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SHORT RESEARCH ARTICLE

Hybrid vigour studies for root yield traits across the environments in Ashwagandha (*Withania somnifera* L.)

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Abstract

In the present experiment, 45 F_1 hybrids of Ashwagandha were included in relation to investigate extent of heterosis for dry root yield and its attributing characters. The pooled ANOVA depicted the valuable amount of diversity existed among genotypes for all the characters. The significant estimates of heterosis in desirable direction were recorded in 22 hybrids over the mid parent, six hybrids over the better parent and six hybrids against the superior check (JA-134) for dry root yield, out of which the cross, UWS-309 × RVA-100 exhibited highest useful heterosis (17.42 %) for dry root yield across the environments, hence, the cross may be gainfully utilized.

Keywords: Ashwagandha, dry root yield, environments, F_1 hybrids, heterosis

The international market of herbal products is around $6.2 billion, which is poised to grow to $5 trillion by the year 2050 (Kumar et al. 2020a). Ashwagandha (*Withania somnifera* (L.) Dunal) known as 'Indian Ginseng' is one of the important medicinal plant, belongs to the family Solanaceae, primarily an autogamous and self-compatible crop (Mir et al. 2012), mentioned as the 'royal herb'. The phytochemicals from root extracts have antiviral activity and may be effective in controlling the viral infections (Kumar et al. 2020b), furthermore, it also acts as aphrodisiac, liver-tonic, anti-inflammatory agent, which reduces bacterial infections, venom-toxins and senile-dementia astringent and more recently used to treat ulcers (Kumar et al. 2011).

Due to its high value and demand not only at national but also at international level, resulting in a few cultivars already being commercially cultivated, but increasing demand with low productivity give rise to pressure on its wild germplasms, whereas, the genetic diversity of this crop is less therefore all the attempts should be made for its improvement (Bhat et al. 2012) and to overcome such limitations, heterosis breeding (Shull 1914) may become a better approach, furthermore, diverse environmental conditions can also influence heterosis, as already reported by several workers (Li et al. 2018; Munaro et al. 2011). Hence, hybridization attempts were made in Ashwagandha in relation to estimation of the magnitude of heterosis over the environments for dry root yield along with other yield components.

The present investigation was carried out with 3 replications during *kharif* season of 2018-19 at three different locations/environments *viz.,* Instructional Field, Rajasthan College of Agriculture Udaipur (E1), Krishi Vigyan Kendra Chittorgarh (E2) and Agriculture Research Sub-Station Vallabhnagar (E3). The experimental material comprised of 65 genotypes including 15 lines, namely, UWS-301 (L1), UWS-302 (L2), UWS-303 (L3), UWS-304 (L4), UWS-305 (L5), UWS-306 (L6), UWS-307 (L7), UWS-308 (L8), UWS-309 (L9), UWS-310 (L10), UWS-311 (L11), UWS-312 (L12), UWS-313 (L13), UWS-314 (L14), UWS-315 (L15); three testers viz., UWS-10 (T1), WS-90-146 (T2), RVA-100 (T3), and their resultant 45 F_1s crosses along with two checks, JA-134 and JA-20. The 45 F_1 hybrids were produced during *kharif* 2017-18 taking 15 lines (females) and 3 testers (males) in line × tester mating design (Kempthorne 1957). The observations were recorded on days

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to 50 % flowering (DFF), number of primary branches/plant (NPB), root length (RL), dry plant weight (DPW) and dry root yield (DRY). The data collected over three environments were pooled and subjected to statistical analysis to estimate average heterosis (M/P), heterobeltiosis (B/P), economic (E/H) or standard heterosis (S/H).

Estimation of heterosis

The analysis of variance on pooled basis indicates the existence of significant amount of variation among the parents and crosses. The mean square with respect to parents vs crosses and due to genotypes x environments, parents x environments along with crosses x environments were also significant for all the characters indicating appreciable influence of environment. The heterosis also called as hybrid vigour is an important aspect in any crop for development of hybrid, in Ashwagandha, the reported range of heterosis on mid-parent (average heterosis), better-parent (heterobeltiosis) and the superior check (useful heterosis) on pooled basis is shown (Table 1). In any crop, early maturity is an useful trait to obtain potential economic yield benefit in a short time, hence heterosis in negative direction is desirable. The estimate of heterosis for days to 50 per cent flowering revealed that out of 45 hybrids, 4 hybrids showed significant relative heterosis in negative direction, while the only one hybrid i.e. L12 x T3 (-6.29 %) exhibited negative significant heterobeltiosis, whereas, the crosses *viz.*, $L12_2$ x T1 (-8.64 %) followed by L12 x T3 (-8.02 %), L10 x T1 (-6.34 %) and L15 x T2 (-5.23 %) were identified earliest for days to 50 per cent flowering, against best check i.e., JA-20. Out of 45 hybrids, positive and significant average heterosis for number of primary branches per plant were exhibited by 15 hybrids, whereas, helerobeltiosis shown by 4 crosses furthermore, in case of desirable economic heterosis, it was depicted by 7 hybrids with the highest value shown by L1 x T3 (11.72 %),). Heterosis for the above mentioned traits has also been observed earlier (Arpan et al. 2014).

The longer root is very important and advantageous trait in ashwgandha. In the present study, significant heterosis for root length was displayed by 4 crosses in positive direction as compared to mid parental value, however, none of the cross showed better parents (Table 2). Three F_1 hybrids showed

Table 1. Range of heterosis (%) among hybrids on pooled basis for various traits in Ashwagandha

Sr. no.	Traits	Range of heterosis (%) over		
		Mid parent (in both the directions)	Batter parent (in desirable direction)	Superior check* (in desirable direction)
1	Days to 50 % flowering (DFF)	-6.91 to 11.99	-0.04 to -6.29	-0.07 to -8.64
2	Number of primary branches/plant (NPB)	-16.51 to 26.87	1.86 to 25.38	0.68 to 11.72
3	Root length (RL)	-41.55 to 12.03	0.67 to 2.44	3.49 to 8.40
4	Dry plant weight (DPW)	-26.98 to 28.25	4.43 to 18.46	6.01 to 7.67
5	Dry root yield (DRY)	-31.54 to 39.45	3.94 to 19.46	1.63 to 17.42

*Superior check, out of two (JA-20 and JA-134) for concern trait

Table 2. Pooled hybrid vigour in Ashwagandha

SN.		DFF			NPB			RL			DPW			DRY		
		M/P	B/P	S/H	M/P	B/P	S/H	M/P	B/P	S/H	M/P	B/P	S/H	M/P	B/P	S/H
1.	$L_1 \times T_1$	0.30	-	-	-0.10	-	-	-29.10**	-	-	-5.55	-	-	10.95*	-	-
2.	$L_2 \times T_1$	0.67	-	-	20.43**	16.79**	-	-41.55**	-	-	-14.39**	-	-	7.95	-	-
3.	$L_3 \times T_1$	4.56*	-	-0.07	10.33**	6.13*	-	-37.62**	-	-	-5.79	-	-	1.01	-	-
4.	$L_4 \times T_1$	0.72	-	-2.88	3.15	-	-	-21.27**	-	-	-10.55	-	-	23.80**	19.46**	-
5.	$L_5 \times T_1$	7.40**	-	-	15.35**	-	5.28*	-5.78*	-	-	17.02**	-	-	39.45**	-	-
6.	$L_6 \times T_1$	1.93	-	-1.57	2.31	-	-	-35.35**	-	-	-12.97*	-	-	19.20**	9.37	-
7.	$L_7 \times T_1$	4.48*	-	-0.34	25.94**	25.38**	-	-35.14**	-	-	-8.51	-	-	2.52	-	-
8.	$L_8 \times T_1$	2.95	-	-	26.87**	18.94**	-	-4.29	-	-	-16.14**	-	-	9.73*	-	-
9.	$L_9 \times T_1$	5.10*	-	-	10.42**	-	-	-11.44**	-	-	6.17	-	-	35.41**	-	-
10.	$L_{10} \times T_1$	-0.72	-0.04	-6.34**	1.45	-	-	-29.55**	-	-	-4.54	-	-	1.55	-	-
11.	$L_{11} \times T_1$	3.05	-	-2.18	0.09	-	-	-22.61**	-	-	-4.65	-	-	22.35**	4.93	-
12.	$L_{12} \times T_1$	-5.41*	-2.50	-8.64**	8.41**	1.86	-	-2.46	-	-	23.32**	18.46**	-	28.03**	5.06	-
13.	$L_{13} \times T_1$	-1.88	-	-2.65	7.02*	2.74	-	-4.77	-	-	-7.00	-	-	13.98*	11.19	-
14.	$L_{14} \times T_1$	5.29*	-	-	15.17**	-	-	3.88	-	6.44	22.31**	4.43	-	32.85**	-	-
15.	$L_{15} \times T_1$	0.66	-	-2.42	7.14**	-	-	-12.76**	-	-	-7.74	-	-	-4.78	-	-

Cont...

SN.		DFF			NPB			RL			DPW			DRY		
		M/P	B/P	S/H	M/P	B/P	S/H	M/P	B/P	S/H	M/P	B/P	S/H	M/P	B/P	S/H
16.	L_1 x T_2	8.31**	-	-	-0.29	-	-	-14.63**	-	-	5.23	-	-	19.60**	18.98**	-
17.	L_2 x T_2	6.99**	-	-	-1.35	-	-	-6.95*	-	-	-15.15**	-	-	6.05	-	-
18.	L_3 x T_2		-	-	-7.56**	-	-	-31.66**	-	-	-26.43**	-	-	-19.59**	-	-
19.	L_4 x T_2	2.89	-	-2.00	5.89**	-	-	-11.28**	-	-	-19.53**	-	-	1.43	-	-
20.	L_5 x T_2		-	-	-4.65**	-	0.68	3.51	0.67	-	1.78	-	-	26.55**	3.94	3.12
21.	L_6 x T_2	0.74	-	-3.92	6.96**	-	-	-0.31	-	-	3.97	-	-	27.89**	-	-
22.	L_7 x T_2	5.47*	-	-0.65	-4.90*	-	-	-5.65	-	-	-2.80	-	-	1.16	-	-
23.	L_8 x T_2	5.61**	-	-	-0.24	-	-	-13.90**	-	-	-5.64	-	-	0.45	-	-
24.	L_9 x T_2	6.22**	-	-	3.37	-	6.80**	7.30*	2.15	4.88	5.67	-	-	35.49**	12.07**	9.22**
25.	L_{10} x T_2		-	-	-3.04	-	-	-24.69**	-	-	-8.76	-	-	-8.60*	-	-
26.	L_{11} x T_2	5.57*	-	-1.05		-	-	7.49*	-	-	-19.94**	-	-	9.13	-	-
27.	L_{12} x T_2	4.54*	-	-0.27		-	-	-1.02	-	-	13.89**	-	-	11.19**	10.48*	-
28.	L_{13} x T_2	0.96	-	-1.04	-1.93	-	-	12.03**	-	-	11.07*	-	-	10.80*	-	-
29.	L_{14} x T_2	5.05*	-	-	-0.76	-	-	0.37	-	-	13.25**	10.65*	-	30.65**	10.68**	1.63
30.	L_{15} x T_2	-1.03	-	-5.23*		-	-	-0.01	-	-	1.95	-	-	14.90**	-	-
31.	L_1 x T_3	1.56	-	-	3.91*	-	11.72**	-1.50	-	-	28.25**	7.73*	7.67*	16.66**	-	1.96
32.	L_2 x T_3	3.68	-	-	-7.80**	-	-	-8.86**	-	-	-5.42	-	-	-12.55**	-	-
33.	L_3 x T_3	5.91**	-	-		-	-	-8.79*	-	-	-6.20	-	-	-17.87**	-	-
34.	L_4 x T_3	0.96	-	-0.40	17.06**	-	1.45	-3.34	-	-	15.29**	-	-	2.34	-	-
35.	L_5 x T_3		-	-	-3.83*	-	9.24**	4.60	0.84		2.96	-	6.13	9.58**	4.05	14.82**
36.	L_6 x T_3	2.11	-	-	-1.43	-	-	2.54	-	-	-4.64	-	-	-0.38	-	-
37.	L_7 x T_3	9.63**	-	-	-6.53**	-	-	-27.87**	-	-	-20.85**	-	-	-27.20**	-	-
38.	L_8 x T_3	-5.91**	-1.07	-2.90		-	-	3.72	-	3.49	-26.98**	-	-	-27.24**	-	-
39.	L_9 x T_3	5.77**	-	-	-2.66	-	8.35**	2.19	0.67	6.53	6.10	6.06	6.01	13.00**	6.40*	17.42**
40.	L_{10} x T_3	0.40	-	-3.05		-	-	-6.14	-	-	-13.01**	-	-	-31.54**	-	-
41.	L_{11} x T_3	6.03**	-	-		-	-	-4.90	-	-	-11.81**	-	-	-5.36	-	-
42.	L_{12} x T_3	-6.91**				-	-	-23.49**	-	-	5.66	-	-	-12.09**	-	-
43.	L_{13} x T_3	-4.33*	-1.13	-2.96	-6.99**	-	-	-17.02**	-	-	5.90	-	-	-7.43*	-	-
44.	L_{14} x T_3	6.85**	-	-	5.40**	-	10.60**	7.28*	2.44		-4.17	-	-	8.96**	-	10.15**
45.	L_{15} x T_3	5.90**	-	-	-4.17**	-	8.21**	2.16	1.67		0.56	-	-	-11.88**	-	-

*, ** Significant at 5% and 1%, respectively; M/P = Mid-parental heterosis, B/P = Better-parental heterosis, S/H = Heterosis against standard check

(Here, heterosis value against better parent and standard check mentioned only in desirable direction)

useful heterosis with the highest estimate was expressed by the cross, L14 x T3 (8.40 %) against best check (JA-20). Plant weight at dry stage also showed significant and positive estimate of relative heterosis which was manifested by 8 hybrids, while, 3 crosses were found significantly superior based on heterobeltiosis. The hybrid, L1 x T3 also showed positive and significant heterosis against the superior check (JA-134) with the magnitude of 7.67 per cent. To get higher economic yields in Ashwagandha, the ideal plant type should have high dry root yield. In the present study, significantly positive heterosis was recorded by 22 hybrids on mid parental value, while in terms of heterobeltiosis it was shown by 6 hybrids. Furthermore the heterosis against superior check (JA-134) was also shown by 4 hybrids but highest magnitudes of useful heterosis was shown by only 3 crosses viz., L9 x T3 (17.42 %), L5 x T3 (14.82 %), L14 x T3 (10.15 %). These hybrids were also found superior with respect of the traits, number of primary branches/plant and root length. Hence, these crosses can be gainfully utilized for the economic gains with respect to dry root yield.

Authors' contribution

Conceptualization of research (RBD, IA); Designing of the experiments (RBD, IA); Contribution of experimental materials (IA, RBD, SH); Execution of field/lab experiments and data collection (IA, SH); Analysis of data and interpretation (IA, RBD); Preparation of manuscript (IA).

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