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Gene effects and interaction analysis for forage yield and quantitative traits in genus *Avena*

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Abstract

Six generations (P_1, P_2, F_1, F_2, B_1 and B_2) of six crosses involving four diverse parents of oats *viz*., PLP 1, PLP 9. PO 22 and JHO 822 were evaluated for various yield and morphological traits in a compact family randomized block design with two replications at Palampur. The data of six generations were subjected to scaling tests to analyse genetic parameters m, d, h, i, j and l and to detect epistasis. The predominant role of dominant genic effects was observed for most of the traits studied in one or the other cross. In some of the cases, both dominance as well as additive genic effects were present. Plant height at 50 % flowering showed mainly additive genic effect in three of the six crosses. The type of gene action was observed to be trait cross specific. PLP 1 × PLP 9 showed positive heterosis for fresh forage yield and grain yield and the cross JHO 822 × P022 showed positive heterosis for fresh forage yield and dry matter yield. Crosses PLP 1 × PLP 9 and JHO 822 × PO 22 have been observed to be the potential crosses for yield. The cross, PO 22 × PLP 9 can be utilized for developing dual purpose types.

Key words: Oats, generation means, gene action, yield traits, morphological traits

Introduction

Oats (*Avena sativa* L.) are the important cereals in the temperate climates of the world. serving as fodder and feed for cattle and bovine. Oats as fodder crop are of considerable significance in north India as well which can substantially alleviate the fodder shortage of this area. However, increasing population has led to a competition between humans and livestock for foodgrains and fodder which restricted intershifting of area coverage and necessitated intensified efforts towards more efficient forage production through development of high yielding, fast growing and nutritious varieties of fodder crops coupled with improved management practices.

A knowledge of the nature of gene effects for productivity and characters related to it always helps in the choice of effective and efficient breeding methods. Besides high yield, correlated morphological traits are also important for harnessing the yield potential fully. Therefore, in order to have rapid genetic amelioration of oats, the present biometrical investigation was undertaken to study the nature and magnitude of gene action for various yield and morphological attributes and to create variability for recovery of desirable recombinants.

Materials and methods

The material for the present study consisted of four diverse parents of oats *viz*., PLP 1 (Algerian selection). PLP 9 (PLP 1 × Naked oats EC 6415 → F_1 × EC 6415), PO 22 (pedigree not known) and JHO 822 (IGO-8268 × INDIO), their possible six F_1 cross combinations, six F_2S, six B_1s and six B_2S. F_1s were raised during *rabi* 1999-2000 at Palampur to develop F_2, B_1 and B_2 generations as well as during off-season (April to September 2000) at Kukumseri (Lahaul and Spiti) to get sufficient seed of all the generations. Simultaneously, crosses were also attempted to generate F_1s to ensure sufficient seed for final evaluation. The experimental materials (six generations of six crosses) were evaluated in compact family randomized complete block design with two replications, during *rabi* 2000-01 at the Experimental Farm of HPKV, Palampur. The plot size consisted of a row length of 4 metre having row-to-row distance of 30 cm and plant-to-plant distance of 4 cm. Five randomly taken plants in case of parents and their F_1s and twenty plants each in F_2s and back cross generations (B_1 and B_2) in each replication were used for recording the observation on various characters such as number of tillers per plant, number of leaves per plant, days to 50% flowering, plant height at 50 % flowering (cm), fresh forage yield per plant (g) at 50 % flowering, dry matter per plant (g) at 50 flowering and grain yield per plant (g). Estimation of Mather's simple scaling test, Joint scaling test of Cavalli, estimation of genic effects Jinks and Jones were carried out as per in detail by Mather and Jinks [1] using SPAR I programme [2]. Heterosis over better parent for each cross was also estimated trait wise.

Results and discussion

In oats, the most important component which contributes directly towards the high forage yield as well as grain yield is the number of tillers per plant. In the present study (Table 1) dominance genic effects were positive in three crosses, namely, PLP 1 × JHO 822, PLP 1 × PLP 9 and JHO 822 × P022 indicating the predominant role of dominance genic effects for this trait as reported earlier also [3]. In the cross PLP 1 × PLP 9, besides dominance, positive additive × additive and negative dominance × dominance genic effects were also present confirming the earlier reports [4,5]. In this cross, epistasis was of duplicate type, [h] and [l] being of opposite signs. In the above discussed three crosses, though sufficient genetic variability has been generated but considering the nature of gene action, early generation selection may be futile and it would be advisable to delay the selection to later generations in order to improve the yield in oats through tillers per plant.

Number of leaves per plant contributes in both forage and grain yield being the site for photosynthesis. The cross PLP 1 × PLP 9 showed high positive dominance genic effect along with positive additive × additive and negative dominance × dominance non-allelic interaction effects, thereby indicating the presence of duplicate type of epistasis. Dominance genic effect was also observed in the cross PLP 1 × PO 22. The cross PO 22 × PLP 9 showed higher magnitude of dominance genic effect along with positive additive × additive type of interaction. In these crosses, dominance genic effects were more predominant as recorded earlier also in one of the crosses [6]. However, partial dominance was observed for number of leaves per tiller [7]. For leaves per plant also, looking at the nature of genetic variability generated in the above mentioned crosses, the selection in the later generations may prove useful. However, in two of the crosses of JHO 822 with PO 22 and PLP 9, negative additive genic effects were noticed.

The crosses PLP 1 × JHO 822, PLP 1 × PO 22 and PLP 1 × PLP 9 had predominantly positive additive genic effects for days to 50 per cent flowering. These crosses can be profitably used for developing late flowering genotypes through simple selection even in early generations. Dominance genic effect was also appreciable in PLP 1 × JHO 822 cross. Presence of positive and significant dominance genic effect along with duplicate type of epistasis was observed in PO 22 × PLP 9 cross as recorded by some earlier workers also [5, 7]. Selection in this cross for late types may be useful only in the later generations.

Since oats are mainly used as a fodder crop, plant height at 50 per cent flowering directly or indirectly contributes towards high forage yield. More the plant height, higher is the fresh forage yield, and in turn more dry matter yield. Cross combinations *viz.*, PLP 1 × JHO 822, PLP 1 × PO 22 and JHO 822 × PO 22 exhibited, mainly positive additive genic effects for the genetic control of plant height at 50 per cent flowering. Thus, these crosses can be exploited even in early generation through simple selection for tallness. Earlier workers have also reported predominance of additive genic effects for plant height [8, 9]. However, PO 22 × PLP 9 had both negative additive and dominance genic effects as has been reported earlier also in oats [5]. This cross can be utilized for developing dwarf types in future specifically for dual purposes.

Fresh forage yield needs due consideration in a crop like oats which is mainly cultivated as fodder crop in our country. Two of the crosses. PLP 1 × PLP 9 and JHO 822 × PO 22 showed high amount of heterosis over better parent (Table 2). The crosses, PLP 1 × JHO 822. PLP 1 × PLP 9 and JHO 822 × PO 22 had mainly or predominantly dominance genic effects (Table 1) as reported earlier [8, 10]. In these crosses, it would be advisable to start the selection at a later generation. However, cross JHO 822 × PLP 9 had additive genic effects but of negative nature. The cross JHO 822 × PO 22 exhibited positive and significant heterosis for dry matter yield (Table 2). Crosses PLP 1 × JHO 822, PLP 1 × PLP 9 and JHO 822 ×PO 22 had mainly or predominantly positive dominance genic effects as reported earlier by [8. 10]. These are the potential crosses provided the selection is deferred to later generations for dry, matter yield. However, the cross JHO 822 ×PLP 9 had additive genic effects but negative in nature.

For grain yield in oats (Table 1), mainly additive × additive non-allelic interaction genic effects were noticed in PLP 1 × JHO 822 cross, as observed earlier also [11]. However, additive genic effect for grain yield was also reported earlier [12].

Grain yield in this cross can be improved by one or two cycles of simple recurrent selection in early generations. The cross PLP 1 × PLP 9 had predominantly positive dominance genic effects along with appreciable amount of additive × additive and negatively dominance ×dominance non-allelic interaction genic effects indicating duplicate type of epistasis. Similarly the cross JHO 822 × PO 22 exhibited predominant role of dominance genic effects beside appreciable amount of additive, additive × additive and negatively additive × dominance non-allelic interaction genic effects. In this cross, type of epistasis could not be ascertained. Dominance genic effects were noticed in the cross PO 22 × PLP 9. Among these crosses, PLP 1 × PLP 9 having high amount of heterosis over better parent (Table 2), appears to be potential

Table 1. Estimates of genic effects with respect to six crosses studied for different morphological characters in *Avena*

Parameters/cross	PLP 1 × JHO 822	PLP 1× PO 22	PLP 1 × PLP9	JHO 822 × PO 22	JHO 822 × PLP 9	PO 22 × PLP 9
Number of tillers/plant						
m	9.02*±0.77	8.92*±0.83	–5.55±5.85	9.48*±0.51	6.54±4.37	5.85±3.73
[d]	1.13±0.71	–0.57±0.82	1.20±1.26	–0.63±0.45	–0.80*±0.21	0.50±1.04
[h]	4.28*±2.03	2.11±1.68	38.35*±15.51	4.53*±1.25	8.87±13.08	7.25±10.65
[i]	-	-	13.95*±5.71	-	1.96±4.36	2.85±3.58
[j]	-	-	–0.25±5.04	-	5.37±4.37	–5.15±3.82
[j]	-	-	–19.60*±9.92	-	–7.88±8.71	–0.70±7.21
χ^2 (3 d.f)	1.61	1.93	10.24*	2.19	327.53*	10.82*
Number of leaves/plant						
m	–1.10±35.74	40.57*±2.18	–31.00±28.74	47.30*±2.02	30.28±16.70	18.14±10.76
[d]	–1.85±1.12	–3.61±2.19	5.25±3.47	–7.98*±0.75	–1.15*±0.30	–0.55±3.15
[h]	123.71±78.54	14.60*±4.92	190.81*±72.18	7.12±4.19	38.28±48.65	64.89*±30.09
[i]	35.25±35.73	-	72.65*±28.52	-	10.64±16.70	23.61±10.29
[j]	11.95±14.34	-	–6.75±20.41	-	17.30±15.78	–10.80±10.69
[l]	–83.21±45.60	-	–91.70*±44.55	-	–27.42±32.47	–22.91±21.21
χ^2 (3 d.f)	10.69*	1.66	7.26	0.68	42.50*	7.54
Days to 50 % flowering						
m	121.71*±0.55	126.58*±1.14	126.49*±8.25	117.28*±0.96	115.86*±0.82	113.25±4.45
[d]	9.12*±0.55	1.85*±1.14	3.00*±0.35	–3.31*±0.94	–3.79*±0.79	1.75±1.68
[h]	6.17*±2.08	–2.02±1.94	–22.48±23.28	–2.80±2.17	5.83*±1.31	26.25*±12.62
[i]	-	-	–1.99±8.25	-	-	9.00*±4.12
[j]	-	-	12.00±7.25	-	-	–22.50*±4.92
[l]	-	-	14.99±16.14	-	-	–19.50*±8.44
χ^2 (3 d.f)	4.05	2.51	6.82	2.42	6.10	26.31*
Plant height at 50% flowering						
m	66.72*±0.52	55.43*±1.77	67.92*±0.97	71.80*±9.93	68.05*±1.30	58.05*±2.53
[d]	1.61*±0.48	13.38*±1.76	–0.80±0.94	9.75*±1.04	1.12±1.40	–12.03*±2.38
[h]	1.63±1.03	–17.16*±3.55	1.23±2.10	–34.80±25.77	–1.32±1.84	–9.33*±4.25
[i]	-	-	-	–13.75±9.87	-	-
[j]	-	-	-	8.65±7.55	-	-
[l]	-	-	-	13.10±16.26	-	-
χ^2 (3 d.f)	3.44	1.79	2.11	5.71	0.14	2.64
Fresh forage yield (g) at 50 % flowering/plant						
m	28.84*±2.35	29.23*±2.69	33.48*±1.77	35.87*±0.97	38.1.2*±1.11	39.49*±2.34
[d]	–2.49±2.24	–3.22±2.73	1.72±1.77	–3.30*±0.97	–6.40*±1.12	–3.37±2.23
[h]	13.06*±3.76	9.77±6.09	31.83*±1.91	16.36*±2.13	–2.95±3.73	5.14±4.20
[i]	-	-	-	-	-	-
[j]	-	-	-	-	-	-
[l]	-	-	-	-	-	-
χ^2 (3 d.f)	4.92	3.53	4.53	0.48	4.10	2.00
Dry matter yield (g)/plant						
m	8.61*±0.45	–4.06±7.30	9.50*±0.77	10.22*±0.33	10.54*±0.42	11.70*±0.91
[d]	–0.99*±0.44	–1.17±0.77	0.78±0.72	0.19±0.33	–1.40*±0.42	–0.57±0.92
[h]	2.50*±0.71	32.70±21.25	9.07*±1.76	2.53*±0.33	–0.74±1.06	0.10±1.47
[i]	-	12.61±7.26	-	-	-	-
[j]	-	6.41±6.99	-	-	-	-
[l]	-	–16.22±14.37	-	-	-	-
χ^2 (3 d.f)	4.06	5.92	6.63	0.30	3.31	0.91
Grain yield (g)/plant						
m	4.00±5.65	14.01*±0.16	–1.94±1.19	11.84*±1.86	15.33*±0.67	12.41*±0.66
[d]	1.36±1.32	–0.11±0.16	–0.01±0.21	1.58*±0.42	–0.06±0.67	–0.50±0.61
[h]	18.06±14.26	–0.77±0.51	40.37*±3.37	14.56*±5.47	–0.09±1.41	5.19*±1.85
[i]	11.56*±5.50	-	14.80*±1.18	4.54*±1.82	-	-
[j]	5.62±4.46	-	–0.83±1.11	–5.48*±1.89	-	-
[l]	0.57±9.22	-	–20.07*±2.25	–6.85±3.98	-	-
χ^2 (3 d.f)	21.28*	2.94	244.73*	10.69*	0.87	5.64

*Significant at 5% level; -Indicates absence of non-allelic interaction.

Table 2. Estimates of heterosis (%) over better parent (BP) for different morphological characters in *Avena*

Parameters/cross	PLP 1 × JHO 822	PLP 1 × PO22	PLP 1 × PLP9	JHO 822 × PO 22	JHO 822 × PLP 9	PO 22 × PLP 9
Number of tillers/plant						
BP	9.57	23.71	37.50	20.00	−19.35*	34.78
SE (±)	3.67	2.38	2.53	2.09	0.32	1.17
Number of leaves/plant						
BP	9.44	24.66	45.20	−0.76	−2.14	42.08
SE (±)	7.05	6.02	7.21	6.80	2.77	7.74
Days to 50 % flowering						
BP	−6.11	−3.52	−6.67	−4.92	2.07	−3.23
SE (±)	5.10	1.80	3.04	2.83	1.80	3.16
Plant height at 50% flowering						
BP	1.27	−38.61*	4.36	−26.11*	−3.75	−33.10
SE (±)	1.23	4.36	3.33	1.63	2.20	5.55
Fresh forage yield (g) at 50 % flowering/plant						
BP	17.68	29.22	80.43*	33.33*	−17.57	11.00
SE (±)	6.74	8.21	4.10	2.75	4.48	5.53
Dry matter yield (g)/plant						
BP	3.03	27.78	69.08	22.13*	−14.85	6.47
SE (±)	1.48	2.17	2.76	0.36	1.20	1.78
Grain yield (g)/plant						
BP	33.83	12.54	41.67*	8.85	2.63	9.63
SE (±)	2.89	1.99	0.28	1.03	1.65	3.37

*Significant at 5% level.

one either by exploiting through hybrid or by selection deferred to later generations coupled with biparental approach. For grain yield in oats, earlier workers [3, 9] have also indicated the predominant role of dominance. The presence of epistasis as documented in the present study has also been reported earlier [4].

PLP 1 × PLP 9 cross showed positive heterosis for fresh forage yield and grain yield and the cross JHO 822 ×PO 22 showed positive heterosis for fresh forage yield and dry matter yield. The predominant role of dominant genic effects was observed for most of the traits studied in one or the other cross. In some of the cases both dominance as well as additive genic effects were present. Plant height at 50 per cent flowering showed mainly additive genic effects in three of the six crosses. The type of gene action in present study was trait and cross specific. PLP 1 × PLP 9 and JHO 822 × PO 22 have been observed to be the potential crosses for yield. The cross, PO 22 ×PLP 9 can be utilized for developing dual purpose types.

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