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Genetic diversity analysis in *Solanum surattense* – An endangered medicinal plant

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Abstract
Forty nine accessions of *Solanum surattense* were collected from different parts of India and used for study at the Department of Medicinal and Aromatic Crops, Tamil Nadu Agricultural University, Coimbatore during 2020-21. The field trial was laid out in Randomized Block Design (RBD) and replicated thrice. Diversity analysis was done by Mahalanobis D² method utilizing 34 traits of *Solanum surattense*. The accessions were grouped into six clusters indicating the presence of a huge amount of diversity among the accessions. The maximum intra cluster distance was registered in cluster VI (137.94) followed by cluster I (123.88). The lowest intra cluster distance was recorded in cluster II (20.62). Clusters I and VI had the highest inter cluster distance (128.25) followed by clusters V and VI (115.36). Cluster IV recorded the maximum mean value for nine traits. Maximum contribution towards divergence was observed for root dry weight (33.25%) followed by dry berry weight per plant (10.29%). From this study, a great insight to select promising traits / promising accessions for further breeding programmes can be visualized. The selection of diverged parents would be useful to get more variability in segregating generations.

Key words: Genetic diversity, *Solanum surattense*, Cluster analysis, Mahalanobis D², Intra and inter cluster distances.

INTRODUCTION
Kantakari (*Solanum surattense* Burm. F) is the plant belonging to the brinjal family, Solanaceae. It is a spreading annual plant with thorns in all parts except flowers. This plant can be seen in dry tracts, roadsides and wastelands. Due to over exploitation for its high medicinal value and indiscriminate and destructive collection from the habitat, the species is in threatened position and lead to an endangered status (Khan and Frost, 2001). *Solanum surattense* is also valued for its antispasmodic, antitumor, cardiotonic, hypotensive and anaphylactic activities. *Solanum surattense* produces glycolalkaloids, solanine, solamargine and solasodine. Solasodine is considered as a potential alternative to diosgenin for commercial steroid drug synthesis like progesterone and cortisone (Galanes et al., 1984). There are huge numbers of literature describing the uses of *Solanum surattense*. But, information on breeding or evolving newer varieties of the species is scanty. Breeding is an important tool to develop a variety for a particular crop. For every crop improvement program, understanding the available diversity of the plant species is an important aspect to develop a variety and to indulge in crosses. Hence, an experiment was done to analyse the available diversity for *Solanum surattense*.

MATERIALS AND METHODS
Forty nine accessions of *Solanum surattense* were collected from different parts of Tamil Nadu, Rajasthan,
Table 1. Passport data of collected germplasm of *Solanum surattense*

| S. No. | Accession | Place of collection | Latitude° (N) | Longitude° (E) |
|--------|-----------|---------------------|--------------|----------------|
| 1      | Ss - 1    | Govinthapuram, Thanjavur, TN | 11.0083 | 79.4674 |
| 2      | Ss - 2    | Parivallikkottai, Ottapidaram, TN | 8.9212 | 77.8746 |
| 3      | Ss - 3    | Kollankinaru, Ottapidaram, TN | 8.8899 | 77.8703 |
| 4      | Ss - 4    | Ottapidaram, Tuticorin, TN | 8.9077 | 78.0210 |
| 5      | Ss - 5    | Onamakulam, Ottapidaram, TN | 8.9647 | 77.8582 |
| 6      | Ss - 6    | Sillangulam, Ottapidaram, TN | 8.9655 | 77.9432 |
| 7      | Ss - 7    | Kilakottai, Ottapidaram, TN | 10.2800 | 77.9452 |
| 8      | Ss - 8    | Kalappanpati, Devakottai, TN | 10.4934 | 77.9369 |
| 9      | Ss - 9    | Maruthanvalvo, Ottapidaram, TN | 8.8680 | 77.8603 |
| 10     | Ss - 10   | Kothali, Belgium, Karnataka | 16.4240 | 74.5068 |
| 11     | Ss - 11   | Seelaiplayarpadur, Trichy, TN | 13.1356 | 80.1621 |
| 12     | Ss - 12   | Nagayanallur, Trichy, TN | 11.0204 | 78.0766 |
| 13     | Ss - 13   | Karur, TN | 10.9601 | 78.2163 |
| 14     | Ss - 14   | Kattuputhur, Trichy, TN | 10.9912 | 78.5908 |
| 15     | Ss - 15   | Jabalpur, Madhya Pradesh | 23.1815 | 79.9864 |
| 16     | Ss - 16   | Chennampatti, Trichy, TN | 11.6772 | 77.6537 |
| 17     | Ss - 17   | Mayanur, Trichy, TN | 10.9557 | 78.1917 |
| 18     | Ss - 18   | Unniyur, Trichy, TN | 11.0022 | 78.1917 |
| 19     | Ss - 19   | Aalampalayam, Trichy, TN | 12.1359 | 80.1621 |
| 20     | Ss - 20   | Chinnapalayam, Trichy, TN | 10.8727 | 77.8703 |
| 21     | Ss - 21   | Sullipalayam, Trichy, TN | 11.2631 | 78.9432 |
| 22     | Ss - 22   | Kalamboi, Maharashtra | 19.0328 | 73.1012 |
| 23     | Ss - 23   | Narayanapuram, Trichy, TN | 19.0432 | 74.4395 |
| 24     | Ss - 24   | Yeola, Maharashtra | 20.0432 | 74.4840 |
| 25     | Ss - 25   | Andakudi, Sivagangai, TN | 9.5844 | 78.6881 |
| 26     | Ss - 26   | Sithakur, Pudukottai, TN | 10.0093 | 78.9916 |
| 27     | Ss - 27   | Keeran, Sivagangai, TN | 9.9192 | 78.9029 |
| 28     | Ss - 28   | Devakottai, TN | 9.9554 | 78.8162 |
| 29     | Ss - 29   | Okkur, Pudukottai, TN | 9.9464 | 78.5235 |
| 30     | Ss - 30   | Pothuvakkur, Pudukottai, TN | 10.8850 | 78.5908 |
| 31     | Ss - 31   | Thalimalai, Trichy, TN | 10.7749 | 78.6902 |
| 32     | Ss - 32   | Kadaladi, Ramanad, TN | 11.3092 | 78.2974 |
| 33     | Ss - 33   | Madesampalayam, Namakkal, TN | 11.1726 | 78.0029 |
| 34     | Ss - 34   | Mohanur, Namakkal, TN | 11.0599 | 78.1422 |
| 35     | Ss - 35   | Puliyur, Karur, TN | 10.6390 | 78.8326 |
| 36     | Ss - 36   | Sankari, Salem, TN | 11.4745 | 77.8691 |
| 37     | Ss - 37   | Palnadai, Namakkal, TN | 11.4208 | 78.8180 |
| 38     | Ss - 38   | Manaparai, Trichy, TN | 10.6098 | 78.4233 |
| 39     | Ss - 39   | Tirupurankundram, Madurai, TN | 9.8823 | 78.0720 |
| 40     | Ss - 40   | S.Puthuputalam, Namakkal, TN | 11.2734 | 78.0210 |
| 41     | Ss - 41   | Kaggalai, Rajastan | 24.8387 | 72.2778 |
| 42     | Ss - 42   | Roadsides, Rajastan | 28.9726 | 73.2557 |
| 43     | Ss - 43   | Bhatwas – 1, Rajastan | 24.7145 | 72.2509 |
| 44     | Ss - 44   | Bhatwas – 2, Rajastan | 27.6195 | 75.1245 |
| 45     | Ss - 45   | CSWRI, Avikanagar, Rajastan | 26.3092 | 75.4186 |
| 46     | Ss - 46   | CSWRI, Avikanagar, Rajastan | 26.2485 | 75.7541 |
| 47     | Ss - 47   | Bhatathali, Karnataka | 16.4065 | 74.3876 |
| 48     | Ss - 48   | Ottanchathiram, TN | 10.4897 | 77.7544 |
| 49     | Ss - 49   | Adikanpati, Madurai, TN | 11.2390 | 78.8702 |
| 50     | Ss - 50   | Ottampatti, Trichy, TN | 11.1954 | 78.1905 |
| 51     | Ss - 51   | Ottampatti – 1, Trichy, TN | 11.1954 | 78.1905 |
| 52     | Ss - 52   | FC & RI, Mettupalayam, TN | 11.3028 | 78.9383 |
| 53     | Ss - 53   | Pudukottai, TN | 10.3833 | 78.8001 |
| 54     | Ss - 54   | Erode, TN | 11.3410 | 77.7172 |
| 55     | Ss - 55   | Arkad, TN | 11.9282 | 79.8135 |
| 56     | Ss - 56   | Kolliadriver, Ariyalur, TN | 11.3306 | 79.7203 |
| 57     | Ss - 57   | Chinnamanur, Theni, TN | 9.8427 | 77.3830 |
| 58     | Ss - 58   | Aniyapuram, Namakkal, TN | 11.1259 | 78.1674 |
Gujarat, Maharashtra, Karnataka, Arunachal Pradesh, Madhya Pradesh and West Bengal was given in Table 1. The research was conducted at the Department of Medicinal and Aromatic Crops, Tamil Nadu Agricultural University, Coimbatore during 2020-21. The field trial was laid in Randomized Block Design (RBD) and replicated thrice. All the necessary intercultural operations were carried out.

Observations on days for germination, seedling length, shoot length, root length, number of leaves, seedling leaf length, seedling leaf width, seedling fresh weight, shoot fresh weight, root fresh weight, seedling dry weight, shoot dry weight, root dry weight, seedling fresh: dry ratio, plant spread [(North-South) and (East-West)], the number of branches, the number of flower clusters per plant, leaf length, leaf width, stem girth, petiole length, internodal length, the number of thorns at the upper surface of a leaf, the number of thorns at the lower surface of a leaf, days taken for first flowering and 50% flowering, the number of berries, berry diameter, fresh single berry weight, dry single berry weight, fresh berry weight per plant, fresh to dry ratio and dry berry weight per plant were recorded at an appropriate stage of the crop using appropriate methodology. Diversity analysis was done as described by Mahalanobis $D^2$ method (1936) for 34 traits of Solanum surattense.

RESULTS AND DISCUSSION
Genetic diversity analysis was done using the data generated for 49 accessions of Solanum surattense for 34 characters by calculating $D^2$ values for all possible $n(n-1)/2$ pairs of combinations. The accessions were grouped into six clusters indicating the presence of a huge amount of diversity among the accessions. The composition of clusters based on $D^2$ values of 49 accessions of Solanum surattense is presented in Table 2. Among six clusters, cluster VI had the highest number of genotypes (33) followed by cluster I (8). The remaining clusters viz., cluster II, cluster III, cluster IV and cluster V had two accessions each in their clusters. The grouping was done based on the available diversity observed and not because of their geographical distributions. This is in accordance with the findings of Rathi et al. (2011), Ahmed et al. (2014), Madhavi et al. (2015) in brinjal and Mithlesh kumar et al. (2021) in ashwagandha.

The inter and intra cluster distances of six clusters are presented in Table 3. The maximum intra cluster distance was registered in cluster VI (137.94) followed by cluster I (123.88). The lowest intra cluster distance was recorded in cluster II (23.61). Clusters I and VI had the highest inter cluster distance (128.25) followed by clusters V and VI (115.36). The lowest inter cluster distance (23.61) was

Table 2. Composition of clusters based on $D^2$ values of 49 accessions of kantakari (Solanum surattense)

| S. No. | Cluster name | Number of genotypes | Name of genotypes |
|--------|--------------|---------------------|-------------------|
| 1      | Cluster I    | 8                   | Ss- 1, Ss- 2, Ss - 3, Ss - 4, Ss- 5, Ss- 6, Ss- 7 and Ss- 9 |
| 2      | Cluster II   | 2                   | Ss – 27 and Ss - 32 |
| 3      | Cluster III  | 2                   | Ss – 18 and Ss - 48 |
| 4      | Cluster IV   | 2                   | Ss – 23 and Ss - 26 |
| 5      | Cluster V    | 2                   | Ss – 42 and Ss - 44 |
| 6      | Cluster VI   | 33                  | Ss - 10, Ss - 11, Ss - 12, Ss - 13, Ss - 14, Ss - 15, Ss - 17, Ss - 19, Ss - 20, Ss - 21 , Ss - 22, Ss - 24, Ss - 25, Ss - 31, Ss - 33, Ss - 34, Ss - 35, Ss - 36, Ss - 38, Ss - 39, Ss - 41, Ss - 43, Ss - 45, Ss - 49, Ss - 50, Ss - 51, Ss - 52, Ss - 53, Ss - 54, Ss - 55, Ss - 56, Ss -57 and Ss – 58 |

Table 3. Average intra (in bold) and inter cluster $D^2$ distances of kantakari (Solanum surattense)

| Cluster | I      | II     | III    | IV     | V      | VI     |
|---------|--------|--------|--------|--------|--------|--------|
| I       | 123.88 | 94.25  | 94.16  | 91.97  | 100.34 | 128.25 |
| II      | 20.62  | 23.61  | 52.77  | 32.52  | 107.47 |
| III     | 20.97  | 59.46  | 37.88  | 107.72 |
| IV      | 21.21  | 65.00  | 102.82 |
| V       |        | 21.27  | 115.36 |
| VI      |        |        | 137.94 |
recorded between cluster II and III. The highest intra and inter cluster distance indicate the presence of a wide range of diversity within the cluster and between the clusters. This finding is in line with the results of Ravali et al. (2017), Singh et al. (2006) in Solanum melongena and Parthsinh et al. (2021) in chilli.

Cluster mean values for 34 characters of Solanum surattense for six groups are presented in Table 4. Cluster IV recorded maximum mean value for nine traits viz., days taken for germination (15.00), shoot length (10.93 cm), the number of leaves (5.25), seeding leaf length (6.25 cm), root fresh weight (0.05 g), root dry weight (0.01 g), seeding fresh: dry (7.72), plant spread (North-South) (112.33 cm) and the number of flower cluster per plant (20.47). Cluster I had the maximum mean values for eight traits viz., seedling fresh weight (0.59 g), shoot fresh weight (0.54 g), root dry weight (0.01 g), stem girth (9.08 mm), internodal length (9.14 cm), the number of berries (89.09), fresh berry weight per plant (209.21 g) and dry berry weight per plant (62.36 g).

Cluster V recorded the maximum mean value for seven traits viz., seedling leaf length (3.90 cm), days for first flowering (54.83), days to 50% flowering (66.00), plant spread (East-West)(107.13 cm), the number of thorns at the upper surface of a leaf (14.03), the number of thorns at the lower surface of a leaf (14.07) and

Table 4. Cluster mean values for 34 characters of Solanum surattense

| Cluster | Days taken for germination (Days) | Seedling length (cm) | Shoot length (cm) | Root length (cm) | Number of leaves | Leaf length (cm) | Leaf width (cm) | Seedling fresh weight (g) | Shoot fresh weight (g) | Root fresh weight (g) | Seedling dry weight (g) | Shoot dry weight (g) |
|---------|----------------------------------|----------------------|-------------------|-----------------|-----------------|-----------------|-----------------|--------------------------|-----------------------|----------------------|------------------------|----------------------|
| I       | 13.73                            | 18.87                | 9.91              | 6.50            | 3.73            | 5.08            | 2.87            | 0.59                     | 0.54                  | 0.04                 | 0.09                   | 0.08                 |
| II      | 12.50                            | 21.37                | 9.65              | 7.25            | 4.75            | 5.13            | 3.37            | 0.44                     | 0.40                  | 0.05                 | 0.10                   | 0.09                 |
| III     | 13.50                            | 13.51                | 8.98              | 6.38            | 4.25            | 4.90            | 3.63            | 0.51                     | 0.47                  | 0.04                 | 0.11                   | 0.11                 |
| IV      | 15.00                            | 21.02                | 10.93             | 6.22            | 5.25            | 6.25            | 2.03            | 0.42                     | 0.38                  | 0.05                 | 0.06                   | 0.05                 |
| V       | 14.50                            | 17.94                | 8.68              | 7.40            | 3.75            | 4.75            | 3.90            | 0.34                     | 0.30                  | 0.03                 | 0.06                   | 0.06                 |
| VI      | 14.67                            | 17.90                | 10.15             | 7.07            | 3.80            | 4.67            | 2.74            | 0.58                     | 0.53                  | 0.05                 | 0.09                   | 0.08                 |

Table 4. Contd….

| Cluster | Root dry weight (g) | Seedling fresh: dry ratio | Days for first flowering | Days for 50% flowering | Plant spread (N-S) (cm) | Plant spread (E-W) (cm) | Number of branches | Number of flower cluster per plant | Leaf width (cm) | Leaf length (cm) | Stem girth (mm) | Petiole length (cm) |
|---------|---------------------|--------------------------|-------------------------|-------------------------|------------------------|-----------------------|--------------------|-----------------------------------|-----------------|-----------------|-----------------|---------------------|
| I       | 0.01                | 7.18                     | 35.82                   | 52.21                   | 105.39                 | 103.34                | 5.23               | 15.19                             | 5.97            | 8.87            | 9.08            | 5.45                |
| II      | 0.00                | 4.67                     | 48.33                   | 51.67                   | 103.27                 | 103.97                | 5.90               | 18.03                             | 6.49            | 8.67            | 7.88            | 4.89                |
| III     | 0.00                | 4.75                     | 47.67                   | 52.83                   | 98.00                  | 98.43                | 6.77               | 16.77                             | 8.20            | 10.09           | 7.39            | 6.08                |
| IV      | 0.01                | 7.72                     | 32.17                   | 48.00                   | 112.33                 | 101.90                | 5.10               | 20.47                             | 7.99            | 9.00            | 8.52            | 4.86                |
| V       | 0.00                | 5.26                     | 54.83                   | 66.00                   | 104.57                 | 107.13                | 5.77               | 16.10                             | 5.68            | 7.51            | 7.22            | 6.02                |
| VI      | 0.01                | 7.25                     | 39.59                   | 55.36                   | 99.91                  | 107.13                | 5.62               | 15.26                             | 7.41            | 9.96            | 8.77            | 4.74                |

Table 4. Contd….

| Cluster | Internodal length (cm) | Number of thorns in upper side of the leaf | Number of thorns in lower side of the leaf | Number of berries | Berry diameter (mm) | Fresh single berry weight (g) | Dry single berry weight (g) | Fresh berry to dry ratio | Dry berry weight (g) |
|---------|------------------------|--------------------------------------------|--------------------------------------------|-------------------|---------------------|-----------------------------|----------------------------|-----------------------|---------------------|
| I       | 9.14                   | 12.73                                      | 13.02                                      | 89.09             | 16.61               | 2.51                        | 0.64                      | 209.21               | 3.30                | 62.36               |
| II      | 7.02                   | 13.17                                      | 12.70                                      | 49.37             | 15.23               | 2.42                        | 0.63                      | 122.70               | 2.79                | 44.28               |
| III     | 8.57                   | 13.10                                      | 13.10                                      | 53.35             | 15.74               | 2.33                        | 0.68                      | 118.44               | 2.77                | 42.35               |
| IV      | 7.40                   | 13.43                                      | 13.63                                      | 63.40             | 17.22               | 2.04                        | 0.62                      | 130.06               | 2.86                | 44.74               |
| V       | 8.31                   | 14.03                                      | 14.07                                      | 47.63             | 16.93               | 2.57                        | 0.77                      | 117.64               | 2.79                | 42.10               |
| VI      | 8.15                   | 13.04                                      | 13.12                                      | 77.11             | 17.34               | 2.69                        | 0.68                      | 202.88               | 3.31                | 59.79               |

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dry single berry weight (0.77 g). Cluster VI had the maximum mean values for six traits viz., root fresh weight (0.05 g), root dry weight (0.01 g), plant spread (East-West) (107.13 cm), berry diameter (17.34 mm), fresh single berry weight (2.69 g) and fresh to dry ratio (3.31). Cluster III recorded the maximum mean value for six traits viz., seedling dry weight (0.11 g), shoot dry weight (0.11 g), the number of branches (6.77), leaf length (8.20 cm), petiole length (6.08 cm). Cluster II had the maximum mean values for three traits viz., seedling length (21.37 cm) and root length (7.25 cm). Similar findings have also been reported by Senapathi et al. (2009) and Dutta et al. (2009) in brinjal. Crossing the accessions from the most divergent clusters will be useful to get better hybrids with desirable segregants. This result is in agreement with the divergence studies done by Vidhya and Kumar (2014) in brinjal.

Table 5. Relative contribution of 34 traits towards genetic divergence in 49 Solanum surattense accessions

| S. No. | Character                                      | Number of first rank | Per cent contribution |
|--------|-----------------------------------------------|----------------------|-----------------------|
| 1.     | Days taken for germination                     | 2                    | 0.17                  |
| 2.     | Seedling length                               | 0                    | 0.00                  |
| 3.     | Shoot length                                  | 2                    | 0.17                  |
| 4.     | Root length                                   | 11                   | 0.94                  |
| 5.     | Number of leaves                              | 8                    | 0.68                  |
| 6.     | Leaf length                                   | 36                   | 3.06                  |
| 7.     | Leaf width                                    | 40                   | 3.40                  |
| 8.     | Seedling fresh weight                         | 0                    | 0.00                  |
| 9.     | Shoot fresh weight                            | 58                   | 4.93                  |
| 10.    | Root fresh weight                             | 2                    | 0.17                  |
| 11.    | Seedling dry weight                           | 42                   | 3.57                  |
| 12.    | Shoot dry weight                              | 0                    | 0.00                  |
| 13.    | Root dry weight                               | 391                  | 33.25                 |
| 14.    | Seedling fresh:dry ratio                      | 95                   | 8.08                  |
| 15.    | Days for first flowering                       | 0                    | 0.00                  |
| 16.    | Days for 50 % flowering                        | 0                    | 0.00                  |
| 17.    | Plant spread (N-S)                            | 7                    | 0.60                  |
| 18.    | Plant spread (E-W)                            | 0                    | 0.00                  |
| 19.    | Branch number                                 | 0                    | 0.00                  |
| 20.    | Flower cluster per branch                     | 13                   | 1.11                  |
| 21.    | Leaf length                                   | 5                    | 0.43                  |
| 22.    | Leaf width                                    | 87                   | 7.40                  |
| 23.    | Stem girth                                    | 27                   | 2.30                  |
| 24.    | Petiole length                                | 55                   | 4.68                  |
| 25.    | Internodal length                             | 96                   | 8.16                  |
| 26.    | Number of thorns in upper side of the leaf    | 2                    | 0.17                  |
| 27.    | Number of thorns in lower side of the leaf    | 0                    | 0.00                  |
| 28.    | Number of berries                             | 3                    | 0.26                  |
| 29.    | Berry diameter                                | 0                    | 0.00                  |
| 30.    | Fresh single berry weight per plant            | 3                    | 0.26                  |
| 31.    | Dry single berry weight                       | 15                   | 1.28                  |
| 32.    | Fresh berry weight                            | 41                   | 3.49                  |
| 33.    | Fresh to dry ratio                            | 14                   | 1.19                  |
| 34.    | Dry berry weight per plant                    | 121                  | 10.29                 |
The relative contribution of characters towards divergence is presented in Table 5. Maximum contribution towards divergence was observed for root dry weight (33.25%) followed by dry berry weight per plant (10.29%). The contribution towards divergence ranged from 0.1 to 1.0 per cent for days taken for germination, shoot length, root fresh weight, the number of thorns at the upper surface of a leaf, the number of leaves, plant spread (North-South), leaf length, the number of berries, fresh single berry weight and root length. Seedling leaf length, seedling leaf width, shoot fresh weight, seedling dry weight, seedling fresh: dry, the number of flower cluster per plant, leaf width, stem girth, petiole length, internodal length, dry single berry weight, fresh berry weight per plant and fresh to dry ratio registered 1 to 10 per cent of contribution towards divergence. Contribution towards the divergence is important to know the variability that exists in the traits of interest which are reflected by the increased per cent of the contribution. This will offer more scope to practice selection for that trait. The trait (dry berry weight per plant) with a high contribution towards divergence, high mean yield and high intra cluster distance may help in realizing diversity in segregating generations on planned crosses as reported by Patel et al. (2014).

From this study, it is concluded that significant diversity among the accessions of Solanum suarttense was observed for seed germination, seedling characters, morphological and yield traits of plants. Wide divergence was recorded for dry berry weight per plant among the 34 characters studied. Selection of genotypes based on the above trait for the crossing programme would be useful since it is an economic part of the plant. Cluster analysis resulted in grouping 49 accessions into six clusters. From this analysis, promising traits can be improved through breeding promising accessions from selected clusters.

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