



## Genetic variability and character association in bread wheat (*Triticum aestivum*)

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### ABSTRACT

Forty seven released varieties of common bread wheat (*Triticum aestivum* L.) were evaluated during *rabi* 2007-08 to 2010-11 for four years under irrigated conditions at Directorate of Seed Research, Mau. Analysis of variance on 12 quantitative characters was carried out and pooled analysis was conducted over the seasons. The mean, range, phenotypic, genotypic and environmental variance, genotypic and phenotypic coefficient of variation, heritability in broad sense and genetic advance were calculated. Path coefficient analysis was carried out using correlation coefficients to establish the inter-relationship and direct and indirect contributions of component traits towards grain yield. Analysis of variance revealed the considerable amount of genetic variability in genotypes for all the traits. High genetic advance (GA) coupled with moderate to high heritability for grains/spike and 1000-seed weight indicated the effectiveness of selection for these traits. Number of grains/spikelet, grain yield/spike and effective tillers/m<sup>2</sup> were positively associated with grain yield. Similarly, effective tillers/m<sup>2</sup>, number of grains/spike and grain yield/spike had higher phenotypic and genotypic direct effects on grain yield/m<sup>2</sup>, revealing that indirect selection for these traits would be effective in improving the grain yield. The higher direct and indirect contribution of grains/spike, tillers/m<sup>2</sup>, 1000-seed weight, spikelets/spike and grains/spikelet towards total grain yield would be of great use for indirect selection for yield improvement.

**Key words:** Correlation, Genetic variability, Heritability, Path analysis, *Triticum aestivum*

Wheat (*Triticum aestivum* L.) is an important cereal crop in India, plays an important role in nutritional as well as food security of the sub-continent of Asia. It stands second next to rice in production among cultivated crops and has been considered as “versatile cereal food”. India recorded all time high 94.88 million tonnes of wheat production from an area of 29.90 million hectare during 2011-12 (DWR 2013) and contributed about 13.53 % to the global wheat production (FAO 2013). High yielding varieties along with better crop management boosted India’s wheat productivity levels, which has increased from mere 0.91 tonnes/ha during 1965 to about 3.1 tonnes/ha during 2011-12. Yield increases may be effectively tackled on the basis of performance of yield components and other closely related traits (Singh *et al.* 2008). Wheat is grown under diverse agro-climatic conditions leading to wide fluctuation in productivity from region to region. Since the growing period of the crop becomes restricted due to sudden increase in the temperature after winter; the sowing time has an important bearing on production potential of a genotype. Moreover,

in intensive production system, farmers have to adjust the sowing time to suit different crops (Banerjee *et al.* 2006). The North-Western Plains Zone (NWPZ), North-Eastern Plains Zone (NEPZ) and Central Zone (CZ) are the major wheat producing regions of India, where, the prevailing conditions are highly suitable for wheat cultivation. Manifestation of wheat yield fluctuates widely as a result of its interaction with the environment, because grain yield in wheat is a complexly inherited character and is the product of several contributing factors that affect it directly or indirectly (Hristov *et al.* 2011). Availability of wider gene pool in the form of genetic diversity is a pre-requisite for crop improvement. The traits for which variability present should be highly heritable as the progress through selection depends on heritability, selection intensity and genetic advance of the trait. An estimate of genetic advance along with heritability is helpful in assessing the reliability of character for selection. Yield is complexly inherited character and it is dependent on several contributing traits, generally inherited quantitatively (Yadav *et al.* 2011, Kalimullah 2012). The relationship between two traits plays an important role in breeding programme, as changes brought about by natural or artificial selection in a trait, especially in one of the major adaptive traits, are associated with changes in other trait (Hadjichristodoulou 1989). With respect to their

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magnitude and nature, various morphological characters differ in their inter-relationship with yield, though they show a continuous variation and are influenced by environment. The traits with high heritability exhibiting positive association with yield can be used for indirect selection for yield and will serve as an alternate mode of selection for yield improvement. When the indirect associations become complex, path coefficient analysis is the most effective mean to find out direct and indirect causes of association among the different variables. Path coefficient analysis can discriminate between the realistic (genetic effects) and inflated (environmental effects) correlations (Yadav *et al.* 2011). Hence, the knowledge of direct and indirect effects of different components on yield is of prime importance in selection of high yielding genotypes.

Hence, in the context of yield improvement, when selecting desirable genotypes it is very important to know the nature and extent of variation present within a set of breeding material as well as the interrelationship between each yield component and grain yield and the exact contribution of each component to yield *via* direct and indirect effects. It is known that the improvement of the genetic architecture of yield must be based on a more intensive study of individual yield components. Keeping this in view, the present study was undertaken to ascertain the extent of genetic variability, heritability, genetic advance and inter-relationship of yield components to establish their implications in the selection of better genotypes of wheat.

#### MATERIALS AND METHODS

The field experiments were conducted for four years at the experimental farm, Directorate of Seed Research, Mau during *rabi* 2007-08 to 2010-11 under irrigated conditions. The experimental materials for the study comprised 47 released varieties of common bread wheat having wider adaptability in the areas of their recommendation. There were twelve varieties from UP and Uttarakhand (UP 2382, C 306, UP 2425, NW 1076, HUW 468, K 9107, HUW 234, NW 1014, VL 616, VL 804, VL 829, HUW 510), nine from

Delhi (HD 2733, HD 2824, DL 153-2, DL 788-2, HD 2189, HD 2687, HD 2851, HW 2004, WR 544), six from Punjab (PBW 343, PBW 502, PBW 296, PBW 443, PBW 154, PBW 373), six from Haryana (DBW 17, DBW 14, DBW 16, DBW 28, DBW 39, CBW 38), four from Gujarat (GW 322, GW 366, LOK 1, GW 173), three from Rajasthan (Raj 3077, Raj 4120, Raj 4037), three from HP (HS 240, HS 375, HS 420), two from MP (MP 4010, HI 1531) and two from Maharashtra (NIAW 34 and NIAW 917).

In all the four years, the trials were laid out under randomized complete block design with three replications with plot size of 1.5 × 6 m. The genotypes were planted in 6 rows of 6 meter with row to row distance of 25 cm. All the recommended cultural and management practices were followed to raise a good uniform crop during all the four seasons under irrigated condition. The observations were recorded on twelve characters, viz. days to 50% spike emergence, flag leaf length (cm), flag leaf width (cm), peduncle length (cm), plant height (cm), number of effective tillers/m<sup>2</sup>, number of grains per spike, number of spikelets per spike, number of grains per spikelet, grain yield per spike (g), 1000-seed weight (g) and grain yield/m<sup>2</sup>. The data on number of effective tillers and total grain yield was recorded on per m<sup>2</sup> basis, while, data on days to 50% spike emergence was recorded on plot basis. The observations on rest of the traits were recorded on randomly selected ten competitive plants in the middle four rows of each plot in all the three replications. Standard procedures were followed for analysis of variance. The phenotypic and genotypic coefficients of variation (PCV, GCV) were calculated as per method suggested by Burton (1954). The correlation coefficients at genotypic and phenotypic level were computed as per Johnson *et al.* (1955). Path coefficient analysis was done by using correlation coefficients as suggested by Dewey and Lu (1959). Path coefficient analysis was carried out by taking grain yield/m<sup>2</sup> as dependent variable and other observed traits as independent variables. The pooled analysis was done by pooled data of all the four years.

Table 1 Estimates of different genetic parameters of variation over four seasons (pooled data)

| Character                        | Mean   | Range         | PCV   | GCV   | H <sup>2</sup> (%) | GA    | GA as % of mean |
|----------------------------------|--------|---------------|-------|-------|--------------------|-------|-----------------|
| Days to 50% spike emergence      | 78.16  | 66.67-88.92   | 6.03  | 5.66  | 88.10              | 8.56  | 10.95           |
| Flag leaf length (cm)            | 25.80  | 22.42-29.17   | 10.57 | 6.15  | 33.90              | 1.90  | 7.36            |
| Flag leaf width (cm)             | 1.85   | 1.59-2.09     | 9.98  | 6.77  | 45.90              | 0.18  | 9.73            |
| Peduncle length (cm)             | 36.92  | 29.34-47.47   | 12.62 | 10.15 | 64.70              | 6.21  | 16.82           |
| Plant height (cm)                | 92.89  | 76.09-111.61  | 9.75  | 8.00  | 67.40              | 12.57 | 13.53           |
| Effective tillers/m <sup>2</sup> | 449.24 | 365.92-552.50 | 17.06 | 8.35  | 24.00              | 37.82 | 8.42            |
| Grains/spike                     | 50.18  | 37.99-62.82   | 16.49 | 11.07 | 45.00              | 7.68  | 15.3            |
| Spikelets/spike                  | 17.31  | 13.26-22.77   | 15.85 | 7.69  | 23.50              | 1.33  | 7.68            |
| Grains/spikelet                  | 2.92   | 2.44-3.30     | 10.61 | 5.25  | 24.50              | 0.16  | 5.48            |
| Grain yield/spike (g)            | 1.96   | 1.47-2.38     | 15.71 | 7.87  | 25.10              | 0.16  | 8.16            |
| 1000-grain weight (g)            | 38.85  | 30.25-51.27   | 12.91 | 10.52 | 66.50              | 6.87  | 17.68           |
| Grain yield /m <sup>2</sup> (kg) | 0.368  | 0.263-0.435   | 19.50 | 7.15  | 13.40              | 0.02  | 5.43            |

PCV: Phenotypic coefficient of variation, GCV: Genotypic coefficient of variation, H<sup>2</sup>: Heritability (broad sense), GA: Genetic advance

RESULTS AND DISCUSSION

Analysis of variance for individual as well as pooled data indicated significant differences amongst genotypes for all the twelve characters studied. Variance due to genotype was highly significant for all the traits indicating the presence of considerable amount of genetic variability in the genotypes selected for the study. Significant genetic variability among wheat genotypes for days to 50% spike emergence, plant height (cm), number of tillers, grains/spike, spikelets/spike, grains/spikelet, grain yield/spike, 1000-grain weight (g) and grain yield/plant were reported by many workers (Kumar *et al.* 2003, Palve and Raghavaiah 2002, Mahato and Kerketta 2004, Shankarrao *et al.* 2010). The reason for the presence of high magnitude of genetic variability in present investigation might be due to the fact that the genotypes selected for study were of diverse nature as they were developed in different breeding programmes and were released for different agro-climatic conditions of the country. Mir *et al.* (2012) reported a considerable amount of genetic diversity among 263 released cultivars bread wheat.

Phenotypic coefficient of variation for all the characters was higher than the genotypic coefficient of variation (Table 1) which reflects the influence of environment on the expression of traits. Grain yield/m<sup>2</sup> recorded highest values of PCV indicating the higher influence of environmental factors on this trait. Traits like peduncle length, number of grains per spike, 1000-grain weight and effective tillers/m<sup>2</sup> recorded high values of GCV and moderate to high values of PCV suggesting that these characters are under the influence of genetic control. High genotypic and phenotypic coefficient of variation for number of productive tillers and grain yield per plant was reported by Hokrani *et al.* (2013). Similar findings pertaining to presence of high genetic variability were reported for different traits including grain yield/plant (Dwivedi 2003, Shankarrao 2010). Results revealed the presence of high amount of genetic variability in the evaluated genotypes for the major yield contributing characters along with grain yield indicating that further improvement for these traits is possible.

Days to 50% spike emergence, plant height, 1000 seed weight and peduncle length exhibited high heritability (Table 1). High heritability for days to 50% flowering and 1000-seed weight has been reported earlier also (Hokrani *et al.* 2013). Heritability for remaining traits, viz. flag leaf length, flag leaf width, tiller number/m<sup>2</sup>, grains/spike, spikelets/spike, grains/spikelet, grain yield/spike and grain yield/m<sup>2</sup> were moderate to low. Falconer (1961) stated that characters associated with reproductive fitness, such as yield, manifest low h<sup>2</sup>, while those that are least important, as judged on biological grounds, show high heritabilities. Genetic advance as per cent of mean was higher for 1000-seed weight, peduncle length and number of grains per spike indicating that selection for these traits would be effective for the improvement. Similar findings pertaining to high genetic advance as per cent of mean for different traits were earlier reported by many workers (Shankarrao *et al.* 2010, Hokrani

Table 2 Phenotypic (above diagonal) and genotypic (below diagonal) correlations (pooled)

| Character                        | Days to 50% spike emergence | Flag leaf length (cm) | Flag leaf width (cm) | Peduncle length (cm) | Plant height (cm) | Effective tillers/m <sup>2</sup> | Grains/spike | Spikelets/spike | Grains/spikelet | Grain yield/spike (g) | 1000-grain weight (g) | Grain yield/m <sup>2</sup> (g) |
|----------------------------------|-----------------------------|-----------------------|----------------------|----------------------|-------------------|----------------------------------|--------------|-----------------|-----------------|-----------------------|-----------------------|--------------------------------|
| Days to 50% spike emergence      | 1.000                       | 0.029                 | -0.051               | -0.151               | 0.247             | -0.064                           | 0.236        | 0.343*          | -0.031          | -0.162                | -0.558**              | -0.242                         |
| Flag leaf length (cm)            | 0.012                       | 1.000                 | 0.320*               | 0.201                | 0.142             | 0.088                            | -0.050       | 0.101           | -0.151          | -0.095                | -0.105                | 0.112                          |
| Flag leaf width (cm)             | -0.123                      | 0.255                 | 1.000                | 0.004                | -0.123            | 0.072                            | 0.014        | 0.096           | -0.038          | 0.045                 | 0.015                 | 0.199                          |
| Peduncle length (cm)             | -0.209                      | 0.300*                | -0.074               | 1.000                | 0.590             | -0.004                           | -0.079       | -0.021          | -0.049          | 0.001                 | 0.054                 | -0.055                         |
| Plant height (cm)                | 0.320*                      | 0.101                 | -0.329*              | 0.688**              | 1.000             | 0.057                            | 0.158        | 0.170           | 0.048           | 0.074                 | -0.213                | -0.019                         |
| Effective tillers/m <sup>2</sup> | -0.132                      | -0.268                | -0.201               | -0.268               | -0.274            | 1.000                            | -0.261       | -0.123          | -0.119          | -0.273                | -0.039                | 0.419**                        |
| Grains/spike                     | 0.365*                      | -0.033                | 0.025                | -0.117               | 0.241             | -0.620**                         | 1.000        | 0.336*          | 0.633**         | 0.621**               | -0.394**              | 0.081                          |
| Spikelets/spike                  | 0.709**                     | 0.195                 | 0.183                | -0.141               | 0.329             | -0.739**                         | 0.913**      | 1.000           | 0.020           | 0.297*                | -0.290*               | 0.042                          |
| Grains/spikelet                  | -0.118                      | -0.332*               | -0.093               | -0.092               | 0.028             | -0.246                           | 0.787**      | 0.474**         | 1.000           | 0.455**               | -0.223                | 0.086                          |
| Grain yield/spike (g)            | -0.405**                    | -0.124                | 0.182                | -0.014               | 0.060             | -0.803**                         | 0.460**      | 0.291*          | 0.408**         | 1.000                 | 0.359*                | 0.149                          |
| 1000-grain weight (g)            | -0.751**                    | -0.076                | 0.123                | 0.070                | -0.322            | 0.051                            | -0.731**     | -0.759**        | -0.542**        | 0.252                 | 1.000                 | 0.072                          |
| Grain yield/m <sup>2</sup> (kg)  | -0.610**                    | -0.378**              | 0.274                | -0.665**             | -0.784            | 0.228                            | 0.223        | -0.219          | 0.549**         | 0.426**               | 0.142                 | 1.000                          |

\*Significant at P=0.05; \*\*Significant at P=0.01

Table 3 Phenotypic and genotypic direct (main diagonal) and indirect path coefficients (pooled)

| Character                        | Path | Days to 50% spike emergence | Flag leaf length (cm) | Flag leaf width (cm) | Peduncle length (cm) | Plant height (cm) | Effective tillers/m <sup>2</sup> | Grains/spike | Spikelets/spike | Grains/spikelet | Grain yield/spike (g) | 1000-grain weight (g) | Grain yield /m <sup>2</sup> (g) |
|----------------------------------|------|-----------------------------|-----------------------|----------------------|----------------------|-------------------|----------------------------------|--------------|-----------------|-----------------|-----------------------|-----------------------|---------------------------------|
| Days to 50% spike emergence      | G    | -0.460                      | -0.005                | -0.023               | -0.169               | -0.517            | -0.182                           | 1.594        | -2.343          | 0.420           | -0.998                | 2.073                 | -0.610                          |
|                                  | P    | -0.299                      | 0.002                 | -0.006               | 0.021                | 0.017             | -0.030                           | 0.045        | 0.029           | 0.001           | -0.014                | -0.008                | -0.242                          |
| Flag leaf length (cm)            | G    | -0.005                      | -0.426                | 0.047                | 0.242                | -0.163            | -0.37                            | -0.145       | -0.643          | 1.18            | -0.305                | 0.209                 | -0.378                          |
|                                  | P    | -0.009                      | 0.065                 | 0.040                | -0.028               | 0.010             | 0.041                            | -0.010       | 0.009           | 0.003           | -0.008                | -0.001                | 0.112                           |
| Flag leaf width (cm)             | G    | 0.057                       | -0.109                | 0.185                | -0.060               | 0.531             | -0.278                           | 0.111        | -0.604          | 0.330           | 0.450                 | -0.340                | 0.274                           |
|                                  | P    | 0.015                       | 0.021                 | 0.123                | 0.000                | -0.009            | 0.033                            | 0.003        | 0.008           | 0.001           | 0.004                 | 0.000                 | 0.199                           |
| Peduncle length (cm)             | G    | 0.096                       | -0.128                | -0.014               | 0.809                | -1.112            | -0.370                           | -0.510       | 0.464           | 0.326           | -0.034                | -0.193                | -0.665                          |
|                                  | P    | 0.045                       | 0.013                 | 0.000                | -0.138               | 0.041             | -0.002                           | -0.015       | -0.002          | 0.001           | 0.000                 | 0.001                 | -0.055                          |
| Plant height (cm)                | G    | -0.147                      | -0.043                | -0.061               | 0.557                | -1.616            | -0.378                           | 1.053        | -1.086          | -0.100          | 0.147                 | 0.890                 | -0.784                          |
|                                  | P    | -0.074                      | 0.009                 | -0.015               | -0.081               | 0.070             | 0.026                            | 0.030        | 0.014           | -0.001          | 0.006                 | -0.003                | -0.019                          |
| Effective tillers/m <sup>2</sup> | G    | 0.060                       | 0.114                 | -0.037               | -0.217               | 0.443             | 1.379                            | -2.709       | 2.441           | 0.872           | -1.980                | -0.140                | 0.228                           |
|                                  | P    | 0.019                       | 0.006                 | 0.009                | 0.001                | 0.004             | 0.462                            | -0.050       | -0.010          | 0.003           | -0.023                | -0.001                | 0.419                           |
| Grains/spike                     | G    | -0.168                      | 0.014                 | 0.005                | -0.094               | -0.389            | -0.855                           | 4.371        | -3.016          | -2.796          | 1.133                 | 2.018                 | 0.223                           |
|                                  | P    | -0.071                      | -0.003                | 0.002                | 0.011                | 0.011             | -0.121                           | 0.190        | 0.028           | -0.014          | 0.052                 | -0.005                | 0.081                           |
| Spikelets/spike                  | G    | -0.326                      | -0.083                | 0.034                | -0.114               | -0.532            | -1.020                           | 3.993        | -3.302          | -1.682          | 0.717                 | 2.096                 | -0.219                          |
|                                  | P    | -0.103                      | 0.007                 | 0.012                | 0.003                | 0.012             | -0.057                           | 0.064        | 0.084           | 0.000           | 0.025                 | -0.004                | 0.042                           |
| Grains/spikelet                  | G    | 0.054                       | 0.142                 | -0.017               | -0.074               | -0.046            | -0.339                           | 3.442        | -1.564          | -3.551          | 1.007                 | 1.496                 | 0.549                           |
|                                  | P    | 0.009                       | -0.010                | -0.005               | 0.007                | 0.003             | -0.055                           | 0.121        | 0.002           | -0.022          | 0.038                 | -0.003                | 0.086                           |
| Grain yield/spike (g)            | G    | 0.186                       | 0.053                 | 0.034                | -0.011               | -0.096            | -1.107                           | 2.009        | -0.960          | -1.450          | 2.466                 | -0.697                | 0.426                           |
|                                  | P    | 0.048                       | -0.006                | 0.006                | 0.000                | 0.005             | -0.126                           | 0.118        | 0.025           | -0.010          | 0.084                 | 0.005                 | 0.149                           |
| 1000-grain weight (g)            | G    | 0.345                       | 0.032                 | 0.023                | 0.057                | 0.521             | 0.070                            | -3.194       | 2.505           | 1.923           | 0.622                 | -2.762                | 0.142                           |
|                                  | P    | 0.167                       | -0.007                | 0.002                | -0.007               | -0.015            | -0.018                           | -0.075       | -0.024          | 0.005           | 0.031                 | 0.014                 | 0.072                           |

et al. 2013, Kumar et al. 2003). Likewise, high heritability with high genetic advance for 1000-seed weight was earlier reported by Shah (1998) and number of grains per spike by Rana et al. (1999). These findings clearly support the results of present investigation.

The improvement of yield components and the knowledge of their association with its main component is beneficial in formulating the breeding programme. Correlation coefficients were estimated between grain yields/m<sup>2</sup> and other component traits revealed that grain yield was positively associated with number of grains/spikelet and grain yield/spike at genotypic level while it was significantly associated with number of effective tillers/m<sup>2</sup> at phenotypic level (Table 2). 1000-seed weight was positively correlated with grain yield/spike. Number of grains/spike was positively associated with number of spikelets/spike, number of grains/spikelet and grain yield/spike at both phenotypic and genotypic level. The similar findings for association of different traits were reported earlier by many workers (Hokrani et al. 2013, Khan and Dar 2010, Mahesh et al. 2001). It has been observed that the traits like grains/spike, spikelets/spike, grains/spikelet and grain yield/spike were positively associated with each other and these are the major components for yield. Hence, selection for these traits would also help in improving the grain yield in this crop. 1000-seed weight showed negative association with grains/spike, spikelets/spike, and grains/spikelet. Singh et al. (2008) also reported negative association of 1000-seed weight with grains/spike and spikelets/spike. Singh et al. (1998) also reported negative association of 1000-seed weight with grains/spike.

The results of path coefficient indicated that number of effective tillers/m<sup>2</sup>, number of grains per spike, grain yield per spike and flag leaf width exhibited positive phenotypic and genotypic direct effects on grain yield/m<sup>2</sup> (Table 3). Genotypic direct effect of peduncle length on grain yield/m<sup>2</sup> is positive, however, its phenotypic direct

effect and correlation coefficients at both the levels was reported negative indicating that the importance of restricted selection for exploitation of direct effects noticed. The phenotypic direct effect of flag leaf length, plant height, number of spikelets per spike and 1000 seed weight were positive but low, therefore, direct selection for these traits may not help in yield improvement. Alternatively, effective tillers/m<sup>2</sup>, number of grains per spike, grain yield per spike had higher phenotypic and genotypic direct effects on grain yield/m<sup>2</sup>, thus, the correlation coefficient between grain yield and these three traits is real one, revealing that indirect selection for these traits would be effective in improving grain yield. The findings are in accordance with the earlier reports where direct positive effects for number of grains per spike (Narwal *et al.* 1999, Khan and Dar 2010) and number of tillers/plant (Narwal *et al.* 1999) has been reported in wheat.

The data indicated that different component traits had their indirect effect on grain yield/m<sup>2</sup>. Indirect contribution towards grain yield was exhibited by 1000-seed weight *via* number of spikelets/spike and number of grains/spikelet. Number of grains/spike showed higher positive indirect effect on grain yield/m<sup>2</sup> through 1000-seed weight and grain yield/spike at genotypic level. Similarly, indirect positive effect of grains / spikelet was exhibited *via* number of grains/spike and 1000-seed weight, while, number of effective tillers had indirect positive effect through spikelets/spike and grains/spikelet. Indirect positive effect of 1000-seed weight *via* spikelets/spike in wheat was earlier reported by Khan and Dar (2010). Path coefficient analysis revealed that number of grains/spike, effective tillers/m<sup>2</sup>, grain yield/spike, 1000-seed weight, spikelets/spike and grains/spikelet had higher direct and indirect positive contributions towards total grain yield. Hence, indirect selection for these traits would be effective in improving the grain yield. Thus, the material studied is of diverse nature and information emanated would help in designing the selection methodology which can further be used in the breeding programme for improvement of grain yield.

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