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S Venugopal
Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, Telangana, India

M Padma
Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, Telangana, India

M Rajkumar
Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, Telangana, India

N Seenivasan
Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, Telangana, India

P Saidaiah
Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, Telangana, India

G Sathish
Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, Telangana, India

Corresponding Author:
S Venugopal
Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, Telangana, India

Genetic variability studies in ashwagandha (*Withania somnifera* L.) for yield and quality traits

S Venugopal, M Padma, M Rajkumar, N Seenivasan, P Saidaiah and G Sathish

Abstract
The experiment was laid out in a completely Randomized Block Design with 29 ashwagandha accessions as treatments during *Kharif*, 2018 at Medicinal and Aromatic Plant Research Station, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad. Each treatment was randomly replicated thrice. The analysis of variance indicates presence of significant amount of variability in the genotypes population which was studied. The study revealed that high PCV and GCV estimates recorded for plant height, number of branches per plant, leaf length, leaf width, days to flower initiation, fresh leaf weight per plant, dry leaf weight per plant, seed yield per plant, seed yield per hectare, main root length, root diameter, number of secondary roots per plant, fresh root weight per plant, dry root weight per plant, fresh root yield per hectare, dry root yield per hectare have indicated the existence of wider genetic variability for these traits in the genotypes studied.
High heritability coupled with high genetic advance as per cent mean indicates existence of additive gene action which was observed in plant height, leaf width, leaf length, days to flower initiation, fresh leaf weight per plant, dry leaf weight per plant, number of berries per plant, seed yield per plant, seed yield per hectare, main root length, number of secondary roots per plant, fresh root weight per plant, dry root weight per plant, fresh root yield per plant, dry root yield per plant, starch estimation, fiber content, starch fiber ratio, total alkaloid content. Thus, considering the estimates of genetic parameters like genotypic coefficients of variation, heritability and genetic advances per cent of mean together, it is evident that the plant height, leaf width, leaf length, days to flower initiation, fresh leaf weight per plant, dry leaf weight per plant, number of berries per plant, seed yield per plant, seed yield per hectare, main root length, number of secondary roots per plant, fresh root weight per plant, dry root weight per plant, fresh root yield per plant, dry root yield per plant, starch estimation, fiber content, starch fiber ratio, total alkaloid content are most important characters. Selection for these characters could be more effective for improving dry root yield and quality in ashwagandha.

Keywords: Ashwagandha, genetic variability, PCV, GCV, heritability and genetic advance

Introduction
Ashwagandha (*Withania somnifera* L.) belongs to the family Solanaceae with chromosome number 2n = 48. Ashwagandha is one of the most popular medicinal crops being commercially cultivated as a dry land crop in late *kharif* season in India. It is commonly known as Indian Winter Cherry, Asgandh and Indian Ginseng. The origin of ashwagandha is North-Western and Central India as well as Mediterranean region of North Africa (Srivastava *et al*., 2017) [22]. The plant is an evergreen erect under shrub which is 30-150 cm tall and it produces flowers indeterminately round the year with a peak of flowering between March and July (Mir *et al*., 2012) [18]. High pollen load on the stigma and stiff pollen competition within a flower strongly favours self-pollination (Mir *et al*., 2012) [18].
The economic part of ashwagandha is root which is rich in alkaloids, steroidal lactones and saponins. The medicinal properties of the root are attributed to the chemical quality, i.e., alkaloids (isopelletierine, anaferine), steroidal lactones (withanolides, withaferins) and saponins containing an additional acyle group (Sitoindoside VII and VIII) content (Gupta and Rana, 2007) [11]. The total alkaloid content in the Indian roots range between 0.13% and 0.31%. Withaferin A and Withanolide D are the two main withanolides which contribute to most of the biological activity of ashwagandha (Matsuda *et al*., 2001) [16]. The commercial value of roots depends upon the physical (textural) quality and root morphology. Brittle, robust and lengthy roots have high market value (Misra *et al*., 1998) [19].
Ashwagandha roots have a tremendous medicinal value and constituent of various formulations in the traditional Indian medical systems such as Ayurveda, Unani and Siddha.

(Sharma *et al*., 2014). It has anti-stress (Bhattacharya and Muruganandam, 2003) [4], immunomodulatory, cytotoxic, anti-bacterial, antifungal, and immunosuppressive properties (Atta-ur-Rahman *et al*., 1998) [3], treatment of rheumatic pain, inflammation of joints, female disorders, hiccups, coughs and colds, ulcers, leprosy, as a sedative etc, (Al-Hindwani *et al*., 1992) [1]. The bruised leaves of this plant are used in the treatment of tumors, tubercular glands and as an anti-inflammatory agent (Jayaprakasam *et al*., 2003; Chopra, 1994) [6] due to its antibacterial, antifungal, and antitumor properties (Devi *et al*., 1993) [8].

One of the important factors restricting the large-scale production and development of better varieties is the availability of meagre information about the genetic variability and genetic relationship among ashwagandha genotypes. Assessment of variability is most important as well as first step of any breeding programme. Greater the variability in the genetic material better are the chances of genetic improvement, provided the heritability is high and expected genetic gain under selection is more for the characters under study.

Materials and Methods

The experiment was laid out in a completely Randomized Block Design with 29 ashwagandha accessions as treatments during *Kharif*, 2018 at Medicinal and Aromatic Plant Research Station, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad. Each treatment was randomly replicated thrice.

The experimental material comprised of 29 germplasm lines of ashwagandha were obtained from DMAPR, Anand, Gujarat; CIMAP, Lucknow, Uttar Pradesh and PDKV, Akola, Maharashtra (Table 1.). The recommended agronomical practices were adopted to raise a healthy crop. The experimental material was evaluated for 25 characters *viz*., Plant height (cm), number of branches per plant, leaf length (cm), leaf width (cm), days to flower initiation, days to fruit formation, days to root harvest, fresh leaf weight per plant (g), dry leaf weight per plant (g), number of berries per plant, berry diameter (cm), number of seeds per berry, seed yield per plant (g), seed yield (q ha-1), main root length (cm), diameter of root (cm), number of secondary roots per plant, fresh root weight per plant (g), dry root weight per plant (g), fresh root yield (q ha-1), dry root yield(q ha-1), crude fiber estimation (%), starch estimation (%), starch and fiber ratio, total alkaloid content (%). Analysis of variance was calculated with the method suggested by Panse and Sukhatme, 1978 [20]. The genotypic and phenotypic coefficient of variation (GCV and PCV) was estimated as per Burton, 1953, while classification of GCV and PCV were followed by Sivasubramanian and Madhavamenon, 1973 [21]. Heritability in the broad sense and genetic advance (GA), suggested by Allard, 1960 and genetic gain expressed as a percentage of mean were computed according to Johnson *et al*., 1955 [12].

Results and Discussion

The analysis of variance in 29 ashwagandha genotypes indicated highly significant difference among the genotypes for all the 25 quantitative characters studied, indicating the existence of adequate genetic variability among the genotypes. The simple measure of variability like mean, range and the major components of variability such as phenotypic and genotypic coefficients of variation (PCV and GCV), heritability in broad sense (h^2), genetic advance and genetic advance as per cent of mean are presented in Table 2.

Most of selection responsive characters could not be identified on the basis of phenotypic and genotypic variances. However, magnitude of variability can be assessed with the help of coefficient of variation. The study revealed that PCV was higher than the corresponding GCV for all the characters which indicated that all characters have interacted with environment to some degree. Among different characters studied, high PCV and GCV estimates recorded for plant height, number of branches per plant, leaf length, leaf width, days to flower initiation, fresh leaf weight per plant, dry leaf weight per plant, seed yield per plant, seed yield per hectare, main root length, root diameter, number of secondary roots per plant, fresh root weight per plant, dry root weight per plant, fresh root yield per hectare, dry root yield per hectare have indicated the existence of wider genetic variability for these traits in the genotypes studied. On the other hand, PCV and GCV estimates were moderate to low for berry diameter, number of seeds per berry, fiber content, starch estimation, starch fiber ratio, total alkaloid content which suggested moderate to narrow range of genetic variability.

The genotypic coefficients of variation alone do not indicate the proportion of total heritable variation. Lush (1949) [14] gave the concept of heritability in broad sense as the ratio of genotypic variance to phenotypic variance. The results of the present study indicated that heritability was high for plant height (cm), number of branches per plant, leaf length (cm), leaf width (cm), days to flower initiation, days to fruit formation, fresh leaf weight per plant (g), dry leaf weight per plant (g), number of berries per plant, seed yield per plant (g), seed yield (q ha^{-1}), main root length (cm), diameter of root (cm), number of secondary roots per plant, fresh root weight per plant (g), dry root weight per plant (g), fresh root yield (q ha^{-1}), dry root yield (q ha^{-1}), crude fiber estimation (%),starch estimation (%), starch and fiber ratio, total alkaloid content (%). Moderate heritability was exhibited by days to root harvest, berry diameter (cm), number of seeds per berry.

High heritability indicates the effectiveness of selection based on phenotypic performance but does not necessarily mean a high genetic advance as per cent of mean for a particular character. Consideration of both heritability and genetic advance as per cent of mean is more important for predicting effectiveness of selection than heritability alone. Johnson *et al*. (1955) [12] found it more useful to estimate heritability values together with genetic advance in predicting the ultimate choice of the best individual by selection. In the present investigation high value of genetic advance as per cent mean was exhibited by plant height (cm), leaf length (cm), leaf width (cm), days to flower initiation, fresh leaf weight per plant (g), dry leaf weight per plant (g), number of berries per plant, seed yield per plant (g), seed yield (q ha^{-1}), main root length (cm), diameter of root (cm), number of secondary roots per plant, fresh root weight per plant (g), dry root weight per plant (g), fresh root yield (q ha^{-1}), dry root yield (q ha^{-1}), crude fiber estimation (%), starch estimation (%), starch and fiber ratio, total alkaloid content (%). Moderate to low genetic advance as per cent mean was exhibited by berry diameter (cm), days to fruit formation, days to root harvest.

High heritability accompanied with high genetic advance as per cent of mean indicates preponderance of additive gene effects. In such cases selection may be effective. High heritability with low genetic advance as per cent of mean reveals preponderance of non-additive gene action. High

heritability is due to favorable environmental effects rather than genotype selection for such traits may not be rewarding. Low heritability with high genetic advance as per cent of mean indicates preponderance of additive gene effects. Selection may be effective for such traits. Low heritability with low genetic advance as per cent of mean reveals high influence of environment on traits hence selection would not be effective for such traits.

In the present investigation high heritability coupled with high genetic advance as per cent mean indicates existence of additive gene action which was observed in plant height, leaf width, leaf length, days to flower initiation, fresh leaf weight per plant, dry leaf weight per plant, number of berries per plant, seed yield per plant, seed yield per hectare, main root length, number of secondary roots per plant, fresh root weight per plant, dry root weight per plant, fresh root yield per plant, dry root yield per plant, starch estimation, fiber content, starch fiber ratio, total alkaloid content. Similar results were obtained by Sundesha and Tank (2013) [23], Sunita *et al*. (2013) [24], Joshi *et al*. (2014) [13] and Manivel *et al*. (2017) [15] for dry root yield per plant and Sandesha and Tank (2013) [23], Joshi *et al*. (2014) [13] and Gami *et al*. (2015) [9], reported similar high heritability coupled with high genetic advance as per cent of mean for total alkaloid content**.**

High heritability with low genetic advance reveals preponderance of non- additive gene action which was observed in days to fruit formation. High heritability is due to favorable environmental effects rather than genotype selection for such traits may not be rewarding. Moderate to low heritability with moderate to low genetic advance reveals high influence of environment on traits which was observed in berry diameter and days to root harvest hence selection would not be effective for such traits.

Thus, considering the estimates of genetic parameters like genotypic coefficients of variation, heritability and genetic advances per cent of mean together, it is evident that the plant height, leaf width, leaf length, days to flower initiation, fresh leaf weight per plant, dry leaf weight per plant, number of berries per plant, seed yield per plant, seed yield per hectare, main root length, number of secondary roots per plant, fresh root weight per plant, dry root weight per plant, fresh root yield per plant, dry root yield per plant, starch estimation, fiber content, starch fiber ratio, total alkaloid content are most important characters. Selection for these characters could be more effective for improving dry root yield and quality in ashwagandha.

Table 1: List of genotypes used for evaluation along with their sources

S. No	Accession. No	Genotype	Source
1	A_1	AKAS-13	PDKV, Akola
2	A_2	AKAS-11	PDKV, Akola
3	A_3	AKAS-10	PDKV, Akola
4	A_4	AKAS-02	PDKV, Akola
5	A_5	MWS-324	DMAPR, Gujarat
6	A_6	MWS-100	DMAPR, Gujarat
7	A_7	MWS-132	DMAPR, Gujarat
8	A_8	MWS-323	DMAPR, Gujarat
9	A_9	MWS-218	DMAPR, Gujarat
10	A_{10}	RAS-7	DMAPR, Gujarat
11	A_{11}	RAS-28	DMAPR, Gujarat
12	A_{12}	RAS-57	DMAPR, Gujarat
13	A_{13}	RAS-65	DMAPR, Gujarat
14	A_{14}	RAS-67	DMAPR, Gujarat
15	A_{15}	IC-310620(A)	DMAPR, Gujarat
16	A_{16}	IC-310620(B)	DMAPR, Gujarat
17	A_{17}	IC-283662	DMAPR, Gujarat
18	A_{18}	IC-286632	DMAPR, Gujarat
19	A_{19}	IC-283966	DMAPR, Gujarat
20	A_{20}	IC-283942	DMAPR, Gujarat
21	A_{21}	IC-310595	DMAPR, Gujarat
22	A_{22}	Red berry	DMAPR, Gujarat
23	A_{23}	BHM-42	DMAPR, Gujarat
24	A_{24}	JA-134	DMAPR, Gujarat
25	A_{25}	NMITLI-118	CIMAP, Lucknow
26	A_{26}	NMITLI-101	CIMAP, Lucknow
27	A_{27}	CIM-Chetak	CIMAP, Lucknow
28	A_{28}	CIM-Pratap	CIMAP, Lucknow
29	A_{29}	Poshita	CIMAP, Lucknow

Table 2: Estimates of variability, heritability and genetic advance as percent of mean for 25 characters in 29 genotypes of Ashwagandha

		Range		Mean	Variance		PCV (%)	GCV (%)	h^2 (%)	GA	GA as percent of mean
		Min	Max		Phenotypic	Genotypic					
1	Plant height (cm)	42.48	119.09	72.85	460.70	335.83	29.46	25.15	72.90	32.23	44.24
2	Number of branches per plant	2.52	7.20	4.85	1.89	0.96	28.37	20.19	50.63	1.43	29.59
3	Leaf length (cm)	4.25	10.19	6.52	2.30	1.43	23.25	18.34	62.23	1.94	29.80
4	Leaf width (cm)	1.98	7.77	3.91	1.54	0.96	31.72	25.02	62.23	1.59	40.66
5	Days to flower initiation	59.40	119.90	73.04	282.93	276.93	23.03	22.78	97.88	33.92	46.43
6	Days to fruit formation	30.89	39.12	34.96	4.41	2.92	6.01	4.89	66.13	2.86	8.19
7	Days to root harvest	189.34	208.63	197.55	78.09	29.10	4.47	2.73	37.27	6.78	3.43

8	Fresh leaf weight per plant (g)	27.76	295.92	103.05	3624.03	3397.41	58.42	56.56	93.75	116.26	112.82
9	Dry leaf weight per plant (g)	9.24	67.32	28.14	154.08	139.33	44.11	41.94	90.43	23.12	82.17
10	Number of berries per plant	58.46	378.86	200.64	6539.56	5836.93	40.30	38.08	89.26	148.69	74.11
11	Berry diameter (cm)	0.49	0.81	0.65	0.01	0.00	13.84	10.43	56.86	0.11	16.21
12	Number of seeds per berry	20.80	42.22	33.32	56.62	30.08	22.58	16.46	53.12	8.23	24.71
13	Seed yield per plant (g)	1.56	8.99	4.12	4.24	3.90	49.96	47.93	92.02	3.90	94.71
14	Seed yield (q ha^{-1})	3.46	19.98	9.16	20.94	19.27	49.97	47.94	92.04	8.68	94.74
15	Main root length (cm)	6.90	18.40	11.84	9.25	7.29	25.68	22.80	78.80	4.94	41.69
16	Diameter of root (cm)	0.59	2.64	1.45	0.25	0.22	34.17	32.46	90.27	0.92	63.54
17	Number of secondary roots per plant	1.49	7.08	3.53	2.57	1.96	45.40	39.59	76.07	2.51	71.14
18	Fresh root weight per plant (g)	1.64	29.70	8.42	42.50	40.23	77.42	75.32	94.65	12.71	150.96
19	Dry root weight per plant (g)	0.90	13.78	3.83	9.49	9.07	80.39	78.59	95.56	6.06	158.26
20	Fresh root yield (q ha^{-1})	3.64	66.00	18.71	209.96	198.73	77.43	75.33	94.65	28.25	150.97
21	Dry root yield (q ha^{-1})	2.00	30.63	8.52	46.87	44.79	80.40	78.60	95.57	13.48	158.28
22	Crude fiber estimation	24.29	42.30	32.30	21.74	16.58	14.44	12.61	76.26	7.32	22.68
23	Starch estimation	9.51	15.87	12.02	3.83	3.17	16.28	14.80	82.67	3.33	27.72
24	Starch and fiber ratio	0.28	0.46	0.37	0.002	0.002	11.93	11.51	93.11	0.09	22.89
25	Total alkaloid	0.20	0.44	0.31	0.004	0.003	20.75	16.47	62.99	0.08	26.93

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