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Rashmi Bakhla
Department of Forest Products & Utilization, Faculty of Forestry, Birsa Agricultural University, Ranchi, Jharkhand-India

Jai Kumar
Department of Forest Products & Utilization, Faculty of Forestry, Birsa Agricultural University, Ranchi, Jharkhand-India

Correspondence
Rashmi Bakhla
Department of Forest Products & Utilization, Faculty of Forestry, Birsa Agricultural University, Ranchi, Jharkhand-India

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Study on trait association pattern with regards to yield improvement in *Rauvolfia serpentina* (Sarpgandha)

Rashmi Bakhla and Jai Kumar

Abstract
Keeping in view the importance of selection of traits for higher yield, a systematic research trial was undertaken to study trait association pattern with regards to yield to facilitate selection of traits in different Sarpgandha germplasm through its qualitative and quantitative traits at AICRP (M&APs) farm, BAU, Ranchi. Research was laid out in RBD with 25 treatments replicated thrice. Experimental material consisted of 25 germplasm of Sarpgandha (BRS_1 to BRS_{25}) collected from different districts of Jharkhand. Different qualitative and quantitative parameters were measured as per NBPGR guidelines. The replicated data of all the 25 germplasm for quantitative traits was subjected to correlation matrix and path value analysis. Correlation matrix showed that plant height had highly significantly positive correlation with dry root yield/plant (0.594) and significantly positive correlation between root length and dry root yield/plant (0.414). Path analysis of different growth parameter affecting seed yield/plant indicated maximum direct positive impact by number of flowers/ inflorescence (0.658) and maximum direct negative impact by number of fruits/inflorescence (-0.486). In case of dry root yield/plant, maximum direct positive effect was shown by plant height (0.590) and maximum direct negative effect was by root diameter (-0.472). So plant height & root length may be selected as suitable traits for improving dry root yield/plant in Sarpgandha.

Keywords: Sarpgandha, *Rauvolfia serpentina*, correlation, path value analysis

Introduction
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. The estimates of correlation coefficients mostly indicate interrelationship 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 [13]. Through screening and optimization of M&APs germplasm based upon morpho-physiological characterization and evaluation, productivity can be increased and socio-economic conditions of the stake holders and farmers can be improved.

Keeping in view the importance of trait association studies to screen out superior traits which have profound impact on root yield of Sarpgandha, a systematic research trial was undertaken through its qualitative and quantitative traits at AICRP (M&APs) farm, Birsa Agricultural University, Ranchi to study on trait association pattern with regards to yield to facilitate selection of traits. *Rauvolfia serpentina* Benth ex. Kurtz., an endangered medicinal plant, of family Apocynaceae is a woody evergreen perennial shrub, grows up to 60 cm of height. It is native to India and several species of *Rauvolfia* found in different edapho-climatic conditions in humid tropics of Nepal, Sri Lanka, Burma, Cambodia etc [3]. It is also commonly known as Sarpgandha, Snake root plant etc [6]. It is an erect, evergreen perennial shrub with a long, irregular, nodular, yellowish root stock, growing to a height of 60-90 cm [2]. Sarpgandha prefers soil with plenty of humus and rich in nitrogenous and organic matter with good drainage [14]. *Rauvolfia serpentina* is threatened with extinction in India due to indiscriminate collection and over exploitation of natural resources for commercial purposes to meet the requirement of the pharmaceutical industry, coupled with limited cultivation [7] [15]. To reduce the pressure on natural resources, a profitable cultivation technique to obtain higher root yield and total alkaloid content is essential as well as the rate of plant propagation is important for commercial cultivation to meet the pharmaceutical demand for reserpine.

Material and Methods

The experimental site was at AICRP Research Farm, Birsa Agricultural University, Kanke, Ranchi, located in the plateau region of Jharkhand. Geographically, it is located at $23^0$26'30" N latitude and $85^0$18'20" E longitude in Chhotanagpur plateau, situated in north eastern part of India and at an altitude of between 646 m above the mean sea level. The soil of the site is lateritic, developed from granite-gneiss, sandy loam in texture, sedentary in nature and well drained with low water holding capacity and poor consistency. The general climate of the region is classified as ‘sub humid megathermal’ with mean daily temperature of about 24.2^0C. The mean relative humidity is about 70.88 % with its range from 57.0 to 92.0% in the area. The average annual rainfall of this area is approximately 1400mm which is mostly erratic, punctuated with occasional dry spells.

The experimental materials comprised of twenty five genotypes of Sarpgandha, for which seeds/cuttings were collected from forest area of Jharkhand and Bihar. Collected seed samples were germinated, raised in polytubes and maintained under identical growing conditions in experimental area and used for analyzing qualitative and quantitative variations. Forty five days old seedlings were transplanted in field at a spacing of 50 cm × 50 cm. Normal cultural practices such as weeding, hoeing and irrigation were given in the field. Experiment was laid out in Randomized Block Design with 25 treatments replicated thrice by following the procedure outlined by [10]. Forty-five days old seedlings at 8-10 leaf stage were transplanted and grown in the experimental field. Ten plants were selected randomly from all the treatments for collection of data on different qualitative and quantitative aspects as per NBPGR format [16] at different growth stages. Studied parameters were plant height, stem diameter, number of primary branches per plant, number of leaves/plant, inflorescence length, number of inflorescences/plant, number of flowers per inflorescence, number of fruits/inflorescence, root length, root diameter, dry root yield/plant and seed yield/plant, subjected to correlation and path value analysis.

Correlation is a measure of association between two variables. The correlation coefficient between characters was calculated by using the formula suggested by [8]. The significance of the correlation coefficient was determined from the t-statistic. As yield is one of the most important characters among all other economic characters, correlation of yield with other attributes would facilitate effective selection schemes to improve the yield. Path coefficient analysis is a standardized partial regression coefficient and measures the direct influence of one variable upon another and permits the separation of correlation coefficient into components of direct and indirect effects. The path analysis helps to resolve the correlation further and throws more light on the way in which component traits contribute towards specifically identifying important component traits. The technique of analysis of path coefficient was reported by [18].

Results and Discussion

Correlation matrix of different growth parameters of Sarpgandha with seed yield/plant - Table 1 represents correlation matrix between different growth parameters of Sarpgandha germplasm with its seed yield/plant. Non-significant correlation was observed between seed yield/plant, however it was positively correlated with number of primary branches/plant (0.122), number of leaves/plant (0.325), number of flowers/inflorescence (0.113) and number of fruits/inflorescence (0.100) and negatively correlated with plant height (-0.071), stem diameter (-0.011), inflorescence length (-0.198) and number of inflorescences/plant (-0.222). The plant height of Sarpgandha germplasm had significant positive relation with number of leaves/plant (0.439) and number of inflorescences/plant (0.409). Stem diameter of Sarpgandha germplasm has non-significant correlation with all the growth parameters. Significant positive correlation was observed between number of primary branches per plant with number of inflorescences/plant (0.461). Number of leaves/plant and inflorescence length had non-significant relation with all the growth parameters. Similarly number of inflorescences/plant had non-significant relation with all the growth parameters. Number of flowers/inflorescence had highly positive significant correlation with number of fruits/inflorescence (0.985).

Table 1: Correlation matrix of different growth parameters of Sarpgandha with seed yield/plant

	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9
V_1	1.000								
V_2	0.308^{NS}	1.000							
V_3	0.265^{NS}	-0.005^{NS}	1.000						
V_4	0.439^{*}	0.395^{NS}	0.358^{NS}	1.000					
V_5	0.092^{NS}	0.095^{NS}	0.120^{NS}	-0.028^{NS}	1.000				
V_6	0.409^{*}	-0.007^{NS}	0.461^{*}	0.131^{NS}	0.236^{NS}	1.000			
V_7	0.035^{NS}	0.199^{NS}	-0.068^{NS}	0.022^{NS}	0.114^{NS}	0.053^{NS}	1.000		
V_8	-0.027^{NS}	0.206^{NS}	-0.083^{NS}	-0.015^{NS}	0.089^{NS}	0.019^{NS}	0.985^{**}	1.000	
V_9	-0.071^{NS}	-0.011^{NS}	0.122^{NS}	0.325^{NS}	-0.198^{NS}	-0.222^{NS}	0.113^{NS}	0.100^{NS}	1.000

Where V_9 (Dependent Variable) – Seed yield/plant

Independent variables V_1 - Plant height, V_2 – Stem diameter, V_3 – Number of primary branches/plant, V_4 – Number of leaves/plant, V_5 – Inflorescence length, V_6 – Number of inflorescence/plant, V_7 – Number of flower/inflorescence, V_8 – Number of fruits/inflorescence

Positive correlation of leaf dry weight with leaf area of plant which in turn depends on leaf life and rate of leaf production [12]. Plant height, intermodal length, seed number, dry herbage were positively correlated with fresh herbage yield and also had positive direct effect in Kalmegh accession [9]. Significant positive correlation between root yield and other morphological characters such as days to 50% flowering, days to maturity, plant height, number of primary roots, and number of secondary roots, fresh roots weight, dry roots weight and main roots length [11]. However, there was significant negative correlation observed in number of branches, spread (E-W) of plants, spread (N-S) of plants and seed yield per plants in Ashwagandha. Correlation studies revealed that, the characters viz., days to 50% flowering, number of primary branches per plant and root length were positively and significantly correlated with dry root yield.

Correlation matrix of different growth parameters of Sarpgandha with seed yield/plant: Table 2 represents correlation matrix between different yield parameters of Sarpgandha germplasm with its dry root yield/plant. Correlation matrix between different yield parameters of Sarpgandha germplasm showed highly significantly positive correlation with plant height (0.594) and significantly positive correlation with root length (0.414). Dry root yield/plant showed non-significant negative correlation with stem diameter, number of primary branches/plant and root diameter, while it had non-significant positive correlation with number of leaves/plant. Stem diameter had non-significant correlation with all the yield parameters. Number of primary branches/plant showed highly significantly negative correlation with root length (-0.539). Root length showed non-significant correlation with root diameter.

Table 2: Correlation matrix of different yield parameters of Sarpgandha with dry root yield/plant

	V_1	V_2	V_3	V_4	V_5	V_6	V_7
V_1	1.000						
V_2	-0.324^{NS}	1.000					
V_3	-0.252^{NS}	0.022^{NS}	1.000				
V_4	0.157^{NS}	-0.275^{NS}	-0.170^{NS}	1.000			
V_5	0.159^{NS}	-0.180^{NS}	-0.539^{**}	-0.076^{NS}	1.000		
V_6	-0.192^{NS}	-0.123^{NS}	0.356^{NS}	-0.213^{NS}	-0.410^{*}	1.000	
V_7	0.594^{**}	-0.355^{NS}	-0.391^{NS}	0.149^{NS}	0.414^{*}	-0.347^{NS}	1.000

Where V_7 (Dependent Variable) – Dry root yield/plant
Independent variables V_1 - Plant height, V_2 – Stem diameter, V_3 – Number of primary branches/plant, V_4 – Number of leaves/plant, V_5 – Root length, V_6 – Root diameter

Dry herbage yield was positively correlated with fresh herbage yield [9]. Positive and significantly correlation of fresh root yield/ plant with number of berries/plant, fresh weight of berries/plant, seed yield/plant and root diameter [13]. Highly significant correlations between herbage yield and the relevant components like shoot dry weight per plant, leaf dry weight per plant and stem dry weight per plant in different Kalmegh accessions of Malaysia [17]. Negative correlation between stem dry weight per plant and andrographolide percentage per plant was observed by them. Dry root yield was significantly and positively associated with all component traits in Ashwagandha [4].

Path analysis of different growth parameters affecting seed yield/plant of Sarpgandha - Table 3 represents path value analysis of growth characters influencing seed yield/plant in Sarpgandha germplasm. Three characters namely number of primary branches/plant (0.171), number of leaves/plant (0.399) and number of flowers/inflorescence (0.658) had direct positive effect on the seed yield/plant. Five characters namely plant height (-0.157), stem diameter (-0.139), inflorescence length (-0.145), number of inflorescences/plant (-0.281) and number of fruits/inflorescence (-0.486) showed direct negative effect on seed yield/plant. Maximum direct positive effect on seed yield/plant was shown by number of flowers/inflorescence (0.658), while maximum direct negative effect was shown by number of fruits/inflorescence (-0.486).

Table 3: Path analysis of different growth parameters affecting seed yield/plant

Variables	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	Correlation coefficient
V_1	-0.157	-0.043	0.045	0.175	-0.013	-0.115	0.023	0.013	-0.072
V_2	-0.048	-0.139	-0.0008	0.157	-0.0134	0.002	0.131	-0.100	-0.011
V_3	-0.041	0.0006	0.171	0.143	-0.017	-0.130	-0.044	0.040	0.123
V_4	-0.069	-0.055	0.061	0.399	0.004	-0.037	0.014	0.007	0.324
V_5	-0.014	-0.013	0.020	-0.011	-0.145	-0.067	0.075	-0.043	-0.198
V_6	-0.064	0.001	0.079	0.052	-0.034	-0.281	0.035	-0.009	-0.221
V_7	-0.005	-0.028	-0.011	0.009	-0.016	-0.015	0.658	-0.478	0.114
V_8	0.004	-0.029	-0.014	-0.006	-0.013	-0.005	0.649	-0.486	0.100

Where V_1 - Plant height, V_2 – Stem diameter, V_3 – Number of primary branches/plant, V_4 – Number of leaves/plant, V_5 – Inflorescence length, V_6 – Number of inflorescence/plant, V_7 – Number of flower/inflorescence, V_8 – Number of fruits/inflorescence

Plant height contributed maximum indirect positive effect through number of leaves/plant (0.175) and maximum indirect negative effect through number of inflorescence/plant (–0.115). Stem diameter contributed maximum indirect positive effect through number of leaves/plant (0.157) and maximum indirect negative effect through number of fruits/inflorescence (–0.100). Number of primary branches/plant contributed maximum positive indirect effect through number of leaves/plant (0.143) and maximum negative indirect effect through number of inflorescence/plant (–0.130). Number of leaves/plant contributed maximum positive indirect effect through number of primary branches/plant (0.061) and maximum negative indirect effect through plant height (–0.069). Inflorescence length contributed maximum positive indirect effect through number of flowers/inflorescence (0.075) and maximum negative indirect effect through number of inflorescence/plant (–0.067). Number of inflorescences contributed maximum positive indirect effect through number of primary branches/plant (0.079) and maximum negative indirect effect through plant height (–0.064). Number of flowers/inflorescence contributed maximum positive indirect effect through number of leaves/plant (0.009) and maximum negative indirect effect through number of fruits/inflorescence (–0.478). Number of fruits/inflorescence contributed maximum positive indirect effect through number of flowers/inflorescence (0.649) and maximum negative indirect effect through stem diameter (–0.029).

Number of grains per panicle was the major yield attributing trait to be given selection pressure for improving yield [19]. Days to 50% flowering (0.121), plant height (0.268), seed no./pod (0.018), leaf width (0.030), petiole length (0.220), collar girth (0.662) and dry herbage yield (0.518) has direct positive effect on herbage yield per plant therefore these traits should be given due importance while practicing selection with aimed to improve herbage yield of Kalmegh [9]. Traits like pod length (-0.447) and leaf length (-0.109) showed direct negative impact on herbage yield of Kalmegh. Highest positive direct and indirect effect of plant height and stem branches on root yield in Ashwagandha [5]. High direct contribution of fruits per plant, fruit weight and flowers per inflorescence on fruit yield, while fruits per cluster, days to flowering exhibited negative direct effect in tomato [1].

Path analysis of different growth and yield parameters affecting dry root yield/plant of Sarpgandha: Table 4 represents path value analysis of growth and yield characters influencing dry root yield/plant in Sarpgandha germplasm. Four characters plant height (0.590), namely number of primary branches/plant (0.131), number of leaves/plant (0.224) and inflorescence length (0.135) had direct positive effect on the dry root yield/plant. Two characters namely stem diameter (-0.286) and number of inflorescences/plant (-0.472) showed direct negative effect on dry root yield/plant. Maximum direct positive effect on dry root yield/plant was shown by plant height (0.590), while maximum direct negative effect was shown by number of inflorescences/plant (-0.472). Plant height contributed maximum indirect positive effect through inflorescence length (0.017) and maximum indirect negative effect through number of inflorescence/plant (–0.185). Stem diameter contributed maximum indirect positive effect through plant height (0.108) and maximum indirect negative effect through number of leaves/plant (–0.080). Number of primary branches/plant contributed maximum positive indirect effect through stem diameter (0.119) and maximum negative indirect effect through plant height (–0.217).

Table 4: Path analysis of different growth and yield parameters affecting dry root yield/plant

Variables	V_1	V_2	V_3	V_4	V_5	V_6	Correlation coefficient
V_1	0.590	-0.052	-0.048	-0.073	0.017	-0.185	0.248
V_2	0.108	-0.286	-0.054	-0.080	0.027	-0.076	-0.361
V_3	-0.217	0.119	0.131	0.030	-0.063	0.115	0.115
V_4	-0.191	0.102	0.018	0.224	-0.038	0.223	0.338
V_5	0.074	-0.058	-0.061	-0.062	0.135	-0.003	0.026
V_6	0.231	-0.046	-0.032	-0.106	0.001	-0.472	-0.424

Where V_1 - Plant height, V_2 – Stem diameter, V_3 – Number of primary branches/plant, V_4 – Number of leaves/plant, V_5 – Root length, V_6 – Root diameter

Number of leaves/plant contributed maximum positive indirect effect through number of inflorescences/plant (0.223) and maximum negative indirect effect through plant height (–0.191). Root length contributed maximum positive indirect effect through plant height (0.074) and maximum negative indirect effect through number of leaves/plant (–0.062). Root diameter contributed maximum positive indirect effect through plant height (0.231) and maximum negative indirect effect through number of leaves/plant (–0.106). Highest direct effect of root length followed lowed by number of secondary branches per plant on dry root yield at the same root length also had significant and positive correlation with dry root yield per plant in Ashwagandha [11].

Conclusion
Correlation matrix of different growth parameter showed non-significant impact on seed yield/plant, however plant height showed highly significantly positive correlation with dry root yield/plant (0.594) and significantly positive correlation between root length and dry root yield/plant (0.414). Path analysis of different growth parameter affecting seed yield/plant indicated maximum direct positive impact by number of flowers/ inflorescence (0.658) and maximum direct negative impact by number of fruits/inflorescence (-0.486). In case of dry root yield/plant, maximum direct positive effect was shown by plant height (0.590) and maximum direct negative effect was by root diameter (-0.472). So plant height & root length may be selected as suitable traits for improving dry root yield/plant in Sarpgandha.

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