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Evaluation of elite *desi* cotton genotypes based on morpho-physiological and biochemical parameters

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Abstract : The present experiment was conducted on 50 *desi* cotton (*Gossypium arboreum* L.) genotypes under irrigated condition with the objective to decipher genetic variability, heritability, genetic advance, correlation and path analysis for variousmorpho physiological and biochemical parameters. For experimentation, randomized block design was used with three replications at Research Area of Cotton Section, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar (Haryana) during *kharif* 2021. The observations recorded on five randomly selected plants were subjected to various statistical analysis. Sufficient amount of variability was present among all the genotypes for all the studied traits. The estimates of GCV, PCV, genetic advance and heritability were high for most of the studied traits. High heritability coupled with high genetic advance as percentage over mean was observed for plant height, monopods/plant, bolls/plant, seed cotton yield/plant, photosynthesis rate, stomatal conductance and transpiration rate. The correlation study revealed that plant height, bolls/plant, boll weight and seeds/plant had a significant positive association with seed cotton yield/plant. Furthermore, path analysis indicated that the maximum positive direct effect was exhibited by bolls/plant followed by boll weight.

Keywords: Correlation, cotton, path, seed cotton yield, variability

Cotton, popularly known as "King of Fibre' and "White Gold", is one of the most important global cash crops which is ultimate source for textile fibres. It plays a predominant role in national economy in terms of providing employment directly and indirectly, contribution in trade, industrial activities and earning foreign exchange. In north India, only two species of cotton, *G. hirsutum* and *G. arboreum*, are cultivated commercially. In India, the area under cotton cultivation is declining day by day and also its productivity is very low as compared to other cotton growing countries (Sangwan *et al.*, 2022). Keeping in view the future needs of the country, it is essential to develop new high yielding variety with good fibre quality parameters. Yield is not only the major component in terms of production but also the main target of all breeding programmes. It is a complex trait that is governed by polygenes and is highly influenced by environmental factors. Therefore, direct selection for yield could be misleading. Hence, it is necessary to differentiate between heritable and non heritable components of observed variability by using statistical tools like genotypic and phenotypic coefficients of variation, heritability and genetic advance expressed in terms of per cent mean. Furthermore, effective selection is based on correlation and path analysis delineating the relationship between yield and its component traits. The degree of the correlation between yield and its attributing traits determines the net effect of the correlation discovered between two traits. Selection based on correlation analysis solely is not effective, therefore, path analysis is also an important statistical tool which permits separation of direct and indirect effects *via.* other traits and provide better insight of characters association. A combination of these analyses provides a more realistic view of

the inter relationship among various yield components. Hence the present investigation was planned to decipher the genetic variability, heritability, genetic advance, correlation and path analysis for various yield and its attributing traits in a set of 50 *desi* cotton genotypes.

The present investigation comprised of 50 elite *desi* cotton (*Gossypium arboreum* L.) genotypes, including three checks (HD 123, HD 324 and HD 432) was carried in randomized block design with three replications in the Research Area of Cotton Section, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana) during *kharif* 2021. Each genotype was grown in row of 6.0m length. The spacing of 67.5 cm between rows and 30 cm between plants was maintained. Recommended cultural practices for *desi* cotton were adopted throughout the crop season. The observations from five randomly selected plants from each genotype in each replication were recorded on eight morphological traits *viz.*, plant height, monopods/plant, days to first flower, bolls/plant, boll weight, seed cotton yield/plant, seeds/boll, ginning outturn; six physiological traits *viz.* relative water content, photosynthesis rate, stomatal conductance, transpiration rate, total chlorophyll content, proline content and three biochemical traits *viz.* crude protein content, seed oil content, gossypol content and then the mean of these five plants was used for further statistical analysis.

The data was statistically analyzed to estimate genotypic, phenotypic correlation coefficients, heritability (broad sense) and expected genetic advance as per cent of mean, correlations and path analysis using phenotypic correlation coefficients.

Variability studies:

The analysis of variance was carried out for all the studied traits among 50 elite *desi* cotton genotypes (Table 1 and 2). It is evident from their results that mean sum of squares due to genotypes were highly significant for all 17 traits, reflecting that sufficient genetic variability was present among all the genotypes for all the studied traits.

Further, various genetic parameters viz. phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability (h^2) andgenetic advance over mean for all the traits are estimated and presented in Table 3 and 4. Estimates of GCV and PCV were categorized into three groups depending on their per cent. It was observed that among all examined traits, photosynthetic rate (22.15% and 22.23%), stomatal conductance (28.54% and 28.70%) and transpiration rate (22.33% and 22.50%) demonstrated significant high GCV and PCV (>20%) respectively. Moderate value of GCV and PCV (10-20%) was exhibited by plant height (10.89% and 10.93%), monopods/plant (14.75% and 18.71%), bolls/plant (16.93% and 17.31%), seed cotton yield/plant (16.20% and 16.67%) and gossypol content (10.75% and 12.50%). Traits which exhibited low GCV and PCV (< 10%) were days to first flower (4.00% and 4.37%), boll weight (3.72% and 3.97%), seeds/boll (4.10% and 6.84%), ginning outturn (4.36% and 5.05%), relative water content (7.03% and 7.48%), total chlorophyll content (3.76% and 4.58%), proline content (8.04% and 9.72%), and seed oil content (1.78% and 2.92%). Low GCV and medium PCV was exhibited by crude protein content (9.89% and 10.32%), respectively. The phenotypic coefficient of variation (PCV) was found to be greater than genotypic coefficient of variation for all the traits which revealed that expressions of these traits were little affected by the environmental factors. Selection of such traits for improvement may sometimes be misleading. These findings were also supported by Baloch *et al.*, (2004), Ranganatha *et al.*, (2013), Pujer *et al.*, (2014a) and Raza *et al.*, (2016).

High broad sense heritability (> 60%) was observed for plant height (89.27%), monopods/plant (62.09%), days to first flower (83.74%), bolls/plant (95.64%), boll weight (87.44%), seed cotton yield/plant (94.39%), seeds/boll (65.94%), ginning outturn (74.44%), relative water content (88.50%), photosynthesis rate (99.23%), stomatal conductance (98.89%), transpiration rate (98.43%), total chlorophyll content (67.50%), proline content (68.51%), crude protein content (91.80%) and gossypol content (73.97%) except seed oil content (37.27%) as it exhibited moderate broad sense heritability (30-60%). These findings were agreed with earlier findings of Khan *et al.* (2009), Ranganatha *et al.* (2013), Farooq *et al.* (2014) and Nikhil *et al.* (2018a). This suggested the more effectiveness of selection and improvement to be expected for these traits.

Heritability estimates alone are not enough for determining the effectiveness of selection. High heritability coupled with high genetic advance expressed as percent of mean revealed that additive gene action played a predominant role in governing the traits and further it also indicated the suitability of selection of traits for further improvement among genotypes under studied. If heritability is mainly due to non-additive gene effect, the expected genetic advance would be low, whereas if there is additive gene effect, a high genetic advance may be expected. In the present investigation, high heritability coupled with high genetic advance as percentage over mean was observed for plant height (89.27 and 22.35), monopods/plant (62.09 and 23.93), bolls/plant (95.64 and 34.11), seed cotton yield/plant (94.39 and 32.42), photosynthesis rate (99.23 and 45.45), stomatal conductance (98.89 and 58.47) and transpiration rate (98.43 and 45.63), respectively. It revealed the influence of additive gene action for these traits. Hence the improvement of these traits can be made through direct phenotypic selection. Similar results were reported by Ranganatha *et al.*, (2013), Farooq *et al.*, (2014) and Pujer *et al.*, (2014b).

Correlation analysis:

Correlation coefficients reveals the degree as well as direction of a relationship between two or more variables. It is important to analyze and find out the correlation between yield and its contributing traits at genotypic and phenotypic level as it aids in successful selection process. The genotypic and phenotypic correlation coefficient between yield and its components are presented in Table 5. Seed cotton yield/plant, at both genotypic and phenotypic levels, showed highly significant and positive correlation with traits *viz.*, plant height, bolls/plant, boll weight and seeds/boll. It indicated that the selection based on these traits would ultimately improve seed cotton yield. So, these traits can be directly selected for breeding programme. Furthermore, it exhibited highly significant but negative correlation with transpiration rate and negatively significant correlation with days to first flower and gossypol content. On the other hand, at genotypic level, seed cotton yield/plant had shown significant but negative correlation with relative water content and seed oil content. Similar results were also reported by Tomar and Singh (1992), Kaushik *et al.* (2003), Salahuddin *et al.* (2010), Tulasi *et. al.* (2012), Pujer *et al.* (2014b), Erande *et al.* (2014), Kalpande *et al.* (2014), Latif *et al.* (2015), Chaudhari *et al.*, (2017), Chinchane *et al.* (2018), Satish *et. al.*, (2020) and Sakthivel and Somasundaram (2021).

Path coefficient analysis:

Path coefficient analysis was used for evaluation of direct and indirect effects of different traits on seed cotton yield/plant considering seed cotton yield/plant as dependable variable and remaining traits as independent variables. For this, correlation matrix at phenotypic level were taken into

Table1. Analysis of variance of 50 Desi cotton genotypes for eight morphological traits

Source of Variation	D.F	Mean sum of square							
		Plant height (cm)	Number of monopods per plant	Days to first flower	Number of bolls per plant	Boll weight (g)	Seed cotton yield per plant (g)	Number of seeds per boll	Ginning out turn (%)
Replications	2	64.86	0.04	1.85	13.35	0.01	138.09	6.34	0.78
Treatments	49	73909.75**	13.51**	1004.69**	5958.09**	1.34**	34741.86**	344.94**	588.34**
Error	98	358.78	4.57	122.15	178.26	0.12	1350.57	206.14	120.87

** Significant at 1% level of significance, D.F: Degree of freedom

Table2. Analysis of variance of 50 Desi cotton genotypes for nine physiological and biochemical traits

Source of Variation	D.F	Mean sum of square								
		Relative water content (%)	Photosynthesis rate (µmol CO_2 m^{-2} s^{-1})	Stomatal conductance (mmol H_2O m^{-2} s^{-1})	Transpiration rate (mmol H_2O m^{-2} s^{-1})	Total chlorophyll content (SPAD value)	Proline content (µmoles/g)	Crude protein content (%)	Seed oil content (%)	Gossypol content (%)
Replications	2	12.35	0.02	0.00	0.01	7.31	0.00	0.26	1.09	0.00
Treatments	49	1707.31**	352.27**	0.14**	99.44**	624.66**	0.05**	691.50**	16.88**	0.22**
Error	98	142.09	1.82	0.00	1.05	172.68	0.01	39.94	12.12	0.05

** Significant at 1% level of significance, D.F: Degree of freedom

Table 3. Genotypic coefficient of variance (GCV), Phenotypic coefficient of variance (PCV), Genetic advance% mean and heritability for eight morphological traits

Variables	Plant Height	Number of monopods per plant	Days to first flower	Number of bolls per plant	Boll weight	Seed cotton yield per plant	Number of seeds per boll	Ginning out turn
Heritability (bs-%)	89.27	62.09	83.74	95.64	87.44	94.39	65.94	74.44
GCV (%)	10.89	14.75	4.00	16.93	3.72	16.20	4.10	4.36
PCV (%)	10.93	18.71	4.37	17.31	3.97	16.67	6.84	5.05
Genetic advance % mean	22.35	23.93	7.53	34.11	16.74	32.42	5.07	7.74

Plant height (cm), number of monopods per plant, days to first flower, number of bolls per plant, boll weight (g), seed cotton yield per plant (g), number of seeds per boll and ginning out turn (%)

Table 4. Genotypic coefficient of variance (GCV), Phenotypic coefficient of variance (PCV), Genetic advance% mean and heritability for nine physiological and biochemical traits

Variables	Relative water content	Photosynthesis rate	Stomatal conductance	Transpiration rate	Total chlorophyll content	Proline content	Crude protein content	Seed oil content	Gossypol content
Heritability (bs-%)	88.50	99.23	98.89	98.43	67.50	68.51	91.80	37.27	73.97
GCV (%)	7.03	22.15	28.54	22.33	3.76	8.04	9.89	1.78	10.75
PCV (%)	7.48	22.23	28.70	22.50	4.58	9.72	10.32	2.92	12.50
Genetic advance % mean	13.63	45.45	58.47	45.63	6.36	13.71	19.52	2.24	19.05

Relative water content (%), photosynthesis rate (µmol CO_2 m^{-2} s^{-1}), stomatal conductance (mmol H_2O $m^{-2}s^{-1}$), transpiration rate (mmol H_2O $m^{-2}s^{-1}$), total chlorophyll content (SPAD value), proline content (µg g^{-1} DW), crude protein content (%), seed oil content (%) and gossypol content (%)

consideration. Maximum positive direct effects were exhibited by bolls/plant (0.9220) followed by boll weight (0.2320), total chlorophyll content (0.0156), days to first flower (0.0154), monopods/plant (0.0133), seed oil content (0.0081), gossypol content (0.0073), transpiration rate (0.0065), ginning outturn (0.0037) and plant height (0.0028). The estimation of path analysis indicated that emphasis should be given to bolls/plant as this

Table 5. Genotypic correlation coefficients (below diagonal) and phenotypic correlation coefficients (above diagonal) among seed cotton yield per plant and other characters

Variable	PH	NM/P	DFF	NB/P	BW	NS/B	GOT	RWC	PR	SC	TR	TCC	PC	CPC	SOC	GC	SCY/P
PH	1	0.160	0.128	0.337**	-0.036	-0.005	0.185*	0.029	0.137	0.161*	-0.268**	-0.081	0.158	0.064	0.087	0.162*	0.335**
NM/P	0.207*	1	0.072	0.016	-0.054	0.115	0.010	0.020	0.124	-0.163*	0.039	0.043	0.087	0.256**	0.092	0.062	-0.01
DFF	0.133	0.143	1	-0.157	-0.018	0.049	0.201*	0.204*	0.344**	0.033	0.083	0.017	0.133	0.108	-0.102	0.108	-0.163*
NB/P	0.348**	0.051	-0.176*	1	-0.247**	0.155	0.008	-0.207*	0.058	-0.157	-0.383**	-0.043	-0.127	0.011	-0.239**	-0.161*	0.970**
BW	-0.038	-0.052	-0.003	-0.278**	1	-0.020	0.104	0.061	-0.191*	0.162*	-0.037	-0.058	0.057	-0.106	0.127	-0.007	0.018**
NS/B	0.007	0.073	0.063	0.290**	0.042	1	0.045	0.103	0.094	-0.232**	0.099	0.169*	0.105	-0.074	-0.079	-0.133	0.306**
GOT	0.214**	0.037	0.240**	0.018	0.126	0.015	1	0.147	0.064	0.028	-0.076	0.004	0.147	0.046	0.116	-0.030	0.052
RWC	0.029	0.011	0.203*	-0.231**	0.074	0.171*	0.161*	1	0.066	0.188*	-0.048	0.215**	0.048	0.033	0.017	0.096	-0.226**
PR	0.139	0.151	0.373**	0.062	-0.208*	0.144	0.073	0.069	1	-0.242**	-0.133	0.024	-0.013	-0.033	-0.198*	-0.001	-0.002
SC	0.161*	-0.208*	0.030	-0.164*	0.174*	-0.394**	0.030	0.196*	-0.243**	1	-0.017	0.046	0.059	0.092	0.159	0.319**	-0.134
TR	-0.273**	0.050	0.092	-0.393**	-0.038	0.164*	-0.083	-0.048	-0.133	-0.018	1	0.045	0.082	0.121	-0.088	0.044	-0.412**
TCC	-0.102	0.010	0.003	-0.050	-0.060	0.267**	0.055	0.266**	0.028	0.056	0.045	1	0.233**	-0.027	0.037	0.181*	-0.056
PC	0.208*	0.201*	0.219**	-0.152	0.049	0.160	0.262**	0.076	-0.015	0.081	0.099	0.420**	1	-0.116	-0.014	0.081	-0.15
CPC	0.068	0.316**	0.094	0.018	-0.108	-0.166*	0.041	0.043	-0.036	0.099	0.131	-0.023	-0.130	1	-0.065	-0.007	-0.019
SOC	0.151	0.108	-0.028	-0.400**	0.204*	-0.073	0.152	0.108	-0.321**	0.271**	-0.159	-0.023	0.025	-0.074	1	0.048	-0.362**
GC	0.188*	0.073	0.171*	-0.196*	-0.029	-0.203*	-0.026	0.150	-0.006	0.373**	0.057	0.261**	0.136	-0.041	0.111	1	-0.206*
SCY/P	0.348**	0.029	-0.182*	0.974**	0.058**	0.156**	0.035	-0.203*	-0.004	-0.128	-0.399**	-0.048	-0.119	-0.012	-0.207*	-0.161*	1

** Significant at 1% level of significance, * Significant at 5% level of significance

PH: Plant height (cm), NM/P: Number of monopods per plant, DFF: Days to first flower, NB/P: Number of bolls per plant, BW: Boll weight (g), NS/B: Number of seeds per boll, GOT: Ginning out turn (%), RWC: Relative water content (%), PR: Photosynthesis rate (µmol CO2 m-2s-1), SC: Stomatal conductance (mmol H2O m-2s-1), TR: Transpiration rate (mmol H2O m-2s-1), TCC: Total chlorophyll content (SPAD value), PC: Proline content (µmoles/g), CPC: Crude protein content (%), SOC: Seed oil content (%), GC: Gossypol content (%) and SCY/P: Seed cotton yield per plant (g).

Table 6. Path coefficient analysis showing direct (diagonal and bold) and indirect effects of component traits on seed cotton yield per plant

Variable	PH	NM/P	DFF	NB/P	BW	NS/B	GOT	RWC	PR	SC	TR	TCC	PC	CPC	SOC	GC
PH	0.0028	0.0005	0.0004	0.0010	-0.0001	0.0000	0.0006	0.0001	0.0004	0.0004	-0.0008	-0.0003	0.0005	0.0002	0.0003	0.0005
NM/P	-0.0025	0.0133	-0.0015	-0.0005	0.0007	-0.0012	-0.0003	-0.0002	-0.0018	0.0025	-0.0006	-0.0003	-0.0020	-0.0039	-0.0013	-0.0009
DFF	0.0020	0.0018	0.0154	-0.0026	-0.0001	0.0008	0.0035	0.0031	0.0056	0.0005	0.0014	0.0001	0.0028	0.0015	-0.0009	0.0022
NB/P	0.3590	0.0388	-0.1764	0.9220	-0.2787	0.2303	0.0152	-0.2315	0.0631	-0.1686	-0.4061	-0.0492	-0.1483	0.0161	-0.3308	-0.1904
BW	-0.0086	-0.0122	-0.0020	0.0620	0.2320	0.0029	0.0272	0.0162	-0.0469	0.0393	-0.0087	-0.0137	0.0122	-0.0248	0.0381	-0.0047
NS/B	0.0000	-0.0006	-0.0004	-0.0015	-0.0001	-0.0069	-0.0002	-0.0009	-0.0008	0.0021	-0.0009	-0.0015	-0.0009	0.0008	0.0005	0.0011
GOT	0.0007	0.0001	0.0008	0.0001	0.0004	0.0001	0.0037	0.0006	0.0003	0.0001	-0.0003	0.0001	0.0008	0.0002	0.0005	-0.0001
RWC	-0.0001	-0.0001	-0.0008	0.0009	-0.0003	-0.0005	-0.0006	-0.0040	-0.0003	-0.0008	0.0002	-0.0010	-0.0003	-0.0002	-0.0003	-0.0005
PR	-0.0034	-0.0034	-0.0089	-0.0015	0.0050	-0.0029	-0.0017	-0.0017	-0.0246	0.0060	0.0033	-0.0006	0.0004	0.0009	0.0063	0.0001
SC	-0.0028	0.0033	-0.0005	0.0028	-0.0030	0.0054	-0.0005	-0.0034	0.0043	-0.0175	0.0003	-0.0009	-0.0013	-0.0017	-0.0037	-0.0062
TR	-0.0018	0.0003	0.0006	-0.0025	-0.0002	0.0009	-0.0005	-0.0003	-0.0009	-0.0001	0.0065	0.0003	0.0006	0.0008	-0.0008	0.0003
TCC	-0.0015	0.0004	0.0001	-0.0007	-0.0009	0.0034	0.0005	0.0038	0.0004	0.0008	0.0007	0.0156	0.0053	-0.0004	0.0001	0.0036
PC	-0.0017	-0.0014	-0.0017	0.0013	-0.0005	-0.0012	-0.0020	-0.0006	0.0001	-0.0007	-0.0008	-0.0031	-0.0092	0.0011	0.0000	-0.0010
CPC	-0.0004	-0.0018	-0.0006	-0.0001	0.0007	0.0007	-0.0003	-0.0002	0.0002	-0.0006	-0.0008	0.0002	0.0008	-0.0062	-0.0003	-0.0006
SOC	0.0010	0.0008	-0.0005	-0.0026	0.0013	-0.0006	0.0011	0.0005	-0.0021	0.0017	-0.0010	0.0001	0.0000	0.0003	0.0081	0.0006
GC	0.0013	0.0005	0.0011	-0.0013	-0.0002	-0.0012	-0.0002	0.0009	0.0000	0.0026	0.0004	0.0017	0.0008	0.0007	0.0006	0.0073
SCY/P	0.3440	0.0403	-0.1749	0.9768	-0.0440	0.2300	0.0455	-0.2176	-0.0030	-0.1323	-0.4072	-0.0525	-0.1378	-0.0146	-0.2836	-0.1887

Residual effect= 0.0479

PH: Plant height (cm), NM/P: Number of monopods per plant, DFF: Days to first flower, NB/P: Number of bolls per plant, BW: Boll weight (g), NS/B: Number of seeds per boll, GOT: Ginning out turn (%), RWC: Relative water content (%), PR: Photosynthesis rate (µmol CO2 m-2s-1), SC: Stomatal conductance (mmol H2O m-2s-1), TR: Transpiration rate (mmol H2O m-2s-1), TCC: Total chlorophyll content (SPAD value), PC: Proline content (µmoles/g), CPC: Crude protein content (%), SOC: Seed oil content (%), GC: Gossypol content (%) and SCY/P: Seed cotton yield per plant (g).

trait showed high direct positive effects (0.9220) on seed cotton yield/ plant (Table 6). The residual effect was 0.0479 which showed that component traits under study were responsible for about 96 per cent of variability in seed cotton yield/plant. These results are in conformity with reports of Yuan *et al.* (1994), Karademir *et al.* (2009), Salahuddin *et al.* (2010), Ly *et al.* (2012), Gnanasekaran *et al.* (2020) and Sakthivel and Somasundaram (2021) suggesting that the direct contribution of the above character to yield would be highly important for formulating an appropriate selection.

Maximum positive indirect effects were exhibited by plant height (0.3590) through bolls/plant followed by seeds/boll (0.2303) bolls/plant; photosynthesis rate (0.0631) through bolls/plant; bolls/plant (0.0620) through boll weight; stomatal conductance (0.0393) through boll weight; monopods/plant (0.0388) through bolls/plant; seed oil content (0.0381) through boll weight and ginning outturn (0.0272) through boll weight. Highest negative indirect effect was shown by transpiration rate (-0.4061) through bolls/plant followed by seed oil content (-0.3308) through bolls/plant; boll weight (-0.2787) through bolls/plant; relative water content (-0.2315) through bolls/plant; gossypol content (-0.1904) through bolls/plant; days to first flower (-0.1764) through bolls/plant; stomatal conductance (-0.1686) through bolls/plant; and proline content (-0.1483) and total chlorophyll content (-0.0492) through bolls/plant.

CONCLUSION

Findings of the investigation revealed that high heritability coupled with high genetic advance as percentage of mean was observed for plant height, monopods/plant, bolls/plant, seed cotton yield/plant, photosynthesis rate, stomatal conductance and transpiration rate. This revealed that additive gene action played a predominant role in governing these traits and further it also indicated the suitability of selection of these traits for further improvement among genotypes under studied. Correlation analysis revealed that simultaneous selection based on plant height, bolls/plant, boll weight and seeds/boll will bring about improvement in cotton yields since these traits had a significant positive association with seed cotton yield/plant. Path analysis revealed that bolls/plant has positive and high direct effect on seed cotton yield/plant. Therefore, direct selection for trait *viz.* number of bolls/plant is suggested for obtaining yield improvement in cotton.

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