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Correlation and path analysis for dry root yield in Ashwagandha [*Withania somnifera* (L.) Dunal]

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Abstract
Correlation and path-coefficient analysis were carried out for twelve different quantitative traits in a population of forty six genotypes of ashwagandha(*W. somnifera*). The analysis revealed strong positive association of dry root yield per plant with root diameter, root length, plant height, root branches and days to maturity. The plant height and root branches per plant had positive direct effect on dry root yield per plant. Hence, plant height and root branches per plant may be good for improvingdry root yield per plantthrough selection in ashwagandha.

Keywords: Ashwagandha,Correlation, Path analysis, Dry root yield

Introduction

Ashwagandha (*Withania somnifera* (L.)Dunal) is known as a winter cherry in English and Asgandh in Hindi.Ashwgandha has long been considered as an excellent rejuvenator, a general health tonic and a cure for a number of health complaints. It is a sedative, diuretic, anti-inflammatory and generally respected for increasing energy, endurance, and acts as an-adaptogen that exerts a strong immune stimulatory and ananti-stress agent. It is taken for treatment of cold and coughs, ulcers, emaciation, diabetes, conjunctivitis, epilepsy, insomnia, senile dementia, leprosy, Parkinson's disease, nervous disorders, rheumatism, arthritis, intestinal infections, bronchitis, asthma, impotence and a suppressant in HIV/AIDS patients. Thisis an ancient medicinal plant with immense therapeutic uses in traditional (Ayurveda, SidhdhaandUnani) and modern system of medicine. The roots contain withanolids and other alkaloids. For evaluating the dry root yield potential of ashwagandhaplant, it is necessary to give attention to dry root yield and its contributing charactersand it is alsoessentials to assess the degree of association of various characters in order to initiate effective selection programme. The knowledge of association of the various plant characters with dry root yield and among themselves is required for selection in breeding programme of ashwagandha.

Materials and Methods

Forty six genotypes along with two check entries *viz*. JA-20 and JA-134 of ashwagandha (Table 1) received from different sources were evaluated at the Botanical garden, C.P. College of Agriculture, Sardarkrushinagar, North Gujarat during *Kharif*2011-12. The experiment was laid out in a Randomized Block Design with three replications. Each entry was planted in single row of 1.0 meter length placed at 45cm apart. Five plants were randomly selected from each genotype and observations were recorded for dry root yield per plant, plant height, number of berries per plant, number of primary branches, number of secondary branches, root diameter, root length, root branches, days to flowering, days to maturity and seeds per berry. Total alkaloid content was determined as per methodologies suggested by Mishra (1998).Data were analysed for correlation as per method suggested byPanse and Sukhatme(1978) and for path analysis as per Dewey and Lu(1959).

Results and Discussion

Yield is a complex character and is the multiplicative end product of other quantitative traits as components of the yield Whitehouse *et al.*,(1958). Hence, the selection of superior genotypes based on root yield as such would not be much effective but several component characters have to be handled together. (Table 2)

Thecorrelation coefficientsrevealed high degree of association among the characters at genotypic level. In a few instance, the phenotypic correlation were slightly higher than their genotypic counterparts like correlation of dry root yield with primary branches and alkaloid content. The non-genetic environmental factorsmay be responsible in inflating the value of genotypic correlation. Similar findings were also reported in some traits by Mohsina and Datta (2007) and Dubey(2010).

Dry root yield per plant was found to be highly and positively correlated with plant height, root diameter, root length, root branch and days to maturity indicating these attributes were mainly influencing the dry root yield in ashwagandha. Thus, selection practiced for improvement in component character will automatically result in

the improvement in the dry root yield. Kandalkar*et al.,* (1993) observed positive correlation of dry root yield with plant height, stem branches, root length and root diameter.Similarly, correlation of dry root yield with plant height and root length were observed by Kubsad*et al.,* (2009) and Rameshkumar*et al.,* (2011).

Number of berries per plant had nonsignificant correlation with the dry root yield. The days to maturity had positive correlation with the yield of dry roots per plant. Selection for dry root yield should be practiced considering medicinal quality of the root irrespective of the days to maturity and number of berries per plant.

The root traits *i.e.* root length, root diameter and root branches were positively correlated with each other. Ultimately they were positively correlated with the yield of dry roots per plant. Similar condition was observedby Kandalkar*et al.,* (1993)for those traits.The root length was also positively correlated with plant height, dry root yield per plant, number of berries per plant, number primary and secondary branches in ashwagandha.

Total alkaloid content hadnonsignificant correlation with dry root yield but it had positive significant correlation with root length. Thus, root length is an important trait for improving alkaloid content through phenotypic selection.

The simple correlation being calculated on an average basis, may not give a clear picture of the cause and effect system operating on the material selected for study. In addition to this, when variables increases, the situation becomes complex.In order to achieve a clear picture of interrelationship of various component characters with root yield, direct and indirect effects were calculated using path coefficient analysis at genotypic level.(Table 3)

The plant height had the highest positive direct effect on dry root yield. The other traits having high positive direct effect on dry root yield were root diameter, root branches, seeds per berry,days to flowering,root length and total alkaloid content. Maximum direct effects of plant height and root diameter on dry root yield per plant wereobserved by Kandalkar*et al.,* (1993) andKubsad*et al.,* (2009). In other reports, Dubey(2010) and Rameshkumar*et al.,* (2011) also noticed the major contribution of root length and root diameter towards dry root yield per plant in ashwagandha.

Total alkaloid content in dry roots is an important quality parameter in ashwagandha. Similar to the results of present investigation, Das *et al.,* (2011) reported noticeable direct effect of total alkaloids on dry root yield per plant.
The major negative direct effects days to maturity on dry root yield was observed in present investigation. Instead of negative direct effect observed in present investigation, Dubey (2010) reported positive direct effect of number of primary branches and days to maturity on dry root yieldper plant.

The plant height manifested highly significant positive genotypic correlation with dry root yield per plant.(Table 3). This trait also exhibited strong positive direct effect and notable indirect positive effect through root diameter. Similarly, the root diameter exhibited high direct effect along with major indirect effect through plant height. Thus, plant height and root diameter appears to be the most important yield components, which can be utilized as indicator characters in selection programme for genetic improvement in dry root yield per plant.

Days to maturity had high negative direct effect on dry root yield per plant though its correlation coefficient was high and positive. Days to maturity effected positively indirectly via number of secondary branches per plant, root diameter and root branches. Therefore, direct selection of days to maturity for increasing dry root yield may not be fruitful. Instead, root diameter, root branches and number of secondary branches on stems should be used for selection.

Negative direct effect of number of berries per plant was neutralized by its indirect positive effects via plant height, days to maturity and root diameter. Even though, selection for number of berries per plant may be avoided.

Primary and secondary branches per plant had negative direct effect on dry root yield per plant but their positive indirect effect via root branches and days to maturity, respectively, was substantial. These two traits also had nonsignificant genotypic correlation with dry root yield. Therefore, these characterswere not seemed important for improving dry root yield per plant in present population.

The quality character, total alkaloid content in root had nonsignificant genotypic correlation with the yield of dry roots per plant. This trait had also smaller direct and indirect effects on dry root yield per plant. Therefore it can be concluded that increased alkaloid content in roots may not have any adverse effect on dry root yield per plant.

The path diagram revealed residual effect of -0.3470 suggesting that there were few more component traits other than those included in the

present investigation which had negligible influence on the dry root yield per plant.

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Table 1. List of ashwagndha (*Withaniasomnifera*) genotypes used in the research.

Sr. No.	Genotypes	Sr. No.	Genotypes
1	IC 286632	24	RAS 23
2	IC 283662	25	RAS 15
3	IC 283942	26	RAS 33
4	IC 283966	27	RAS 67
5	IC 310595	28	RAS 11
6	IC 310620-A	29	RAS 29
7	IC 310320-B	30	RAS 32
8	MWS 311	31	RAS 57
9	MWS 316	32	RAS 55
10	MWS 226	33	RAS 65
11	MWS 205	34	MPAS-2
12	MWS 322	35	MPAS-3
13	MWS 302	36	MPAS-4
14	MWS 201	37	MPAS-5
15	MWS 217	38	MPAS-6
16	MWS 329	39	MPAS-7
17	MWS 309	40	MPAS-10
18	MWS 101	41	MPAS-12
19	MWS 204	42	MPAS-15
20	MWS 208	43	MPAS-16
21	RAS 18	44	K-86
22	RAS 16	45	JA-134
23	RAS 21	46	JA-20

Table 2. Phenotypic (P) and Genotypic (G) correlation coefficients between dry root yield and different traits inashwagndha

Characters		Plant height (cm)	No. of Berry per plant	No. of primary branches	No. of Secondary branches	Root diameter (mm)	Root length (cm)	Root branches	Days to flowering	Days to maturity	Seed per berry	Total Alkaloid content
Dry root yield Per plant (gm)	Gg	0.921**	0.219	0.164	-0.082	1.161**	0.984**	0.496**	-0.184	0.432**	-0.032	0.120
	Gp	0.485**	0.199	0.186	0.006	0.619**	0.412**	0.230	-0.075	0.210	-0.003	0.136
Plant height (cm)	Gg		0.579**	0.013	0.043	0.784**	0.899**	-0.090	-0.713**	-0.062	-0.231	0.085
	Gp		0.328*	0.124	0.075	0.458**	0.477**	0.112	-0.172	-0.177	0.008	0.176
No. of Berry per plant	Gg			0.162	0.508**	0.202	0.537**	-0.214*	-0.546**	-0.462**	0.102	0.114
	Gp			0.178	0.409**	0.150	0.284	0.046	-0.063	-0.161	0.060	0.090
No. of primary branches	Gg				0.432**	0.195*	0.377**	0.758**	-0.391**	-0.119	-0.089	0.096
	Gp				0.403**	0.103	0.176	0.236	-0.146	-0.001	-0.018	0.038
No. of Secondary branches	Gg					-0.021	0.306*	0.156	-0.708**	-0.756**	0.222	-0.027
	Gp					0.025	0.116	0.129	-0.173	-0.298*	0.086	0.006
Root diameter (mm)	Gg						0.855**	0.619**	-0.018	0.624**	0.034	0.166
	Gp						0.292*	0.239	0.052	0.203	0.122	0.114
Root length (cm)	Gg							0.537**	-1.374**	-0.126	-0.360*	0.341*
	Gp							0.263	-0.146	-0.125	-0.025	0.195
Root branches	Gg								0.153	0.385**	-0.281	-0.054
	Gp								-0.017	0.027	-0.172	0.010
Days to flowering	Gg									0.430**	0.306*	-0.072
	Gp									0.347*	-0.007	0.044
Days to maturity	Gg										-0.315*	0.022
	Gp										-0.130	0.019
Seed per berry	Gg											-0.226
	Gp											-0.091

* Significant at 5% level and **significant at 1% level

Table 3. Direct and Indirect effects of different characters on dry root yield in ashwagndha

Characters	Plant height (cm)	No. of Berry per plant	No. of primary branches	No. of Secondary branches	Root diameter (mm)	Root length (cm)	Root branches	Days to flowering	Days to maturity	Seed per berry	Total Alkaloid content	correlation coefficients (rg)
Plant height (cm)	**0.636**	-0.124	-0.002	-0.008	0.473	0.071	-0.033	-0.076	0.018	-0.038	0.004	0.921**
No. of Berry per plant	0.368	**-0.214**	-0.022	-0.096	0.122	0.042	-0.078	-0.058	0.133	0.017	0.005	0.219
No. of primary branches	0.008	-0.035	**-0.134**	-0.082	0.117	0.030	0.277	-0.042	0.034	-0.015	0.004	0.164
No. of Secondary branches	0.027	-0.109	-0.058	**-0.189**	-0.013	0.024	0.057	-0.075	0.218	0.037	-0.001	-0.082
Root diameter (mm)	0.499	-0.043	-0.026	0.004	**0.603**	0.067	0.227	-0.002	-0.180	0.006	0.007	1.161**
Root length (cm)	0.572	-0.115	-0.051	-0.058	0.515	**0.079**	0.197	-0.146	0.036	-0.059	0.014	0.984**
Root branches	-0.057	0.046	- 0.102	- 0.030	0.373	0.042	**0.366**	0.016	-0.111	-0.046	-0.002	0.496**
Days to flowering	-0.454	0.117	0.052	0.134	-0.011	-0.108	0.056	**0.106**	-0.124	0.050	-0.003	-0.184
Days to maturity	-0.039	0.099	0.016	0.143	0.376	-0.010	0.141	0.046	**-0.289**	-0.052	0.001	0.432**
Seed per berry	-0.147	-0.022	0.012	-0.042	0.020	-0.028	-0.103	0.033	0.091	**0.164**	-0.009	-0.032
Total Alkaloid content	0.054	-0.024	-0.013	0.005	0.100	0.027	-0.020	-0.008	-0.006	-0.037	**0.042**	0.120

* Significant at 5% level and **significant at 1% level **(Residual effect: -0.3470)**