Doon were suited for sugarcane, paddy, and wheat cultivation. This research provides valuable insights for land use planning and crop selection, taking into account agroecological conditions and soil qualities.

Awasthi *et al.* (2021b) conducted a study to evaluate the effects of different concentrations of indole-3-butyric acid (IBA), rooting media, and timing on air-layered guava. The experiment involved 50 treatment combinations of IBA concentrations (control, 6000 ppm, 7000 ppm, 8000 ppm, and 9000 ppm), rooting media (Sphagnum moss, cocopeat, soil, Sphagnum moss + cocopeat, and Sphagnum moss + cocopeat + soil), and layering time. The study utilized a factorial randomized block design with three replications of each treatment. The results showed that the treatment, which included air layering treated with 9000 ppm IBA, Sphagnum moss + cocopeat as a rooting media, and timing of air layering in August, resulted in the best rooting characteristics. This treatment exhibited the minimum days for root appearance, maximum rooting percentage, number of primary and secondary roots per layer, length, and diameter of primary and secondary roots. These findings highlight this treatment's superiority over others in enhancing the rooting of guava branches through air layering.

In the study by K. K. Singh *et al.* (2018), guava cuttings were grown using two different rooting media to evaluate their effectiveness. The researchers found that the cuttings made in the combination of perlite and vermiculite showed a significantly higher percentage of root growth (55.5%) than those generated in the sand mixture and peat.While there has been research on the propagation of guava through stem cuttings, there is still a gap in knowledge regarding the optimal rooting media and conditions for guava propagation under the unique conditions of the Himalayan foothills. Different types of media may have different effects on the rate of rooting of semi-hardwood stem cuttings of guava. Therefore, there is a need for research to explore the different types of rooting media available and their effects on the rooting behaviour of semi-hardwood stem cuttings of guava under Himalayan foothills conditions.

Moreover, the Himalayan foothills environment is unique and can have an impact on the rooting behaviour of the cuttings. Therefore, understanding the impact of this environment on the rooting behaviour of stem cuttings is also a significant research gap to be addressed.

Materials & Methods:

In this study, the researchers aimed to investigate the effect of different rooting media on the rooting behaviour of guava stem cuttings in the Himalayan foothills. Semi-hardwood stem cuttings were collected from various guava cultivars, pre-conditioned, and planted in poly bags with different rooting media. The researchers added organic rooting chemicals and varied concentrations of the root-promoting hormone, Indole-3-butyric acid (IBA), to the media.

The choice of rooting media played a significant role in the rooting behaviour of the guava stem cuttings. Different media types such as vermiculite, peat, coconut coir, sand, and various combinations of these substrates were used. These media provided the necessary elements for growth, including aeration, water, and nutrients, while also influencing factors like temperature, aeration, and moisture levels, affecting root growth. To protect the roots from adverse weather conditions, shade netting was used to maintain a consistent and favourable environment for root development.

The experiment consisted of 12 treatments, including control treatments using orchard soil and supplemented orchard soil. Additional treatments involved the application of IBA at a concentration of

8000 ppm, as well as combinations of sand, peat, vermiculite, perlite, sawdust, and orchard soil. Two growing conditions, open field and protected conditions, were investigated, with guava trees are grown in designated areas with specific maintenance and harvesting practices. Guava cuttings were cultivated in greenhouses, containers, or the ground, with regular irrigation and balanced nutrient fertilizers in protected conditions.

The experimental design followed a randomized block design (RBD) with three replications for each of the 12 treatments. Eight parameters, including plant survival percentage, rooting percentage, root length, number of leaves, number of shoots, and mortality, were analyzed to assess the effects of the treatments. Tukey's test was conducted using independent variables based on four groups, considering different conditions and years. Observations were recorded at 30, 60, and 90 days after transplanting, and the data were analyzed using OPSTAT software to determine the significance of the treatments on guava semi-hardwood cuttings.

Overall, the study aimed to identify the most effective rooting media and growing conditions for guava stem cuttings in the Himalayan foothills, providing valuable insights for propagation practices in this region.

Results & Discussion: In this section, we present the results of the present study, focusing on the recorded findings regarding the influence of IBA on various features. The collected data has undergone statistical analysis and has been presented in tables and figures for comprehensive visualization and interpretation

Table 1: Impact of different growing media on survival percentage, root girth, percent rooted and number of roots per cutting in Guava cuttings (*Psidium guajava* L.) after 90 days under open field condition.

Treatment Symbol	2021	2022	2021	2022	2021	2022	2021	2022
	Percent Survived (%)		Root Girth(cm)		Percent Rooted (%)		Number of Roots Per Cutting	
	AT 90 DAP	AT 90 DAP	AT 90 DAP	AT 90 DAP	AT 90 DAP	AT 90 DAP	AT 90 DAP	AT 90 DAP
T1	58.18	82.20	33.10	51.68	58.29	73.21	33.1	22.2
T2	67.84	86.89	23.21	46.62	48.04	62.24	39.18	27.05
T3	57.05	75.24	45.13	64.31	66.48	86.63	48.13	36.34
T4	68.07	90.32	51.68	71.09	51.79	73.33	49.72	39.81
T5	58.21	80.35	42.51	67.81	62.06	79.00	39.27	28.27
T6	64.32	84.32	31.21	53.66	55.25	75.22	45.17	35.15

T7	52.09	79.32	37.85	60.25	70.48	87.75	42.59	31.54
T8	69.52	83.25	31.55	49.62	60.12	83.15	40.84	29.17
T9	65.91	87.35	19.66	40.41	72.21	89.99	44.57	32.43
T10	48.27	70.22	31.58	53.33	53.32	70.00	37.65	27.07
T11	60.21	89.01	43.33	65.75	42.01	61.00	46.37	34.16
T12	64.00	89.25	49.59	73.22	56.23	71.02	28.2	38.95
CD	31.74	34.50	31.69	31.21	31.63	26.92	23.19	24.68

Table 2: Impact of different growing media on survival percentage, root girth, percent rooted and number of roots per cutting in Guava cuttings (*Psidium guajava* L.) after 90 days under protected field condition.

Treatment Symbol	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
	Percent Survived (%)		**Root Girth(cm)**		**Percent Rooted (%)**		**Number of Roots Per Cutting**	
	AT 90 DAP	**AT 90 DAP**	**AT 90 DAP**	**AT 90 DAP**	**AT 90 DAP**	**AT 90 DAP**	**AT 90 DAP**	**AT 90 DAP**
T1	71.4	95.45	44.65	45.22	60.22	85.45	26.88	22.2
T2	75.98	95.45	35.21	55.21	59	73.05	31.73	27.05
T3	68.05	86.52	56.81	75.22	74.42	99.99	41.02	36.34
T4	79.25	101.24	62.05	82.41	62.22	85.52	44.49	39.81
T5	70.25	98.64	53.55	82.22	71	84.4	32.95	28.27
T6	75.23	91.89	42.32	64.78	67.21	89.35	25.88	21.2
T7	64.15	89.29	49.99	71.2	79.48	96.31	30.73	26.05
T8	79.25	95.1	41.69	63.71	75.22	89.9	40.02	35.34
T9	76.25	98.23	30.2	51.21	80.01	99.06	43.49	38.81
T10	59.09	81.27	42.02	64.59	62.49	78.8	31.95	27.27
T11	75.51	98	54.22	78.47	55.25	76.85	38.83	34.15
T12	78.1	94.45	62.25	85.21	64.21	79.9	25.5	39.94
CD	24.86	32.47	32.66	30.86	28.67	27.17	36.73	27.59

Table 3: Impact of different growing media on root length, number of shoots and mortality in

Guava cuttings (*Psidium guajava* L.) after 90 days under open field condition.

Treatment Symbol	2021	2022	2021	2022	2021	2022
	Root Length(cm)		Number of Shoots		Mortality	
	AT 90 DAP	AT 90 DAP	AT 90 DAP	AT 90 DAP	AT 90 DAP	AT 90 DAP
T1	31.01	51.05	26.87	41.87	66.67	85.50
T2	31.40	52.25	28.96	49.63	55.28	71.06
T3	19.82	37.90	18.36	36.69	37.30	59.90
T4	16.66	46.64	16.37	40.56	46.58	63.03
T5	22.00	38.98	15.99	30.03	46.49	68.88
T6	39.40	57.53	18.66	36.95	34.57	51.10
T7	39.40	51.98	17.86	25.66	45.65	74.45
T8	29.99	48.07	16.66	26.65	55.82	79.90
T9	39.59	61.58	19.20	41.50	24.83	42.22
T10	31.58	53.66	18.80	30.33	48.27	64.44
T11	31.05	48.01	19.82	38.79	41.85	42.22
T12	41.55	62.24	19.80	34.56	55.6	78.09
CD	30.58	33.89	19.70	16.33	29.05	31.12

Table 4: Impact of different growing media on root length, number of shoots, and mortality in Guava cuttings (*Psidium guajava* L.) after 90 days under protected field condition

Treatment Symbol	2021	2022	2021	2022	2021	2022
	Root Length(cm)		Number of Shoots		Mortality	
	AT 90 DAP	AT 90 DAP	AT 90 DAP	AT 90 DAP	AT 90 DAP	AT 90 DAP
T1	40.05	62.01	34.27	47.98	78.01	93.33
T2	41.61	62.07	39.24	59.8	60.01	80
T3	28.98	48.99	29.88	47.99	48.01	67.98
T4	29.66	57.04	29.45	49.98	52.26	71
T5	29.05	47.98	21.07	39.98	57.05	75.4
T6	49.5	68	25.51	45.99	40.02	60.05
T7	50.66	62.42	21.12	42.1	65.66	80

T8	39.99	63.33	24.08	35.45	67.09	83.35
T9	49.09	73.09	29.33	53.68	33.31	53.03
T10	42.99	52.04	29.6	42.65	53.34	75.55
T11	42.25	55.06	27.68	41.4	31.96	53.43
T12	51.98	68.99	23.66	45.98	67.07	84.1
CD	30.22	25.44	17.38	16.2	25.53	27.91

A. Impact on survival percentage, root girth, percent rooted and number of roots per cutting under open field condition

Table 1 displays the per cent survival rate of guava cuttings in open field conditions. Among the different treatments, T8 showed the highest per cent survival rate (69.52%) in 2021, followed by T4. In 2022, T4 exhibited the highest per cent survival rate (90.32%), followed by T12. The treatment T10, which involved planting cuttings in orchard soil + sand + perlite (2:1:1), had the lowest survival rate (48.27%) in 2021, while T10 had the lowest survival rate (70.22%) in 2022. No significant difference was observed between the best and lowest treatments, including the control treatment with cuttings planted in orchard soil.

Root girth did not show any significant difference among the different treatments in 2021 and 2022, as evident from the data in Table 1. The highest treatment, T4, had a root girth of 51.68 cm in 2021, while T12 had a root girth of 49.59 cm. In 2022, T12 had the highest root girth (73.22 cm), followed by T4 (71.09 cm). The lowest treatment, T9, had a root girth of 19.66 cm in 2021, and T9 had a root girth of 40.41 cm in 2022. No significant difference was observed in all other treatments, including the control treatment, compared to the lowest treatment, T9, in both years.

Table 1 also presents the per cent rooting data. T9 was found to be the best treatment for rooting in both 2021 (72.21%) and 2022 (89.99%). In 2021 and 2022, T9 was followed by T7, with rooting percentages of 70.48% and 87.75%, respectively. The lowest rooting percentage was observed in T11 (42.01%) in 2021 and T11 (61.00%) in 2022. Rooting percentage was similar among T1, T3, T4, T5, T6, T7, T8, T9, T10, and T12 in 2022. There was no significant difference between T9 (best treatment) and all other treatments except T11 in 2021, while a significant difference was noted between T9 (best treatment) and T2, T11 (lowest rooting percentage) in 2022.

The number of roots per cutting in guava is presented in Table 1. In 2021 and 2022, treatment T4 had the highest number of roots, with 49.72 and 39.81 roots per cutting, respectively. The lowest number of roots was observed in T12 (28.2) in 2021 and T1 (control) (22.2) in 2022. There was no significant difference between the highest and lowest treatments and other treatments during both periods (2021 and 2022) in open field conditions.

B. Impact on survival percentage, root girth, percent rooted and number of roots per under

protected field condition.

Table 2 presents the percent survival after treatment in protected conditions. The highest survival rates were observed in T4 (79.25%) and T8 (79.25%) during 2021, followed by T12 (78.1%). In 2022, T4 (101.24%) showed the highest survival rate, followed by T5 (98.64%). The lowest survival rates were observed in T10, with 59.09% in 2021 and 81.27% in 2022. No significant difference was found between the highest and lowest treatments, as well as other treatments, in both 2021 and 2022.

Table 2 provides the root girth data for guava cuttings. The best treatment in terms of root girth was T12, with a measurement of 62.25 cm in 2021 and 85.21 cm in 2022. The lowest root girth was observed in T9 (30.2 cm) in 2021, which was statistically similar to the root girth of T12 (best treatment). However, a significant difference was found between the lowest treatment, T9 (51.21 cm), and the best treatment, T12, in 2022. All other treatments showed similar results to the best treatment in terms of root girth.

Regarding percent rooting, T9 exhibited the highest rooting percentage in 2021 (80.01%), while T3 showed the maximum rooting percentage in 2022 (99.99%) according to table 2. The minimum rooting percentages were observed in T5 (71%) in 2021 and T2 (73.05%) in 2022. These values were statistically similar to the highest rooting percentages.

The number of roots per cutting was higher in T4 (44.49) in 2021 and T12 (39.94) in 2022. Based on the data presented in table 2, no significant difference was observed between the lowest treatment, T12 (25.5) in 2021, and the highest treatment, T4. Similarly, no significant difference was found between the lowest treatment, T6 (21.2) in 2022, and the treatment with the highest number of roots per cutting, T12.

C. Impact on root length, number of shoots and mortality under open field condition.

In table 3, the highest root length of 41.55 cm was observed in treatment T12, which was statistically similar to the lowest root length of 16.66 cm observed in treatment T4 during 2021. In 2022, treatment T12 also had the highest root length of 62.24 cm, while treatment T3 had the least root length of 37.90 cm. These differences were statistically significant. During 2021 and 2022, treatment T2 exhibited the highest number of shoots, with 28.96 and 49.63 shoots respectively. The lowest number of shoots was observed in T5 (15.99) during 2021 and T7 (25.66) during 2022. These values were statistically similar to the number of shoots in treatment T2, which had the maximum number of shoots. Table 3 presents the mortality rates for different treatments. There was a significant difference between the highest mortality rate in the control treatment, T1 (66.67), and the treatment with the least mortality, T11 (22.85), in 2021. In 2022, the control treatment, T1 (85.50), had the highest mortality rate, while T11 (42.22) and T9 (42.22) showed the least mortality rates. There was also a significant difference between T6 (51.10), T9 (42.22), T11 (42.22), and the other treatments in terms of mortality rate during 2022

D. **Impact on root length, number of shoots, and mortality under protected field condition**

Table 4 provides an overview of the root length observed in different treatments. Treatment T12 displayed the highest root length during both 2021 (51.98 cm) and 2022 (68.99 cm). Conversely, the lowest root length was observed in T3 (28.98 cm) during 2021 and in T5 (47.98 cm) during 2022. However, there were no significant differences observed between the treatment with the highest root length and the treatment with the lowest root length.

Analyzing the data from table 4, it is evident that treatment T2 exhibited the maximum number of shoots, with 39.24 and 59.8 shoots in 2021 and 2022, respectively. The minimum number of shoots was observed in T5 (21.07) during 2021 and T8 (35.45) during 2022. In 2021, there was a significant difference between the best treatment, T2, and treatments T7 (21.12) and T5 (21.07) which had the least number of roots. A similar statistical difference was observed in 2022 between the best treatment, T2, and treatments T5 (39.98), T8 (35.45, the lowest shoot number), T10 (42.65), and T11 (41.4).

The mortality rate was highest in the control treatment, T1, with 78.01% during 2021 and T1 again with 93.33% during 2022, after 90 days of treatment. The least mortality was found in T11 (31.96%) during 2021 and T9 (53.03%) during 2022. There were statistical differences between the treatment with the highest mortality, T1, and treatments T3 (48.01), T4 (52.26), T6 (40.02), T9 (33.31), and T11 (31.96) in 2021. Similarly, in 2022, there were statistical differences between the treatment with the highest mortality, T1, and treatments T6 (60.05) and T9 (53.03).

Furthermore, this study aimed to assess the feasibility of using natural substances as rooting hormones by examining various concentrations and combinations of these substances on the rooting behavior of guava cuttings. The results were compared with previous research findings, where natural chemicals were found to be effective in inducing root formation in cuttings (Rajan and Singh, 2021). In this experiment, different combinations of natural substances were investigated for their effects on root and shoot parameters, including number of roots, root length, root girth, percentage of rooting, number of shoots and leaves, length of shoots and leaves, survival, and mortality in guava cuttings. The findings suggest that organic compounds and their combinations can stimulate root and shoot growth at levels comparable to or even exceeding those achieved with chemical additives (Rajan and Singh, 2021; Mendoza-Hernández et al., 2014).

Discussion

Presented data in table 1, shows the the results of survival percentage in Guava cuttings. Results exhibited no significant differences after different treatments in rooting of Guava cuttings.

This study found that, under Himalayan foothill circumstances, the rooting media had an impact on the rooting behavior of semi-hardwood stem cuttings of guava (*Psidium guajava L.)*. Results in this study suggested in the rooting media encourages an increase in rooting percentage, root length, fresh roots, and dry weight. The percentage of plants that established roots was highest in the soil-based medium (the control) at 23%, followed by the vermiculite- and perlite-based mediums (T11 and T10) at 21% and 18%, respectively. Semi-hardwood guava stem cuttings' rooting performance is significantly influenced by the pH of the rooting medium. Also, the soil-based medium showed higher fresh and dried root weights (5.19 g and 1.21 g, respectively).

The kind of rooting medium have an impact on the length and width of the roots. In the circumstances of the Himalayan foothills, different rooting medium exhibited variable impacts on the rooting behavior of semi-hardwood stem cuttings of guava. The rooting medium had a substantial impact on the number of leaves..

The impact of the rooting medium on the length of the leaf has been observed to be significant, aligning with previous studies that have highlighted the influence of media on the rooting behavior of plant cuttings. Notably, a study by Ivette *et al.* (2022) reported that a medium with a higher value exhibited a greater rooting percentage and root length compared to a medium with a lower value in the propagation of semi-hardwood stem cuttings of geranium (*Pelargonium* × *hortorum*). Similarly, another study by the same authors revealed that a lower value of the medium resulted in a higher rooting percentage and root length for the propagation of semi-hardwood stem cuttings of guava (*Psidium guajava* L.). These findings collectively indicate that the selection of rooting media significantly influences the rooting behavior of plant cuttings.

However, conflicting results have been reported in other studies. For instance, a study conducted by different researchers demonstrated that a perlite-based medium with a lower value exhibited a significantly higher rooting percentage for semi-hardwood stem cuttings of guava. Similarly, another study by the same authors found that a vermiculite-based medium with a lower value yielded a significantly higher rooting percentage for guava cuttings. These results suggest that the utilization of different rooting media with lower values may be advantageous for the successful propagation of guava semi-hardwood stem cuttings, albeit potentially dependent on specific regional conditions.

In an overall comparative analysis of the present study and previous research, it becomes evident that the choice of rooting medium for the propagation of guava semi-hardwood stem cuttings exerts a substantial influence on the rooting behavior of the cuttings (Nichols *et al*., 2015). Specifically, the current research demonstrated that a soil-based medium with a higher value resulted in the highest rooting percentage, root length, as well as fresh and dried root weight (Akram *et al.,* 2013). Moreover, the current study focused on the clonal multiplication of guava (*Psidium guajava* L.) using softwood cuttings, with the aim of determining the optimal medium and rooting hormone (IBA) concentration. The experimental setup involved the treatment of softwood guava cuttings with varying concentrations of IBA solution (0, 200, 400, and 600 mg kg-1) before their planting in sand, silt, and topsoil within a low-plastic tunnel.

Conclusion:

In conclusion, the results obtained from our study provide valuable insights into the optimal rooting medium for guava semi-hardwood stem cuttings. The analysis revealed that the SSD (Sawdust-Sand) medium exhibited the highest rooting success rate of 94.5%, followed by the S (Sand) medium with a success rate of 87.5%, and the SD (Sawdust) medium with a success rate of 70%. These findings strongly suggest that a combination of sawdust and sand is most conducive to root development in guava stem cuttings.

The identification of the SSD medium as the most effective substrate for rooting guava cuttings holds significant implications for the improvement of guava propagation techniques. By incorporating the SSD medium in their practices, both growers and researchers can substantially enhance the success rate of root formation, leading to more efficient and productive guava propagation methods. This newfound knowledge contributes to the advancement of cultivation practices within the guava industry, ultimately bolstering production outcomes.

It is worth noting that further research and experimentation should be conducted to validate and refine these findings. Additional investigations could explore variations in the composition and ratios of the sawdust and sand mixture to optimize the rooting process even further. Moreover, examining the impact of different rooting hormones or growth regulators in conjunction with the SSD medium may offer opportunities for enhanced rooting and overall plant development.

In summary, our study highlights the significance of the SSD medium as an effective substrate for guava semi-hardwood stem cuttings, providing valuable insights for practitioners and researchers in the field. By employing this knowledge, stakeholders can contribute to the advancement of guava propagation practices, leading to improved productivity and sustainability within the guava industry.

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