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Correlation and Path Coefficient Analysis in Scented Rice (*Oryza sativa* L.) under Sodicity

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Abstract

The association among yield components, their direct and indirect influences on grain yield was estimated in 40 diverse genotypes of scented rice including traditional landraces, high yielding varieties / advanced lines and two standards check varieties IR-28 and CSR-30 under three environments. Significant variations were observed for all characters in genotypes used in the experiment. Grain yield/plant showed strong positive and highly significant association phenotypic levels in all the environments with panicle bearing tillers / plant, harvest-index, biological yield / plant, L / B ratio and significant positive correlation with 1000-grain weight in all environments and pooled level. Path coefficient analysis indicated that harvest index had the highest positive direct effect followed by biological yield / plant and kernel length on grain yield / plant in all environments and pooled level. So the improvement in grain yield would be effective and economical, if the selection is based on these component traits.
Key words : Quantitative traits, Association, Path coefficient, Scented rice, Sodisity.

Aromatic rice constitutes a small but special group of rice which is considered best in quality and fetches much higher price than high quality non-aromatic rice in International market. Scented rice with an aroma and flavor is extremely popular in India, Pakistan and Middle East and is becoming popular in Europe as well. Export price for scented rice in these areas generate more than twice of non-scented long grain rice. Besides, their importance, pace of improvement of this category has been rather slow. Aromatic rice emits specific aroma in the fields at the time of flowering, at harvesting in storage, during milling, cooking and eating (1). The biochemical basis of aroma was identified as 2-acety 1- pyroline and more than 100 other volatile compounds. Considering cross compatibility of scented rice with high yielding non-aromatic rices and expression of yield and quality contributing traits with consistency in performance under heterogeneous environments, it is imperative to study selection criteria and approaches for screen out best genotypes. Therefore, information on nature and magnitude of correlations among yield and its contributing characters is pre-requisite for success of breeding programme. The path analysis helps in determining the forces governing the correlation and thus provides a tool for selection of better genotypes. The present investigation was therefore undertaken to determine the direct and indirect effects of different traits on yield and to know the associated performance of the characters for productive improvements of genotypes unique to three diverse ecosystems.

Methods

The materials for the present investigation were comprised of 40 genotypes of scented rice collected from different part of the country including two standards (checks) varieties viz., IR28 and CSR30 for salinity susceptible and resistant, respectively. These were grown in randomized complete block design with three replications during *kharif* 2008 under three environments viz., normal condition (E_1 : pH = 8.00, EC = 0.24, ESP = 24.5), saline condition (E_2 pH = 9.2, EC = 0.38, ESP = 34.5) and alkali condition (E_3 : pH = 10.1, EC = 0.57, ESP = 52.6) at Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (UP) India. Genotypes were planted in three-

Table 1. Phenotypic correlation coefficient between different characters over environment in scented rice. *, **Significant at 5 and 1% probability levels, respectively.

Characters	Environment	Days to 50% flowering	Plant height (cm)	Panicle bearing tillers/ plant	Spikelet/ panicle	No. of grains/ panicle	Spikelet fertility (%)	1000-grain weight (g)
Days to 50% flowering	E_1		0.294	– 0.268	0.468**	0.480**	0.039	– 0.377*
	E_2		0.325*	– 0.203	0.460**	0.487**	0.145	– 0.364*
	E_3		0.352*	0.123	0.392*	0.380*	0.076	– 0.301
	Pooled		0.387*	– 0.130	0.464**	0.494**	0.121	– 0.346*
Plant height (cm)	E_1			– 0.315*	0.264	0.308*	0.160	– 0.291
	E_2			– 0.203	0.287	0.369*	0.332*	– 0.196
	E_3			– 0.032	0.066	0.121	0.059	– 0.123
	Pooled			– 0.276	0.226	0.279	0.210	– 0.248
Panicle bearing tillers/plant	E_1				– 0.163	– 0.164	– 0.036	0.326*
	E_2				– 0.188	– 0.169	0.036	0.226
	E_3				– 0.094	– 0.156	– 0.148	0.333*
	Pooled				– 0.162	– 0.171	– 0.022	0.283
Spikelet/ panicle	E_1					0.960**	– 0.038	– 0.543**
	E_2					0.951**	0.034	– 0.532**
	E_3					0.877**	0.022	– 0.449**
	Pooled					0.963**	– 0.006	– 0.533**
No. of grains/panicle	E_1						0.239	– 0.537**
	E_2						0.333*	– 0.528**
	E_3						0.475**	– 0.427**
	Pooled						0.263	– 0.539**
Spikelet fertility (%)	E_1							– 0.055
	E_2							– 0.100
	E_3							– 0.065
	Pooled							– 0.082
1000-grain weight (g)	E_1							
	E_2							
	E_3							
Kernel length (mm)	E_1							
	E_2							
	E_3							
	Pooled							
Kernel width (mm)	E_1							
	E_2							
	E_3							
	Pooled							
L/B ratio	E_1							
	E_2							
	E_3							
	Pooled							
Biological yield/plant (g)	E_1							
	E_2							
	E_3							
	Pooled							
Harvest index (%)	E_1							
	E_2							
	E_3							
	Pooled							

Table 1. Continued.

Characters	Environment	Kernel length (mm)	Kernel width (mm)	L/B ratio	Biological yield/ plant (g)	Harvest index (%)	Grain yield/ plant
Days to 50% flowering	E_1	–0.324*	–0.451**	–0.142	0.343*	–0.386*	–0.025
	E_2	–0.322*	–0.438**	–0.087	0.373*	–0.320*	0.041
	E_3	–0.300	–0.367*	–0.097	0.387*	–0.270	0.032
	Pooled	–0.319*	–0.425	–0.111	0.386*	–0.352*	0.015
Plant height (cm)	E_1	–0.194	–0.177	–0.123	0.142	–0.565**	–0.337*
	E_2	–0.102	–0.157	–0.037	0.252	–0.474**	–0.162
	E_3	–0.143	–0.255	–0.019	0.383*	–0.481**	–0.160
	Pooled	–0.167	–0.226	–0.068	0.285	–0.577**	–0.259
Panicle bearing tillers/plant	E_1	0.430**	0.117	0.383*	0.472**	0.502**	0.734**
	E_2	0.351*	0.104	0.290	0.472**	0.436**	0.704**
	E_3	0.414**	0.004	0.391*	0.439**	0.348*	0.591**
	Pooled	0.426**	0.106	0.372*	0.475**	0.516**	0.759**
Spikelet/panicle	E_1	–0.580**	–0.217	–0.477**	0.369*	–0.354*	–0.004
	E_2	–0.598**	–0.167	–0.472**	0.312	–0.374*	–0.052
	E_3	–0.545**	–0.192	–0.401**	0.446**	–0.303	–0.003
	Pooled	–0.596**	–0.193	–0.471**	0.379*	–0.387*	–0.037
No. of grains/ panicle	E_1	–0.590**	–0.194	–0.500**	0.399**	–0.376*	0.010
	E_2	–0.597**	–0.195	–0.465**	0.367*	–0.375*	–0.005
	E_3	–0.492**	–0.168	–0.366*	0.443**	–0.135	0.142
	Pooled	–0.606**	–0.191	–0.486**	0.398**	–0.403**	–0.032
Spikelet fertility (%)	E_1	–0.110	0.074	–0.148	0.114	–0.092	0.038
	E_2	–0.125	–0.093	–0.094	0.214	–0.056	0.137
	E_3	–0.019	–0.002	–0.018	0.086	0.299	0.311
	Pooled	–0.112	–0.005	–0.120	–0.097	–0.070	0.030
1000-grain weight (g)	E_1	0.907**	0.355*	0.743**	–0.001	0.449**	0.354*
	E_2	0.866**	0.419**	0.623**	–0.004	0.376*	0.303
	E_3	0.889**	0.234	0.721**	–0.002	0.387*	0.343*
	Pooled	0.896**	0.365*	0.700**	–0.008	0.447**	0.362*
Kernel length (mm)	E_1		0.177	0.911**	0.021	0.565**	0.447**
	E_2		0.163	0.873**	0.020	0.524**	0.420**
	E_3		0.165	0.870**	–0.005	0.522**	0.447**
	Pooled		0.171	0.887**	0.012	0.567**	0.461**
Kernel width (mm)	E_1			–0.240	–0.148	–0.069	–0.130
	E_2			–0.332*	–0.135	–0.115	–0.155
	E_3			–0.336*	–0.178	0.009	–0.082
	Pooled			–0.299	–0.153	–0.065	–0.132
L/B ratio	E_1				0.080	0.593**	0.497**
	E_2				0.095	0.555**	0.479**
	E_3				0.093	0.501**	0.475**
	Pooled				0.090	0.581**	0.510**
Biological yield/ plant (g)	E_1					–0.110	0.663**
	E_2					–0.125	0.677**
	E_3					–0.099	0.532**
	Pooled					–0.131	0.628**
Harvest index (%)	E_1						0.664**
	E_2						0.635**
	E_3						0.780**
	Pooled						0.683**

rows of 5 m length with row to row and plant to plant spacing of 20 cm and 15 cm, respectively. All recommended agro-techniques were followed to raise a healthy crop.

Observations on ten randomly selected plants per genotypes in each replication of all the three environments were recorded on different characters viz., days to 50% flowering, plant height (cm), panicle

Table 2. Direct (digonal bold) and indirect effect of 12 characters on grain yield/plant at phenotypic level in scented rice. Bold values indicate direct effect. Residual factor = 0.0075 (E_1), 0.0097 (E_2), 0.0123 (E_3) and 0.0098 (pooled).

Characters	Environ-ment	Days to 50% flowering	Plant height (cm)	Panicle bearing tillers/ plant	Spikelet/ panicle	No. of grains/ panicle	Spikelet fertility (%)	1000-grain weight (g)
Days to 50% flowering	E_1	**0.032**	– 0.006	– 0.005	– 0.124	0.129	– 0.002	– 0.007
	E_2	**0.017**	– 0.010	– 0.010	– 0.007	0.021	0.001	– 0.014
	E_3	**0.040**	0.002	0.004	0.002	– 0.010	0.002	– 0.010
	Pooled	**–0.009**	0.006	– 0.012	– 1.279	1.431	– 0.093	– 0.038
Plant height (cm)	E_1	0.009	**– 0.020**	– 0.006	– 0.073	0.083	– 0.009	– 0.005
	E_2	–0.005	**– 0.031**	– 0.010	– 0.005	0.016	0.001	– 0.008
	E_3	0.014	**0.006**	– 0.001	0.000	– 0.003	0.001	– 0.004
	Pooled	–0.003	**0.017**	– 0.026	– 0.621	0.807	– 0.161	– 0.027
Panicle bearing tillers/plant	E_1	–0.009	0.006	**0.006**	0.041	– 0.044	0.002	0.006
	E_2	–0.003	0.006	**0.049**	0.003	– 0.007	0.000	0.009
	E_3	0.005	– 0.000	**0.033**	– 0.000	0.004	– 0.003	0.010
	Pooled	0.001	– 0.005	**0.095**	0.446	– 0.494	0.017	0.031
Spikelet/panicle	E_1	0.015	– 0.005	– 0.006	**– 0.265**	0.257	0.002	– 0.009
	E_2	0.008	– 0.009	– 0.010	**– 0.016**	0.041	0.000	– 0.021
	E_3	0.016	0.000	– 0.003	**0.006**	– 0.023	0.000	– 0.014
	Pooled	– 0.004	0.004	– 0.015	**– 2.754**	2.787	0.005	– 0.059
No. of grains/ panicle	E_1	0.015	– 0.006	– 0.006	– 0.254	**0.268**	– 0.031	– 0.009
	E_2	0.008	– 0.012	– 0.008	– 0.015	**0.043**	0.001	– 0.021
	E_3	0.015	0.001	– 0.005	0.005	**0.026**	0.011	– 0.013
	Pooled	– 0.004	0.005	– 0.016	– 2.652	**2.894**	– 0.202	– 0.059
Spikelet fertility (%)	E_1	0.001	– 0.003	– 0.001	– 0.010	0.064	**– 0.055**	– 0.001
	E_2	0.002	– 0.010	0.002	– 0.001	0.014	**0.003**	– 0.004
	E_3	0.003	0.000	– 0.005	0.000	– 0.012	**0.023**	– 0.002
	Pooled	–0.001	0.003	– 0.002	0.018	0.762	**– 0.768**	– 0.009
1000-grain weight (g)	E_1	–0.012	0.006	0.006	0.144	– 0.144	0.003	**0.017**
	E_2	–0.006	0.006	0.011	0.009	– 0.023	– 0.000	**0.039**
	E_3	–0.021	– 0.001	0.011	– 0.003	0.011	– 0.002	**0.032**
	Pooled	0.003	– 0.004	0.027	1.469	– 1.560	0.063	**0.110**
Kernel length (mm)	E_1	–0.010	0.004	0.008	0.154	– 0.158	0.006	0.016
	E_2	–0.005	0.003	0.017	0.010	– 0.026	– 0.001	0.034
	E_3	–0.012	– 0.001	0.014	– 0.003	0.013	– 0.000	0.028
	Pooled	0.003	– 0.003	0.041	1.641	– 1.754	0.086	0.099
Kernel width (mm)	E_1	–0.014	0.004	0.002	0.057	– 0.052	– 0.004	0.006
	E_2	–0.007	0.005	0.005	0.003	– 0.008	– 0.000	0.016
	E_3	–0.015	– 0.002	0.000	– 0.001	0.004	0.000	0.007
	Pooled	0.004	– 0.004	0.010	0.532	– 0.554	0.004	0.039
L/B ratio	E_1	–0.005	0.003	0.007	0.126	– 0.134	0.008	0.013
	E_2	–0.001	0.001	0.014	0.008	– 0.020	–0.000	0.024
	E_3	–0.004	– 0.000	0.013	– 0.003	0.010	– 0.000	0.023
	Pooled	0.001	– 0.001	0.035	1.297	– 1.408	0.092	0.077
Biological yield/ plant (g)	E_1	0.011	– 0.003	0.009	– 0.098	0.107	– 0.006	– 0.000
	E_2	0.006	– 0.008	0.023	– 0.005	0.016	0.001	– 0.000
	E_3	0.016	0.002	0.015	0.003	– 0.012	0.002	– 0.000
	Pooled	– 0.003	0.005	0.045	– 1.044	1.153	– 0.075	– 0.001
Harvest index (%)	E_1	–0.012	0.011	0.010	0.094	– 0.101	– 0.005	0.008
	E_2	–0.005	0.015	0.021	0.006	– 0.016	– 0.000	0.015
	E_3	–0.010	– 0.003	0.012	– 0.002	0.004	0.070	0.012
	Pooled	0.003	– 0.010	0.049	1.067	– 1.165	0.054	0.049

Table 2. Continued.

Characters	Environ-ment	Kernel length (mm)	Kernel width (mm)	L/B ratio	Biolo-gical yield/plant (g)	Harvest index (%)	Correla-tion with grain yield
Days to 50% flowering	E_1	–0.146	0.074	0.067	0.250	– 0.287	– 0.025
	E_2	–0.217	0.145	0.060	0.276	– 0.220	0.041
	E_3	–0.116	0.070	0.043	0.232	– 0.227	0.032
	Pooled	–0.106	0.087	0.050	0.253	– 0.275	0.015
Plant height (cm)	E_1	–0.088	0.029	0.058	0.104	– 0.420	– 0.337
	E_2	–0.069	0.052	0.026	0.186	– 0.326	– 0.162
	E_3	–0.056	0.049	0.008	0.229	– 0.404	– 0.160
	Pooled	–0.055	0.046	0.031	0.186	– 0.451	– 0.259
Panicle bearing tillers/plant	E_1	0.195	– 0.019	– 0.181	0.345	0.373	0.734
	E_2	0.236	– 0.034	– 0.201	0.349	0.300	0.704
	E_3	0.160	– 0.001	– 0.173	0.263	0.292	0.591
	Pooled	0.141	– 0.022	– 0.167	0.311	0.403	0.759
Spikelet/panicle	E_1	–0.263	0.036	0.226	0.269	– 0.263	– 0.004
	E_2	–0.403	0.055	0.328	0.230	– 0.257	– 0.052
	E_3	–0.212	0.037	0.177	0.267	– 0.255	– 0.003
	Pooled	–0.198	0.039	0.212	0.248	– 0.303	– 0.037
No. of grains/ panicle	E_1	–0.270	0.032	0.236	0.291	– 0.279	0.010
	E_2	–0.403	0.065	0.324	0.270	– 0.258	– 0.005
	E_3	–0.191	0.032	0.162	0.265	– 0.113	0.142
	Pooled	–0.201	0.039	0.219	0.261	– 0.315	– 0.032
Spikelet fertility (%)	E_1	–0.050	– 0.012	0.070	0.083	– 0.068	0.038
	E_2	–0.084	0.031	0.065	0.157	– 0.039	0.137
	E_3	–0.008	0.000	0.008	0.051	0.252	0.311
	Pooled	–0.037	0.001	0.054	0.064	– 0.055	0.030
1000-grain weight (g)	E_1	0.410	– 0.058	– 0.351	– 0.001	0.333	0.354
	E_2	0.583	– 0.139	– 0.434	– 0.002	0.259	0.303
	E_3	0.346	– 0.045	– 0.319	– 0.001	0.325	0.343
	Pooled	0.297	– 0.072	– 0.316	– 0.005	0.350	0.362
Kernel length (mm)	E_1	**0.452**	– 0.029	– 0.431	0.015	0.420	0.447
	E_2	**0.674**	– 0.054	– 0.608	0.015	0.360	0.420
	E_3	**0.389**	– 0.031	– 0.384	– 0.003	0.440	0.447
	Pooled	**0.331**	– 0.035	– 0.399	0.008	0.443	0.461
Kernel width (mm)	E_1	0.080	**– 0.164**	0.114	– 0.108	– 0.051	– 0.130
	E_2	0.110	**– 0.332**	0.232	– 0.100	– 0.079	– 0.155
	E_3	0.064	**– 0.190**	0.148	– 0.106	0.007	–0.082
	Pooled	0.057	**– 0.204**	0.135	– 0.100	– 0.051	– 0.132
L/B ratio	E_1	0.412	0.039	**– 0.473**	0.059	0.441	0.497
	E_2	0.588	0.111	**– 0.697**	0.070	0.381	0.479
	E_3	0.338	0.064	**– 0.442**	0.057	0.421	0.475
	Pooled	0.294	0.061	**– 0.451**	0.059	0.454	0.510
Biological yield/ plant (g)	E_1	0.009	0.024	– 0.038	**0.729**	– 0.081	0.663
	E_2	0.014	0.045	– 0.066	**0.738**	– 0.086	0.677
	E_3	–0.002	0.034	– 0.041	**0.599**	– 0.083	0.532
	Pooled	0.004	0.031	– 0.040	**0.655**	– 0.102	0.628
Harvest index (%)	E_1	0.256	0.011	– 0.280	– 0.080	**0.742**	0.664
	E_2	0.353	0.038	– 0.386	– 0.092	**0.688**	0.635
	E_3	0.203	– 0.002	– 0.221	– 0.059	**0.841**	0.780
	Pooled	0.188	0.013	– 0.262	– 0.086	**0.782**	0.683

bearing tillers/plant, spikelets / panicle, grains/panicle, spikelet fertility (%), 1000-grains weight (g), kernel length (mm), kernel width (mm), L/B ratio, biological yield/plant (g), harvest index (%) and grain yield/plant.

The phenotypic correlation coefficient among different characters was carried out as per procedure suggested by Searle (2). The path coefficient analysis was done as suggested by Dewey and Lu (3).

Results and Discussion

The analysis of variance showed significant differences among genotypes in respect of all the characters studied, indicating the presence of considerable variability in the material. In all E_1, E_2 and E_3 environments, the magnitude of correlation coefficient at phenotypic level was higher than the corresponding phenotypic levels (Table 1). This indicated that inspite of a strong inherent association between various characters studied and the phenotypic expression of the correlation was lessened under the influenced of environment. The higher phenotypic expression of the association was form a sound base for their practical implication. Similar results were also reported by Khedikar et al. (4).

Grain yield / plant showed strong positive and highly significant association both at phenotypic and phenotypic levels in all the environments with panicle bearing tillers/plant, harvest index, biological yield/plant, L/B ratio and significant positive correlation with 1000-grain weight in all the environments and pooled level. The finding seem in conformity with those of earlier investigators (5—7). Harvest index exhibited highly significant positive correlation with L/B ratio, kernel length, panicle bearing tillers/plant in all the environments and 1000-grain weight in E_1 environment and pooled level, whereas, its significant positive associations was observed in E_2 and E_3 environment ; while days to 50% flowering in E_1, E_2 and pooled level depicted significant positive association to harvest index. These results are in accordance with earlier reported by Patil and Sarawgi (8). Plant height showed highly significant and negative association in all environments and pooled level, and grains/panicle only at pooled level with harvest index. Days to 50% flowering, spikelet/panicle and grains panicle were also observed to have highly significant negatively correlated with harvest index in E_1, E_2 environment and pooled level. L/B ratio exhibited to be highly significant and positive association with 1000-grain weight and grains panicle in all environments and pooled level, while, spikelet / panicle in E_1, E_2 environment and pooled level. Its significant and positive correlation was also observed with panicle bearing tillers/plant in E_3 environment.

The trait 1000-grain weight exhibited significant and negative association with spikelets/panicle, number of grains/panicle in all environments and pooled level, whereas, panicle bearing tillers/plant depicted significant positive correlation with 1000-grain weight. Days to 50% flowering exhibited significant and negative association with 1000-grain weight in E_1 and pooled level. Spikelet fertility exhibited highly significant and positive association with grains/panicle in E_1 and E_2. Spikelet / panicle showed highly significant and positive correlation with days to 50% flowering in all environments and pooled level. This is in agreement with Ramkrishnan et al. (6).

In all the environments, traits like panicle bearing tillers/plant, spikelet/panicle, grains / panicle, spikelet fertility and 1000-grain weight were the most important traits correlated with yield and yield contributing traits. Thus, the genetic improvement in yield was highly correlated with direction and magnitude of these yield contributing traits.

The direct and indirect effects of different characters on grain yield/plant were worked out, using path coefficient values at phenotypic level (Table 2). Harvest-index had the highest positive direct effect followed by biological yield / plant and kernel length on grain yield / plant in all environments and pooled level. This suggests a true relationship between these traits with grain yield plant and direct selection for these traits would be rewarding for yield improvement. Thus, the selection pressure on these traits may lead to an overall increase in yield. These results are in accordance with earlier reports (4, 9). The high positive phenotypic correlation between harvest index and grain yield plant was due to high positive direct effect of harvest index and high positive indirect effect via kernel length and kernel width, while negative indirect effect via L/B ratio and biological yield/plant was recorded. A high positive correlation between kernel length and grain yield/plant was mainly due to high positive direct effect recorded. Another trait showing high positive correlation between panicle bearing tillers/plant and grain yield/plant was due to high positive direct effect of harvest index and biological yield/plant and low effect of grains / panicle and spikelets/panicle. This is in agreement with the results of Yadav et al. (7) and Girolkar et al. (10). The association of plant height with grain yield/plant in E_1 location is mainly due to high negative direct effect of harvest index. The high positive direct effect of grain / panicle was nullified by high negative indirect effect via spikelets / panicle and harvest index, kernel length at pooled level leading to negative correlation with grain yield. It is also interesting to note that the high negative effect of spikelets/panicle was nullified with high positive effect of number of grain / panicle, L/B ratio and biological yield/plant because of low association with grain yield at pooled level. The residual effect i.e. 0.0075, 0.0097, 0.0123 and 0.0098 at E_1, E_2 and E_3 environments and pooled level, respectively were of very low magnitude, subjecting that most of the important component contributing to grain yield have been estimated in present investigation.

Based on character association and path analysis, it can be concluded that panicle bearing tillers/ plant, harvest index, biological yield, L/B ratio, kernel length, 1000-grain weight in all environments and pooled level applied to be major field contributing characters and, therefore, due consideration should be given to improve these traits for yield enhancement and sustainability. Spikelet fertility (%) and harvest index showed positive and significant correlation with seed yield per plant both at phenotypic and phenotypic levels. Results of path-coefficient analysis revealed that productive tillers per plant had the highest positive direct effect on grain yield followed by harvest index spikelet fertility (%) (11). The variation in estimates of direct and indirect effects of traits on grain yield and also correlation among various components characters in all the environments and pooled level may be due to the different in activity of particular set of genes in the three environments. The selection of genotype on the basis of these traits in individual environments would certainly lead to some improvements in grain yield and also assists in the selection of donors for different breeding programs in specific environments.

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