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Correlation and path analysis studies in ashwagandha [*Withania somnifera* (L.) Dunal]

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Abstract
This study was aimed at probing into interrelationship among dry root yield per plant and some of its components by estimating their correlation and path coefficients. The result on phenotypic and genotypic correlation coefficient revealed that dry root yield was significantly and positively correlated with fresh root yield per plant (rp = 0.3343**, rg = 0.378**) and harvest index (rp = 0.732**, rg = 0.739**). However, days to flowering (rp = -0.203**, rg = -0.265**) and number of primary branch per plant (rp = -0.160*, rg = -0.252*) showed significantly and negatively correlated with dry root yield. Negative correlation of dry root yield both at genotypic and phenotypic level was seen with total alkaloid content in root (r_g= -0.095, r_p = -0.086). Path coefficient analysis revealed that most of the evaluated traits exhibited positive direct effects on dry root yield per plant was exhibited by harvest index (1.235) followed by dry plant weight per plant (0.647), days to 75 per cent maturity (0.134), number of secondary branches per plant (0.109), fresh plant weight per plant (0.102), leaf area index (0.038), plant height (0.016), root length (0.014) and total alkaloid content (0.006) these characters play a major role in recombination breeding and suggested that direct selection based on these traits will be rewarded for crop improvement of ashwagandha. But some characters which had negative and direct effect on dry root yield per plant followed by fresh root yield per plant, 100 seed weight, root diameter in collar region, number of primary branch per plant. The breeding methods such as selection would be effective for genetic improvement of these traits.

Keywords: Variabity, correlation, path analysis

1. Introduction
Ashwagandha [*Withania somnifera* (L.) Dunal] also known as Indian ginseng (poison) gooseberry or winter cherry is a plant of the solanaceae family (mir *et al*., 2013) with chromosome 2n=48 is native of north-western region and central India as well as Mediterranean region of north Africa. In India two species of genus *withania viz*., *Withania somnifera* (L.) Dunal (ashwagandha) *withania coagulans* (L.) Dunal (panir) are found. *Withania somnifera* (L.) is an erect evergreen, 60-70 cm tall, under domestication and it is grown for its roots, leaves are simple ovate and opposite. The flowers are inconspicuous greenish or dull yellow and bisexual. *Withania coagulans* is rigid grey under shrub of 60-120 cm height. The fruit is called berry and orange/red in colour when mature. The seeds are small flat yellow and uniform in shape and very light in weight (Atal *et al.*, 1961). It is also an in gradient of medicaments prescribed for curing disability and sexual weakness in males. Seeds are diuretic, warm leaves are used for providing comfort during eye disease (Nigam and Kandalkar, 2006). Ashwagandha is cultivated mainly in Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Punjab and Uttar Pradesh whereas *Withania coagulans* (L.) found in wild. It is indigenous to India and is also found in Spain, Egypt, Israel, Jordan, Sudan, Iran, Afghanistan, Morocco, Baluchistan, Pakistan, Shrilanka, and Mediterranean region of east Africa. It is late *kharif* crop and grown under dry climate or required less irrigation for plant growth and rain fed cultivation. It is grown between 600-1200 meters altitudes. The semi tropical area receiving 60-75 cm annual rainfall with high temperature 20°c to 35°c is suitable for its cultivation. Ashwagandha is grown on marginal lands of Neemach and Mandsaur district of M.P. and Kota, Jhalawar, Pratapgarh, Chittorgarh and Baran districts of Rajasthan. The medicinal utility of roots is due to present of number of alkaloids. The total alkaloids content in the roots varied from 0.16 to 0.66 percent (Biennial Progress Report of AICRP on Medicinal & Aromatic Plant, 2006-08).

2. Material and Method

The Experiment was laid out late *kharif*-2017 in the Botany farm at Rajasthan college of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur to assess genetic divergence among sixty three genotypes with three standard check (JA-20, JA-134 and RVA-100) by growing them in a Randomized Block Design (RBD) with three replications a single row plot of 4.0 meter length maintaining a crop geometry of 30 X 5 cm. The correlations among various variables and the path coefficient were estimated as per the procedure of Dewy and Lu (1959) [6].

3. Result & Discussion

3.1 Correlation between dry root yield per plant and other characters:

The correlation between dry root yield per plant with different yield attributes and amongst the attributes themselves are presented in the Table 1. The correlation analysis revealed that dry root yield per plant was highly significant and positively correlated phenotypic as well as genotypic level with fresh root yield per plant (rp = 0.3343**, rg = 0.378**) and harvest index (rp = 0.732**, rg = 0.739**). The similar results were also reported by Kubsad *et al*., (2009) [15], Kumar *et al.,* (2011), Joshi *et al* (2013), Sukhdev *et al*., (2015) and Sundesh *et al.,* (2016). Dry root yield per plant was negatively and significantly correlated at both phenotypic as well as genotypic level with days to flowering (rp = -0.203**, rg = -0.265**) and number of primary branch per plant (rp = -0.160*, rg = -0.252*). Negative correlation of dry root yield both at genotypic and phenotypic level was seen with total alkaloid content in root (r_g= -0.095,r_p = -0.086).The similar results were also reported by Sukhdev *et al*. (2015) and Sundesh *et al*. (2016).

Days to flowering showed significant correlation in positive direction at both phenotypically and genotypically level with number of primary branch per plant (rp = 0.164*, rg = 0.212*). However, days to flowering also showed significant and negative correlation at both phenotypically and genotypically level with root length (rp = -0.162*, rg = -0.258*), dry plant weight per plant (rp = -0.238**, rg = -0.310**) and fresh plant weight per plant (rp = -0.188**, rg = -0.231**). The similar results were also reported by Patel and Desai *et al*. (2017).

Days to 75 per cent maturity exhibited significant and positive correlation at both phenotypically and genotypically level with fresh plant weight per plant (rp =0.182*, rg = 0.448 *). The similar results were also reported by Gami *et al*. (2016) [10].

The plant height exhibited significant and positive correlation at both phenotypically and genotypically level with root diameter in collar region (rp = 0.162*, rg = 0.225*), total alkaloid content (rp = 0.151*, rg = 0.202*). The similar results were also reported by Kubsad *et al*. (2009) [15], Sukhdev *et al*. (2015) and Sundesh *et al*. (2016), However, number of secondary branches per plant also exhibited significant and negative correlation at both phenotypically and genotypically level with number of pods per cluster (rp = -0.164*, rg = -0.231*) and dry plant weight per plant (rp = -0.183*, rg = -0.220*). The similar results were also reported by Kumar *et al*. (2012) [17].

The number of primary branch per plant showed significant and negative correlation at both phenotypically and genotypically level with 100 seed weight (rp = -0.146*, rg = -0.238*).The similar results were also reported by Sundesh *et al*. (2016)

The number of secondary branch per plant showed significant and negative correlation at both phenotypically and genotypically level with fresh root yield per plant (rp = -0.219**, rg = -0.311**). The similar results were also reported by Sundesh *et al*. (2016)

The root length showed significant and negative correlation at both phenotypically and genotypically level with root diameter in collar region (rp = -0.151*, rg = -0.192*) and leaf area index (rp = -0.159*, rg = -0.205*).The similar results were also reported by Kumar *et al.* (2011) and Sundesh *et al*. (2016).

The fresh root yield per plant showed significant and positive correlation at both phenotypically and genotypically level with harvest index (rp = 0.279**, rg = 0.303**) and also showed significant and negative correlation with leaf area index (rp = -0.181*, rg = -0.218*).The similar results were also reported by Kumar *et al*. (2012) [17].

The dry plant weight per plant showed significant and positive correlation at both phenotypically and genotypically level with fresh plant weight per plant (rp = 0.666**, rg = 0.751**) and also showed significant and negative correlation with harvest index (rp = -0.608**, rg = -0.628**).

The fresh plant weight per plant showed significant and negative correlation at both phenotypically and genotypically level with (rp = -0.340**, rg = -0.411**).

Leaf area index showed significant and positive correlation at both phenotypically and genotypically level with 100 seed weight (rp = 0.181*, rg = 0.263*).

3.2 Path coefficient analysis

Path coefficient analysis was worked out to get an insight into the direct and indirect effects of 14 dependent characters on dry root yield and the results are presented in the Table 2.

3.3 Direct effects

Out of fourteen characters, nine characters showed positive and direct effect on fresh root yield per plant at genotypic level. The highest positive direct effect on dry root yield per plant was exhibited by harvest index followed by dry plant weight per plant, days to 75 per cent maturity, number of secondary branches per plant, fresh plant weight per plant, leaf area index, plant height, root length and total alkaloid content. The characters which had negative and direct effect on dry root yield, days to flowering followed by fresh root yield per plant, 100 seed weigh, root diameter in collar region, number of primary branch per plant, respectively. The similar results were also reported by Kubsad *et al*. (2009) [15].

3.4 Indirect effects

Dry plant weight per plant (0.486) and days to flowering (0.033) exhibited considerable positive indirect effect on dry root yield per plant through fresh plant weight but harvest index (-0.508) and number of secondary branch per plant (-0.015) showed considerable negative indirect effect on it through fresh plant weight per plant.

Harvest index (0.375) followed by days to 75 per cent maturity (0.060), dry plant weight per plant (0.0127) and fresh plant weight per plant (0.0121) exhibited considerable positive indirect effect on dry root yield per plant through fresh plant weight per plant but (-0.033) and leaf area index (-0.008) showed considerable negative indirect effect on it via fresh plant weight per plant. The similar results were also reported by Kubsad *et al*., (2009) [15].

Table 1: genotypic and phenotypic correlation between dry root yield per plant and other characters studied in Ashwagandha

Character		Days to flowering	Days to 75% maturity	Plant height	No. of primary branches/ plant	No. of secondary branches/ plant	Root length	Fresh root yield/plant	Root diameter in collar region	Dry plant weight/ plant	Fresh plant weight/ plant	Harvest index	Leaf area index	Total alkaloid content	100-seed weight	Dry root yield/ plant
Days to Flowering	G	1.0000	0.2322	0.1551	0.2125*	-0.0456	-0.2587*	-0.0208	0.0930	-0.3106**	-0.2314*	0.0700	-0.0553	0.0078	-0.0870	-0.2650**
	P	1.0000	0.0358	0.1082	0.1643*	-0.0245	-0.1622*	-0.0885	0.0808	-0.2380**	-0.1884*	0.0455	-0.0516	0.0172	-0.0820	-0.2034**
Day to 75% Maturity	G		1.0000	0.0377	-0.1596	-0.2471	0.1286	0.4484*	0.2081	0.0568	-0.1120	-0.1181	-0.3430	-0.3156	0.5108	-0.1175
	P		1.0000	0.0421	-0.0391	-0.0822	0.0766	0.1829*	0.0884	0.0102	-0.0570	-0.0945	-0.1232	-0.1230	0.1021	-0.0980
Plant Height	G			1.0000	0.0611	-0.2318*	0.1307	0.0067	0.2257*	-0.2201*	-0.1250	0.1186	-0.1878	0.2025*	-0.0230	-0.0512
	P			1.0000	0.0947	-0.1649*	0.0687	0.0477	0.1627*	-0.1835*	-0.1230	0.1116	-0.1255	0.1515*	-0.0813	-0.0172
Number of Primary Branches/ Plant	G				1.0000	-0.0276	0.0878	-0.2237	-0.0418	0.0685	0.0197	-0.1993	-0.0258	0.1007	-0.2387*	-0.2525*
	P				1.0000	0.0352	0.0209	-0.1317	-0.0660	0.0604	0.0415	-0.1312	-0.0179	0.0764	-0.1465*	-0.1602*
Number of Secondary Branches/ Plant	G					1.0000	-0.1638	-0.3113**	0.1823	0.0153	-0.1424	-0.1401	0.1459	-0.0262	0.0436	-0.0893
	P					1.0000	-0.1121	-0.2195**	0.0948	0.0238	-0.0639	-0.1095	0.0771	-0.0156	0.0618	-0.0602
Root Length	G						1.0000	0.1856	-0.1924*	-0.1403	0.0122	0.1981	-0.2058*	-0.1316	0.1157	0.1911
	P						1.0000	0.0566	-0.1518*	-0.1221	0.0130	0.1283	-0.1596*	-0.0977	0.0535	0.1146
Fresh Root Yield /Plant	G							1.0000	-0.0375	0.0196	0.1181	0.3035**	-0.2188*	-0.1325	-0.0913	0.3782**
	P							1.0000	0.0171	0.0234	0.0793	0.2793**	-0.1818*	-0.1188	-0.1016	0.3436**
Root Diameter In Collar Region	G								1.0000	0.0478	0.0079	-0.0446	-0.0330	-0.0435	0.0247	-0.0387
	P								1.0000	0.0528	-0.0152	-0.0224	-0.0542	-0.0261	0.0180	-0.0065
Dry Plant Weight/plant	G									1.0000	0.7519**	-0.6288*	-0.0526	-0.0267	0.0646	-0.0147
	P									1.0000	0.6661**	-0.6083*	-0.0421	-0.0219	0.0359	0.0035
Fresh Plant Weight/plant	G										1.0000	-0.4118*	-0.0816	-0.0543	-0.0579	0.0733
	P										1.0000	-0.3403*	-0.0836	-0.0485	0.0079	0.0872
Harvest Index	G											1.0000	-0.0277	-0.0302	-0.0144	0.7394**
	P											1.0000	-0.0396	-0.0315	0.0234	0.7328**
Leaf Area Index	G												1.0000	0.0288	0.2633*	-0.0648
	P												1.0000	0.0244	0.1817*	-0.0732
Total Alkaloid content	G													1.0000	0.0986	-0.0957
	P													1.0000	0.0711	-0.0868
100 Seed Weight	G														1.0000	0.0755
	P														1.0000	0.0931
Dry Root Yield/plant	G															1.0000
	P															1.0000

Table 2: Direct and indirect effects of different correlated characters towards dry root yield per plant in Ashwagandha

Character	Day to flowering	Day to 75% maturity	Plant height cm	Number primary branches/ Plant	Number secondary branches/ Plant	Root length (cm)	Fresh root yield g/plant	Root diameter in collar region	Dry plant weight /plant	Fresh plant weight /plant	Harvest index	Leaf area index	Total alkaloid content	100 Seed weight	Dry root yield
Day to Flowering	-0.1451	-0.0337	-0.0225	-0.0308	0.0066	0.0375	0.003	-0.0135	0.045	0.0336	-0.0102	0.008	-0.0011	0.0126	-0.265
Day to 75% Maturity	0.0313	0.1349	0.0051	-0.0215	-0.0333	0.0174	0.0605	0.0281	0.0077	-0.0151	-0.0159	-0.0463	-0.0426	0.0689	-0.1175
Plant Height cm	0.0026	0.0006	0.0166	0.001	-0.0039	0.0022	0.0001	0.0038	-0.0037	-0.0021	0.002	-0.0031	0.0034	-0.0004	-0.0512
Number of Primary Branches/ Plant	-0.0056	0.0042	-0.0016	-0.0264	0.0007	-0.0023	0.0059	0.0011	-0.0018	-0.0005	0.0053	0.0007	-0.0027	0.0063	-0.2525
Number of Secondary Branches/ Plant	-0.005	-0.0269	-0.0253	-0.003	0.109	-0.0178	-0.0339	0.0199	0.0017	-0.0155	-0.0153	0.0159	-0.0029	0.0048	-0.0893
Root Length (cm)	-0.0038	0.0019	0.0019	0.0013	-0.0024	0.0145	0.0027	-0.0028	-0.002	0.0002	0.0029	-0.003	-0.0019	0.0017	0.1911
Fresh Root Yield g/Plant	0.0012	-0.0257	-0.0004	0.0128	0.0178	-0.0106	-0.0573	0.0021	-0.0011	-0.0068	-0.0174	0.0125	0.0076	0.0052	0.3782
Root Diameter In Collar Region	-0.0048	-0.0107	-0.0116	0.0021	-0.0093	0.0099	0.0019	-0.0512	-0.0024	-0.0004	0.0023	0.0017	0.0022	-0.0013	-0.0387
Dry Plant Weight/plant	-0.201	0.0368	-0.1425	0.0444	0.0099	-0.0908	0.0127	0.031	0.6472	0.4866	-0.407	-0.034	-0.0173	0.0418	-0.0147
Fresh Plant Weight/plant	-0.0238	-0.0115	-0.0128	0.002	-0.0146	0.0012	0.0121	0.0008	0.0772	0.1027	-0.0423	-0.0084	-0.0056	-0.0059	0.0733
Harvest Index	0.0865	-0.146	0.1465	-0.2462	-0.1731	0.2447	0.375	-0.0551	-0.7769	-0.5089	1.2356	-0.0342	-0.0373	-0.0178	0.7394
Leaf Area Index	-0.0021	-0.0133	-0.0073	-0.001	0.0056	-0.008	-0.0085	-0.0013	-0.002	-0.0032	-0.0011	0.0387	0.0011	0.0102	-0.0648
Total Alkaloid content	0	-0.002	0.0013	0.0006	-0.0002	-0.0008	-0.0008	-0.0003	-0.0002	-0.0003	-0.0002	0.0002	0.0064	0.0006	-0.0957
100 Seed Weight	0.0045	-0.0262	0.0012	0.0122	-0.0022	-0.0059	0.0047	-0.0013	-0.0033	0.003	0.0007	-0.0135	-0.0051	-0.0513	0.0755
Residual effect = 0.3059 ** Significant at level 1% level, Bold value indicate direct effect															

Harvest index (0.244) and days to flowering (0.037) and days to 75% maturity (0.017) exhibited considerable positive indirect effect on dry root yield per plant through root length but dry plant weight per plant (-0.09) and fresh root yield per plant (-0.010) showed considerable negative indirect effect on it through root length. The similar results were also reported by Kubsad *et al*., (2009) [15].

Harvest index (0.146) followed by days to 75 per cent maturity (0.005) and root length (0.0019) exhibited considerable positive indirect effect on dry root yield per plant through plant height but dry plant weight per plant (0.142) and number of secondary branch (-0.025) showed considerable negative indirect effect on it via plant height.

Harvest index (0.086) and days to 75 per cent maturity (0.031) exhibited considerable positive indirect effect on dry root yield per plant through days to flowering but dry plant weight per plant (-0.201) and fresh plant weight per plant (-0.023) showed considerable negative indirect effect on it through days to flowering. The residual effect on dry root yield per plant was 0.30 indicated that 99.70 per cent of variability was governed by above said character and 0.30 per cent variability was due to environment effect.

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