Research in Plant Biology, 3(2): 32-36, 2013 ISSN : 2231-5101
www.resplantbiol.com

Regular Article

# Genetic variability, character association and path analysis in ashwagandha [*Withania somnifera* (L.) Dunal] under rainfed conditions

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**Twenty six diverse genotypes of ashwagandha [*Withania somnifera* (L.) Dunal] were evaluated for fourteen quantitative traits under rainfed conditions. Both phenotypic and genotypic coefficients of variation were higher for important traits like number of berries/plant, fresh weight of berries/plant, biomass yield at maturity and ratio of fresh above ground biomass: fresh root biomass. High heritability in conjunction with high genetic advance were observed for number of berries/plant, fresh weight of berries/plant, seed yield/plant, fresh root yield/plant, biomass yield at maturity and ratio of fresh above ground biomass : fresh root biomass which indicated predominant role of additive gene action for the expression of these characters. Fresh root yield/ plant was found to be positively and significantly correlated with number of berries/plant, fresh weight of berries/plant, seed yield/plant and root diameter. Path analysis revealed that total alkaloid content showed the highest positive direct effect on fresh root yield/plant followed by biomass yield at maturity, seed yield/plant, root diameter and number of berries/plant which suggested that selection for these traits would be quite effective to improve fresh root yield in ashwagandha.**

**Key words**: Ashwagandha, genetic variability, heritability, genetic advance, correlation, path analysis

Ashwagandha [*Withania somnifera* (L.) Dunal] is one of the most valuable medicinal plants used in Indian and Unani systems of medicine since ancient times. This species is under domestication for a long period in the central India. It is of interest to record that the cultivated plants have sizable differences from the wild plants not only in their morphological characters including low branching but also in their therapeutically action. 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. A large proportion, however, comprises still wild or semi wild plants, or primitive cultivars which have not acquired genes for high productivity under cultivation. There is great potential to improve the yield and quality of these plants. In India the plant grows wild in north western regions such as Gujarat, Rajasthan, Madhya Pradesh, Uttar Pradesh and Punjab plains extending to mountainous region of Punjab, H.P. and Jammu ascending to an altitude of 1500 m. It thrives well under low irrigation or rainfed conditions. Its roots and occasionally its leaf and seed are used in Ayurvedic and Unani medicines. The pharmacological activity of the roots is attributed to the presence of several alkaloids and withaniols. The roots are prescribed in medicines for hiccup, several

Received: 11.2.2013; Revised: 4.4.2013; Accepted: 5.4.2013

female disorders, bronchitis, rheumatism, dropsy, stomach, lung inflammation and spin diseases. Very little work has been done with respect to genetic improvement of this crop in spite of the long history of its domestication.

For the effective and purposeful exploitation of the genetic variability, it is necessary to recognize and measure it and assessment of parameters like phenotypic and genotypic coefficients of variation, heritability in broad sense and genetic advance as % of mean is a pre-requisite for making effective selection programmes. Further, yield is a complex trait, polygenic in inheritance and more prone to environmental fluctuations. Understanding the association between yield and its components is of paramount importance for making the best use of these relationships in selection. The path coefficient analysis helps the breeders to explain direct and indirect effects and hence, has extensively been used in breeding experiments in different crop species by various researchers. Therefore, the present investigation was carried out to assess the genetic variability, character association and path coefficient analysis in ashwagandha.

**Materials and methods**

Twenty six diverse genotypes of ashwagandha were grown under rainfed conditions at Dryland Research Area, CCS Haryana Agricultural University, Hisar in randomized block design with three replications at row to row and plant to plant distance of 22.5 and 5.0 cm, respectively. Recommended package of practices to raise a good crop was followed however, no irrigation was applied after raising the crop till harvesting. The observations were recorded on five competitive plants for fourteen characters, *viz* days to 50% flowering, days to maturity, plant height (cm), number of berries/plant, number of seeds/berry, fresh weight of berries/ plant (g), seed yield/plant (g), root length (cm), shoot : root length ratio, root diameter (mm), fresh root yield/plant (g), biomass yield at maturity (g), ratio of fresh above ground biomass : fresh root biomass and total alkaloid content (%). The total alkaloid content in roots was determined as per Mishra (1996). The phenotypic and genotypic coefficients of variation (GCV and PCV), heritability in broad sense, genetic advance as % of mean, correlation coefficients at genotypic and phenotypic level and path coefficient analysis were carried out by standard methods as suggested by different workers.

**Results and discussion**

Wide range of variation was observed for most of the traits like plant height, number of berries/plant, fresh weight of berries/plant, seed yield /plant, root length, shoot : root length ratio, root diameter, biomass yield at maturity and ratio of fresh above ground biomass : fresh root biomass (Table 1). Estimates of both PCV and GCV were observed higher for different characters like number of berries / plant, fresh weight of berries/plant, biomass yield at maturity and ratio of fresh above ground biomass : fresh root biomass. Similar results have also been reported earlier by Misra *et al.* (1998 a), Misra *et al.* (1998 b), Kandalkar *et al.* (1993) and Laxminarayan and Mukund (2003) in ashwagandha.

The coefficient of variation doesn't offer the full scope of heritable variation. It can be found out with greater degree of accuracy when heritability in conjunction with genetic advance is studied. Hence, heritability and genetic advance are important parameters to study the scope of improvement in various characters through selection. High heritability estimates along with high genetic advance are more helpful in predicting the gain under selection than heritability estimates alone. In the present study, high heritability coupled with high genetic advance was observed for number of berries/plant, fresh weight of berries /plant, seed yield/plant, fresh root yield/plant, biomass yield at maturity and ratio of fresh above ground biomass: fresh root biomass. This indicated that in these

traits improvement could be made through simple selection. Panse (1957) expressed that high heritability together with high genetic advance was indicative of additive gene effects and high heritability associated with low genetic advance was an indication of dominance and epistatic effects. Similar findings have also been reported by Laxminarayan and Mukund (2003) and Misra *et al.* (1998 a).

**Table 1: Estimates of genotypic (GCV) and phenotypic (PCV) co-efficients of variation, heritability (bs) and genetic advance (% of mean) for fresh root yield and component traits in ashwagandha**

| Characters | Mean | Range | | GCV | PCV | Heritability (%) | Genetic advance (% of mean) |
|---|---|---|---|---|---|---|---|
| | | Minimum | Maximum | | | | |
| Plant height (cm) | 34.08 | 21.70 | 49.00 | 4.18 | 16.96 | 86.23 | 30.15 |
| Days to 50% flowering | 110.39 | 103.00 | 120.00 | 1.45 | 3.87 | 93.66 | 7.47 |
| Days to maturity | 231.29 | 223.00 | 239.00 | 1.18 | 1.73 | 59.40 | 1.97 |
| No. of berries/plant | 239.45 | 96.00 | 612.00 | 13.94 | 45.14 | 99.62 | 92.58 |
| No. of seeds/berry | 30.85 | 21.00 | 38.00 | 6.43 | 13.02 | 94.97 | 25.37 |
| Fresh weight of berries/ plant (g) | 16.23 | 6.40 | 41.00 | 11.91 | 44.64 | 99.44 | 91.46 |
| Seed yield/plant (g) | 30.97 | 5.74 | 32.00 | 9.63 | 38.84 | 99.76 | 79.79 |
| Root length (cm) | 16.34 | 10.93 | 22.71 | 3.45 | 16.70 | 99.42 | 34.21 |
| Shoot : root length ratio | 2.15 | 1.19 | 3.17 | 5.40 | 22.18 | 99.38 | 45.40 |
| Root diameter (cm) | 8.65 | 5.38 | 12.62 | 4.85 | 18.77 | 99.84 | 38.61 |
| Fresh root yield/plant (g) | 4.64 | 2.09 | 10.34 | 9.53 | 40.16 | 99.68 | 82.46 |
| Biomass yield at maturity (g) | 51.62 | 25.00 | 106.00 | 25.22 | 39.35 | 91.93 | 74.28 |
| Ratio of fresh above ground biomass : root biomass | 10.30 | 4.93 | 16.11 | 20.17 | 43.92 | 99.25 | 79.78 |
| Total alkaloid content (%) | 0.89 | 0.88 | 0.95 | 0.56 | 1.67 | 99.53 | 3.43 |

**Table 2: Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among fresh root yield and its component traits in ashwagandha**

| Character | PH (cm) | DF | DM | NB/P | NS/B | FWB/P (g) | SY/P (g) | RL (cm) | S/R | RD (mm) | FRY/P (g) | BYM (g) | RFGB/ RB | TA (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PH (cm) | | 0.089 | 0.183 | 0.071 | -0.164 | 0.078 | 0.075 | -0.010 | 0.627** | -0.095 | 0.074 | -0.027 | -0.208 | -0.004 |
| DF | 0.068 | | 0.419* | 0.199 | 0.015 | 0.198 | 0.193 | -0.168 | 0.308 | -0.255 | -0.237 | 0.271 | 0.554** | 0.556** |
| DM | 0.282 | 0.557 | | 0.314 | 0.288 | 0.315 | 0.302 | 0.064 | 0.068 | 0.219 | 0.281 | 0.446* | 0.223 | 0.117 |
| NB/P | 0.075 | 0.202 | 0.406 | | -0.024 | 0.997* | 0.988** | 0.552** | -0.266 | 0.598** | 0.572** | 0.573** | 0.431* | 0.118 |
| NS/B | -0.188 | 0.008 | 0.372 | -0.025 | | -0.020 | -0.018 | -0.034 | -0.177 | -0.030 | 0.054 | 0.219 | -0.027 | -0.389 |
| FWB/P (g) | 0.090 | 0.205 | 0.410 | 1.000 | -0.023 | | 0.988** | 0.545** | -0.249 | 0.588** | 0.580** | 0.575** | 0.420* | 0.114 |
| SY/P (g) | 0.078 | 0.198 | 0.388 | 0.991 | -0.017 | 0.992 | | 0.580** | -0.263 | 0.563** | 0.561** | 0.537** | 0.424* | 0.121 |
| RL (cm) | -0.014 | -0.174 | 0.087 | 0.555 | -0.031 | 0.548 | 0.582 | | -0.592** | 0.426* | 0.199 | 0.355 | 0.056 | -0.285 |
| S/R | 0.681 | 0.317 | 0.081 | -0.267 | -0.185 | -0.251 | -0.264 | -0.596 | | -0.467* | -0.177 | -0.143 | -0.127 | 0.228 |
| RD (mm) | -0.107 | -0.265 | 0.288 | 0.599 | -0.031 | 0.590 | 0.568 | 0.427 | -0.468 | | 0.794** | 0.450* | -0.054 | 0.022 |
| FRY/P (g) | 0.083 | -0.246 | 0.365 | 0.574 | 0.056 | 0.583 | 0.563 | 0.199 | -0.178 | 0.796 | | 0.353 | -0.143 | 0.075 |
| BYM (g) | -0.022 | 0.279 | 0.635 | 0.595 | 0.256 | 0.603 | 0.563 | 0.368 | -0.148 | 0.470 | 0.367 | | 0.242 | -0.163 |
| RFGB/ RB | -0.229 | 0.570 | 0.280 | 0.435 | -0.028 | 0.424 | 0.426 | 0.057 | -0.128 | -0.054 | -0.143 | 0.255 | | 0.362 |
| TA (%) | -0.010 | 0.574 | 0.155 | 0.119 | -0.398 | 0.115 | 0.121 | -0.286 | 0.229 | 0.023 | 0.075 | -0.167 | 0.364 | |

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

**PH =** Plant Height, **DF =** Days to 50% flowering, **DM =** Days to maturity, **NB/P =** No. of berries/plant, **NS/B =** No. of seeds/berry, **FWB/P =** Fresh weight of berries/plant, **SY/P =** Seed yield/plant, **RL =** Root length, **S/R =** Shoot : root length ratio, **RD =** Root diameter, **FRY/P =** Fresh root yield/plant, **BYM =** Biomass yield at maturity, **RFGB/RB =** Ratio of fresh above ground biomass : root biomass, **TA =** Total alkaloid content

**Table 3: Direct and indirect effects of different characters on fresh root yield in ashwagandha**

| Character | PH (cm) | DF | DM | NB/P | NS/B | FWB/P (g) | SY/P (g) | RL (cm) | S/R | RD (mm) | BYM (g) | RFGB/ RB | TA (%) | Genotypic Correlation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PH (cm) | -1.219 | -0.394 | -0.374 | 1.544 | -0.145 | 2. 762 | 3.045 | -2.421 | -0.378 | -2.066 | 1.008 | 0.211 | -1.060 | 0.083 |
| DF | 0.222 | 0.688 | 0.045 | 0.049 | 0.168 | 0.007 | 0.015 | 0.085 | 0.022 | -1.993 | 0.093 | 0.092 | 0.216 | -0.246 |
| DM | -0.889 | -0.852 | -0.865 | -0.967 | -0.517 | -0.269 | -0.440 | -0.361 | 2.192 | 1.255 | -0.341 | 1.355 | 1.065 | 0.365 |
| NB/P | -3.825 | 0.263 | 0.259 | 0.833 | 0.979 | 1.848 | 1.830 | -0.022 | 0.954 | 0.176 | 0.420 | 0.075 | -3.170 | 0.574 |
| NS/B | 0.057 | 0.378 | 1.361 | 1.526 | 1.549 | 2.894 | 3.242 | -3.944 | -3.260 | -1.977 | 1.121 | -1.997 | -0.885 | 0.056 |
| FWB/P (g) | 12.633 | -0.159 | -0.417 | -0.623 | -0.418 | -5.578 | -0.482 | -0.898 | -3.182 | -0.943 | -7.303 | -0.183 | 8.752 | 0.583 |
| SY/P (g) | 1.622 | 0.461 | 0.576 | 0.848 | 0.874 | 0.819 | 1.851 | -0.200 | 0.129 | 0.641 | 2.760 | 0.373 | -4.003 | 0.563 |
| RL (cm) | -0.663 | -0.135 | -0.168 | 0.616 | 3.401 | -0.215 | 0.141 | -1.336 | 0.297 | 2.711 | -0.235 | -0.077 | -4.114 | 0.199 |
| S/R | -0.063 | -0.096 | 0.813 | -0.330 | 0.432 | -0.374 | -0.347 | 0.045 | -0.205 | 0.607 | -0.073 | -0.132 | -0.461 | -0.178 |
| RD (mm) | 1.588 | -0.353 | -0.411 | 0.590 | -0.196 | 0.158 | 0.074 | -0.902 | -2.737 | 0.937 | -0.284 | 0.916 | 1.390 | 0.796 |
| BYM (g) | -1.897 | 0.978 | 0.875 | 0.029 | 0.681 | 0.417 | 0.421 | 0.405 | 0.826 | -3.342 | 2.295 | -0.985 | -0.406 | 0.367 |
| RFGB/ RB | 0.255 | -0.413 | 0.698 | -0.060 | 1.522 | -0.048 | -0.298 | -0.085 | -0.250 | -0.443 | 0.654 | -1.476 | -0.258 | -0.143 |
| TA (%) | 0.503 | 0.998 | -0.066 | -4.979 | -1.644 | -5.550 | -6.226 | 2.864 | 5.068 | 4.270 | -0.509 | 2.453 | 2.879 | 0.075 |

Residual effect = 0.27150

**PH =** Plant Height**, DF =** Days to 50% flowering**, DM =** Days to maturity**, NB/P =** No. of berries/plant**, NS/B =** No. of seeds/berry**, FWB/P =** Fresh weight of berries/plant**, SY/P =** Seed yield/plant**, RL =** Root length**, S/R =** Shoot : root length ratio**, RD =** Root diameter**, FRY/P =** Fresh root yield/plant**, BYM =** Biomass yield at maturity**, RFGB/RB =** Ratio of fresh above ground biomass : root biomass**, TA =** Total alkaloid content

In the present study, the genotypic correlation coefficients were higher in magnitude than their corresponding phenotypic correlation coefficients for most of the characters indicating the depression of phenotypic expression by the environmental influence. Fresh root yield/ plant was found to be positively and significantly correlated with number of berries/plant, fresh weight of berries/plant, seed yield/plant and root diameter (Table 2). Such positive association of fresh root yield/ plant with all these characters in ashwagandha has also been observed by Misra *et al.* (1998 a), Kandalkar *et al.* (1993) and Kumar *et al.* (2011). However, Kubsad *et al.* (2009) indicated that harvest index had exhibited the highly significant and positive correlation with dry root yield/plant followed by plant height and dry matter/ plant in ashwagandha. Total alkaloid content was positively and significantly associated with days to 50% flowering whereas, shoot : root length ratio had negative significant relationship with root length which implies that delay in flowering is responsible for direct increase in total alkaloid content which is a desirable trait and enhanced shoot : root length leads to smaller roots which is undesirable trait in ashwagandha.

The estimates of correlation coefficients mostly indicate inter-relationship of different characters but it does not furnish information on cause and effect. Under such situation path analysis helps the breeder to identify the index of selection. The residual effect (0.271) indicates that the choice of characters for path analysis was appropriate. Total alkaloid content showed the highest positive direct effect on fresh root yield/plant followed by biomass yield at maturity, seed yield/plant, root diameter and number of berries/plant (Table 3). These traits also showed positive correlation with fresh root yield/plant. Thus, these traits turned out to be the major components of fresh root yield and direct selection for these traits may be rewarding for further improvement in fresh root yield. These results are in agreement with the findings of Misra *et al.* (1998 a), Kubsad *et al.* (2009) and Kumar *et al.* (2011). The trait fresh weight of berries/plant had the highest negative direct effect on fresh root

yield/plant followed by ratio of fresh above ground biomass: fresh root biomass, root length and plant height. Similarly, indirect effects of other traits *via* these traits generally showed negative effects. Thus, the material studied is of diverse nature and information emanated would help in designing the selection methodology which can further be used in the breeding programme for improvement of fresh root yield in ashwagandha.

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