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PERFORMANCE OF OAT (*AVENA SATIVA* L.) GENOTYPES FOR FODDER YIELD AND ITS COMPONENTS UNDER TIMELY AND LATE SOWN CONDITIONS

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SUMMARY

Forty-eight oat genotypes (45 test entries and three checks) were evaluated in augmented design under timely and late sown conditions at Hisar and Kaul (Haryana) during *Rabi* 2024-25 and 2025-26 to assess the effect of late sowing on fodder yield and its components and to identify genotypes suited to late sowing. Under timely sowing, the genotypes recorded mean green fodder and dry matter yields of 152.82 and 50.65 q/ha, respectively, with OS 427, HFO 917 and GP 335 among the highest yielders. Late sowing significantly reduced all the traits studied. Green fodder yield declined by 45.38 per cent (152.82 to 83.48 q/ha) and dry matter yield by 29.55 per cent (50.65 to 35.68 q/ha). Losses were greater at Hisar (60.2 and 41.9%) than at Kaul (27.2 and 16.7%). Flowering was hastened by about 19.5 days, and peduncle length (-52.62%) and leaf to stem ratio (-45.54%) were the most affected component traits. Several genotypes that ranked highest under timely sowing suffered the heaviest losses under late sowing. Based on stress tolerance and stress susceptibility indices, OS 346, OS 405, GP 72 and the check HFO 707 combined high yield under both conditions with low susceptibility, and are recommended for late sown conditions and as donors for breeding.

Key words: Fodder oat, late sowing, green fodder yield, dry matter yield, stress tolerance index, stress susceptibility index

Oat (*Avena sativa* L.) is an important *Rabi* season cereal fodder of north-western India. It is valued for its fast growth, high palatability, good regeneration and high crude protein, and it fills the lean period of green fodder availability in winter. In Haryana, the crop is commonly sown after the harvest of *Kharif* crops such as rice, cotton and pearl millet. Delayed harvest of these preceding crops, together with the competing demand for land and labour for wheat sowing, frequently pushes the sowing of oat beyond the recommended time.

A late sown crop has a shorter growing period and meets rising temperatures during its vegetative and reproductive phases, which hastens flowering and reduces biomass accumulation. Such a decline in fodder yield with delayed sowing has been reported in oat by Kadam *et al.* (2022) and Samal *et al.* (2024), the latter recording a decrease of 0.7 per cent in green fodder and 1.2 per cent in dry fodder yield for each day's delay in sowing. Most of these studies, however, have compared sowing dates on one or a few released varieties. Information on how a wider set of genotypes responds to late sowing, and whether some genotypes can maintain their yield under it, is limited. Such genotypes would be valuable both for direct cultivation in late sown situations and as donors in breeding programmes.

Stress indices based on yield under non-stress and stress conditions, such as the stress susceptibility index (Fischer and Maurer, 1978) and the stress tolerance index (Fernandez, 1992), have been used widely to identify genotypes tolerant to late-sowing-induced heat stress in wheat (Jat *et al.*, 2018; Poudel *et al.*, 2020; K.C. *et al.*, 2021). The present study was therefore undertaken to assess the effect of late sowing on fodder yield and its component traits in 48 oat genotypes over two locations and two years, and to identify genotypes combining high yield with low susceptibility to late sowing.

MATERIALS AND METHODS

The experimental material comprised 45 oat genotypes and three checks (HFO 607, HFO 707 and HFO 906), collected from CCS HAU, Hisar; PAU, Ludhiana; GBPUAT, Pantnagar; MPKV, Rahuri;

SKUAST, Jammu; CSKHPKV, Palampur; IGFRI, Jhansi; and exotic sources. The genotypes were evaluated at two locations, the Forage Research Area of the Department of Genetics and Plant Breeding, CCS HAU, Hisar (29°092′ N, 75°412 E′, 215 m amsl) and the Regional Research Station, Kaul (29°512′ N, 76°392 E, 250 m amsl), during *Rabi* 2024-25 and 2025-26. In each year and location, the material was sown on two dates: timely sowing (first fortnight of November) and late sowing (first fortnight of December). This gave four timely and four late sown environments. Experiments were laid out in an augmented design (Federer, 1956) with three blocks, the checks being repeated in every block. Each genotype was sown in a four-row plot of 3 m length with a spacing of 25 cm × 10 cm, and the recommended package of practices was followed.

Observations were recorded on plant height (cm), length of second leaf from the top (cm) and width of the second leaf from the top (mm), peduncle length (cm), number of nodes on the main culm, main culm diameter (mm), number of leaves per plant, number of tillers per metre row length, leaf to stem ratio (fresh weight basis), days to 50 per cent flowering, green fodder yield (q/ha), and dry matter yield (q/ha). Plant-based traits were recorded on five randomly selected plants. Green fodder yield was recorded on a plot basis at 50% flowering, and dry matter yield was estimated after shade-drying the harvested biomass.

Block-adjusted means of the genotypes were obtained for each environment. For each genotype, the mean of the four timely sown environments (Yp) and of the four late sown environments (Ys) was computed, and the significance of the difference between sowing conditions was tested by a paired t-test over the 48 genotypes. The percent change due to late sowing was calculated as $[(Ys - Yp)/Yp] \times 100$. For green fodder and dry matter yield, the stress susceptibility index, $SSI = [1 - (Ys/Yp)]/SI$, where $SI = 1 - (2s/2p)$ (Fischer and Maurer, 1978), and the stress tolerance index, $STI = (Yp \times Ys)/2p^2$ (Fernandez, 1992), were computed. Here 2p and 2s are the means of all genotypes under timely and late sowing, respectively. Genotypes with SSI < 1 were considered less susceptible to late sowing, and those with high STI as high-yielding under both conditions.

RESULTS AND DISCUSSION

Performance under timely sown conditions

When sown at the recommended time, the crop completed its normal growth cycle and reached 50 per cent flowering in about 105 days at both the locations (Table 1). Over the four timely sown environments, the genotypes produced on average 152.82 q/ha of green fodder and 50.65 q/ha of dry matter. Mean plant height was 155.39 cm, with 41.04 leaves per plant, 79.83 tillers per metre row length and a leaf to stem ratio of 0.42. Green fodder yield was higher at Hisar (168.15 q/ha) than at Kaul (137.49 q/ha), while dry matter yield was similar at the two locations (51.57 and 49.72 q/ha). Green fodder yield was also better in the first year, 2024-25, at both locations. The drop in the second year was more marked at Hisar (180.43 to 155.88 q/ha) than at Kaul (140.67 to 134.32 q/ha). A wide range of variation was observed among the genotypes. Green fodder yield varied from 108.91 q/ha in GP 151 to 199.60 q/ha in OS 427, and dry matter yield from 34.49

TABLE 1
Mean performance of 48 oat genotypes under timely (T) and late (L) sown conditions at Hisar and Kaul (pooled over *Rabi* 2024-25 and 2025-26) and percent change due to late sowing

Trait	Hisar T	Hisar L	Change (%)	Kaul T	Kaul L	Change (%)	Pooled T	Pooled L	Change (%)
Green fodder yield (q/ha)	168.15	66.91	-60.2	137.49	100.05	-27.2	152.82	83.48	-45.4**
Dry matter yield (q/ha)	51.57	29.97	-41.9	49.72	41.39	-16.7	50.65	35.68	-29.5**
Plant height (cm)	158.92	116.11	-26.9	151.86	139.55	-8.1	155.39	127.83	-17.7**
Leaf length (cm)	45.35	28.23	-37.8	43.21	34.95	-19.1	44.28	31.59	-28.7**
Leaf width (mm)	20.94	15.57	-25.6	20.46	16.42	-19.8	20.70	15.99	-22.7**
Peduncle length (cm)	30.73	15.40	-49.9	24.91	10.96	-56.0	27.82	13.18	-52.6**
Number of nodes	5.50	4.85	-11.8	4.62	4.24	-8.3	5.06	4.54	-10.2**
Main culm diameter (mm)	5.60	4.13	-26.3	6.78	4.39	-35.2	6.19	4.26	-31.2**
Number of leaves per plant	41.51	29.35	-29.3	40.58	27.58	-32.0	41.04	28.47	-30.6**
Tillers per metre row	80.61	63.99	-20.6	79.05	60.51	-23.4	79.83	62.25	-22.0**
Leaf to stem ratio	0.43	0.23	-47.2	0.40	0.23	-43.8	0.42	0.23	-45.5**
Days to 50% flowering	105.12	80.04	-23.9	104.29	90.42	-13.3	104.71	85.23	-18.6**

*, ** Significant at 5 and 1% level of probability by paired t-test over 48 genotypes; Change (%) = [(L " T)/T] × 100.

q/ha in GP 55 to 69.16 q/ha in HFO 917 (Table 3). The best performers for green fodder yield were OS 427, HFO 917, OL 1769, OS 346 and GP 335. For dry matter yield, HFO 917, GP 152, OS 427 and GP 335 were the best.

Effect of late sowing on fodder yield and its components

Late sowing significantly ($p<0.01$) reduced the mean performance of the genotypes for all the traits studied (Table 1). Green fodder yield declined from 152.82 to 83.48 q/ha (-45.38%) and dry matter yield from 50.65 to 35.68 q/ha (-29.55%). The smaller reduction in dry matter than in green fodder yield indicates that the late sown crop, which flowered about 19.5 days earlier (104.71 vs 85.23 days), was harvested at a more advanced physiological stage with less moisture. Among the component traits, peduncle length (-52.62%), leaf to stem ratio (-45.54%), main culm diameter (-31.19%), number of leaves per plant (-30.64%) and leaf length (-28.66%) were the most affected, while number of nodes (-10.18%) and plant height (-17.74%) were the least affected. The number of tillers per metre row length also declined by 22.02 per cent (79.83 to 62.25). The sharp fall in leaf to stem ratio (0.42 to 0.23) and in the number of leaves indicates that late sowing lowered not only the quantity but also the leafiness, and hence the palatability, of the fodder. A decline in fodder yield and its attributes with delayed sowing in oat has also been reported by Kadam *et al.* (2022) and Samal *et al.* (2024). Samal *et al.* (2024) attributed it to the lower accumulation of growing degree days, helio-thermal units and photo-thermal units by late sown crops.

The adverse effect of late sowing was much more severe at Hisar than at Kaul (Fig. 1). At Hisar, green fodder and dry matter yield decreased by 60.2 and 41.9 per cent respectively, against 27.2 and 16.7 per cent at Kaul. Plant height (-26.9 vs -8.1%), leaf length (-37.8 vs -19.1%) and days to 50 per cent flowering (-23.9 vs -13.3%) were likewise more strongly reduced at Hisar. The weather data (Table 2) suggest that the drier conditions at Hisar, where seasonal rainfall was 46.9–52.9 mm against 94.8–107.9 mm at Kaul, and its higher maximum temperatures in March (up to 35–37°C against 32°C), accelerated phenology and limited the biomass of the late sown crop. The

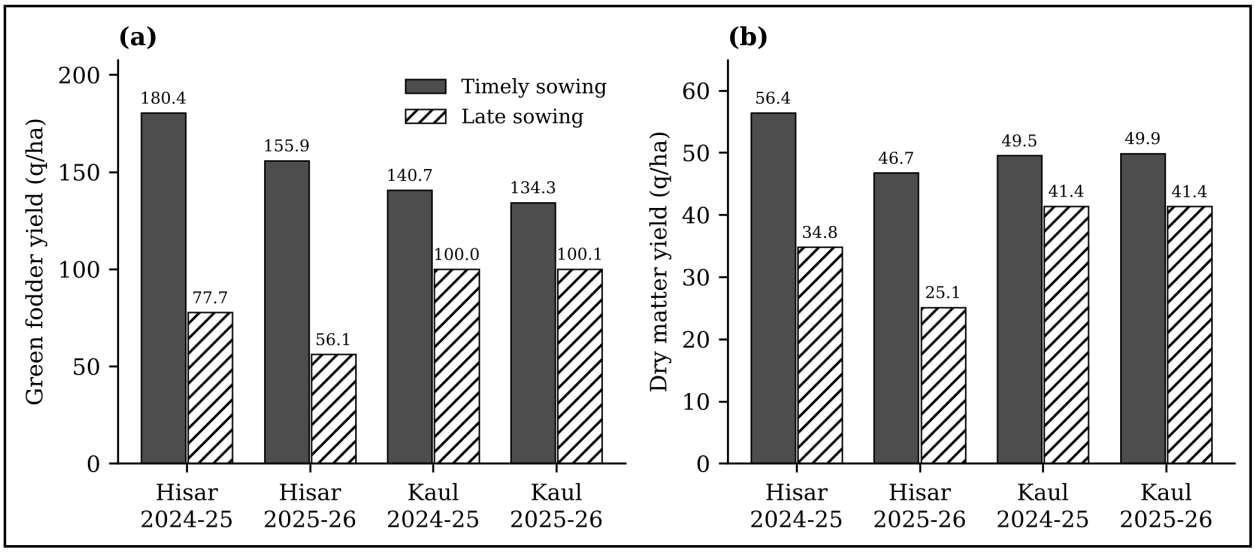

Fig. 1. Mean green fodder yield (a) and dry matter yield (b) of 48 oat genotypes under timely and late sown conditions at Hisar and Kaul during *Rabi* 2024-25 and 2025-26.

TABLE 2
Monthly temperature range (°C) and total seasonal rainfall at the experimental locations during *Rabi* 2024-25 and 2025-26

Location	Year	Nov	Dec	Jan	Feb	Mar	Rainfall (mm)
Hisar	2024-25	8–34	1–27	3–25	4–30	6–37	52.9
Hisar	2025-26	6–32	4–25	0–23	5–31	9–35	46.9
Kaul	2024-25	9–30	5–24	6–23	8–25	11–32	107.9
Kaul	2025-26	7–29	7–24	4–18	7–26	13–32	94.8

Source: Department of Agrometeorology, CCS HAU, Hisar.

TABLE 3
Green fodder yield (GFY) and dry matter yield (DMY) of oat genotypes under timely (Yp) and late (Ys) sowing (mean of four environments each), per cent reduction, stress susceptibility index (SSI) and stress tolerance index (STI)

S. No.	Genotype	GFY Yp	GFY Ys	Red. (%)	SSI	STI	DMY Yp	DMY Ys	Red. (%)	SSI	STI
1	HFO 870	140.29	53.23	62.06	1.37	0.32	43.42	24.40	43.80	1.48	0.41
2	HFO 50	156.07	64.23	58.85	1.30	0.43	55.84	29.57	47.04	1.59	0.64
3	UPO 212	169.49	81.29	52.04	1.15	0.59	56.66	34.98	38.25	1.29	0.77
4	OS 427	199.60	94.04	52.89	1.17	0.80	65.61	36.84	43.85	1.48	0.94
5	HFO 611	142.82	79.23	44.52	0.98	0.48	39.86	33.46	16.04	0.54	0.52
6	OL 1769	182.99	92.59	49.40	1.09	0.73	57.05	40.88	28.35	0.96	0.91
7	RO-11-1	180.04	93.43	48.11	1.06	0.72	45.41	44.00	3.10	0.10	0.78
8	OL 16	132.93	89.79	32.46	0.72	0.51	44.24	35.45	19.87	0.67	0.61
9	ALGERIAN	163.71	97.48	40.46	0.89	0.68	55.73	35.16	36.90	1.25	0.76
10	SKO 244	152.10	69.04	54.61	1.20	0.45	50.00	33.59	32.83	1.11	0.65
11	OL 1876	147.49	66.87	54.66	1.20	0.42	45.96	31.52	31.43	1.06	0.56
12	HFO 498	151.26	63.45	58.05	1.28	0.41	56.20	31.37	44.18	1.50	0.69
13	OS 346	182.10	94.76	47.96	1.06	0.74	61.46	47.01	23.51	0.80	1.13
14	KLOSAN	156.99	73.54	53.16	1.17	0.49	54.21	35.31	34.88	1.18	0.75
15	HFO 917	194.82	84.98	56.38	1.24	0.71	69.16	38.94	43.69	1.48	1.05
16	SABZAR	156.83	105.12	32.97	0.73	0.71	59.77	35.93	39.88	1.35	0.84
17	PLP 27	167.30	91.01	45.60	1.01	0.65	56.84	38.58	32.11	1.09	0.85
18	GP 55	126.03	63.39	49.70	1.10	0.34	34.49	30.24	12.34	0.42	0.41
19	OS 7	139.08	87.53	37.06	0.82	0.52	37.67	33.95	9.90	0.34	0.50
20	HJ 8	135.88	94.95	30.12	0.66	0.55	47.09	35.81	23.96	0.81	0.66
21	HFO 114	143.47	102.45	28.59	0.63	0.63	47.97	39.14	18.39	0.62	0.73
22	OL 13	137.58	87.25	36.58	0.81	0.51	42.81	40.51	5.37	0.18	0.68
23	HFO 806	133.08	100.72	24.31	0.54	0.57	49.92	40.79	18.29	0.62	0.79
24	OS 405	169.77	101.00	40.51	0.89	0.73	52.80	49.25	6.71	0.23	1.01
25	OS 377	156.00	72.52	53.51	1.18	0.48	41.70	33.39	19.93	0.67	0.54
26	HFO 1014	148.69	87.59	41.09	0.91	0.56	43.15	37.08	14.08	0.48	0.62
27	OS 6	124.64	75.08	39.76	0.88	0.40	36.01	27.89	22.55	0.76	0.39
28	HFO 915	137.47	82.30	40.13	0.88	0.48	52.14	27.93	46.42	1.57	0.57
29	KENT	127.63	85.31	33.16	0.73	0.47	49.96	37.05	25.83	0.87	0.72
30	JHO 822	142.25	99.22	30.24	0.67	0.60	43.26	34.18	20.98	0.71	0.58
31	GP 335	181.68	75.71	58.33	1.29	0.59	64.15	33.95	47.08	1.59	0.85
32	OS 403	150.02	79.74	46.85	1.03	0.51	53.87	27.80	48.39	1.64	0.58
33	GP 115	166.85	69.89	58.11	1.28	0.50	57.46	29.77	48.19	1.63	0.67
34	GP 153	160.46	74.53	53.55	1.18	0.51	49.30	26.87	45.50	1.54	0.52
35	GP 1	126.96	70.35	44.59	0.98	0.38	47.73	28.72	39.83	1.35	0.53
36	GP 35	166.57	84.90	49.03	1.08	0.61	56.53	40.34	28.64	0.97	0.89
37	GP 334	138.71	80.77	41.77	0.92	0.48	48.58	37.37	23.08	0.78	0.71
38	GP 304	131.35	79.07	39.80	0.88	0.44	44.44	37.37	15.91	0.54	0.65
39	GP 152	161.68	79.90	50.58	1.11	0.55	66.64	38.84	41.72	1.41	1.01
40	GP 222	176.51	90.62	48.66	1.07	0.68	59.86	37.35	37.60	1.27	0.87
41	GP 332	127.69	74.29	41.82	0.92	0.41	44.57	34.99	21.49	0.73	0.61
42	GP 151	108.91	77.77	28.59	0.63	0.36	39.09	33.37	14.62	0.49	0.51
43	GP 61	166.54	88.10	47.10	1.04	0.63	56.17	38.91	30.73	1.04	0.85
44	GP 53	119.26	86.53	27.45	0.60	0.44	42.08	39.20	6.83	0.23	0.64
45	GP 72	175.85	99.05	43.67	0.96	0.75	53.97	42.43	21.38	0.72	0.89
C1	HFO 607 (check)	140.04	72.96	47.90	1.06	0.44	40.49	30.88	23.75	0.80	0.49
C2	HFO 707 (check)	163.97	107.94	34.17	0.75	0.76	55.28	43.68	20.98	0.71	0.94
C3	HFO 906 (check)	174.11	81.35	53.28	1.17	0.61	54.41	36.58	32.76	1.11	0.78
	Mean	152.82	83.48	45.38	1.00	0.55	50.65	35.68	29.55	1.00	0.71

Yp, Ys in q/ha. Red. (%) = [(Yp " Ys)/Yp] × 100.

milder climate of Kaul thus allowed a better performance of oat under late sowing. The ranking of the two locations was reversed under late sowing: Kaul, which had the lower green fodder yield under timely sowing, out-yielded Hisar under late sowing (100.05 vs 66.91 q/ha). Late sown yields at Kaul were also nearly the same in the two years (99.97 and 100.12 q/ha), whereas at Hisar, it fell from 77.67 q/ha in 2024-25 to 56.14 q/ha in 2025-26. Late sown oat was therefore both lower yielding and less stable at Hisar.

Genotypic response to late sowing

The genotypes differed widely in their response to late sowing (Table 3). The reduction in

green fodder yield ranged from 24.31 percent (HFO 806) to 62.06 percent (HFO 870), and in dry matter yield from 3.10 per cent (RO-11-1) to 48.39 per cent (OS 403). No genotype yielded more under late than under timely sowing. The ranking of genotypes changed considerably between the two sowing conditions, so that genotypes selected under timely sowing would not necessarily perform well under late sowing. HFO 917, OS 427, GP 152 and GP 335, which were among the highest yielders under timely sowing, suffered heavy losses under late sowing (SSI 1.41–1.59 for dry matter yield) and appear suited only to timely sown conditions.

SSI measures only the relative loss in yield and therefore tends to favour genotypes with low yield potential, whereas STI rewards genotypes that yield well under both conditions (Fernandez, 1992). Genotypes were therefore selected on the basis of high STI together with SSI below unity, an approach used for late sown wheat by Jat *et al.* (2018) and K.C. *et al.* (2021).

Considering high STI together with SSI below unity, OS 346 (STI 1.13, SSI 0.80), OS 405 (1.01, 0.23), HFO 707 (0.94, 0.71) and GP 72 (0.89, 0.72) were the most desirable genotypes for dry matter yield. OS 405 (49.25 q/ha), OS 346 (47.01 q/ha), RO-11-1 (44.00 q/ha), HFO 707 (43.68 q/ha) and GP 72 (42.43 q/ha) recorded the highest dry matter yield under late sowing. For green fodder yield, HFO 707 (107.94 q/ha under late sowing, SSI 0.75), SABZAR (105.12 q/ha, SSI 0.73), OS 405 (101.00 q/ha, SSI 0.89) and GP 72 (99.05 q/ha, SSI 0.96) combined high STI with low susceptibility. OS 405, GP 72 and HFO 707 were thus superior for both green fodder and dry matter yield, while OS 346 combined the highest STI for dry matter yield with a near-average susceptibility for green fodder yield (SSI 1.06). GP 53, HFO 114 and HFO 806 were the least susceptible for both yields (SSI 0.23–0.63), though their yields under timely sowing were moderate. JHO 822, which also showed a low reduction in both yields (SSI 0.67 and 0.71), was found to be the most productive variety under different sowing dates in Bihar by Samal *et al.* (2024). Twenty genotypes exceeded the late-sown mean for both green fodder (83.48 q/ha) and dry matter yield (35.68 q/ha) (Table 3). In contrast, GP 335, GP 115 and HFO 50 were among the most susceptible genotypes for both green fodder and dry matter yield.

CONCLUSION

Late sowing reduced the green fodder and dry matter yield of oat by 45 and 30 per cent respectively, mainly through a shortened vegetative phase, and the losses were much greater at Hisar than at Kaul. Since the ranking of genotypes differed between the two sowing conditions, genotypes for late sown conditions need to be selected under those conditions. OS 346, OS 405, GP 72 and HFO 707 combined high yield with low susceptibility to late sowing and can be recommended for late sown situations in Haryana and used as donors in breeding fodder oat for tolerance to terminal heat.

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