Electronic Journal of Plant Breeding, 5(4): 875-880 (Sep 2014)
ISSN 0975-928X

Research Note

Genetic variability, correlation and path analysis inAshwagandha [*Withania somnifera* (L.) Dunal]

Nilesh R. Joshi*, M. A. Patel, K.N. Prajapati and A. D. Patel
Medicinal and Aromatic Plants Project,
Anand Agricultural University,
Anand-388 110, Gujarat
* Email: mapanand2008@gmail.com

(Received: 25 June 2014; Accepted:11 Aug 2014)

Abstract
Forty diverse genotypes of Ashwagandha [*Withania somnifera* (L.)Dunal] were evaluated for 12 quantitative characters. Higher magnitude of genotypic and phenotypic coefficient of variation was recorded for leaf width, number of primary branches per plant, number of secondary branches per plant, root length, dry weight of root, withanoloide content and starch content. High heritability in conjuction with high genetic advance were observed for dry weight of root, root length, diameter of root at collar region, withanoloide content and starch content which indicated that selection could be effective for these traits. The estimates of correlation coefficient revealed that the genotypic correlations were higher than their corresponding phenotypic correlation for all characters. It was observed that root length, diameter of root at collar region, plant height, leaf length, leaf width, days to flower initiation and days to maturity showed significant positive association with dry weight of root at genotypic as well as phenotypic levels. Path analysis revealed that plant height, days to maturity, diameter of root at collar region and leaf width were major characters having positive direct effect and significant association with dry root yield per plant. Hence selection for these trait would be quite effective to improve dry root yield in Ashwagandha.

Keywords:
Ashwagandha, genetic variability, correlation, path analysis.

Ashwagandha (*Withania somnifera* (L.)Dunal.) (2n=48), also known as Indian ginseng, (poison) gooseberry or winter cherry is a plant of the *solanaceae*family (Mir *et al*., 2013). It is native of North-Western and Central India as well as Mediterranean region of North Africa. It grows in dry and sub-tropical regions. In India, two species of genus Withania *viz., Withania sornnifera* (L.)Dunal (Ashwagandh) and *Withania coagulants* (L.)Dunal (Panir) are found. Ashwagandha is cultivated mainly in Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Punjab and Uttar Pradesh, whereas, *Withania coagulants* (L.) found in wild. It is late *kharif* crop and grows under dry climate or requires less irrigation for plant growth and rainfed cultivation. Mostly it is grown on marginal lands of Neemuch and Mandsaur districts of Madhya Pradesh and Kota, Jhalawar, Pratapgarh, Chittorgarh and Barandistricts of Rajasthan. Among the various medicinal plants, Ashwagandha is cultivated over an area of 15,000 ha (with a production of 60,000 q/ha and productivity of 4.00 q/ha (Patidar, 2012). In Madhya Pradesh, it is cultivated over an area of 8,000 ha with a production of 32,000 q and productivity of 4.00 q/ha. In Ayurveda, the roots of Ashwagandha known to possess health maintenance and restoration properties, which are similar to ginseng roots; hence it is called as Indian ginseng. It is an adoptogenic herb and its roots, seeds and leaves are used in Ayurvedic and Unani medicines. The root drug finds an important place in treatment of rheumatic pain, inflammation of joints, nervous disorders, female disorders, hiccup, cold, cough, as a sedative, ulcers and leprosy etc. Ashwagandha and its extracts are used in the preparation of herbal tea, powders, tablets and syrups. The main active constituents are alkaloids and steroidal lactones. The leaves contain the steroidal lactones, withanoloide. Ashwagandha root contains 0.4 - 1.2% alkaloids, 40-65% starch, 40-65% fibres and minor quantity of oil. The important chemical constituents are alkaloids (withanoloide) that are present in roots, leaf and berries. Limited

breeding work has been done in this important medicinal crop for developing high yielding varieties. There are strong possibilities to develop genotypes having high dry root yield and withanoloide content. Assessment of variability present in Ashwagandha accessions is an important aspect for improvement of this crop. Characteristic quantification of genetic variability has long been a major goal in breeding. Therefore, the present investigation was carried out to access the genetic variability, correlation and path analysis in Ashwagandha.

The experimental material consist of 40 genotypes of Ashwagandha were sown in randomized block design comprising three replications with two rows plot each of 3.0 m length, maintaining crop geometry of 45 x 10 cm at the research farm of Medicinal and Aromatic Plants Project, Anand Agricultural University, Anandduring *Kharif* 2012-13. The recommended agronomical practices were adopted to raise a healthy crop. The experimental material was evaluated for 12 characters *viz.*, plant height (cm), leaf length (cm), leaf width (cm), days to flower initiation, days to maturity, number of primary branches per plant, number of secondary branches per plant, root length (cm), diameter of root at collar region (cm), dry weight of root (g/plant), total withanoloide content (%) and starch content (%). Analysis of variance to test the significant difference among accessions for each character was carried out as per methodology advocated by (Panse and Sukhatme, 1967a). PCV and GCV were calculated by the formula given by (Panse and Sukhatme, 1967b), heritability in broad sense (h^2) was worked out by using the formula suggested by (Burtan and Devane, 1953) and genetic advance were calculated by using the procedure given by (Johnson*et al.*, 1955). The genotypic and phenotypic correlation were calculated following the method of Singh and Chaudhary (1985) whereas the path coefficient analysis as per the method given by Dewey and Lu (1959).

The analysis of variance revealed that significant differences among genotypes for all the characters under study, which indicated that experimental material had sufficient genetic variability for different traits (Table 1). High degree of variability in the experimental material existed for characters like number of secondary branches per plant, dry weight of root, withanoloide content and starch content as revealed by high PCV and GCV estimates; while rest of characters were having low to moderate GCV per cent. All characters showed high magnitude of heritability which indicated the less influence of environment on these traits. The estimates of genetic advance as per cent of mean were high coupled with high heritability recorded for all traits except days to maturity (Table 2). The similar results have also been reported earlier by Dubey (2010) and Sangwan *et al.* (2013) in Ashwagandha.

In the present investigation, the genotypic correlation coefficient was higher in magnitude than their corresponding phenotypic correlation coefficient for most of the characters indicating the depression of phenotypic expression by environmental influences (Table 3). Dry weight of root showed positive and signficant high association with root length, diameter of root at collar region, dry weight of root were plant height, leaf length, leaf width, days to flower initiation and days to maturity at both the genotypic and phenotypic levels. Starch content, no. of primary and secondary branches showed no association with dry weight of root. Hence these traits may be considered as selection indices for the improvement of dry weight of root (Table 3). The withanoloid had significant and negative association with leaf length both at genotypic and phenotypic level. Leaf width and dry weight of root had significant and negative association at phenotypic level only and it may be due to environment influence. Hence improvement of dry root weight through its selection indices except leaf length will not affect alkaloid level. Such correlations were also obtained by Kandalkar *et al.*, (1993), Kubsad *et al.*, (2009), Dubey (2010), Rameshkumar *et al.*, (2011) and Sangwan *et al.* (2013) in Ashwagandha.

The estimates of correlation coefficient mostly indicate inter-relationship of different characters but it does not furnish information on cause and effect. The contribution of characters towards the yield can be detected by direct and indirect effects. Path analysis helps in estimating both the effects of a specified character on

root yield. The results revealed that plant height and days to maturity, followed by diameter of root at collar region and leaf width were major characters having positive direct effect and significant association with dry root yield per plant. The direct effect of root length and number of primary branches per plant was moderate but its association with dry root yield was positive because of positive and high indirect effect through plant height and leaf width. Negative direct effect of leaf length, days to flower initiation, no. of ssecondary branches, withanoloid and starch content on dry root yield (Table 4). Similar results were also obtained by Kandalkar *et al.*, (1993), Kubsad *et al.*, (2009), Dubey (2010), Rameshkumar *et al.*, (2011) and Sangwan *et al.* (2013) in Ashwagandha. Thus, plant height, days to maturity, diameter of root at collar region and leaf width may be used as selection indices for improvement of dry root yield in Ashwagandha.

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Table 1. Analysis of variance for different characters in Ashwagandha

Characters	Mean sum of squares		
	Replications	Genotypes	Error
d.f.	2	39	78
Plant height (cm)	1.266	115.61**	12.01
Leaf length (cm)	0.305	3.89**	0.17
Leaf width (cm)	0.059	1.363**	0.018
Days to flower initiation	2.34	196.43**	14.11
Days to maturity	21.81	170.75**	33.32
Number of primary branches per plant	0.216	2.32**	0.357
Number of secondary branches per plant	0.104	1.125**	0.121
Root length (cm)	0.006	20.32**	0.407
Diameter of root at collar region (cm)	0.001	0.048**	0.002
Dry weight of root (g/plant)	0.002	1.203**	0.019
Withanoloide content (%)	0.0005	0.0148**	0.0002
Starch content (%)	1.086	138.59**	2.76

Note: *, ** Significant at 5% and 1 % levels, respectively

Table 2. The estimates of variability parameters for different characters in Ashwagandha

Characters	h^2_{bs} (%)	GCV (%)	PCV (%)	GA (% mean)
Plant height (cm)	74.19	12.31	14.29	21.85
Leaf length (cm)	87.84	13.22	14.10	25.52
Leaf width (cm)	96.02	16.17	16.50	32.62
Days to flower initiation	81.38	11.56	12.81	21.44
Days to maturity	57.89	5.13	6.74	8.04
No. of primary branches per plant	64.72	16.55	20.57	27.51
No. of secondary branches per plant	73.36	20.45	23.87	36.06
Root length (cm)	94.22	15.36	15.83	30.70
Diameter of root at collar region (cm)	87.59	11.03	11.78	21.45
Dry weight of root (g/plant)	95.39	31.78	32.54	63.74
Withanoloide content (%)	95.21	24.40	25.01	48.97
Starch content (%)	94.24	25.44	26.21	50.90

Table 3. Genotypic (rg) and phenotypic (rp) correlations among different characters in Ashwagandha

Character		Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Days to flower initiation	Days to maturity	No. of Primary branches per plant	No. of Secondary branches per plant	Root length (cm)	Diameter of root at collar region (cm)	Withanoloide content (%)	Starch content (%)
Dry weight of root (g/plant)	r_g	0.730**	0.765**	0.737**	0.346*	0.448**	-0.080	-0.188	0.672**	0.614**	-0.305	-0.092
	r_p	0.613**	0.693**	0.703**	0.302**	0.312**	-0.088	-0.136	0.640**	0.552**	-0.297**	-0.082
Plant height (cm)	r_g	1.000	0.703**	0.496**	0.273	0.333*	-0.059	0.065	0.541**	0.581**	-0.207	0.384*
	r_p	1.000	0.539**	0.413**	0.189	0.220*	-0.042	0.069	0.463**	0.474**	-0.164	0.332**
Leaf length (cm)	r_g		1.000	0.916**	0.305	0.438**	-0.239	-0.096	0.627**	0.544**	-0.323*	0.132
	r_p		1.000	0.854**	0.287**	0.288**	-0.128	-0.090	0.563**	0.483**	-0.293**	0.125
Leaf width (cm)	r_g			1.000	0.188	0.401*	-0.250	-0.286	0.631**	0.458**	-0.235	-0.015
	r_p			1.000	0.151	0.291**	-0.207*	-0.226*	0.594**	0.431**	-0.220*	-0.011
Days to flower initiation	r_g				1.000	1.008**	-0.177	0.049	0.232	0.140	-0.169	-0.294
	r_p				1.000	0.642**	-0.066	0.062	0.196*	0.124	-0.160	-0.245*
Days to maturity	r_g					1.000	-0.299	-0.157	0.451**	0.093	-0.186	-0.327*
	r_p					1.000	-0.112	-0.052	0.333**	0.048	-0.163	-0.239*
No. of Primary branches per plant	r_g						1.000	0.527**	-0.130	-0.090	0.132	-0.116
	r_p						1.000	0.370**	-0.088	-0.094	0.082	-0.118
No. of Secondary branches per plant	r_g							1.000	-0.230	0.077	-0.187	0.223
	r_p							1.000	-0.185	0.041	-0.169	0.203*
Root length (cm)	r_g								1.000	0.208	-0.169	-0.014
	r_p								1.000	0.189	-0.163	-0.017
Diameter of root at collar region (cm)	r_g									1.000	-0.114	0.100
	r_p									1.000	-0.095	0.107
Withanoloide content (%)	r_g										1.000	0.052
	r_p										1.000	0.047

Note : *, significant at 5% and 1% levels, respectively**

Table 4. Genotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on dry root yield in Ashwagandha

Characters	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Days to flower initiation	Days to maturity	No. of Primary branches per plant	No. of Secondary branches per plant	Root length (cm)	Diameter of root at collar region (cm)	Withanoloide content (%)	Starch content (%)	Genotypic correlation Dry root yield per plant
Plant height (cm)	0.428	-0.078	0.136	-0.058	0.105	-0.010	-0.011	0.075	0.174	0.032	-0.061	0.730**
Leaf length (cm)	0.301	-0.111	0.252	-0.065	0.138	-0.042	0.016	0.087	0.163	0.050	-0.021	0.765**
Leaf width (cm)	0.212	-0.102	0.275	-0.040	0.126	-0.044	0.047	0.087	0.137	0.036	0.002	0.737**
Days to flower initiation	0.117	-0.034	0.052	-0.213	0.317	-0.031	-0.008	0.032	0.042	0.026	0.047	0.346*
Days to maturity	0.142	-0.049	0.110	-0.215	0.315	-0.053	0.026	0.062	0.028	0.029	0.052	0.448**
No. of primary branches per plant	-0.025	0.027	-0.069	0.038	-0.094	0.178	-0.087	-0.018	-0.027	-0.020	0.018	-0.080
No. of secondary branches per plant	0.028	0.011	-0.079	-0.010	-0.049	0.094	-0.166	-0.032	0.023	0.029	-0.036	-0.188
Root length (cm)	0.232	-0.070	0.173	-0.049	0.142	-0.023	0.038	0.138	0.062	0.026	0.002	0.672**
Diameter of root at collar region (cm)	0.249	-0.061	0.126	-0.030	0.029	-0.016	-0.013	0.029	0.299	0.018	-0.016	0.614**
Withanoloide content (%)	-0.089	0.036	-0.065	0.036	-0.058	0.023	0.031	-0.023	-0.034	-0.154	-0.008	-0.305
Starch content (%)	0.164	-0.015	-0.004	0.063	-0.103	-0.021	-0.037	-0.002	0.030	-0.008	-0.160	-0.092

Note: *,** significant at 5% and 1% levels, respectively
Residual effect: 0.148