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Research Article

STABILITY ANALYSIS IN SOME *ASHWAGANDHA* [*WITHANIA SOMNIFERA* (L.) DUNAL] GENOTYPES

[*]O. Sangwan, Ram Avtar and Amit Singh
[*]Department of Genetics & Plant Breeding,CCS Haryana Agricultural University, Hisar – 125 004, India
**Author for Correspondence*

ABSTRACT
An experiment was conducted to determine genotype x environment (G x E) interaction and stability of twenty six *ashwagandha* [*Withania somnifera* (L) Dunal] genotypes and effect of different environments on fresh root yield to understand its adaptation to six varying environments. Genotype x environment interaction was significant for all the six characters under study. Linear and non-linear components of G x E interaction were significant for all the characters studied. Genotype WS-224 was suitable for poor environment whereas, WS-205 and WS-90-100 were suitable for favourable environment and WS-210, WS-90-104, WS-90-135, WS-90-136, JA-20 and Adinath were adaptable to general environments.

Key Words: *G X E Interaction, Stability Analysis, Ashwagandha, Environment*

INTRODUCTION

Medicinal plants are the local heritage with global importance. World is endowed with a rich wealth of medicinal plants. In Ayurveda about 2000 plant species are considered to have medicinal value (Prajapati *et al.*, 1998). Unlike other economic crops, medicinal plants, with few exceptions, continue to be cultivated in the same way as they were grown thousands of years ago. Very little work has been done with respect to genetic improvement of these crops inspite of long history of their domestication. *Withania somnifera* (L.) Dunal (2n = 48) commonly known as *ashwagandha* or *asgandha* is one of the most valuable medicinal plant used in Indian and Unani systems of medicine since ancient times. The species is under domestication for a long period in the central India.

Availability of adequate genetic variability, knowledge of criteria for screening and selection of desirable genotypes are pre-requisites for any breeding programme aimed at development of ideal varieties for a given environment. In *ashwagandha* root yield is of economic importance, being dependent upon a number of other characters. Many of these characters are quantitatively inherited and are highly susceptible to environmental fluctuations. The variability observed in a population, tends to vary with the given environment and this is due to interaction between genotypes and the environments. Plant breeders are becoming increasingly concerned about these interactions because selection made under a certain environment may not prove to be effective for another environment. The genotype x environment interaction contributes substantially to the non-realization of expected gains from selection (Comstock and Moll, 1963) and has a major concern to the plant breeders for developing improved cultivars. A cultivar, to be commercially successful, it must perform well across the range of environments in which it is allowed to grow.The genotypes tested over a number of environments will show the specificity or performance of a particular genotype in a particular environment while some genotypes show better performance over varied environments. Available information of these aspects is meager in *ashwagandha* and therefore, the present study was undertaken to select stable cultivar under varying environmental conditions.

MATERIALS AND METHODS

The experimental material comprised of twenty six genotypes of *ashwagandha* which were grown in six different environment which were created by date of sowing, irrigation conditions and different row to row (R-R) and plant to plant (P-P) spacing in RBD with three replications at experimental research area of Medicinal, Aromatic and Under–Utilized Plants Section, Department of Plant Breeding, CCS Haryana Agricultural University, Hisar. Out of six environments four environments

were under irrigated and two environments were under rainfed conditions. Details of environments under which the material was grown are given below:

S. No.	Environment	Irrigation condition	Spacing (R-R × P-P)
1	E1	Irrigated	22.5 × 2.5 cm
2	E2	Irrigated	22.5 × 5.0 cm
3	E3	Irrigated	30.0 × 2.5 cm
4	E4	Irrigated	30.0 × 5.0 cm
5	E5	Rainfed	22.5 × 2.5 cm
6	E6	Rainfed	22.5 × 5.0 cm

The data were recorded for six characters namely plant height (cm), seed yield/plant (g), root length (cm), root diameter (mm), fresh root yield/plant (g) and total alkaloids content (%) on five random plants in each genotype. The data were analyzed for stability parameters according to the model suggested by Eberhart and Russell (1966). The significance of stability parameters (bi) and its deviation from unity were determined by t-test.

RESULTS AND DISCUSSION

The mean sum of square due to genotypes were highly significant for all the characters when tested against pooled error and pooled deviation (Table 1) which indicated that significant differences existed among the genotypes. Mean squares due to environment (linear) were highly significant indicated linear contribution of the environmental effects on genotypic performance. When genotype × environment (linear) was tested against pooled deviation it was found significant for all the characters studied indicating the importance of G×E (linear) component in describing the performance of a genotype on the basis of environmental indices. Pooled deviation from regression was significant against pooled error for all the characters indicating that genotypic differences were existed. However, linear component of G×E was higher than non-linear component for all the characters studied. According to Eberhart and Russell (1966), a variety/genotype is considered to be stable over environments if it shows high mean performance with unit regression coefficient (bi=1) and minimum deviation (non significant) from the regression ($S^2d=0$).

Estimates of stability parameters of individual genotypes for plant height, seed yield/plant and root lengths are presented in Table 2. For plant height on the basis of the three parameters, *viz.* mean performance of the genotype ($\bar{X}$), linear regression on the environmental mean (b) and deviation from regression coefficients ($S^{-2}d_i$) eleven genotypes had b_i values more than 1 suggesting their suitability to favourable environment whereas, remaining 15 genotypes were suitable to all kinds of environments as these were having b_i value approaching to "1". None of the genotype had b_i value < 1. Out of 26 genotypes 10 genotypes had above average plant height, 13 genotypes below average plant height and 3 genotypes were averages in plant height. WS-90-100 had maximum plant height (55.833 cm) followed by WS-206 (55.756 cm), whereas, WS-90-117 showed minimum plant height (47.333 cm). Out of 22 stable genotypes, above average plant height was exhibited by only 10 genotypes. Among them WS-204, WS-205, WS-206, WS-226, WS-223, WS-135 and JA-20 had above average response indicating their adaptability to favourable environment. Genotypes WS-90-103, WS-90-105 and WS-90-127 had average response, indicating their suitability to all kinds of environments.

Three genotypes gave seed yield/plant above the average mean (15.024 g). Out of twenty six genotypes, eighteen genotypes were found stable as indicated by their non significant $S^{-2}d_i$ values. None of the genotype out of stable ones was found to be suitable for favourable environmental conditions. Genotypes WS-218, WS-90-100, WS-90-104 and JA-20 were found to have average response indicating their capability to be exploited in all kinds of environments.

In case of root length, nine genotypes had b_i value > 1 and seventeen genotypes had b_i value approaching to 1 suggesting their suitability for favourable and general environments, respectively. None of the genotype was found to suit for unfavourable environmental conditions. On the basis of mean performance, fifteen genotypes had average mean, six genotypes had above mean and five

genotypes were below average mean for root length. WS-205 had highest mean value (21.157 cm), above average response and good stability. WS-210, WS-213, WS-90-100, WS-90-103, WS-90-104, WS-90-127, WS-90-135 and JA-20 showed high mean and average response indicating their stability to all kinds of environments.

Estimates of stability parameters of individual genotypes for root diameter, fresh root yield/plant and total alkaloids content are presented in Table 3. The perusal of the table indicates that for root diameter, five genotypes exhibited mean root diameter higher than the average (10.904 cm). Seventeen genotypes had average root diameter and five genotypes had above average root diameter. However below average root diameter was recorded in four genotypes. Genotypes WS-210, WS-90-104, WS-90-127, WS-90-136 and Adinath showed average response with high mean indicating their suitability to varying environments.

In case of fresh root yield/plant, four genotypes were found above average, eighteen genotypes were average and four genotypes were below average. JA-20 (8.883 g) was highest in fresh root yield/plant with average response indicating their suitability to wide range of environments. The $S^{-2}d_i$ values were non-significant for twenty genotypes indicating their stable performance across the environments. Seven genotypes had above average response whereas; fourteen genotypes had average response revealing their adaptability to favourable and general environments, respectively. However, among stable genotypes WS-202 and WS-224 showed below average response which indicated their stability to poor environment. Genotypes WS-205 and WS-90-100 showed average mean value, above average response, whereas, WS-210, WS-90-134, WS-90-135, WS-90-136, JA-20 and Adinath showed high mean and average performance indicating their adaptability for favourable and general environments, respectively.

For total alkaloids content, seven genotypes had $b_i > 1$, another two genotypes had $b_i < 1$ and seventeen genotypes had $b_i = 1$ which suggested their suitability for good, poor and general environments, respectively. All the genotypes showed average mean performance for total alkaloids content. Twenty one genotypes were stable as indicated by their non significant $S^{-2}d_i$ values and out of which WS-213, WS-90-104, WS-90-105, JA-20 and Adinath showed average mean value of total alkaloids with above average response whereas, genotypes namely WS-202, WS-206, WS-90-100, WS-218, WS-90-125 and WS-90-136 possessed average response indicating their adaptability to favourable and general environments, respectively. Genotype WS-90-126 was found to have average mean value of total alkaloid with below average response which suggested its exploitation for poor environment.

Table 1: Analysis of variance for stability parameters for various characters in *ashwagandha*

Source of variation	df	PH (cm)	SY/P (g)	RL (cm)	RD (mm)	FRY/P (g)	TA (%)
Genotypes	25	$55.43^{*,++}$	$19.58^{**,++}$	$15.63^{**,++}$	$5.11^{**,++}$	$14.03^{**,++}$	$1.023^{**,++}$
Environment Linear	1	$35556.3^{**,++}$	$412.87^{**,++}$	$663.13^{**,++}$	$394.84^{**,++}$	$465.98^{**,++}$	$1.02^{**,++}$
G× E Linear	25	$72.1^{**,++}$	$14.89^{**,++}$	$13.09^{**,++}$	$4.69^{**,++}$	$12.77^{*,++}$	$1.13^{**,++}$
Environment +G × E linear	130	$302.87^{**,++}$	$16.44^{**,++}$	$17.56^{**,++}$	$5.91^{**,++}$	$16.18^{**,++}$	$1.21^{**,++}$
Pooled deviation	104	37.12^{++}	8.58^{++}	5.87^{++}	2.43^{++}	6.95^{++}	0.406^{++}
Pooled error	300	1.58	0.49	0.08	0.06	0.19	0.00014

+, ++ P= 0.05 and P = 0.01 respectively against pooled error
**, ** P= 0.05 and P = 0.01 respectively against pooled deviation*
PH = Plant height, SY/P = Seed yield/plant, RL = Root length, RD = Root diameter, FRY/P = Fresh root yield/plant, TA = Total alkaloids content

Table 2: Estimates of stability parameters of individual genotypes for plant height, seed yield/plant (g) and root length (cm)

	Plant height			Seed yield/plant			Root length		
Genotypes	$\bar{X}$	b_i	$S^{-2}d_i$	$\bar{X}$	b_i	$S^{-2}d_i$	$\bar{X}$	b_i	$S^{-2}d_i$
WS-124	48.935	0.920	44.028**	14.607	1.718**	-6.332	19.492	0.966	-2.091
WS-201	50.606	0.837**	21.269	14.015	1.544	12.261*	17.569	0.911	0.417
WS-202	52.501	0.944	-3.538	12.677	0.891	9.306*	18.930	0.628**	-0.767
WS-204	55.584	1.218**	2.407	13.722	0.653	-4.150	20.218	1.526**	1.703*
WS-205	54.800	1.151**	-0.158	14.976	0.391	-4.976	21.157	1.571**	-0.075
WS-206	55.756	1.265**	-16.882	15.854	0.034**	13.564*	19.130	0.694**	-0.262
WS-210	52.373	0.769**	17.213	15.409	1.382	-2.731	20.020	0.898	1.088
WS-213	51.548	0.682**	-14.454	18.704	1.242	35.388**	20.136	0.946	-0.539
WS-218	51.044	1.088	6.671	15.327	0.932	6.803	19.216	0.872	-1.699
WS-220	51.983	0.877	-12.997	14.737	1.879**	-2.642	19.287	1.062	-0.073
WS-223	52.744	0.947	26.735*	12.810	1.575	1.345	17.908	0.634**	2.832**
WS-224	52.290	1.109	5.956	13.038	0.769	7.604	18.674	0.822	-2.367
WS-226	53.749	1.250**	-9.574	12.675	0.506	-3.130	20.381	1.606**	1.775*
WS-90-100	55.833	1.200**	-7.536	16.404	1.059	0.130	20.703	1.258	-1.500
WS-90-103	53.823	1.027	-0.331	15.382	0.227**	7.789*	19.939	0.737	-1.072
WS-90-104	52.184	0.794**	52.510**	15.502	0.530	-8.060	19.732	0.846	-1.972
WS-90-105	54.111	0.951	-13.090	19.201	1.705	59.243**	20.463	1.042	3.287**
WS-90-117	47.333	0.870	-9.785	15.097	1.343	0.355	19.296	1.189	-2.600
WS-90-125	51.477	0.903	-5.797	13.813	1.884	8.729*	18.201	0.967	0.939
WS-90-126	50.256	0.963	-9.355	12.506	1.364	-5.552	17.790	0.403**	-0.935
WS-90-127	53.494	1.132	-16.355	14.404	0.544	-2.273	19.967	1.097	-2.042
WS-90-134	52.066	1.058	-14.622	14.088	0.729	-2.730	20.727	1.783**	1.261*
WS-90-135	54.999	1.371**	-13.102	15.151	1.038	-0.426	19.755	1.025	-1.081
WS-90-136	51.861	0.884	33.851**	15.757	-0.135**	-4.354	19.430	0.353**	0.046
JA-120	54.349	0.769**	5.109	18.357	0.909	-0.718	20.913	1.019	-2.428
Adinath	52.388	1.021	-10.851	17.027	1.589	38.381**	19.062	1.143	-1.150
MMean	52.614	1.000		15.024	1.000		19.542	1.000	
SSEm±	0.230	0.139		0.175	0.715		0.682	0.302	

**, ** Significant at P = 0.05 and P = 0.01 levels, respectively.*

Table 3: Estimates of stability parameters of individual genotypes for root diameter (mm), fresh root yield/plant (g) and total alkaloids content (%)

	Root diameter			Fresh root yield/plant			Total alkaloids content		
Genotypes	$\bar{X}$	b_i	$S^{-2}d_i$	$\bar{X}$	b_i	$S^{-2}d_i$	$\bar{X}$	b_i	$S^{-2}d_i$
WS-124	10.775	1.129	-0.450	6.670	1.086	-1.802	0.781	1.174	0.002
WS-201	10.789	0.516**	-0.276	6.961	0.468**	2.934*	0.781	1.449**	0.004**
WS-202	10.349	0.876	1.115*	5.907	-0.465**	-0.931	0.818	0.880	-0.001
WS-204	10.776	1.228	-0.169	5.654	1.259	-1.010	0.789	1.168	-0.001
WS-205	10.922	1.335**	1.221*	7.758	1.750**	-1.381	0.784	1.131	0.001
WS-206	10.637	1.015	-0.338	6.592	1.091	-0.923	0.813	0.824	-0.002
WS-210	11.386	1.018	-0.073	7.874	0.849	-0.471	0.793	1.012	0.000
WS-213	11.555	1.024	2.116**	8.626	1.295	6.813**	0.853	0.484**	-0.001
WS-218	11.115	1.007	-0.153	7.118	1.216	-1.761	0.811	0.909	-0.001
WS-220	10.773	0.799	0.095	7.049	0.637	1.188	0.781	-1.256**	0.004**
WS-223	10.402	0.592**	-0.474	6.037	0.378**	-1.326	0.799	1.309**	0.000
WS-224	10.614	1.004	-0.037	7.231	-0.605**	0.309	0.806	1.014	-0.001
WS-226	10.607	1.387**	-0.524	7.214	1.423**	3.483*	0.772	1.174	0.001
WS-90-100	11.008	1.079	1.073*	7.704	1.566**	-0.166	0.812	1.048	0.000
WS-90-103	10.870	1.163	-0.735	6.906	1.069	-1.455	0.795	0.976	0.003**
WS-90-104	11.573	0.881	0.642	8.595	0.983	3.350*	0.812	0.710**	0.000
WS-90-105	11.463	0.942	0.972*	7.789	0.960	5.240**	0.847	0.569**	-0.001
WS-90-117	10.618	1.119	-0.521	6.952	1.173	-1.106	0.796	1.088	0.000
WS-90-125	10.929	0.619**	1.355*	7.086	0.458**	3.528*	0.808	1.078	0.002
WS-90-126	10.076	0.830	-0.009	5.544	0.460**	-0.937	0.878	-1.361**	-0.002
WS-90-127	11.174	1.168	-0.218	6.676	0.872	-1.285	0.801	1.165	0.000
WS-90-134	10.391	1.188	-0.684	7.287	1.318	-1.541	0.785	1.064	0.003**
WS-90-135	10.828	1.214	-0.084	7.469	1.741	-0.444	0.816	0.795	-0.002
WS-90-136	10.956	0.964	-0.686	7.171	0.828	-1.657	0.789	1.121	0.004**
JA-120	11.992	0.945	1.346*	8.883	1.015	2.460	0.832	0.666**	-0.001
Adinath	10.958	0.958	0.477	7.196	1.036	2.622	0.854	0.575**	-0.002
MMean	10.904	1.000		7.152	1.000		0.804	1.000	
SSEm±	0.429	0.247		0.718	0.379				

**, ** Significant at P = 0.05 and P = 0.01 levels, respectively.*

To sum up the results, the present study helped to identify some *ashwagandha* genotypes which could be suitable for growing in different kinds of environmental conditions. Out of 26 genotypes studied, none of the genotype was found stable for all the six characters. Considering all the parameters of stability together, the maximum number of desirable genotypes for general environment was three for plant height, followed by six for seed yield/plant, eight for root length, five for root diameter, six for fresh root yield/plant and six for total alkaloids content. Fresh root yield being the most important character, thirteen genotypes exhibited high mean performance for this trait and out of which only nine genotypes were stable. Genotypes WS-224 was suitable for poor environment; WS-205 and WS-90-100 for favourable environment and WS-210, WS-90-104, WS-90-135, WS-90-136, JA-20 and Adinath were adaptable to general environments.

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