

**GENETIC ASSOCIATION AMONG ROOT MORPHOLOGY, ROOT  
QUALITY AND ROOT YIELD IN ASHWAGANDHA (*WITHANIA  
SOMNIFERA*)**

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Ashwagandha (*Withania somnifera*) is a dryland medicinal crop  
and roots are used as valuable drug in traditional systems of medicine.  
Morphological variants (morphotypes) and the parental populations were  
evaluated for root – morphometric, quality and yield traits to study genetic  
association among them. Root morphometric traits (root length, root

diameter, number of secondary roots/ plant) and crude fiber content exhibited strong association among them and showed significant positive genotypic correlation with yield. Starch-fiber ratio (SFR), determinant of brittle root texture showed strong negative association with root yield. The total alkaloid content had positive genotypic correlation with root yield. So genetic upgradation should aim at optimum balance between two divergent groups of traits *i.e.* root yield traits (root morphometric traits and crude fiber content) and root textural quality traits (starch content and SFR) to develop superior genotypes with better yield and quality.

*Key words:* ashwagandha, alkaloid content, genetic correlation, path-coefficient, root texture, root yield

## INTRODUCTION

The dried roots of ashwagandha (*Withania somnifera*) a dryland medicinal plant have been employed as valuable drug in Indian traditional systems of medicine: Ayurveda, Siddha and Unani. The roots of the plant are categorized as rasayanas, and have been used as antioxidant, adaptogen, aphrodisiac, liver tonic, anti-inflammatory agent, astringent and more recently to treat ulcers, bacterial infections, venom toxins and senile dementia.

The root quality of ashwagandha encompasses chemical quality and physical (textural) quality (RAMESH KUMAR *et. al.* 2011b). The medicinal properties of ashwagandha roots are attributed to the chemical quality *i.e.* presence of total alkaloids (SINGH and SUSHIL KUMAR 1998) in them. On the other hand, the market value of the root is based on physical quality (root texture) and root morphology. Brittle, robust and lengthy roots have high market value (MISRA *et. al.* 1998). Starchy brittle roots are highly priced because of their ease in making powder and are quoted to be characteristic root textural features of commercial ashwagandha (ATAL and SCHWARTING 1962).

To breed high yielding ashwagandha cultivars with better root morphology and root quality, knowledge on genetic relationship among these traits is essential. Studies on genetic relationship among these characters are limited and not complete. KANDALKAR *et. al.* (1993) and MISRA *et. al.* (1998) performed genetic correlation and path-coefficient studies on yield components and root yield. However, these studies were devoid of root quality parameters. POL *et. al.* (2003) worked out simple correlations of morphometric traits and root quality traits with root yield, but not genetic correlation and path-coefficient estimates. So the present study was conducted to get an understanding on genetic architecture of root – morphology, quality and yield in ashwagandha, which will facilitate genetic upgradation to develop superior cultivars benefitting both cultivators and consumers.

## MATERIAL AND METHODS

### *Experimental material and design of experiment*

Twenty one morphological variants (morphotypes) and the parental populations: Poshita (variety of CIMAP) and Nagore (cultivated accession) were

evaluated for agro-chemical traits in a RBD trial with three replications at the research farm of the CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP) – Research Centre, Hyderabad, India during 2009 - 2010. The details about the experimental materials are given in RAMESH KUMAR *et al.* (2011b).

Each treatment was accommodated in 1.5m x 1.5m plot. Seeds were sown in nursery during last week of June, 2009. The seedlings were transplanted in lines 30 cm apart with a distance of 15 cm between plant to plant during second week of August, 2009. Normal cultural practices were followed throughout the crop season.

#### *Observation on root morphometric traits*

Data on root morphological traits [root length (cm), root diameter (cm) and number of secondary roots/ plant] and dry root yield/ plant (g) were recorded on ten randomly selected plants in each experimental material in each replication.

#### *Observations on root quality parameters*

The root quality parameters in ashwagandha include total alkaloid content (%), starch content (%), fiber content (%) and starch-fiber ratio (SFR). For quantification of root quality parameters the root materials of each morphotype were bulked replication wise and dried under shade. The dried root material was grinded in pulverizer, sieved and fine root powder was used for analysis.

Total alkaloid content, starch content and crude fiber content were determined as per methodologies suggested by MISRA (1998), HODGE and HOFRIETER (1962) and MAYNARD (1970) respectively. SFR was arrived by dividing starch content with fiber content.

#### *Statistical Analysis*

Correlation and path coefficient were estimated according to MILLER *et al.* (1958) and DEWEY and LU (1959). The statistical analysis was performed utilizing statistical software Windostat.

## RESULTS AND DISCUSSION

The analysis of variance showed significant differences among the morphotypes for all the traits studied, indicating that further genetic study might be carried out. Genotypic correlation coefficients among root yield, root morphometric traits, root textural traits and alkaloid content were worked out and presented in Table 1.

Dry root yield showed positive genotypic correlation with the root morphometric traits, alkaloid, starch and fiber contents. In corroboration, MISRA *et al.* (1998) and KANDALKAR *et al.* (1993) found positive genetic correlation of root yield with all the morphometric traits. POL *et al.* (2003) studied simple correlation and reported that morphometric traits, alkaloid content and starch content were positively correlated with root yield. SFR (-0.761) that determines root textural quality showed significant negative correlation with root yield, indicating that root yield and root textural quality are negatively associated, which is supported by findings of RAMESH KUMAR *et al.* (2011b). Also SFR exhibited negative genotypic correlations with all the traits examined except starch content (0.311).

Table 1. Genetic correlation coefficients for root – morphometric, quality and yield traits in *ashwagandha*

Traits	Root length (cm)	Root diameter (cm)	No. of secondary roots/ plant	Starch content (%)	Crude fiber content (%)	SFR	Total alkaloid content (%)
Root length (cm)	1.000						
Root diameter (cm)	0.852**	1.000					
No. of secondary roots/ plant	0.640**	0.777**	1.000				
Starch content (%)	0.192	0.197	0.149	1.000			
Crude fiber content (%)	0.550**	0.837**	0.603**	0.304	1.000		
SFR	-0.540*	-0.767**	-0.504**	0.311	-0.765**	1.000	
Total alkaloid content (%)	0.198	0.300	0.095	-0.141	0.316	-0.362	1.000
Dry root yield/ plant (g)	0.883**	0.948**	0.770**	0.123	0.764**	-0.761**	0.177

\* Significant at 5% probability level, \*\* Significant at 1% probability level

Observations on genetic relationship between root yield and root physical quality components (starch and fiber contents) revealed that root yield possessed relatively stronger genetic correlation with crude fiber content (0.764) than starch content (0.123) with the former being significant. This indicates that crude fiber content is relatively important component for root yield in comparison to starch content adding bulkiness to the root. This is also evident from our understanding (RAMESH KUMAR *et. al.* 2011a) on starch and fiber accumulation pattern during different growth durations. Dry root yield and crude fiber content showed similar accumulation pattern increasing with crop duration, whereas starch accumulation followed a trend of decrease–increase–decrease due to influence of different crop growth stages.

SFR derived by dividing starch with fiber content, obviously showed negative correlation with fiber content (-0.765), and positive correlation with starch content (0.311). Brittle roots with high starch are considered to be of superior quality. High starch content results in high SFR values and thus better root texture. The alkaloid content was negatively correlated with SFR (-0.362) indicating that root texture and chemical quality are negatively associated with each other. The negative association of alkaloid with SFR was due to negative genetic correlation of the former with starch content (-0.141), whereas fiber content was found to show positive correlation (0.316). Similarly, PATEL *et. al.* (2003) found inverse relationship between starch and alkaloid contents.

Fiber content showed positive genotypic correlation, whereas SFR was negatively correlated with all the root morphological traits, and the correlation was significant in all the cases. Starch and alkaloid contents showed positive correlation with all root morphological traits.

The genotypic correlations were partitioned in to direct and indirect effects by path-coefficient analysis to know the relative importance of root morphology and root quality towards root yield. The data on path-coefficient estimates are presented in Table 2.

Table 2. Path-coefficient analysis in ashwagandha

Traits	Root length (cm)	Root diameter (cm)	No. of secondary roots/ plant	Starch content (%)	Crude fiber content (%)	SFR	Total alkaloid content (%)
Root length (cm)	0.401	0.343	0.258	0.077	0.221	-0.217	0.080
Root diameter (cm)	0.221	0.259	0.201	0.051	0.217	-0.199	0.078
No. of secondary roots/ plant	0.094	0.113	0.146	0.022	0.088	-0.074	0.014
Starch content (%)	0.009	0.010	0.007	0.049	0.015	0.015	-0.007
Crude fiber content (%)	0.010	0.015	0.011	0.005	0.017	-0.013	0.006
SFR	0.168	0.239	0.157	-0.097	0.239	-0.312	0.113
Total alkaloid content (%)	-0.021	-0.032	-0.010	0.015	-0.034	0.039	-0.106
rg	0.883**	0.948**	0.770**	0.123	0.764**	-0.761**	0.177

rg = Genotypic Correlation, \*\* Significant at 1% probability level.

Root morphological traits – root length (0.401), root diameter (0.259) and number of secondary roots/ plant (0.146) having significant positive genotypic correlation showed high positive direct path towards root yield. Indirect contribution of root length (0.221) and root diameter (0.217) towards yield was high through crude fiber. This signifies crude fiber to be an important component of root yield and root morphology as well.

Both the root textural components (starch content – 0.049 and fiber content -0.017) with positive genotypic correlation showed positive direct path towards yield with indirect contribution through root morphological traits. Total alkaloid content (-0.106) showed positive genotypic correlation but had a negative direct path towards root yield. This is because root morphological traits, fiber content and starch content are integral physical components of the root structure thus contributing to root yield, whereas total alkaloids being a chemical content could not contribute to root yield. However, since alkaloid content is positively correlated it can be high in genotypes with high root yield

The present experiment revealed that root morphological traits and crude fiber content were found to be closely associated among each other and were strongly correlated with root yield. On contrary, root textural quality (SFR) showed strong negative correlation with root yield. This is also evident from the findings of ARUN KUMAR *et. al.* (2007) that morphometric and root yield attributes showed higher values in wild accessions (poor root texture) as compared to cultivated ones (good root texture). Total alkaloid content exhibited positive correlation and was not found to be a yield contributing trait. So genetic upgradation should aim upon optimum balance between the two divergent group of traits *i.e.* root yield traits (root morphometric traits and crude fiber) and root textural quality traits (starch content and SFR) to derive superior genotypes with better yield and quality.

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## GENETIČKA ASOCIJACIJA MORFOLOGIJE KORENA, KVALITETA PRINOSA KORENA U *WITHANIA SOMNIFERA*

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### I z v o d

*Withania somnifera* je medicinska biljka suvih zemljišta čiji koren se koristi kao vredna droga u tradicionalnom sistemu medicine. Morfološkim varijantama (morphotipovi) i roditeljskim populacijama je vršeno ocenjivanje korena – morfometrija, kvalitet i prinos u cilju ispitivanja genetičke asocijacije između tih osobina. Za morfometrijske osobine korena (dužina korena, prečnik korena, broj sekundarnih korenova po biljci) i sadržaj sirovog vlakna je utvrđena jaka asocijacija i utvrđena je značajna pozitivna genotipska korelacija sa prinosom. Odnos skroba i sirovog vlakna (SFR), determinant lomljivosti korena su pokazali jaku negativnu asocijaciju sa prinosom mase korena. Sadržaj ukupnih alkaloida ima pozitivnu genotipsku korelaciju sa prinosom mase korena. Genetičko poboljšanje treba da ide u pravcu optimalnog balansa između dve divergentne grupe osobina kao što su osobine priosa korena ( morfometrijske osobine i sadržaj sirovog vlakna) i osobine kvaliteta teksture korena (kvalitet skroba i SFR) da bi se razvili superiorni genotipovi većeg prinosa poboljšanog kvaliteta.

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