Evaluation of parents and F_1s of *Avena sativa* x *Avena sterilis* for various morphological, physiological and biochemical traits

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Six genotypes namely Kent, OS 6, HJ 8, UPO 212, OL 125, OS 346 of *A. sativa*, the cultivated hexaploid and one genotype of *A. sterilis*, the wild hexaploid species of oat, and their 21 F_1s were grown in Randomized Block Design with three replications on 10th Dec 2010 in the farm area of Forage Section, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar, India. The experiment was sown at the spacing of 45 cm between rows and 10 cm between plants. The observations on eleven morphological, three physiological and five biochemical traits were recorded on five competitive and random plants / genotype / replication.

The *per se* performance for various characters of seven parents and their 21 F_1s is given in Table 1. The plant height at maturity ranged from 88.13 cm (*A. sterilis*) to 127.86 cm (*A. sativa* cv. OL 125). The tallest parent (OL 125) was significantly taller to the dwarfest parent (*A. sterilis*). The mean performance of hybrids for this character ranged from 63.17 cm (OS 6 x *A. sterilis*) to 117.10 cm (HJ 8 x UPO 212). The dwarfest hybrid was further significantly dwarfer than the dwarfest parent as 6 more hybrids were at par with the dwarfest hybrid OS 6 x *A. sterilis* for this trait. Five of these 6 dwarf hybrids had *A. sterilis* as their male parent. The two hybrids HJ 8 x OS 6 (116.20 cm) and OS 6 x UPO 212 (113.13 cm) were at par with the tallest parent OL125 (127.86 cm).

The peduncle length among parents ranged from 35.93 cm *(A. sterilis)* to 44.06 cm (*A. sativa* cv. OS 346).The parent with longest peduncle OS 346 (44.06 cm) was significantly longer than the shortest parent *A. sterilis* (35.93 cm). The mean performance of hybrids for this character ranged from 38.50 cm (OS 6 x *A. sterilis*) to 47.40 cm (OS 6 x OL 125). However, the hybrid with shortest peduncle was not significantly shorter than the shortest parent and the hybrid (OS 6 x OL 125) with longest peduncle was at par with the parent (OS 346) having longest peduncle.

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The average internode length among parents ranged from 19.00 cm (OS 6) to 21.73 cm (*A. sativa* cv. Kent). The parent Kent (21.73 cm) with longest internode length was at par with other parents. The mean performance of hybrids for this character ranged from 15.43 cm (OS 6 x UPO 212) to 26.50 cm (Kent x OL 125).

The mean axis length among parents ranged from 22.46 cm (*A. sterilis*) to 41.56 cm (HJ 8).The highest parent HJ 8 was not significantly higher to the shortest parent *A. sterilis*. The mean performance of hybrids for this character ranged from 25.60 cm (OS 346 x *A. sterilis*) to 41.40 cm (HJ 8 x UPO 212).

The *per se* performance of flag leaf length of parents ranged from 35.66 cm *(A. sterilis)* to 62.56 cm (OS 346). The highest parent OS 346 was significantly higher to the shortest parent (*A. sterilis*). Other parents were statistically at par with the parent with longest flag leaf length i.e., OS 346. The mean performance of hybrids for this character ranged from 38.20 cm (Kent x *A. sterilis*) to 69.10 cm (OS 346 x *A. sterilis*). The longest hybrid was significantly longer than their parents.

The average number of tillers/plant in parents ranged from 10.43(OL 125) to 22.13 (HJ 8). The highest parent HJ 8 was significantly higher to the lowest parent OL 125; other parents were statistically at par with the parent with highest number of tillers/plant. The mean performance of hybrids for this character ranged from 14.73 (UPO 212 x OS 346) to 33.83 (OS 6 x *A. sterilis*). The hybrid having high numbers of tillers was significantly higher than their parents.

Number of spikelets/panicle among parents ranged from 50.66 (UPO 212) to 65.33 (HJ 8). The highest parent HJ 8 was significantly higher to the lowest parent UPO 212. Other parents were not statistically at par with the parent with highest number of spikelets/panicle. The mean performance of hybrids for this character ranged from 54.07 (OL 125 x UPO 212) to 87.57 (HJ 8 x *A. sterilis*). The highest hybrid was significantly higher than their parents.

The seed yield among parents ranged from 13.23 g (*A. sterilis*) to 41.55 g (OS 346).The highest parent OS 346 was significantly higher to the lowest parent *A. sterilis*. Other parents were statistically at par with the parent with higher seed yield/plant *i.e*., OS 346. The mean performance of hybrids for this character ranged from 12.35 g (OS 6 x *A. sterilis*) to 41.16 g (OS 6 x OS 346). Hybrid having higher seed yield was significantly higher than their parents.

The mean value for 100-seed weight in parents ranged from 1.57 g (*A. sterilis*) to 4.04 g (OS 346). The highest parent OS 346 was significantly higher to the lowest parent *A. sterilis*. Other parents were statistically at par with the parent with higher test weight *i.e*., OS 346. The mean performance of hybrids for this character ranged from 1.94 g (Kent x *A. sterilis*) to 4.48 g (OS 6 x OS 346). The highest hybrid was significantly highest than their parents. Some *Avena* species have been characterized and evaluated for some morphological traits earlier (Arora and Sangwan, 2014).

The range in variation for photosynthetic rate among parents was from 5.07 µmole/m^2/sec (*A. sterilis*) to 14.86 µmole/m^2/sec (HJ 8). The highest parent HJ 8 was significantly higher to the lowest parent *A. sterilis*. Other parents were significantly of the same length as that of the highest parent. The mean performance of hybrids for this character ranged from 8.26 µmole/m^2/sec (OS 6 x UPO 212) to 18.57 µmole/m^2/sec (Kent x OL 125). The highest hybrid was significantly higher than their parents.

The transpiration rate among parents ranged from 1.20 µmole/m^2/sec (OL 125) to 8.62 µmole/m^2/sec (HJ 8). The highest parent HJ 8 was significantly higher to the lowest parent *A. sterilis*. The mean performance of hybrids for this character is ranged from 1.16 µmole/m^2/sec (OS 6 x *A. sterilis*) to 8.39 µmole/m^2/sec (HJ 8 x UPO 212). Other parents were statistically at par with the parent with higher transpiration rate *i.e*., OL 125. The highest hybrid was significantly highest than their parents.

The mean stomatal conductance for parents ranged from 0.014 µmole/m^2/sec (Kent) to 0.243 µmole/m^2/sec (*A. sterilis*).The highest parent Kent was significantly higher to the lowest parent *A. sterilis*. Other parents were statistically at par with the parent with higher stomatal conductance i.e., Kent. The mean performance of hybrids for this character ranged from 1.16 (OS 6 x *A. sterilis*) to 8.39 (HJ 8 x UPO 212). The highest hybrid was significantly highest than their parents. Heterotic response for physiological traits in oats (*Avena* spp.) has been studied by Pratiksha Mishra, et al (2014).

The range of variation for protein content among parents ranged from 7.79 % (HJ 8) to 14.23 % (*A. sterilis*). The highest parent *A. sterilis* was significantly higher to the lowest parent HJ 8). Other parents were statistically at par with the parent with higher protein content i.e., *A. sterilis.* The mean performance of hybrids for this character ranged from 8.86 % (OS 6 x OS 346) to 13.66 % (Kent x OS 6).The highest hybrid was significantly higher than their parents.

The mean fat content for parents ranged from 7.86 % (HJ 8) to 10.83 % (OS 6). The highest parent OS 6 was significantly higher to the lowest parent HJ 8. Other parents were statistically at par with the parent with higher fat content i.e., OS 6. The mean performance of hybrids for this character ranged from 5.87 % (OL 125 x *A. sterilis*) to 10.60 % (OS 6 x *A. sterilis*).The highest hybrid was significantly higher than their parents.

The total soluble sugar content among parents ranged from 6.06 % (Kent) to 10.55 % (OS 346). The highest parent (OS 346) was significantly higher to the lowest parent (Kent). Other parents were statistically at par with the parent with higher total soluble sugar content i.e., OS 346. The mean performance of hybrids for this character ranged from 3.62 % (HJ 8 x OS 346) to 9.27 % (HJ 8 x OS 346). The highest hybrid was not significantly higher than their parents.

The mean reducing sugar content for parents ranged from 2.85 % (*A. sterilis*) to 4.97 % (OS 6). The highest parent OS 6 was significantly higher to the lowest parent *A. sterilis*. Other

parents were significantly same for reducing sugar content as that of the highest parent. The mean performance of hybrids for this character ranged from 2.00 (HJ 8 x OS 346) to 6.17 (Kent x UPO 212). The highest hybrid was significantly higher than their parents.

The non-reducing sugar content among parents ranged from 1.45 (Kent) to 6.31 (*A. sterilis*).The highest parent *A. sterilis* was significantly higher to the lowest parent Kent. Other parents were statistically at par with the parent with higher non-reducing sugar content i.e., *A. sterilis*. The mean performance of hybrids for this character ranged from 0.82 (UPO 212 x *A. sterilis*) to 4.97 (HJ 8 x UPO 212). The highest hybrid was not significantly higher than their parents. Jayeeta Chakraborty, et al (2014) has evaluated some *Avena* species for quality attributes.

The mean number of days to flowering for parents ranged from 106.33 (OS 6, OL 125, UPO 212, OS 346) to 112.00 (HJ 8). The highest parent HJ 8 was significantly higher to the lowest parents OS 6, OL 125, UPO 212, and OS 346. Other parents were significantly the same for the days to flowering as that of the highest parent. The mean performance of hybrids for this character ranged from 104.67 days (UPO 212 x OS 346) to 115.67 days (Kent x OS 346). The highest hybrid was significantly higher than their parents.

The range of variation among parents for days to maturity was from 131.66 days (*A. sterilis*) to 147.33 days (OL 125). The highest parent OL 125 was significantly higher to the lowest parent *A. sterilis*. Other parents were significantly the same for the days to maturity as that of the highest parent. The mean performance of hybrids for this character ranged from 127.00 days (OS 346 x *A. sterilis*) to 146.00 days (OS 6 x OL 125). The highest hybrid was significantly not higher than their parents.

It is quite obvious from the aforementioned studies that the parents having desirable attributes for various traits can be further utilized in hybridization programme and F_1s showing better per se performance can be further advanced to select for genotypes with high seed yield, better in physiological and quality attributes in future.

References

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Table 1: Mean performance of parents and their F_1 s for various morphological, physiological and biochemical characters in oats

Genotype	Plant height (cm)	Peduncle length (cm)	Inter-node length (cm)	Axis length (cm)	Flag leaf length (cm)	Tillers /plant	Spikelets /panicle	Seed Yield /plant (g)	100-seed weight (g)	Photosynthetic rate (µmole/m^2/sec)
Parents										
Kent	112.53	39.40	**21.73**	34.53	62.26	17.73	50.76	41.24	3.39	8.31
HJ8	126.26	38.86	19.40	**41.56**	60.86	**22.13**	**65.33**	35.83	2.33	**14.86**
OS6	122.40	36.63	19.00	31.93	48.70	14.13	64.96	40.18	2.95	14.01
OL125	**127.86**	40.80	18.46	39.13	61.86	**10.43**	61.73	34.20	2.48	9.67
UPO212	127.30	41.96	**18.43**	37.50	60.20	14.30	**50.66**	30.40	3.04	8.67
OS346	113.36	**44.06**	19.40	37.26	**62.56**	13.60	54.06	**41.55**	**4.04**	10.92
A. sterilis	**88.13**	**35.93**	20.26	**22.46**	**35.66**	18.73	57.73	**13.23**	**1.57**	**5.07**
Range (Parents)	**88.13 to 127.86**	**35.93 to 44.06**	**18.43 to 21.73**	**22.46 to 41.56**	**35.66 to 62.56**	**10.43 to 22.13**	**50.66 to 65.33**	**13.23 to 41.55**	**1.57 to 4.04**	**5.07 to 14.86**
F_1s										
Kent x HJ8	105.53	38.10	20.07	38.00	49.00	20.33	56.03	23.10	2.94	10.32
Kent x OS6	107.33	37.73	23.80	33.73	53.40	24.00	57.33	26.62	2.73	13.88
Kent x OL125	82.27	42.43	**26.50**	32.20	59.47	23.13	57.47	22.38	2.42	**18.57**
Kent x UPO212	85.93	46.20	24.03	38.37	60.23	30.33	67.53	38.55	2.94	12.67
Kent x OS346	70.07	39.37	24.17	33.33	52.27	28.33	61.10	27.45	3.09	9.35
Kent x *A.sterilis*	71.27	41.20	22.07	38.27	**38.20**	23.60	58.53	19.66	**1.94**	10.62
HJ8 x OS6	116.20	46.07	22.03	36.17	**69.10**	16.10	55.07	36.51	3.94	12.41
HJ8 x OL125	107.17	40.17	24.40	39.97	60.33	15.23	63.83	30.73	3.04	11.11
HJ8 x UPO212	**117.10**	43.37	23.50	**41.40**	65.40	15.57	59.83	24.67	2.98	11.98
HJ8 x OS346	104.50	38.90	26.03	38.30	65.03	23.73	79.83	26.53	2.99	11.92
HJ8 x *A.sterilis*	66.90	40.50	21.70	**25.23**	40.30	29.43	**87.57**	24.27	2.15	10.82

OS6 x OL125	79.23	**47.40**	25.90	35.40	57.20	19.00	62.50	30.62	2.63	18.11
OS6 x UPO212	113.13	46.83	**15.43**	35.30	61.17	21.50	62.33	32.20	2.08	**8.26**
OS6 x OS346	81.49	**37.33**	24.63	34.17	51.53	23.17	63.23	**41.16**	**4.48**	15.50
OS6 x *A.sterilis*	**63.17**	38.50	21.33	27.00	39.03	**33.83**	74.63	**12.35**	2.60	10.63
OL125 x UPO212	105.87	43.40	25.20	39.60	62.33	**12.57**	**54.07**	29.96	3.12	8.64
OL125 x OS346	87.27	41.57	21.87	35.73	59.10	20.00	65.05	37.77	3.57	9.20
OL125 x *A.sterilis*	64.87	38.20	23.50	26.39	40.73	23.67	56.40	20.92	2.42	11.06
UPO212 x OS346	108.20	40.57	22.27	35.30	67.50	14.73	62.40	32.27	3.94	15.36
UPO212 x *A.sterilis*	70.25	39.58	21.00	26.77	39.00	28.17	76.07	19.21	2.27	12.85
OS346 x *A.sterilis*	66.43	39.67	24.00	25.60	**38.20**	28.13	66.22	13.77	3.48	8.38
Range (F_1s)	**63.17 to 117.10**	**37.33 to 47.40**	**15.43 to 26.50**	**25.23 to 41.40**	**38.20 to 69.10**	**12.57 to 33.83**	**54.07 to 87.57**	**12.35 to 41.16**	**1.94 to 4.48**	**8.26 to 18.57**
SE (m)(±)	5.40	1.86	1.56	1.16	1.97	1.39	2.82	1.01	0.01	0.06
CD (5%)	15.32	5.28	4.42	3.31	5.58	3.94	7.99	2.88	0.03	0.19

Table 1 contd…: Mean performance of parents and theirF_1 s for various morphological, physiological and biochemical characters in oats

Genotype	Transpiration rate (µmole/m^2/sec)	Stomatal conductance (µmole/m^2/sec)	Crude Protein (%)	Fat (%)	Total soluble Sugars (%)	Reducing sugars (%)	Non-reducing sugars(%)	Number of days to flowering	Number of days to maturity
Parents									
Kent	2.46	**0.014**	13.73	8.41	**6.06**	4.61	**1.45**	106.66	143.66
HJ8	**8.62**	**0.447**	**7.79**	**7.86**	6.46	3.01	3.45	**112.00**	145.00
OS6	5.21	0.140	12.66	**10.83**	8.61	**4.97**	3.63	106.33	136.33

OL125	**1.20**	0.021	13.51	9.53	7.85	3.75	4.09	106.33	**147.33**
UPO212	2.82	0.064	10.63	8.40	9.55	3.45	6.09	**106.33**	135.00
OS346	1.38	0.023	13.06	9.60	**10.55**	4.74	5.80	106.33	146.33
A. sterilis	6.88	0.243	**14.23**	8.26	9.16	**2.85**	**6.31**	109.00	**131.66**
Range (Parents)	**1.20to 8.62**	**0.014to 0.447**	**7.79 to 14.23**	**7.86 to 10.83**	**6.06 to 10.55**	**2.85to 4.97**	**1.45to 6.31**	**106.33to 112.00**	**131.66to 147.33**
F_1s									
Kent x HJ8	5.31	0.17	12.24	7.77	7.40	4.85	2.55	111.00	138.33
Kent x OS6	2.98	0.02	13.46	8.10	7.07	4.75	2.32	111.00	142.00
Kent x OL125	3.36	0.07	12.65	7.77	7.40	3.85	3.62	111.00	139.00
Kent x UPO212	2.77	0.06	13.63	7.47	7.75	**6.17**	1.58	**118.33**	134.67
Kent x OS346	4.56	0.12	13.66	8.63	6.67	5.51	1.15	115.67	143.00
Kent x *A.sterilis*	1.86	0.04	12.67	6.90	7.23	4.52	2.71	**107.00**	137.33
HJ8 x OS6	3.66	0.08	13.06	9.53	**9.27**	3.55	**5.71**	107.33	142.00
HJ8 x OL125	4.98	0.13	**13.88**	6.97	6.60	5.38	1.22	112.00	143.00
HJ8 x UPO212	**8.39**	**0.32**	13.46	7.77	8.72	3.75	4.97	113.00	141.33
HJ8 x OS346	5.82	0.22	**13.88**	7.87	**3.62**	**2.00**	1.62	113.33	143.00
HJ8 x *A.sterilis*	5.28	0.15	13.06	9.97	7.41	4.85	2.56	109.00	137.33
OS6 x OL125	3.96	0.09	**13.88**	9.90	8.32	4.94	3.37	110.00	**146.00**
OS6 x UPO212	3.68	0.09	12.66	7.82	7.89	4.75	3.14	**107.00**	133.67
OS6 x OS346	5.89	0.19	**8.86**	9.80	8.58	3.54	5.04	108.00	138.33
OS6 x *A.sterilis*	1.30	0.03	12.66	**10.60**	5.56	3.20	2.36	107.67	136.33
OL125 x UPO212	2.83	0.06	11.54	7.47	8.78	4.85	3.92	110.67	**146.00**
OL125 x OS346	3.48	0.07	13.05	8.67	8.85	3.25	5.58	110.00	144.00
OL125 x *A.sterilis*	3.80	0.07	13.62	**5.87**	6.35	2.84	3.51	**107.00**	136.67

UPO212 x OS346	7.21	0.22	11.44	9.50	8.90	4.27	4.63	104.67	142.33
UPO212 x *A.sterilis*	3.76	**0.01**	13.46	9.43	5.87	5.05	**0.82**	**107.00**	137.00
OS346 x *A.sterilis*	**1.16**	0.02	13.48	8.47	8.27	3.65	4.61	107.67	**127.00**
Range (F_1s)	**1.16 to 8.39**	**0.01 to 0.32**	**8.86 to 13.88**	**5.87 to 10.60**	**3.62 to 9.27**	**2.00 to 6.17**	**0.82 to 5.71**	**107.00 to 118.33**	**127.00 to 146.00**
SE (m)(±)	0.01	0.01	0.04	0.14	0.04	0.07	0.08	0.83	0.86
CD (5%)	0.04	0.02	0.13	0.41	0.12	0.22	0.25	2.36	2.46