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Research Article

Combining Ability and Heterosis Analysis for Green Fodder Yield in Oat (*Avena sativa* L.)

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ABSTRACT

Thirty F_1s obtained by crossing ten lines and three testers selected from oat germplasm were evaluated along with parents in RBD during winter season of 2017-18. The observations were recorded on eleven metric characters. Analysis of variance showed significant variability among the parents and hybrids for all character under study indicated that the wide spectrum of variation among the parents and crosses. Analysis of variance among lines and testers with respect to gca and sca of crosses was observed significant differences for all traits. Both additive and dominance genetic variances were involved in the determination of these traits. Lines namely, CSAOFSC12-2, CSAOFSC, JHO3-91, OS344, OS1, CSAOFSC11-4, CSAOFSC11-1, ANDO1, NDO25 and CSAOFSC12-1 which having high gca effects in desirable direction for seed yield and yield components characters may be incorporated in crossing programme to have better genotypes for better yield. The good specific combinations were OS1x ANDO2, JHO3-91 x ANDO2, OS344 x ANDO2, CSAOFSC11-5 x ANDO2, CSAOFSC12-2 x ANDO2, ANDO1 x JHO2007-2 and CSAOFSC11-4 x ANDO2 for different traits. These crosses may be utilized for obtaining transgressive sergeants in the next generation for the selection in oat improvement programme. Highest significant and positive heterosis for seed yield per plant was shown by OS344 x ANDO2 followed by CSAOFSC11-4 x Kent, OS344 x Kent ANDO1 x JHO2007-2 and CSAOFSC11-4 x ANDO2 may be used in heterosis breeding programme for enhancement in seed yield per plant.

Keywords: *Oat, Line x tester analysis, Combining ability, SCA, GCA and Heterosis.*

INTRODUCTION

The common Oat (*Avena sativa* L.) is the most important cereal and fodder crop belongs to family *poaceae* grown during Rabi season in many parts of the country including North Western, Central and extending upto the parts of Eastern India. It has ranks sixth in cereal production globally following wheat, maize, rice, barley and sorghum (Choubey & Roy, 1996).

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In respect to human consumption and animal feeding purposes, high contents of protein, carbohydrates, lipids and lower fiber contents are required (Hizbai et al., 2012). The genus Avena is Large and diverse containing both wild and cultivated of polyploidy series with a basic chromosome number of x=7. Three naturally occurring ploidy levels are known within the genus, like diploid (2n=2x=14 having A and C genome), tetraploid (2n=4x= 28 with AB and Ac genome) and hexaploid (2n=6x=42 containing ACD genome) (Loskutov, 2008). In self- pollinated crops like oat, combining ability is mostly used by plant researchers to screening good parental lines to evolve the more progeny of new combinations through their crossing. Knowledge on the mechanisms that control the main characters of farmer's interest of a plant species is fundamental for genetic enhancement and can be acquired through methodologies of line x tester mating design as the one developed by Griffing (1956). The line x tester analysis design can be used to calculate general and specific combining abilities in both self and cross-pollinated plants (Kempthorne, 1957). Line x tester analysis states for the detection of appropriate parents and crosses superior in terms of the investigated characters so application of the analysis has been widely used by plant breeders for selection in early generations which provides information regarding the gene action from co variances half-sibs and full-sibs. Based on the combining ability analysis of different characters, dominance gene action is the result of higher sca values and higher gca effects indicate a greater role of additive gene effects. If sca and gca values are not significant, epistatic gene effects may play an important role in genetic of characters (Sprague, & Tatum, 1942). Oat is a self pollinated crop but natural cross pollination by wind occurs occasionally and ranged varies from 0.4 to 1.3%. In self pollinated plants, the heterosis manifested in the F_1 generation is reduced by 50% in each selfing generation (Ramalho et al., 2004). With the mean values of $F_1$and the calculated heterosis, it is possible to predict the population means in future generations. According to Cruz et al. (1987), the best hybrid combinations are those which have at least one parent with the most favorable GCA effect for the target trait. According to Cruz and Vencovsky (1989), the best hybrid is a result of the cross between parents (a) selected on the basis of gca and parent (b) whose frequency of favorable alleles is superior to the mean population frequency and divergent from parent (c) Crosses of two parents with high general ability do not generate the best hybrid always. With the mean values of F_1 and the calculated heterosis, it is therefore possible to foresee/predict the population means in future generations.

MATERIALS AND METHODS

The experimental material consisted of thirteen genetically diverse genotypes being maintained at forage division of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) India. Out of these thirteen genotypes selected, ten lines namely; CSOFSC-12-2, CSOFSC-11-5, NDO-25, CSOFSC- 11-4, CSOFSC-11-1, CSOFC-12-1, OS-344, ANDO-1, JHO-03-91, OS- 1 were used as female parent and remaining three genotypes viz; Kent, JHO-2007-2 and ANDO-2 were used as male parent. The selected lines were crossed in Line x Tester design during *Rabi* 2016-17 to obtain 30 F_1 crosses at the experimental field of Students Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur and evaluated during 2017-18. All the genotypes were evaluated in a randomized block design with three replications for morphological traits and seed characters were examined in Seed Technology Laboratory. The material was grown in two rows of 3 m length with row to row spacing of 25 cm. Recommended package of practices to raise a good crop was followed. Each replication represented 43 treatments. Observations recorded based on five competitive plants were randomly selected plants from each *F1'*s and parents in each replication were tagged for recording the observations on days to 50% flowering, days to maturity, plant height (cm), biological yield per plant (g), harvest index (%), spike length (cm)germination in percent, seedling length (cm), seedling dry weight per plant (g), seed vigour index and seed yield per plant (g). The data for different characters are statistically analyzed as per the procedure outlined by Panse and Sukhatme (1967).Combining ability analysis was carried out by Kempthorne, 1957 using simple regression model. The average degree of dominance was calculated using the formula suggested by Kempthorne and Curnow (1961). Heterosis expressed as percentage increase or decrease of F_1s over better parent (heterobeltiosis) was calculated by Fonseca and Patterson, 1968.

RESULTS AND DISCUSSION

Analysis of Variance

The analysis of variance for combining ability for different characters is presented in Table 1. The variance among hybrids was partitioned in to different components corresponding to the combining ability of females, males and their interaction in table-2.

Combing abilities

Analysis revealed significant gca and sca mean squares for most of the traits, however non-additive gene action was found to be more predominant for all the traits under evaluation as variances due to sca were higher than gca variances. Hence, these traits can be exploited through heterosis breeding for enhancing the green fodder yield in oat. Variances for hybrids and due to female x male interaction, females and males were significant for all the traits under study. The analysis of variance for combining ability for different characters is presented in Table 1.The variance among hybrids was partitioned in to different components corresponding to the combining ability of females, males and their interaction. Analysis revealed significant gca and sca mean squares for all the traits namely; days to 50% flowering, days to maturity, plant height, biological yield per plant, harvest index, spike length, seed germination in percent, seedling length, seedling dry weight per plant, seed vigour index and seed yield per plant which indicated the wide spectrum of variation among the genotype and further genetic analysis and study would be meaningful. Such an amount of genetic variability for the various traits has also been reported earlier by Ruwali and Deo (2009), Valerio et al., (2009), Wani, et al. (2013), Razvi et al. (2013), Wani, et al. (2013), Chauhan et al. (2018) and Deep et al. (2019).

General combining Ability

The analysis of variance for all the twenty characters showed significance differences among the genotypes with a view to know the clear picture about variability among the parents and F_1's. The treatment variance partitioned in the variance due to parents, F_1's and parent *vs* F_1's. Variance due to parents was further divided in to its components viz, due to line, due to tester and line *vs* testers (Table-2). The 'F' test showed that variance due to genotypes were significant for all the characters studied, exhibiting that genotypes were showed differences among themselves for the characters under study. Variance due to parents were also showed significant values for all traits, showing that these entries significantly differed for all the traits among themselves to carry out genetic studies except biological yield per plant. Such differences of parents lead to development of F_1s that differed significantly among themselves for above characters. The estimates of combining ability variances are translated in to genetic variance to understand the nature and magnitude of gene action and to develop the guidelines for selecting parents for hybridization. It is an established fact that additive genetic variance is comprised of dominant and epistasis. The partitioning of parents due to lines revealed also significant for all the attributes studied except biological yield per plant. Further division of parents variance into lines were exhibited significant variance for all traits except spike length, seedling dry weight per plant and seed vigour index whereas variance due to testers were exhibited significant for all the traits except spike length, seedling dry weight per plant and seed vigour index. Variance due to line *vs* testers was showed significant for all the characters under study except biological yield per plant and seed germination in percent. The variance among the crosses was exhibited significant for the characters and due to parents *vs* crosses had significant for characters studied. These results for the various characters are in agreement with the findings of Manga et al. (1984), Wani, et al. (2013) Mishra et al. (2014) Chauhan et al. (2018) and Deep et al. (2019).

Specific combining Ability

Analysis of Variance for combining ability was performed based on F_1's and the results are present in Table -3. The variance among lines with respect to gca and variances among crosses due to interaction between lines x tester's genotypes with respect to *sca* were exhibited significant for days to 50% flowering, days to maturity, plant height, biological yield per plant, harvest index, spike length, seed germination in percent, seedling length, seedling dry weight per plant, seed vigour index and seed yield per plant. However, variance among testers with respect to *gca* was also observed significant for days to 50% flowering, days to maturity, plant height, number of nodes per plant, number of leaves per plant, biological yield per plant, harvest index, spike length, seed germination in percent, seedling length, seedling dry weight per plant, seed vigour index and seed yield per plant, indicating that both additive and dominance genetic variance were involved in the determination of these attribute and the parents and their progenies differed for their combining ability effects reported that same of the morphological traits were determined by additive and other by non-additive effects for seed yield. The similar findings of characters were also found by Manga et al. (1984), Ruwali and Deo (2009), Valerio et al. (2009), Razvi et al. (2013), Wani, et al. (2013) Mishra et al. (2014), Chauhan et al. (2018) and Deep et al. (2019).

Gene Action

The estimates of components of variance, their ratio and degree of dominance for different characters are given in **Table-4.** The ratio of $\delta^2 g/ \delta^2 s$ being more than unity for days to 50% flowering, days to maturity, biological yield per plant, harvest index, spike length, seed germination in percent, seedling length, and seed yield per plant which indicated that the involvement of additive gene action. To exploitation of additive genetic variance in the improvement of such attributes, pedigree method of breeding may be more appropriate. Similar findings for many of these traits were also studied by Manga et al. (1984), Pixley et al. (1991), Ruwali and Deo (2009), Valerio et al. (2009), Razvi et al. (2013), Wani, et al. (2013) Mishra et al. (2014), Chauhan et al. (2018) and Deep et al. (2019). The plant height, seedling dry weight and seed vigour index had less than unity, indicating the role of non-additive gene action and large amount of non-additive gene action would be more important for maintenance of heterozygosity in the population. Since this type of gene action is not fixable therefore, breeding method such as biparental mating followed by recurrent selection may hasten the rate of genetic improvement for these traits. These results are somewhat in accordance with the findings of Manga et al. (1984), Wani, et al. (2013), Mishra et al. (2014), Chauhan et al. (2018) and Deep et al. (2019).

Estimates of average degree of dominance $(\delta^2 g/ \delta^2 s)^{0.5}$ exhibited partial dominance for days to 50% flowering, days to maturity, biological yield per plant, harvest index, spike length, seed germination in percent, seedling length, and seed yield per plant suggesting there by the preponderance of additive type of gene action with partial dominance in the expression of these characters in this crop. Over dominance was observed for plant height, seedling dry weight and seed vigour index indicated that gene action is fixable and these characters played an important role for population improvement in this crop. Magnitude of δ^2s was recorded higher than δ^2g for all the traits except seed germination in percent and seed yield per plant, indicated that the average degree of dominance was found to be dominance. These findings in respect to several characters are in close conformity with Manga et al. (1984), Wani, et al. (2013), Mishra et al. (2014), Chauhan et al. (2018) and Deep et al. (2019).

The general combining ability effects of the parents were compared with mean values for all the characters and presented in Table-5. In this investigation, the parents among the lines, CSAOFSC12-2 was identified as good combiner for days to flowering. Parent CSAOFSC11-5 appeared as good combiner for days to flowering. Genotypes namely, NDO25 and CSAOFSC11-4 were found to be good general combiner for seedling length . Line CSAOFSC11-1 for days to maturity and plant height. Parent CSAOFSC12-1 expressed their ability as good general combiner for plant height, seedling dry weight per plant and seed vigour index.OS344 was considered as desirable good general combiner for plant height, harvest index and seed yield per plant. Parent namely, JHO3-91 good general combiner for biological yield per plant, seedling length, seedling dry weight per plant, seed vigour index and seed yield per plant. Line OS1 appeared as good general combiner for harvest index. Among the testers Kent was showed their ability as good general combiner for days to maturity, harvest index, seedling dry weight per plant and seed vigour index. Male parent namely, JHO2007-2 had their ability as good general combiner for biological yield per plant and seedling length. Tester ANDO2 emerged as good general combiner for plant height, biological yield per plant, spike length and seed yield per plant. Similar results for the various traits have also been reported by Pixley et al. (1991), Ruwali and Deo (2009), Valerio et al. (2009), Wani, et al. (2013) Chauhan et al. (2018) and Deep et al. (2019).

On the basis of overall performance both general combining ability effects and per se performance among the lines and testers the lines namely, CSAOFSC12-2, CSAOFSC and JHO3-91 were identified as good general combiner for maximum characters including seed yield per plant followed by OS344, OS1, CSAOFSC11-4, CSAOFSC11-1, NDO25 and CSAOFSC12-1 and ANDO1 for three and two characters whereas among the testers Kent was found as good general combiner for six characters including days to maturity while remaining two testers namely, JHO2007-2 and ANDO2 were appeared as general combiner for five traits. These parents may be handled in suitable breeding *visa-vis* selection breeding for improvement productivity of seed yield and per unit area in this crop. High general combining ability effects showed for different characters of economic importance may be useful for sorting out standing parents with favourable alleles for the different components of yield. Specific combining ability effect represent dominance and epistasis component of variation which are non fixable and hence, specific combining ability effect would not tangibly to the improvement in self-pollinated crops except in cases where commercial exploitation of heterosis is feasible. To confirm whether the crosses selected on the basis of specific combining ability effects were the best performing ones, the superior crosses on the basis of mean performance and specific combining ability effect were selected. In general, *sca* effects do not make any worthwhile contributions in the improvement of self-fertilizing crops except where there is possibility of commercial exploitation of heterosis. Breeder’s interest normally, however, rests in obtaining transgressive segregants through crosses in order to produce homozygous lines in autogamous crops. Jinks and Jones (1958) further emphasized that superior *per se* performance of the hybrids may not indicate their ability to produce transgressive segregants due to close correspondence between heterosis and non-additive gene effects. Therefore, study of specific combining ability in segregating generation would be a better preposition for heterosis breeding. The specific combining ability effects and *per se* performance of crosses is given in Table 6.

Magnitude of Heterobeltiosis

Out of the thirty F_1's, only six cross combinations namely, ANDO1 x JHO2007-2, CSAOFSC12-2 x ANDO2, CSAOFSC11-4 x ANDO2, OS344 x ANDO2, JHO3-91 x ANDO2 and OS1 x ANDO2 were showed significant and positive specific combining ability effects indicated that these combinations were found to be as good specific combiners as had significant and positive specific combining ability effects which proved as good specific combiners for *per se* performance for seed yield per plant. For instance the cross combinations namely, OS1 x JHO2007-2 had high and desirable specific combining ability effects for biological yield per plant and spike length and ANDO1 x JHO2007-2, CSAOFSC12-2 x ANDO2, OS344 x ANDO2, JHO3-91 x ANDO2 and OS1 x ANDO2 were also found as good and desirable specific cross combinations for days to maturity, plant height, biological yield per plant, harvest index, spike length, seed germination in percent, seedling length and seed vigour index. These results almost characters were also supported by Manga et al. (1984), Ruwali and Deo (2009), Valerio et al. (2009), Razvi et al. (2013), Wani, et al. (2013), Chauhan et al. (2018) and Deep et al. (2019).

On the basis of overall results and per se performance of F_1's like, OS1x ANDO2, JHO3-91 x ANDO2, OS344 x ANDO2, CSAOFSC11-5 x ANDO2, CSAOFSC12-2 x ANDO2, ANDO1 x JHO2007-2 and CSAOFSC11-4 x ANDO2 were proved to be as good specific combiners for more number of characters including seed yield per plant for maximum to single contributing traits, which may be utilized for obtaining transgressive segregants in the next generation. Breeding for homozygous line by routine pedigree method could mean only partial exploitation of additive genetic variance in order to exploit different type of gene action in a population. It is suggested that a breeding procedure which may accumulate the fixable type of gene effect and at the same time maintains considerable heterozygosity for exploiting the dominance gene effect, might prove most beneficial in improving the population under present study.

In the present investigation better parent has been worked out. Higher yield is desirable, which is reflected by positive heterosis. Yield being the most important yield component entails positive heterosis for better high yielding cultivars. The range of heterosis and number of crosses showing significant desirable heterosis over better parent for *per se* performance has been presented in Table-7.Higher magnitude of heterosis and *per se* performance was exhibited significant and positive desirable heterosis over better parent manifested in cross combinations namely, OS344 x ANDO2, followed by CSAOFSC11-4 x Kent, OS344 x Kent ANDO1 x JHO2007-2 and CSAOFSC11-4 x ANDO2 for seed yield per plant. These cross combinations were also showed more heterotic performance for days to maturity, biological yield per plant, harvest index, spike length, seed germination in percent seedling length, seedling dry weight per plant and seed vigour index were identified for the recombination breeding. These results almost characters were also supported by Prajapati et al., (2009), Ruwali and Deo (2009), Verma and Singh (2010), Wani, et al. (2013), Mishra et al. (2014), Chauhan et al. (2018) and Deep et al. (2019).

Table 1: General ANOVA for seed yield and its components characters in oat

Source of Variation	D.F.	DF	DM	PH(cm)	BYPP(g)	HI (%)	SL(cm)	SG (%)	SLL(cm)	SLDWP P(g)	SVI	SYPP(g)
Replication	2	0.33	1.14	9.93	4.59	55.20	0.19	0.64	1.45	0.0000	0.20	0.07
Treatment	42	12.84**	15.21**	240.49**	2.25**	68.00**	42.39**	11.88**	31.34**	0.0001**	0.87**	0.55**
Error	84	0.53	0.58	9.66	0.27	5.33	4.38	0.31	1.16	0.0000	0.04	0.02

Table 2: Analysis of variance for seed yield and its components in oat

Source of variance	D.F.	DF	DM	PH(cm)	BYPP(g)	HI (%)	SL(c)	SG(%)	SLL(cm)	SLDWPP(g)	SVI	SYPP(g)
Replication	2	0.31	1.15	9.92	0.59	5.21	0.19	0.64	1.45	0.0000	0.19	0.07
Treatment	42	12.84**	15.21**	240.49**	2.25**	68.00**	42.39**	11.88**	31.34**	0.0001**	0.87**	0.55**
Parents	12	10.28**	10.80**	188.10**	0.38	15.91**	36.81**	1.00*	28.69**	0.0002**	1.03**	0.19**
Lines	9	10.44**	11.96**	169.35**	0.33	13.28**	34.31**	1.13**	37.11**	0.0002**	1.14**	0.20**
Testers	2	7.44**	3.44**	84.78**	0.78**	28.82**	2.11**	0.89	3.54**	0.0000	0.06	0.20**
L x T	1	14.44**	15.13**	563.50**	0.08	13.73**	128.67**	0.02	3.16**	0.0003**	1.93**	0.14**
Crosses	29	13.34**	16.54**	122.98**	3.00**	68.27**	43.00**	13.33**	32.53**	0.0001*	0.77**	0.56**
Parent vs Crosses	1	29.09**	29.44**	4277.00**	3.01**	685.48**	91.96**	100.30**	28.64**	0.0004**	1.82**	4.57**
Error	84	0.53	0.58	9.66	0.27	5.33	4.38	0.31	1.16	0.0000	0.04	0.02

*** Significant at 5%, ** Significant at 1% level, respectively**

Table 3: Analysis of variance for combining ability of seed yield and its components in oats

Source of variance	D.F.	DF	DM	PH(cm)	BYPP(g)	HI (%)	SL(c)	SG (%)	SLL(cm)	SLDWPP(g)	SVI	SYPP(g)
Replication	2	0.42	0.67	20.22	3.19	38.59	0.43	0.24	1.51	0.0000	0.13	0.07
GCA (Line)	9	6.25**	12.63**	82.96**	2.06**	65.65**	54.10**	11.75**	36.82**	0.0001**	0.98**	0.67**
GCA (Tester)	2	51.60**	38.15**	215.20**	17.73**	94.29**	57.90**	31.39**	5.85**	0.0001**	0.60**	1.85**
SCA	18	12.64**	16.09**	132.74**	1.83**	66.68**	35.79**	12.12**	33.35**	0.0001**	0.68**	0.37**
Error	58	0.47	0.49	9.80	0.28	4.98	4.50	0.29	1.13	0.0000	0.04	0.02

***, ** significant at 5% and 1% level, respectively**

Table 4: Estimates of components of variance, degree of dominance, its ratio (σ2g /σ2s) for twenty traits in oat

Components	DF	DM	PH(cm)	BYPP(g)	HI (%)	SL(c)	SG (%)	SLL(cm)	SLDWPP(g)	SVI	SYPP(g)
σ2g (A)	10.28	10.80	188.10	0.38	15.91	36.81	1.00	28.69	0.0002	1.03	0.19
σ2s (D)	13.34	16.54	122.98	3.00	68.27	43.00	13.33	32.53	0.0001	0.77	0.56
σ2g/σ2s	0.77	0.65	1.52	0.12	0.23	0.85	0.07	0.88	2.00	1.33	0.33
(σ2g/σ2s)0.5	0.87	0.80	1.23	0.35	0.48	0.92	0.27	0.93	1.41	1.15	0.58
σ2g (L)	10.44	11.96	169.35	0.33	13.28	34.31	1.13	37.11	0.0002	1.14	0.20
σ2g (T)	7.44	3.44	84.78	0.78	28.82	2.11	0.89	3.54	0.0000	0.06	0.20
σ2s(LxT)	13.34	16.54	122.98	3.00	13.73	128.67	0.02	3.16	0.0003	1.93	0.14
					15.91	36.81	1.00	28.69	0.0002	1.03	0.19

Table 5: Estimate of GCA effects and *per se* performance of parents for seed yield and its components in oat

Characters/Parents	DF		DM		PH(cm)		BYPP(g)		HI (%)		SL(cm)	
	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean
CSAOFSC12-2	-1.37**	86.00	0.18	113.00	1.92*	134.67	0.08	9.67	-3.35**	38.17	-1.97**	31.67
CSAOFSC11-5	-0.37*	86.33	0.07	114.00	-1.52	148.00	-0.03	10.00	0.98	37.77	-3.52**	32.67
NDO25	0.08	87.67	0.96**	107.67	-2.41**	152.00	0.31	9.83	-1.52	43.76	-0.86	27.33
CSAOFSC 11-4	0.30	87.67	1.84**	113.67	1.26	145.67	-0.03	9.75	-3.07**	40.30	5.59**	28.00
CSAOFSC 11-1	-0.37*	88.00	-1.93**	112.33	3.70**	146.67	-0.69**	9.07	-0.87	43.20	1.26	35.33
CSAOFSC 12-1	-0.59**	88.00	1.07**	114.00	1.70*	142.00	0.39**	9.67	0.94	39.87	0.92	32.00
OS 344	1.52**	90.33	-0.27	113.00	2.70**	131.67	-0.50**	9.77	3.35**	42.81	-0.63	37.00
ANDO-1	0.52*	87.67	-0.04	115.00	-6.74**	135.67	-0.25	9.67	1.04	41.77	0.48	28.00
JHO3-91	0.86**	92.00	-0.04	113.67	-0.41	132.33	0.97**	10.33	-2.26**	40.42	0.37	30.67
OS1	-0.59	86.33	-1.82**	113.33	-0.19	133.33	-0.25	10.07	4.76**	42.73	-1.63**	35.33
Mean		**88.00**		**112.96**		**140.20**		**9.78**		**41.08**		**25.46**
SE (d)	0.18		0.19		0.83		0.14		0.59		0.56	
CD5%		0.37		0.39		1.70		0.29		1.21		1.15
Kent (T1)	-1.20**	90.00	-1.30**	114.00	-1.41*	145.67	-0.85**	10.00	1.67**	39.17	0.70	36.00
JHO2007-2(T2)	-0.20	87.67	0.70**	115.67	-1.68*	146.67	0.19*	10.33	-1.86**	42.99	-1.60**	35.33
ANDO-2 (T3)	1.40**	90.67	0.60**	113.67	3.09**	155.33	0.65**	9.33	0.19	45.30	0.90*	37.00
Mean		89.44		114.44		149.22		9.88		42.48		36.11
S.Ed. (±)	0.09		1.143		0.05		0.67		0.26		0.07	
CD at 5%		0.25		0.25		1.08		0.19		4.04		3.57

Table 5: Cont….

Characters/Parents	SG (%)		SLL(cm)		SLDWPP(g)		SVI		SYPP(g)	
	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean
CSAOFSC 12-2	-1.02**	80.33	-1.25**	25.27	0.01	0.03	-0.24**	2.17	1.36**	3.82
CSAOFSC 11-5	-0.39*	80.43	1.32**	19.23	0.01	0.02	-0.40**	1.77	1.15*	3.78
NDO25	0.36*	81.08	-1.73**	22.53	0.01	0.03	0.06	2.38	-0.05	4.59
CSAOFSC 11-4	0.13	80.33	-1.41**	21.37	0.00	0.03	-0.03	1.98	1.31**	3.92
CSAOFSC11-1	0.80**	80.03	-0.45	18.43	0.00	0.03	-0.08	2.53	0.33**	3.88
CSAOFSC12-1	-2.07**	79.60	-0.77*	21.80	0.00	0.04	0.33**	3.19	0.21**	3.84
OS 344	-0.98**	81.83	3.12**	19.60	0.00	0.02	-0.43**	1.96	0.13**	4.16
ANDO-1	0.76**	80.67	-1.68**	18.60	0.00	0.03	0.00	2.02	-0.02	4.04
JHO3-91	1.94**	80.60	3.78**	29.57	0.01	0.05	0.66**	3.60	0.08*	4.17
OS1	0.70	80.20	-0.93**	19.40	0.00	0.02	0.13	1.74	0.49**	4.30
Mean		**80.51**		**21.58**		**0.02**		**2.38**		**4.05**
SE (d)	0.14		0.28		0.001		0.05		0.04	
CD5%		0.29		0.57		0.001		0.10		0.08
Kent (T1)	0.47**	80.20	-0.30	21.37	0.00	0.03	0.14**	1.97	-0.17**	3.92
JHO2007-2(T2)	-0.66**	80.00	0.51*	23.47	0.00	0.02	0.01	1.73	-0.12**	4.44
ANDO-2 (T3)	1.18**	81.07	-0.20	21.93	0.00	0.02	-0.15**	1.71	0.29**	4.22
Mean		80.42		22.25		0.02		1.80		4.19
S.Ed. (±)	0.13		0.00		0.02		0.02		003	
CD at 5%		0.48		1.92		0.01		0.39		0.15

Table 6: Estimates of SCA effects of $F_{1,s}$ and their *per se* performance for seed yield and its components in oat

S N	Characters/ Crosses	DF		DM		PH(cm)		BYPP(g)		HI (%)		SL(cm)	
		SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean
1	CSAOFSC12-2 x Kent	-0.53*	87.33	1.86**	113.00	2.92*	127.33	-0.04	9.33	6.39	36.09	-0.37	33.00
2	CSAOFSC11-5 x Kent	0.53*	88.33	8.14**	110.00	7.68**	137.67	6.98**	9.33	5.88**	37.05	0.60	31.67
3	NDO 25 x Kent	-1.07**	88.33	1.29**	114.33	-4.76**	130.00	5.12**	12.00	7.26**	25.97	-0.23	33.33
4	CSAOFSC11-4 x Kent	3.87**	91.67	-0.70	110.33	12.19**	139.00	0.07	9.33	0.98	40.02	8.19**	36.00
5	CSAOFSC11-1 x Kent	-0.13	88.67	-0.70	112.33	-1.54	125.00	-0.97**	9.33	2.04*	37.55	0.82	30.33
6	CSAOFSC12-1 x Kent	-7.73**	86.67	1.40**	114.33	10.64**	120.67	4.90**	11.67	3.02**	34.54	10.01**	27.00
7	OS344 x Kent	0.76*	89.00	0.41	112.33	-5.92**	120.00	0.07	9.67	1.67	38.20	4.19**	38.67
8	ANDO1 x Kent	2.42**	91.67	-0.59	113.33	-3.99**	121.67	-0.31	10.33	1.72*	34.73	-3.51**	28.67
9	JO03-91 x Kent	-3.18**	87.67	0.18	114.00	9.91**	140.33	0.24	11.33	-3.39**	31.66	-0.68	34.00
10	OS1 x Kent	-0.13	88.33	-1.14**	111.67	2.08	131.67	-0.26	9.00	1.84*	36.82	-4.26**	36.67
11	CSAOFSC12-2 x JHO2007-2	0.87*	90.33	-0.14	114.67	-3.32**	126.00	0.03	10.33	1.40	32.85	-1.62	37.00
12	CSAOFSC11-5 x JHO2007-2	-6.73*	90.33	1.29**	116.00	1.24	135.33	0.24	11.00	3.24**	30.27	8.88**	47.00
13	NDO 25 x JHO2007-2	-0.47	87.33	-1.03**	108.00	0.97	133.00	0.40	9.00	1.56	38.75	-0.59	36.00
14	CSAOFSC11-4 x JHO2007-2	-0.47	88.33	-2.70**	108.33	-3.43**	128.33	-0.31	9.33	2.15*	35.81	0.04	34.33
15	CSAOFSC11-1 x JHO2007-2	0.93*	91.33	3.73**	114.67	2.47*	139.00	-0.10	10.00	3.71**	32.00	0.54	37.33
16	CSAOFSC12-1 x JHO2007-2	-1.24**	86.33	-0.03	112.00	-1.03	129.00	1.99**	10.67	7.01**	31.98	-1.59	34.67
17	OS344 x JHO2007-2	0.09	88.67	0.30	114.33	6.57**	136.33	-0.39	10.33	0.91	36.38	-2.62**	31.33
18	ANDO1 x JHO2007-2	1.16**	91.33	-0.27	113.67	-5.53**	129.00	-0.60**	10.58	8.10**	43.63	4.21**	40.67
19	JO03-91 x JHO2007-2	-0.69	89.00	1.63**	112.33	1.63	132.67	-0.21	8.58	-0.90	40.51	0.63	35.33
20	OS1 x JHO2007-2	-0.02	90.67	0.30	113.00	-7.10**	123.67	2.50*	10.33	8.97**	33.91	3.27**	35.67
21	CSAOFSC12-2 x ANDO2	0.71	93.00	-1.93**	110.67	5.47**	141.00	-0.29	10.00	4.86**	44.79	-3.90**	31.00
22	CSAOFSC11-5 x ANDO2	-1.69**	87.00	-1.59**	109.33	3.08**	124.67	-0.38	8.67	3.12**	42.21	1.19	37.00
23	NDO 25 x ANDO2	-1.36**	88.33	2.08**	115.00	-0.32	121.00	6.92**	11.00	-3.17**	29.39	0.49	34.00
24	CSAOFSC11-4 x ANDO2	3.04**	94.33	-0.49	112.33	-2.76	123.33	-0.54*	10.00	8.05**	40.67	9.68	34.33
25	CSAOFSC11-1 x ANDO2	-0.36	88.67	1.41**	112.33	-4.59**	123.33	-0.93**	9.33	0.91	36.70	-4.03**	31.67
26	CSAOFSC12-1 x ANDO2	-1.69**	88.33	0.08	113.00	1.34	129.00	1.03**	12.33	9.68**	27.58	1.93*	35.33
27	OS344 x ANDO2	2.04**	93.67	-1.49**	111.33	3.24**	135.67	-0.10	11.67	8.77**	38.08	2.10*	38.00
28	ANDO1 x ANDO2	-0.58	87.00	-0.81*	108.33	-5.48**	122.67	0.29	9.33	-3.56**	39.26	0.63	34.33
29	JO03-91 x ANDO2	-0.24	88.33	4.52**	115.67	4.12**	132.00	0.58**	10.67	0.71	40.00	0.60	32.00
30	OS1 x ANDO2	0.82*	91.00	-8.71**	107.33	1.36	134.00	-0.88**	9.67	5.84**	44.18	-1.23	32.67
	mean		**89.36**		**112.26**		**130.5**		**10.13**		36.38		34.63
SE		0.26	0.56	0.26	0.57	1.17	0.34	0.20	0.43	0.26		0.79	1.73
CD5%		0.53	1.12	0.53	1.15	2.39	0.68	0.41	0.86		4.04	1.62	3.48

Table 6: Cont…..

SN	Characters/ Crosses	SL(cm)		SG(%)		SLL(cm)		SLDWPP(g)		SVI		SYPP(g)	
		SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean
1	CSAOFSC12-2 x Kent	-0.37	33.00	0.54*	80.20	2.65**	21.80	0.00	0.022	-0.05	1.79	0.22**	3.37
2	CSAOFSC11-5 x Kent	0.60	31.67	0.09	82.67	-0.30	19.67	0.00	0.019	-0.12	1.60	1.56**	3.45
3	NDO 25 x Kent	-0.23	33.33	0.45*	81.33	2.35**	16.90	0.00	0.021	1.17*	1.73	1.40**	3.12
4	CSAOFSC11-4 x Kent	8.19**	36.00	-0.29	81.08	8.86**	17.87	0.00	0.020	-0.09	1.59	0.06	3.72
5	CSAOFSC11-1 x Kent	0.82	30.33	2.54**	80.67	1.19**	23.73	0.00	0.018	-0.05	1.52	1.20**	3.50
6	CSAOFSC12-1 x Kent	10.01**	27.00	4.83**	84.33	9.67**	24.50	0.00	0.018	1.14*	1.55	0.14	4.25
7	OS344 x Kent	4.19**	38.67	-0.12	82.00	1.99**	20.67	0.00	0.026	-0.04	2.10	1.23**	3.69
8	ANDO1 x Kent	-3.51**	28.67	2.71**	84.67	-1.75**	17.73	0.00	0.021	-0.21**	1.81	0.10	3.60
9	JO03-91 x Kent	-0.68	34.00	-0.59**	81.67	-0.24	18.53	0.00	0.026	1.26**	2.12	-0.33**	3.58
10	OS1 x Kent	-4.26**	36.67	-1.56**	80.33	-0.03	18.97	0.00	0.022	-0.29**	1.77	1.12*	3.32
11	CSAOFSC12-2 x JHO2007-2	-1.62	37.00	-1.73**	82.00	-2.21**	17.60	0.00	0.019	-0.35**	1.59	0.74**	3.48
12	CSAOFSC11-5 x JHO2007-2	8.88**	47.00	6.30**	85.33	2.24**	21.33	0.01**	0.028	1.64**	2.42	-0.35**	3.30
13	NDO 25 x JHO2007-2	-0.59	36.00	-0.56**	82.00	4.25**	15.70	0.00	0.028	1.26**	2.27	0.81**	3.49
14	CSAOFSC11-4 x JHO2007-2	0.04	34.33	-0.07	84.33	-1.23**	19.53	0.00	0.023	0.08	1.97	0.11	3.33
15	CSAOFSC11-1 x JHO2007-2	0.54	37.33	0.63**	83.33	5.48**	25.53	0.00	0.017	-0.34**	1.39	-0.43**	3.20
16	CSAOFSC12-1 x JHO2007-2	-1.59	34.67	0.64**	80.33	-0.17	19.47	0.01**	0.037	1.58**	3.00	-0.42**	3.30
17	OS344 x JHO2007-2	-2.62**	31.33	-1.87**	79.67	0.25	20.70	0.00	0.027	-0.17*	2.12	-0.02	3.75
18	ANDO1 x JHO2007-2	4.21**	40.67	1.23**	81.07	-0.07	19.67	-0.01**	0.021	-0.41**	1.73	0.84**	4.61
19	JO03-91 x JHO2007-2	0.63	35.33	0.88**	81.67	2.74**	26.27	0.00	0.018	-0.21**	1.44	-0.17*	3.47
20	OS1 x JHO2007-2	3.27**	35.67	0.04	82.67	-2.84**	21.50	0.00	0.019	0.04	1.57	-0.19*	3.50
21	CSAOFSC12-2 x ANDO2	-3.90**	31.00	-0.92**	80.00	0.10	23.73	0.00	0.019	0.77*	1.55	0.86**	4.45
22	CSAOFSC11-5 x ANDO2	1.19	37.00	1.82**	84.33	-1.96**	16.77	0.00	0.022	-0.23**	1.86	0.17*	3.65
23	NDO 25 x ANDO2	0.49	34.00	2.64**	85.00	3.06**	22.60	0.00	0.025	0.96*	2.13	-0.30**	3.23
24	CSAOFSC11-4 x ANDO2	9.68	34.33	-2.46**	80.20	-1.10**	17.73	0.00	0.023	0.07	1.87	0.13*	4.07
25	CSAOFSC11-1 x ANDO2	-4.03**	31.67	0.63**	84.33	2.98**	27.17	0.01**	0.041	0.71**	3.46	-0.17*	3.42
26	CSAOFSC12-1 x ANDO2	1.93*	35.33	2.13**	87.67	3.70**	28.70	-0.01**	0.025	-0.41**	2.22	-0.23**	3.40
27	OS344 x ANDO2	2.10*	38.00	-2.76**	81.08	6.69**	17.60	0.00	0.027	-0.30**	2.16	0.40**	4.44
28	ANDO1 x ANDO2	0.63	34.33	-0.90**	81.33	-0.07	19.40	-0.01**	0.020	-0.62**	1.60	-0.35**	3.65
29	JO03-91 x ANDO2	0.60	32.00	2.60**	86.67	0.12	20.40	0.01**	0.037	1.03**	3.12	1.20**	4.27
30	OS1 x ANDO2	-1.23	32.67	-1.70**	80.67	-0.04	19.53	0.00	0.019	0.41**	1.53	0.12*	4.57
	Mean		34.63		82.42		20.71		0.023		1.95		3.67
SE		0.79	1.73		0.20	0.40	0.87		0.00	0.07	0.15		0.06
CD at 5%		1.62	3.48		0.41	0.82	1.74		0.00	0.14	0.31		0.12

Table 7: Estimates of Heterosis (%) for Better parents for yield and its components in oats

Sl.no.	Characters/ Crosses	DF		DM		PH(cm)		BYPP(g)		HI (%)		SL(cm)		SG (%)	
		BP	Mean	BP	Mean	BP	Mean	BP	Mean	BP	Mean	BP	Mean	BP	Mean
1	CSAOFSC12-2 x Kent	6.55*	87.33	0.60	113.00	12.59**	127.33	6.67**	9.33	-7.86**	36.09	8.33**	33.00	-0.17	80.20
2	CSAOFSC12-2 x JHO2007-2	6.71**	88.33	5.65**	110.00	-6.14*	137.67	9.68**	9.33	13.82**	37.05	10.38**	31.67	1.97**	82.67
3	CSAOFSC12-2 x ANDO2	5.71**	88.33	1.18	114.33	16.31**	130.00	14.14*	12.00	12.68**	25.97	-9.91**	33.33	1.24**	81.33
4	CSAOFSC11-5 x Kent	6.18**	91.67	-5.22**	110.33	-6.08*	139.00	-6.67**	9.33	2.17	40.02	4.00**	36.00	0.81	81.08
5	CSAOFSC11-5 x JHO2007-2	6.70**	88.67	-1.46*	112.33	15.54**	125.00	-9.68**	9.33	-12.66**	37.55	14.15**	30.33	-0.49	80.67
6	CSAOFSC11-5 x ANDO2	0.39	86.67	0.59	114.33	-02.32**	120.67	16.67**	11.67	13.77**	34.54	2.03**	27.00	4.85**	84.33
7	NDO 25 x Kent	1.52**	89.00	12.33**	112.33	-1.05**	120.00	-3.33**	9.67	-10.71**	38.20	7.41**	38.67	1.13**	82.00
8	NDO 25 x JHO2007-2	7.56**	91.67	9.26**	113.33	-1.96**	121.67	1.00	10.33	10.64**	34.73	10.87**	28.67	4.42**	84.67
9	NDO 25 x ANDO2	0.00	87.67	10.88**	114.00	-9.66**	140.33	15.25**	11.33	10.11**	31.66	-8.11**	34.00	0.72	81.67
10	CSAOFSC11-4 x Kent	0.76	88.33	-1.76**	111.67	-9.61**	131.67	10.00**	9.00	-8.64**	36.82	11.85**	36.67	0.00	80.33
11	CSAOFSC11-4 x JHO2007-2	3.04**	90.33	0.88	114.67	-14.09**	126.00	1.10	10.33	13.60**	32.85	4.72**	37.00	1.15**	82.00
12	CSAOFSC11-4 x ANDO2	3.04**	90.33	2.05**	116.00	12.88**	135.33	12.82**	11.00	13.18**	30.27	12.03**	47.00	6.22**	85.33
13	CSAOFSC11-1 x Kent	-0.76	87.33	-3.86**	108.00	-9.32**	133.00	10.00**	9.00	10.30**	38.75	0.90	36.00	2.46**	82.00
14	CSAOFSC11-1 x JHO2007-2	0.76	88.33	-3.56**	108.33	12.50**	128.33	-9.68**	9.33	17.10**	35.81	-2.83	34.33	4.03**	84.33
15	CSAOFSC11-1 x ANDO2	8.79**	91.33	2.08**	114.67	10.52**	139.00	7.14**	10.00	-09.37**	32.00	0.90	37.33	3.73**	83.33
16	CSAOFSC12-1 x Kent	-1.89**	86.33	-1.75*	112.00	11.44**	129.00	6.67**	10.67	9.79**	31.98	-3.70	34.67	0.42	80.33
17	CSAOFSC12-1 x JHO2007-2	1.14	88.67	0.29	114.33	-7.05**	136.33	1.00	10.33	15.39**	36.38	11.32**	31.33	1.73**	79.67
18	CSAOFSC12-1 x ANDO2	3.79**	91.33	0.00	113.67	16.95**	129.00	9.48**	10.58	-3.70	43.63	9.91**	40.67	0.91	81.07
19	OS344 x Kent	-1.11	89.00	-0.59	112.33	-8.92**	132.67	14.17**	8.58	5.37**	40.51	-4.50*	35.33	-0.20	81.67
20	OS344 x JHO2007-2	3.42**	90.67	0.00	113.00	15.68**	123.67	0.00	10.33	11.14**	33.91	-3.60	35.67	1.02**	82.67
21	OS344 x ANDO2	5.95**	93.00	-2.06**	110.67	-9.23**	141.00	2.39**	10.00	-1.13	44.79	10.22**	31.00	-2.24**	80.00
22	ANDO1 x Kent	-0.76	87.00	-6.09**	109.33	14.42**	124.67	13.33**	8.67	1.05	42.21	2.78	37.00	4.55**	84.33
23	ANDO1 x JHO2007-2	0.76	88.33	0.00	115.00	-17.50**	121.00	6.45**	11.00	11.64**	29.39	-3.77	34.00	4.85**	85.00
24	ANDO1 x ANDO2	10.60**	94.33	-1.17	112.33	-11.60**	123.33	3.45**	10.00	10.23**	40.67	-7.21**	34.33	-0.58	80.20
25	JH03-91 x Kent	-1.48*	88.67	-1.17	112.33	-5.33**	123.33	-9.68**	9.33	-9.20**	36.70	-12.04**	31.67	4.63**	84.33
26	JHO3-91 x JHO2007-2	0.76	88.33	-0.59	113.00	-2.05**	129.00	10.35**	12.33	15.84**	27.58	7.00**	35.33	8.14**	87.67
27	JHO3-91 x ANDO2	3.31**	93.67	-2.05**	111.33	-2.66**	135.67	12.90**	11.67	10.94**	38.08	12.70**	38.00	0.60	81.08
28	OS1 x Kent	0.77	87.00	-7.41**	108.33	-5.79**	122.67	-7.28**	9.33	-8.14**	39.26	-4.63*	34.33	1.41**	81.33
29	OS1 x JHO2007-2	2.32**	88.33	2.06**	115.67	-1.00**	132.00	3.23**	10.67	6.97**	40.00	-9.43**	32.00	6.91**	86.67
30	OS1 x ANDO2	5.41**	91.00	-5.29**	107.33	-1.73**	134.00	3.97**	9.67	-2.48	44.18	11.71**	32.67	0.41	80.67
S.Ed.(±)		0.60	**89.36**	0.62	**112.26**	2.54	**130.5**	0.42	**10.13**	1.88	36.38	1.71	34.63	0.45	82.42
CD at 5%		1.22	0.56	1.27	0.57	5.19	0.34	0.87	0.43	3.84	1.82	3.50	1.73	0.93	0.20

Sl.no.	Characters/ Crosses	SLL(cm)		SLDWPP(g)		SVI		SYPP(g)	
		BP	Mean	BP	Mean	BP	Mean	BP	Mean
1	CSAOFSC12-2 x Kent	13.72**	21.80	7.28**	0.022	7.51**	1.79	14.04**	3.37
2	CSAOFSC12-2 x JHO2007-2	12.16**	19.67	8.40**	0.019	6.27**	1.60	-2.24**	3.45
3	CSAOFSC12-2 x ANDO2	-3.11**	16.90	10.99**	0.021	2.12**	1.73	-6.15**	3.12
4	CSAOFSC11-5 x Kent	10.38**	17.87	10.27**	0.020	9.26**	1.59	4.94**	3.72
5	CSAOFSC11-5 x JHO2007-2	11.14**	23.73	8.18**	0.018	14.15**	1.52	11.11**	3.50
6	CSAOFSC11-5 x ANDO2	11.70**	24.50	6.67**	0.018	12.45**	1.55	6.71**	4.25
7	NDO 25 x Kent	-8.28**	20.67	-2.50**	0.026	10.62**	2.10	12.48**	3.69
8	NDO 25 x JHO2007-2	14.43**	17.73	7.27**	0.021	3.95**	1.81	-2.51**	3.60
9	NDO 25 x ANDO2	7.75**	18.53	-1.36**	0.026	-10.78**	2.12	-2.88**	3.58
10	CSAOFSC11-4 x Kent	-11.23**	18.97	-10.81**	0.022	-10.92**	1.77	15.32**	3.32
11	CSAOFSC11-4 x JHO2007-2	-5.00**	17.60	11.62**	0.019	-12.00**	1.59	-2.49**	3.48
12	CSAOFSC11-4 x ANDO2	-2.74**	21.33	14.86**	0.028	2.02**	2.42	-2.80**	3.30
13	CSAOFSC11-1 x Kent	-6.52**	15.70	-1.63**	0.028	10.53**	2.27	10.89**	3.49
14	CSAOFSC11-1 x JHO2007-2	6.76**	19.53	6.32**	0.023	2.37**	1.97	12.87**	3.33
15	CSAOFSC11-1 x ANDO2	10.41**	25.53	7.37**	0.017	-5.13**	1.39	-2.17**	3.20
16	CSAOFSC12-1 x Kent	10.70**	19.47	-6.67**	0.037	-5.86**	3.00	15.74**	3.30
17	CSAOFSC12-1 x JHO2007-2	-11.79**	20.70	-3.33**	0.027	-3.37**	2.12	15.48**	3.75
18	CSAOFSC12-1 x ANDO2	-10.33**	19.67	-6.67**	0.021	5.71**	1.73	9.24**	4.61
19	OS344 x Kent	8.93**	26.27	-8.38**	0.018	6.86**	1.44	10.73**	3.47
20	OS344 x JHO2007-2	-8.38**	21.50	10.83**	0.019	-3.03**	1.57	-2.11**	3.50
21	OS344 x ANDO2	8.21**	23.73	-9.44**	0.019	1.22**	1.55	5.53**	4.45
22	ANDO1 x Kent	-1.53	16.77	12.00**	0.022	-7.93**	1.86	9.73**	3.65
23	ANDO1 x JHO2007-2	3.69**	22.60	7.00**	0.025	5.45**	2.13	7.12**	3.23
24	ANDO1 x ANDO2	11.15**	17.73	6.67**	0.023	7.27**	1.87	3.63**	4.07
25	JH03-91 x Kent	-8.12**	27.17	8.21**	0.041	3.80**	3.46	10.00**	3.42
26	JHO3-91 x JHO2007-2	-2.93**	28.70	13.28**	0.025	-8.28**	2.22	-3.37**	3.40
27	JHO3-91 x ANDO2	-4.47**	17.60	-9.30**	0.027	-9.85**	2.16	5.13**	4.44
28	OS1 x Kent	-9.20**	19.40	10.27**	0.020	8.92**	1.60	10.18**	3.65
29	OS1 x JHO2007-2	13.07**	20.40	6.67**	0.037	9.85**	3.12	-3.83**	4.27
30	OS1 x ANDO2	10.94**	19.53	-13.64**	0.019	-11.71**	1.53	6.12**	4.57
S.Ed. (±)		0.88	20.71	0.002	0.023	0.16	1.95	0.11	3.67
CD at 5%		1.80	0.87	0.004	0.00	0.33	0.15	0.22	0.06

DF= Days to flowering DM= Days to maturity PH= Plant height (cm), BYPP= Biological yield per plant (g) HI= Harvest Index (%) SL=Spike Length (cm) SG= Seed Germination (%) SLL= Seedling length (cm) SDWPP= Seedling dry weight SVI= Seed Vigour Index SYPP= Seed Yield per Plant (g)

CONCLUSION

The analysis revealed that the CSAOFSC12-2, CSAOFSC and JHO3-91 had significant desirable gca values for maximum traits and was associated with six crosses that exhibited highest sca values. Likewise, OS344 x ANDO2, followed by CSAOFSC11-4 x Kent, OS344 x Kent ANDO1 x JHO2007-2 and CSAOFSC11-4 x ANDO2 displayed maximum value of heterosis for seed yield per plant. Another genotype Kent was found as good general combiner for six characters including days to maturity and was associated with six crosses that exhibited highest sca values. OS344 x ANDO2, followed by CSAOFSC11-4 x Kent, OS344 x Kent ANDO1 x JHO2007-2 and CSAOFSC11-4 x ANDO2 exhibited maximum value of heterosis for seed yield per plant. Hence the three genotypes CSAOFSC12-2, CSAOFSC and JHO3-91 can be used as potential parents for combining desirable traits as well as enhancing the seed yield through heterosis breeding in future oat improvement programmes.

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