Forage Res., **52**(1) : pp. 7-16 (2026) **http://forageresearch.in**

EVALUATION OF OAT VARIETIES FOR SEED YIELD, MINERAL CONTENT AND MINERALS UPTAKE POTENTIAL

DIGVIJAY SINGH[1]* AND AJOY KUMAR ROY[2]

[1]National Dairy Development Board, Anand-388001, India
[2]ICAR-Indian Grassland and Fodder Research Institute, Jhansi-284003, India
**(e-mail: digvijaysingh858@gmail.com)*

(Received: 26 May 2026; Accepted: 25 June 2026)

SUMMARY

Oat (*Avena sativa L.*) is a popular multi-cut cereal crop among dairy farmers for green fodder in India. Every year, many new varieties of oats are released for cultivation purposes. However, limited information on their seed yield potential, yield attributes, mineral content and its uptake potentials are available. Hence, field experiments were conducted during the *Rabi* seasons of 2016-17, 2017-18 and 2018-19 to evaluate 18 oats varieties. Statistical analysis of three years pooled data revealed that there was significant difference among varieties for seed yield potential. The highest yielding variety JHO 822 (14.85 q/ha), at par with OS 346 (14.16 q/ha) and check variety Kent (12.14 q/ha), recorded significantly higher seed yield in comparison to remaining oats varieties. JHO 822 (14.10) variety recorded the highest harvest index and JHO 99-2 (47.67 g) recorded the highest 1000-seed weight. Amongst all oat varieties, non-significant differences were recorded for variation in straw yield, biological yield, plant height, panicle length, tillers/metre, seed weight/panicle and seed /panicle. Crude protein, crude fat, crude fibre and acid insoluble content (%) in oats varieties varied non-significantly in seed; and in straw. NDO 1 recorded significantly higher N (2.81%) and P (0.57%) contents in seed. K content was found to be significantly higher in JHO 851 (0.73%), Mg content was recorded significantly higher in JHO 99-1 (0.24%) and JO 1 variety recorded significantly higher S content (0.23%). JHO 822 recorded significantly higher P_2O_5 (16.46 kg/ha), S (3.30 kg/ha) and Cu (12.59 g/ha) uptake for seed yield. N, K_2O, Ca, and Mg uptake (kg/ha) for seed yield in oats varieties varied non-significantly. Similarly, oat varieties differed non-significantly amongst themselves for Mn, Fe and Zn contents (ppm) in seed.

Key words: Harvest index, minerals, oats, seed yield, test weight, varieties

Oat (*Avena sativa* L.) is an important *Rabi* fodder cereal and is grown under varying soil/climate conditions (Verma *et al*., 2014) for green fodder, hay, silage, and seed/grain purposes. Furthermore, due to their nutritive value, oats-based food products are gaining rapid popularity and are consumed in various forms like probiotic drinks, bread, cookies, biscuits, breakfast cereal flakes, baby food etc. Recent studies have established oats as a suitable diet for celiac patients as well (Rasane *et al*., 2015). Oat green fodder contains crude protein (10%-11%), neutral detergent fibre (55%–63%), acid detergent fibre (30% - 32%), cellulose (22%–25%), and hemicellulose (17%–20%) on a dry matter basis (Das *et al*., 2015). Oat straw is highly palatable, digestible, and acceptable to livestock, providing sufficient energy with moderate protein levels essential for livestock maintenance and growth (Ranjan *et al*., 2024). Oats are strong in oleic and linoleic acids and contain a large amount of fat. It includes vitamins B1, B2 and B6, as well as vitamins A, K and E. They also contain beneficial minerals, antioxidants and sterols. Compared to other cereals, oats have a higher beneficial fatty acid concentration (Hilli *et al.*, 2023). After taking seed production, farmers feed oats straw to bovine due to good nutritive value and palatability. Over the years, due to continuous increase in its cultivated area, demand for quality seed of new varieties of oats is increasing. IGFRI (2011) reported that the total area covered under oats cultivation in India is about 1.0 million ha with 35-50 t/ha green fodder yield. However, over the years, area under oat cultivation declined to approximately 0.25 million hectares (M ha), with the maximum acreage in Uttar Pradesh (34%), followed by Punjab (20%), Bihar (16%), Haryana (9%), and Madhya Pradesh (6%). The green and dry fodder productivity and seed yield range from 50 to 60, 12 to 15, and 2–3 t/ha, respectively Chand *et al*., (2025).

In India, the ICAR–All India Coordinated Research Project on Forage Crops and Utilization (AICRP on FC&U) evaluates all fodder varieties for

their yield and nutritive potential (Chand *et al.*, 2020). In the last 4-5 decades, several oats varieties were released for fodder cultivation. A few old varieties such as Kent, UPO 212 and JHO 822 have been very well received by dairy farmers due to optimum green fodder and seed yields sustainability on farmers' fields under varying agro-climatic conditions in different states. It is reflected in continuous breeder seed demand of these varieties. Fodder seed production and marketing programme through NDDB and dairy cooperative societies network have benefitted farmers in adopting quality fodder seed of newly developed varieties/hybrids for fodder cultivation (Choudhary *et al.*, 2022). A study conducted by Kalamkar *et al.* (2019) under National Dairy Plan-I (NDP-I) on fodder seed production and distribution activity through dairy cooperative society (DCS) network consisting of 18 dairy cooperatives from 8 states indicated that annual green fodder yield on farmers' field could be increased by 39% from 40.0 to 55.6 (t/ha) by using quality seed of improved fodder varieties/hybrids.

The available oat varieties are losing their yield potential with passage of time due to different biotic and abiotic stresses. Therefore, new varieties having better yield potential, nutritive value, resistance to biotic and abiotic stresses and ability to cope up with changing climate scenarios are being developed (Jindal *et al.*, 2024). Due to on-going research & development program on forage crops, new oats varieties are regularly being released for cultivation and notified by the Ministry of Agriculture, Government of India. Genetic gain in terms of farm productivity can be improved significantly by rapidly disseminating improved varieties in place of older ones (Veettil *et al.*, 2018). Therefore, timely introduction of these improved oats varieties in the seed chain is of utmost importance for the benefit of dairy farmers and to improve varietal replacement rate. Chand *et al.* (2025) have reported a moderate varietal replacement rate (22.9%) was observed for recently developed varieties (<5 years) of oats over the past 3 years (2019-2020 to 2021-2022). Before introducing new varieties in the seed chain, information on its seed yield, proximate content, mineral content and uptake potential estimation is very much needed for selecting the right variety for high fodder and seed yield potential and nutrition point of view. Therefore, the present study was planned to evaluate the potential of several old and new oats varieties for seed yield, yield attributes, mineral content and mineral uptake potential in Anand district of central Gujarat, India.

MATERIALS AND METHODS

Study area and soil site: The experiment was carried out at the fodder demonstration unit (FDU) of National Dairy Development Board (NDDB), Anand, Gujarat. Anand is located at 22.57°N latitude and 72.93°E longitude. It has an average elevation of 39 metres during the *Rabi* seasons of 2016-17, 2017-18 and 2018-19 in randomized block design, replicated thrice.

Treatment details: Eighteen oat (*Avena sativa* L.) varieties were evaluated namely; Pant forage

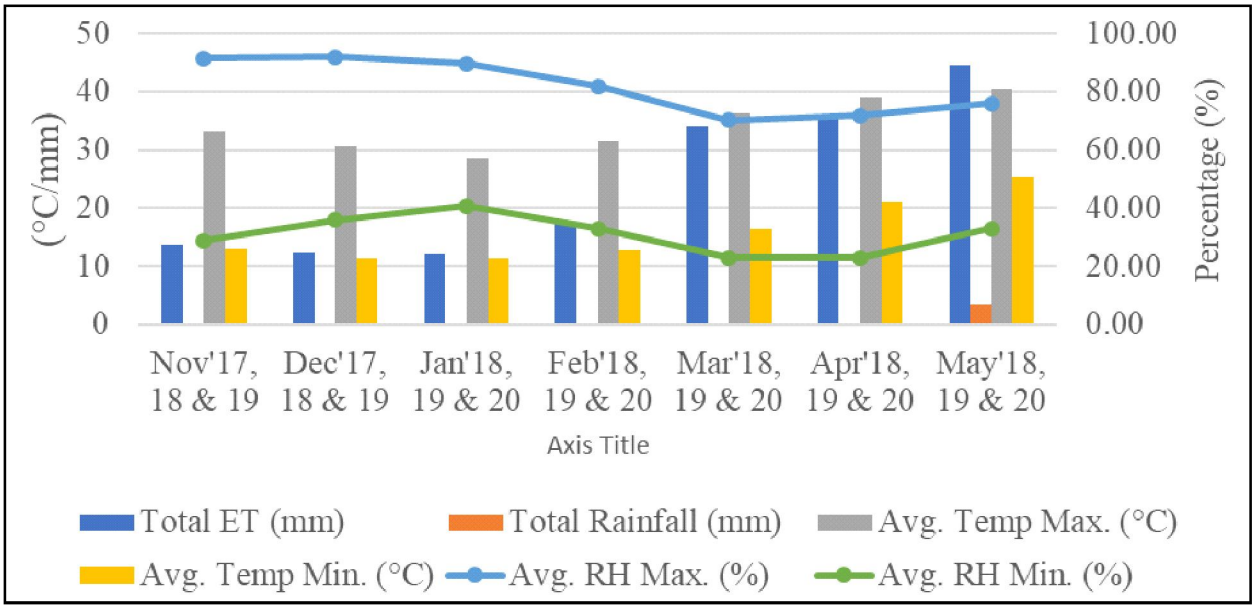

Fig. 1. Monthly weather parameters data recorded at Anand during crop growing season, *Rabi* 2016-17, 2017-18 and 2018-19 (Pooled).

oats 3 (PFO 3), OL 1802, OL 1804, OL 10, OS 6, JHO 2004, Sabzaar, JHO 851, JHO 99-1, JHO 99-2, JHO 822, JO 1, UPO 94, OS 346, NDO 1, JO 03-91, UPO 212 and Kent (Check). The crop was raised following a standard package of practices. The seeds and technical guidance were obtained from AICRP on Forage Crops and Utilization, ICAR-IGFRI, Jhansi, Uttar Pradesh, India. The soil of the experimental site was loamy in texture with EC (0.20), pH (7.74), total nitrogen (879.69 kg/ha), available P_2O_5 (13.83 kg/ha) and available K_2O (262.42 kg/ha). The soil contained DTPA-extractable Fe (5.84 ppm), Mn (4.31 ppm), Zn (1.83 ppm), available S (3.09 ppm) and Cu (1.31 ppm). The crop was sown manually during 3rd week of December in the years 2016, 2017 and 2018. Average monthly weather parameters data of growing seasons of three years are mentioned in Fig. 1.

Land preparation and manure application: The total plot size was 5.0 x 4.0 metre with net plot area of 4.0 x 3.0 meter at harvest. The crop was hand sown with a seed rate of 100 kg/ha at row spacing of 25 cm and immediately irrigated for proper germination. Recommended dose of fertilizers (120 kg N: 60 kg P: 40 kg K/ha) and Farm Yard Manure (FYM) @ 5-ton/ha were applied. Half dose of nitrogen and full dose of FYM, phosphorus and potassium were applied as basal and the remaining half of nitrogen was top dressed at 30 days after sowing. After sowing, pendimethalin herbicide was applied as pre-emergence @ 1.0 litre/ha to control seasonal weeds. In total, 4 irrigations were given during the crop growth period.

Observation recording and analysis: The crop was harvested at complete maturity for seed yield in the second fortnight of May month. Seed yield and its attributes and quality components of oats varieties were recorded and analysed. Plants from each net plot at two randomly selected spots of 1.0 metre row length were harvested and the tillers were counted and recorded as the number of tillers/metre. Plant height, panicle length, seed/panicle and seed weight (g)/panicle from twenty randomly selected tillers from 1.0 metre row length were recorded. Seed, straw, biological yields and 1000 seed weight (g) were recorded from net plot area at maturity. Harvest index was calculated as per the following formula.

$$\text{Harvest index} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

Dry samples were fine ground (1 mm) for chemical analysis. Amount of nitrogen (N) and crude protein content was estimated by using IS/ISO 5983-2 (2005). Proximate analysis was carried out following the standard laboratory procedures (AOAC, 2012). Mineral content was determined according to Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES), Perkin Elmer, OPTIMA-8000. Total uptake of minerals was calculated by the formula:

Uptake of mineral (kg/ha) = [Mineral % × seed or straw yield (kg/ha)] / 100.

Where, mineral uptake (kg/ton of seed or straw yield) = (Mineral uptake) /(seed or straw yield).

Three season's data was pooled and mean values of observations were analysed statistically according to Sheoran *et al.* (1998) using 'F' test of significance. The critical differences were worked out at 5 per cent level of probability for comparing treatment means.

RESULTS AND DISCUSSION

Yield: The pooled data analysis showed significant differences among varieties for yield and yield attributes (Table 1). Variety JHO 822 (14.85 q/ha), at par with many oat varieties viz. OS 346 (14.16 q/ha), UPO 212 (12.49 q/ha), OS 6 (12.45 q/ha), JHO 99-2 (12.19 q/ha), OL 10 (12.18 q/ha), check variety Kent (12.14 q/ha), JHO 2004 (11.88 q/ha), UPO 94 (11.78 q/ha) and JO 03-91 (11.56 q/ha) recorded significantly higher seed yield (q/ha) in comparison to remaining varieties. Low seed yield was observed in NDO-1 (8.05 q/ha). Singh *et al.* (2018b) reported higher seed yield in JHO 822 (22.00 q/ha) as compared to Kent (20.00 q/ha). Singh *et al.* (2022), also reported significant differences among 9 oats varieties for seed yield. Significantly higher straw yield (106.43 q/ha) was recorded in OL 1802 in comparison to many oat varieties but at par with PFO 3, OS 346 and UPO 212. Lowest straw yield (82.02 q/ha) was recorded in JHO 99-2. Monika *et al.* (2018) have recorded 121.70 q/ha straw yield in oat variety HJ 8 after seed harvest. Highest biological yield (117.50 q/ha) was recorded in UPO 212 but at par with OS 346 (101.45 q/ha), OL 1802 (106.43 q/ha) and PFO 3 (102.73 q/ha) varieties.

Growth & Yield attributes: Maximum plant height was recorded in OL 1802 (149.77 cm) but at par with JHO 822 (128.91 cm) and JHO 851 (127.32 cm). Whereas, UPO 94 (128.86 cm) recorded the lowest plant height. OL 10 (30.45 cm) recorded

TABLE 1
Oat varietal differences for yield, growth and yield attributes (Pooled)

Variety	Yield			Growth & Yield Attributes						
	Seed (q/ha)	Straw (q/ha)	Biological (q/ha)	Plant height (cm)	Panicle Length (cm)	Tillers/ metre	Seed/ panicle	Seed weight (g)/panicle	1000-Seed weight (g)	Harvest Index
PFO 3	9.99	102.73	112.72	135.97	27.84	59.42	62.60	2.12	36.20	9.55
UPO 94	11.78	97.97	110.96	128.86	27.16	66.50	69.51	2.22	37.52	11.30
UPO 212	12.49	105.00	117.50	142.31	29.57	64.42	58.46	2.34	38.26	10.77
OL 1802	10.02	106.43	116.46	149.77	29.95	57.50	74.75	2.82	36.19	8.60
OL 1804	10.43	82.50	92.94	137.27	28.99	61.46	71.57	2.38	32.92	11.66
OL 10	12.18	90.18	102.36	143.33	30.45	61.96	77.43	2.21	30.81	11.96
OS 6	12.45	93.41	105.86	139.14	28.67	60.29	62.52	2.24	35.90	12.29
OS 346	14.16	101.45	115.60	133.89	27.78	64.38	66.74	2.74	39.77	12.66
JH0 2004	11.88	92.09	103.96	138.70	29.29	58.50	60.83	2.49	42.23	11.70
JHO 851	9.61	93.70	103.30	127.32	28.58	66.82	66.33	2.08	33.93	9.50
JHO 99-1	9.29	97.69	106.98	138.98	27.24	63.93	56.17	2.16	35.88	9.27
JHO 99-2	12.19	82.02	94.20	136.25	24.94	56.08	42.93	2.20	47.67	13.02
JHO 822	14.85	94.62	109.47	128.91	26.67	65.47	60.85	2.61	44.20	14.10
JO 1	9.46	94.46	102.69	132.75	28.34	64.83	62.42	2.72	43.82	9.58
JO 03-91	11.56	97.67	109.22	136.63	29.41	66.11	64.53	2.63	35.74	10.85
NDO 1	8.05	99.25	107.31	143.63	27.29	52.75	58.45	2.45	42.71	7.88
Sabzaar	9.15	93.40	102.55	141.75	30.43	57.40	59.23	2.54	40.15	8.76
Kent (NC)	12.14	98.82	110.97	131.73	26.35	60.72	54.94	1.88	34.95	11.18
SEM ±	11.20	95.74	106.95	137.07	28.28	61.59	62.79	2.38	38.27	10.81
C. D. (P=0.05)	3.40	5.30	5.10	3.83	1.09	3.96	4.12	0.15	2.89	1.13

significantly highest panicle length at par with Sabzaar (30.43 cm), OL 1802 (29.95 cm), UPO 212 (29.57 cm) and JO 03-91 (29.42 cm). Kebede *et al.* (2023) also observed significant differences among oat varieties for panicle length that varied between 27.20-47.90 cm. Significantly high number of tillers/metre row length were observed in JHO 851 (66.82), at par with varieties UPO 94 (66.50), JO 03-91 (66.11), JHO 822 (65.47), JO 1 (64.83), UPO 212 (64.42) and JHO 99-1 (63.93) (Table 1). OL 10 (77.43) variety at par with OL 1802 (74.75) recorded significantly higher number of seed/panicle in comparison to other varieties (Table 1). Lowest number of seed/panicles was recorded in JHO 99-2 (42.93).

OL 1802 (2.82 g/panicle) statistically at par with OS 346 (2.74 g/panicle) and JO 1 (2.72 g/panicle) recorded higher seed weight in comparison to remaining varieties. Lowest seed weight was found in Kent (1.88 g/panicle). Amongst all varieties, JHO 99-2 (47.67 g) recorded significantly higher 1000 seed weight, whereas lowest was recorded in OL 10 (30.81 g). JHO 822 (14.10) statistically at par with JHO 99-2 (13.02) observed significantly higher harvest index in comparison to remaining varieties including Kent (11.18). Lowest harvest index was found in NDO 1 (7.88). Higher seed yield potential (>14.0 q/ha) recorded in two oat varieties JHO 822 and OS 346 may be attributed to the overall combined effect of various seed yield attributes viz. number of tillers/metre row length, number of seed/panicle, 1000 seed weight and harvest index. Kaur *et al.* (2023) reported that higher oats seed yield was mainly attributed to a greater number of tillers, seed/panicle and panicle length. Kibite (1997) reported that seed yield of crop had strong possible correlation with number of panicles metre/ square^{-}, weight of panicle and 1000 grain weight. Positive and significant correlations of grain yield with number of tillers/metre row length have been reported by Jaipal and Shekhawat (2016).

Proximate parameters: Oat varieties were found to be statistically at par for proximate parameters viz. crude protein, crude fat, crude fibre and acid insoluble ash (silica) content in seed and straw (Table 2). Values of crude protein, crude fat, crude fibre and acid insoluble content varied between 12.91-16.30%, 3.33-5.48%, 10.83-17.61% and 1.33-2.52% in seed and 6.21-7.75%, 1.00-1.58%, 27.89-43.04% and 2.60-4.40% in straw, respectively. Singh *et al.* (2018a) also reported non-significant differences amongst oat varieties for crude protein, crude fibre and silica content

TABLE 2
Varietal differences for proximate parameters content (%) in seed and straw (Pooled)

Variety	Crude protein		Crude fat		Crude fibre		Acid Insoluble Ash (Silica)	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
PFO 3	13.83	7.09	3.33	1.10	15.33	37.08	1.66	3.42
UPO 94	14.61	6.97	4.15	1.35	11.70	35.24	1.61	2.92
UPO 212	13.67	6.94	4.68	1.09	17.61	37.34	1.33	2.81
OL 1802	12.91	7.75	3.56	1.30	15.99	36.09	2.15	3.38
OL 1804	14.07	6.21	3.76	1.00	14.51	38.26	2.52	2.60
OL 10	14.49	7.18	4.09	1.15	15.04	36.49	1.90	2.98
OS 6	14.13	7.30	4.62	1.30	12.19	37.48	1.98	3.42
OS 346	12.97	6.69	4.62	1.37	12.78	36.73	1.59	2.75
JH0 2004	14.31	6.79	4.22	1.15	12.09	36.87	1.44	3.16
JHO 851	14.44	7.52	4.23	1.29	12.66	35.79	1.70	3.38
JHO 99-1	14.93	7.59	4.22	1.31	14.93	43.04	1.98	3.25
JHO 99-2	13.82	6.73	3.89	1.53	13.66	37.42	2.38	3.34
JHO 822	13.29	7.16	4.16	1.36	11.99	37.43	1.39	2.68
JO 1	14.68	6.83	3.78	1.39	12.65	35.88	1.45	3.43
JO 03-91	13.93	6.76	4.64	1.40	12.05	36.62	2.01	3.54
NDO 1	16.30	7.34	5.48	1.58	12.45	36.00	1.56	4.40
Sabzaar	14.18	7.14	4.00	1.53	12.43	37.04	1.63	2.62
Kent (NC)	13.64	7.14	5.37	1.27	10.83	27.89	1.94	2.76
SEM +	0.60	0.34	0.34	0.2	1.11	2.39	0.28	0.38
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

TABLE 3
Varietal differences for macro minerals content (%) in seed and straw of oats (Pooled)

Variety	N		P		K		Ca		Mg		S	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
PFO 3	2.21	1.13	0.45	0.12	0.65	0.82	0.10	0.35	0.19	0.30	0.19	0.19
UPO 94	2.34	1.12	0.41	0.18	0.61	1.23	0.10	0.35	0.18	0.37	0.17	0.17
UPO 212	2.29	1.11	0.48	0.13	0.56	0.85	0.09	0.32	0.18	0.29	0.18	0.19
OL 1802	2.06	1.24	0.47	0.15	0.67	1.25	0.15	0.39	0.23	0.33	0.19	0.20
OL 1804	2.25	0.99	0.47	0.11	0.63	0.98	0.20	0.33	0.22	0.28	0.21	0.19
OL 10	2.32	1.14	0.44	0.13	0.53	0.91	0.12	0.40	0.19	0.32	0.19	0.21
OS 6	2.26	1.17	0.46	0.10	0.61	0.90	0.10	0.36	0.20	0.33	0.20	0.17
OS 346	2.08	1.07	0.43	0.14	0.60	1.08	0.10	0.33	0.19	0.29	0.19	0.20
JH0 2004	2.29	1.10	0.46	0.15	0.60	0.98	0.09	0.36	0.19	0.31	0.20	0.20
JHO 851	2.31	1.20	0.48	0.14	0.73	0.99	0.11	0.33	0.21	0.32	0.21	0.21
JHO 99-1	2.39	1.22	0.51	0.13	0.68	1.02	0.13	0.36	0.24	0.31	0.22	0.19
JHO 99-2	2.21	1.08	0.45	0.10	0.70	1.03	0.12	0.35	0.23	0.31	0.20	0.18
JHO 822	2.13	1.15	0.47	0.13	0.53	0.90	0.10	0.36	0.19	0.31	0.22	0.21
JO 1	2.31	0.81	0.47	0.16	0.65	0.95	0.10	0.33	0.20	0.30	0.23	0.22
JO 03-91	2.27	1.08	0.42	0.14	0.65	1.07	0.11	0.36	0.21	0.35	0.20	0.23
NDO 1	2.81	1.19	0.57	0.19	0.59	1.33	0.09	0.34	0.20	0.33	0.21	0.16
Sabzaar	2.27	1.14	0.44	0.13	0.65	0.84	0.10	0.34	0.19	0.31	0.20	0.18
Kent (NC)	2.28	1.14	0.43	0.13	0.51	1.04	0.10	0.32	0.18	0.30	0.19	0.19
SEM +	0.06	0.09	0.02	0.02	0.04	0.16	0.02	0.03	0.01	0.03	0.01	0.01
C. D. (P=0.05)	0.18	NS	0.06	NS	0.1	NS	0.05	NS	0.03	NS	0.02	0.04

in crop residues (straw) that ranged between 5.09-6.33%, 37.63-40.47% and 2.17-3.80%, respectively but crude fat content varied significantly and highest content was recorded in oat variety JO 1 (2.14%) and lowest in JO-03-91 (1.41%).

Minerals content in seed and straw

Macro-mineral: Significant differences were observed amongst oats varieties for macro-minerals content (%) viz. nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S) in seed. In straw of oats variety, significant differences were observed for S only (Table 3).

Seed: NDO 1 recorded significantly higher N (2.81%) and P (0.57%) contents in seed. Lower N and P contents were observed in OL 1802 (2.06%) and UPO 94 (0.41%), respectively. K content was found to be significantly higher in JHO 851 (0.73%) as compared to many oat varieties including Kent (0.51%) but at par with PFO 3, OL 1802, OL 1804, Sabzaar, JHO 99-1, JHO 99-2 and JO 1. OL 1804 (0.20%) significantly at par with OL 1802 (0.15%) recorded higher Ca content as compared to remaining varieties including check variety Kent (0.09%). Mg content was recorded significantly higher in JHO 99-1 (0.24%) in comparison to Kent (0.18%) but at par with OL 1802, OL 1804, JHO 99-2, JHO 851 and JO 03-91. JO 1 variety recorded significantly higher S content (0.23%) in comparison to many varieties including Kent (0.19%) but statistically at par with OL 1804, JHO 851, JHO 99-1 and NDO 1. Lowest S content was observed in UPO 94 (0.17%). Results are in close conformity with Wilson *et al.* (2021) who reported that in oat grains, N (1.52-1.60%), Ca (0.07-0.10%), Mg (0.13-0.17%) and S (0.15-0.16%) contents differed significantly among the varieties but non-significantly for P (0.38-0.39%) and K (0.47-0.52%) contents. Differences in results may be due to varietal or climatic differences. Ozcan *et al.* (2017) reported that P, K, Ca and Mg contents of grains were found between 0.24-0.46%. 0.31-0.56%, 0.06-1.27%, 0.20-0.13% in oats grain samples, respectively.

Straw: In straw, statistical difference for S was recorded significantly higher in JO 03-91 (0.23%) in comparison to Sabzaar (0.18%), JHO 99-2 (0.18%), OS 6 (0.17%), UPO 94 (0.17%) and NDO 1 (0.16%). Non-significant differences were observed in straw for N, P, K, Ca and Mg mineral contents that ranged between 0.81-1.24%, 0.10-0.19%, 0.82-1.33%, 0.32-0.40% and 0.28-0.37%, respectively (Table 3). Singh *et al.* (2018a) reported that in oat varieties crop residue, JHO 99-1 (0.18%) at par with JO 1 (0.15%) recorded significantly higher P content than remaining oats

TABLE 4
Varietal differences for micro minerals content (ppm) in seed and straw (Pooled)

Variety	Cu		Mn		Fe		Zn	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
PFO 3	8.95	7.00	52.82	60.58	177.99	589.64	30.47	16.06
UPO 94	5.00	6.60	50.88	57.47	55.77	529.13	27.18	28.10
UPO 212	5.99	3.62	48.23	53.16	82.72	497.79	32.33	10.67
OL 1802	11.20	3.22	61.22	64.79	248.17	554.84	28.16	10.67
OL 1804	12.30	4.19	66.82	58.72	184.08	474.31	33.15	10.67
OL 10	9.43	4.89	57.05	64.55	130.89	639.68	29.90	10.67
OS 6	11.07	6.27	52.05	61.95	255.68	552.21	33.32	11.29
OS 346	8.87	4.88	51.83	63.21	144.36	596.27	31.90	10.67
JH0 2004	9.18	5.82	55.14	62.08	146.58	573.73	36.73	10.67
JHO 851	8.22	6.54	66.60	59.84	213.88	389.82	36.43	10.67
JHO 99-1	8.27	4.67	57.95	59.36	418.38	616.92	38.43	10.67
JHO 99-2	8.38	5.12	58.57	67.86	171.77	540.56	32.85	10.67
JHO 822	9.63	5.15	52.04	70.82	137.79	499.10	41.19	10.67
JO 1	8.39	5.84	54.77	70.73	194.49	683.79	27.69	17.57
JO 03-91	9.04	4.83	57.58	67.19	140.32	597.35	28.06	10.67
NDO 1	6.62	7.99	55.80	34.93	86.63	602.85	33.23	28.16
Sabzaar	9.99	5.27	38.21	54.71	133.57	482.31	31.75	10.67
Kent (NC)	8.08	3.61	48.75	57.13	133.90	512.23	28.28	10.67
SEM +	0.85	1.12	5.2	6.33	66.61	99.72	3.56	3.74
C. D. (P=0.05)	2.46	NS	NS	NS	NS	NS	NS	10.79

varieties, however, Ca, Mg, S and K content varied non-significantly between 0.26-0.34%, 0.26-0.30%, 0.20-0.46% and 0.67-0.89 %, respectively at harvest.

Micro-mineral: Significant differences were observed for micro-minerals content (ppm) copper (Cu) in seed and for straw in zinc (Zn) (Table 4). Non-significant differences were found for Cu content in straw, Mn and Fe contents in seed and straw, and Zn content in seed.

Seed: OL 1804 (12.30 ppm) at par with OL 1802 (11.20 ppm), OS 6 (11.07 ppm) and Sabzaar (9.99 ppm) recorded significantly higher Cu contents for seed in comparison to remaining varieties including Kent. Lowest Cu content was recorded in UPO 94 (5.00%). Varieties differed non-significantly amongst themselves for Mn, Fe and Zn contents, however, the values ranged between 38.21-66.82 ppm, 55.77-255.68 ppm and 27.18-41.19 ppm, respectively. *Ozcan et al.* (2017) reported that Fe, Zn and Mn contents of oats ranged between 29.98-80.78 ppm, 15.50-37.68 ppm, 25.82-62.55 ppm, respectively and reported that locations had significant effect on all macro and micro minerals concentrations of oats grains.

Straw: For Zn, statistical differences were recorded in variety NDO 1 (28.26 ppm) in comparison to all the other varieties. Lowest Zn content was recorded similar (10.67 ppm) in many varieties. Non-significant differences were observed in straw for Cu, Mn and Fe contents, however, values ranged between 3.22-7.99 ppm, 34.93-70.82 ppm and 389.82-683.79 ppm, respectively (Table 4). Results are in close conformity with Singh *et al.* (2018a), who also reported non-significant differences among oat varieties for Fe, Cu, Mn and Zn content in crop residues that ranged between 382-875 ppm, 5.75-8.47 ppm, 44.97-60.75 ppm and 11.47-19.74 ppm, respectively.

Minerals uptake

Macro-minerals: Significant differences were observed amongst varieties for macro-minerals [phosphorus (P_2O_5) and sulphur (S)] uptake in seed. Whereas, in straw, non-significant differences were observed for N, P_2O_5, K_2O, Ca, Mg and S uptake. (Table 5).

Seed: Significantly higher P_2O_5 uptake in seed was recorded in JHO 822 (16.46 kg/ha) in comparison to other varieties but at par with varieties viz. OS 346 (14.08 kg/ha), UPO 212 (13.83 kg/ha), OS 6 (13.16 kg/ha) and JHO 99-2 (12.88 kg/ha). Lowest P_2O_5 uptake in seed was observed in Sabzaar (9.23 kg/ha). S uptake in seed was significantly higher in JHO 822 (3.30 kg/ha) in comparison to all other varieties and lowest S uptake was recorded in NDO 1 (1.70 kg/ha). In seed N, K_2O, Ca, and Mg uptake varied non-

TABLE 5
Oat varietal differences on macro minerals uptake (kg/ha) by seed and straw (Pooled)

Variety	N		P_2O_5		K_2O		Ca		Mg		S	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
PFO 3	22.80	116.13	10.49	29.20	7.54	100.75	0.98	35.53	1.91	30.28	1.96	19.38
UPO 94	27.56	109.83	11.08	43.78	8.80	149.15	1.16	34.32	2.12	37.66	2.04	16.40
UPO 212	27.37	117.71	13.83	31.57	8.39	107.29	1.10	33.30	2.23	30.47	2.30	20.50
OL 1802	20.82	131.50	10.80	37.00	8.08	151.93	1.54	40.58	2.34	35.40	1.92	21.31
OL 1804	23.73	81.69	11.38	20.50	7.85	96.19	2.24	27.34	2.33	22.92	2.19	15.77
OL 10	28.40	103.34	12.60	27.80	7.73	99.11	1.48	35.44	2.38	28.61	2.35	18.42
OS 6	28.66	107.63	13.16	22.63	8.76	102.69	1.24	33.12	2.48	30.11	2.44	16.21
OS 346	29.43	108.09	14.08	32.82	9.99	131.74	1.43	33.52	2.66	29.90	2.69	20.14
JH0 2004	27.68	99.55	12.80	31.08	8.47	108.08	1.02	32.69	2.22	28.01	2.40	18.21
JHO 851	22.73	112.35	10.60	31.52	8.16	111.71	1.03	31.58	2.01	29.94	1.98	19.61
JHO 99-1	22.47	118.46	11.12	29.99	7.47	119.59	1.18	34.03	2.23	29.37	2.02	18.59
JHO 99-2	27.44	89.73	12.88	18.55	9.99	99.76	1.39	28.40	2.72	25.45	2.46	14.88
JHO 822	31.56	108.49	16.46	27.40	9.40	102.89	1.48	34.45	2.91	29.58	3.30	20.25
JO 1	22.38	104.37	10.32	35.38	7.35	110.73	0.89	30.58	1.86	28.53	2.14	21.47
JO 03-91	25.62	105.61	11.34	32.67	8.75	126.28	1.24	34.69	2.32	34.35	2.28	23.04
NDO 1	20.47	115.53	10.56	41.60	5.87	144.61	0.68	34.67	1.64	33.06	1.70	16.27
Sabzaar	20.86	106.73	9.23	27.79	7.04	94.29	0.88	31.90	1.70	28.56	1.81	17.15
Kent (NC)	26.52	112.80	12.16	28.87	7.44	122.16	1.19	31.57	2.23	29.99	2.29	18.86
SEM +	2.61	8.19	1,24	5.37	1.00	16.64	0.25	3.27	0.26	3.44	0.26	1.79
C. D. (P=0.05)	NS	NS	3.58	NS	NS	NS	NS	NS	NS	NS	0.74	NS

TABLE 6
Effect of varietal differences in micro minerals uptake (g/ha) of seed and straw (Pooled)

Variety	Cu		Mn		Fe		Zn	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
PFO 3	8.43	72.79	51.76	624.32	158.57	6061.48	32.03	176.75
UPO 94	6.06	64.37	59.69	540.85	65.86	5049.29	32.18	282.76
UPO 212	7.24	39.43	60.56	557.01	96.73	5125.53	39.45	116.20
OL 1802	11.09	35.24	61.14	680.63	245.79	5669.47	28.66	117.05
OL 1804	12.50	33.65	70.69	484.26	191.53	3923.41	34.70	85.03
OL 10	11.05	43.66	68.82	578.75	151.67	5595.77	36.59	100.42
OS 6	12.57	58.25	62.77	570.54	262.92	4973.53	42.30	104.95
OS 346	12.36	47.69	80.45	683.01	186.24	6175.11	39.48	102.68
JH0 2004	9.81	44.03	60.88	575.32	154.67	5417.04	38.13	100.50
JHO 851	7.84	55.45	51.15	585.44	131.18	5557.55	35.39	98.78
JHO 99-1	7.42	63.80	61.58	585.56	194.93	3798.37	34.81	104.47
JHO 99-2	9.67	39.38	69.30	482.04	468.09	4728.26	45.14	96.29
JHO 822	12.59	46.43	88.00	643.12	259.49	4936.82	50.77	101.98
JO 1	8.78	48.60	48.76	658.86	120.70	4598.50	38.58	106.28
JO 03-91	8.51	56.48	61.35	687.14	168.99	6931.29	30.41	159.34
NDO 1	5.47	78.25	45.07	394.35	69.89	6356.86	26.89	264.17
Sabzaar	8.73	49.96	31.08	510.53	119.75	4457.59	28.73	100.38
Kent (NC)	9.65	35.08	59.11	561.88	159.54	4954.78	34.52	103.81
SEM +	1.43	11.89	9.39	64.90	77.80	1157.08	5.48	37.42
C. D. (P=0.05)	4.14	NS	NS	NS	NS	NS	NS	108.01

significantly between 20.47-31.56 kg/ha, 5.87-9.99 kg/ha, 0.68-2.24 kg/ha and 1.64-2.48 kg/ha, respectively (Table 5). Bhat *et al.* (2000) reported nitrogen, phosphorus and potassium nutrient uptake in grain of variety Kent ranged between 40.3-101.8 kg/ha, 6.0-12.4 kg/ha and 11.1-28.8 kg/ha with the application of nitrogen ranging from 0.0 to 150.0 kg/ha.

Straw: In straw, non-significant differences were observed among for macro-minerals N, P_2O_5, K_2O, Ca, Mg and S, however, the value ranged between 81.69-131.50 kg/ha, 18.55-43.78 kg/ha, 96.19-151.93 kg/ha, 27.34-40.58 kg/ha, 22.92-37.66 kg/ha and 14.88-23.04 kg/ha, respectively (Table 5). Bhat *et al.* (2000) reported N, P and K uptake in straw of Kent variety ranged between 45.5-110.3 kg/ha, 4.1-10.6 kg/ha and 94.4-213.2 kg/ha with the application of nitrogen from 0.0 to 150.0 kg/ha. Mean nutrient uptake for secondary minerals viz. Ca, Mg and S was reported to be 20.5 kg/ha, 21.9 kg/ha and 14.5 kg/ha in eight oat varieties in fodder by Singh and Chauhan (2017).

Micro-minerals: Significant differences were observed amongst varieties for micro-mineral uptake copper (Cu) in seed and zinc (Zn) in straw (Table 6).

Seed: Significantly higher Cu uptake in seed was recorded in JHO 822 (12.59 g/ha), in comparison to few varieties but at par with OS 6 (12.57 g/ha), OL 1804 (12.50 g/ha), OL 1802 (11.09 g/ha), OL 10 (11.05 g/ha), JHO 2004 (9.81 g/ha), JHO 99-2 (9.67 g/ha), Kent (9.65 g/ha), JO 1 (8.78 g/ha), Sabzaar (8.73 g/ha) and JO 03-91 (8.51 g/ha). Lowest Cu uptake in straw was observed in NDO 1 (5.47 g/ha). In seed, Mn, Fe and Zn uptake varied non-significantly between 31.08-88.00 g/ha, 65.86-468.09 g/ha and 26.89-50.77 g/ha, respectively (Table 6).

Straw: Non-significant differences were observed for Cu, Mn and Fe uptake in straw, however, the values ranged between 33.65-78.25 g/ha, 394.35-687.14 g/ha and 3798.37-6931.29 g/ha, respectively (Table 6). Variety UPO 94 (282.76 g/ha) at par with NDO 1 (264.17 g/ah) and PFO 3 (176.76 g/ha) recorded significantly higher Zn uptake in straw as compared to other varieties. Singh and Chauhan (2017) reported that mean mineral uptake viz. Fe, Cu, Mn and Zn was 3202 g/ha, 42 g/ha, 487 g/ha and 131 g/ha in eight oat varieties for fodder yield.

CONCLUSION

In this study, two oat varieties JHO 822 (14.85 q/ha) and OS 346 (14.16 q/ha) produced 22.32 and 16.64 per cent higher seed yield than the check variety Kent (12.14 q/ha). However, few other varieties viz. UPO 212, JHO 99-2, OS 6 and OL 10 also performed satisfactory due to more than 12.0 q/ha seed yield under central Gujarat conditions. Seed of NDO 1 was found to be rich source of N, P and S.

Whereas, seed of OL 1804 was found to be rich source of Ca, Cu, Mn and K. Most of the oat varieties in the trial were found to be at similar level for proximate parameters contents in seed and straw. Hence, for taking up oat commercial seed production program, JHO 822 and OS 346 may be highly recommended in comparison to old variety Kent under central Gujarat conditions.

ACKNOWLEDGEMENT

Authors are grateful to the Project In-charge, ICAR-AICRP on Forage Crops & Utilization Project, Jhansi and NDDB for providing the facilities necessary to conduct these studies.

REFERENCES

AOAC. 2012 : *Official Methods of Analysis*. 19th Edn., Association of Official Analytical Chemists, International L, Gaithersburg, MD.

Bhat, M. D., K. N. Singh, A. Bali and M. H. Shah. 2000 : Grain yield of oats *(Avena sativa)* as influenced by sowing time and nitrogen levels under temperate conditions of Kashmir. *Indian Journal of Agronomy*, **45**(1): 199-204.

Chand S., S. Kumar, A. K. Roy, D. Vijay, B.B. Choudhary, Indu, P. Kumar, R. K. Agrawal, V. K. Yadav, P. Kaushal, D. K. Yadava, R. V. Kumar, A. K. Singh, S. Ahmed, D. R. Malaviya, R. K. Singhal, B. Prasad, R. Kapoor, A. K. Jha and R. Panchta. 2025 : Analyzing trends and future projections in fodder oats (*Avena sativa* L.) for quality seed production in India. *Frontiers in Plant Science*, **16**: 1525422. doi: 10.3389/fpls.2025.1525422.

Chand, S., K. Chandra and C. L. Khatik. 2020 : "Varietal release, notification and denotification system in India," in Plant Breeding-Current and Future Views. Ed. I. Y. Abdurakhmonov (Intech Open, London, United Kingdom), 1–12. doi: 10.5772/intechopen.94212.

Choudhary, O. P., N. K. Singh, Digvijay Singh, A. K. Singh and Jagsir Singh. 2022 : Role of dairy cooperatives in fodder seed production system. *Range Management & Agroforestry*, **43**(1): 1-10.

Das, L. K., S. S. Kundu, D. Kumar, and C. Datt. 2015 : Fractionation of carbohydrate and protein content of some forage feeds of ruminants for nutritive evaluation. *Veterinary World*, 8, 197. doi: 10.14202/vetworld.2015.197-202.

Hilli, H. J., R. Kapoor and Amandeep. 2023. Forage Production in India: Bottlenecks and Opportunities by Opening up New Way with an Increase in Fodder Oats Demand: A Review. *Asian Journal of Dairy and Food Research*, 42 (3): 275-285. doi: 10.18805/ajdfr.DR-2050.

IGFRI 2011: Vision 2030: In: Pandey K.C. and A.K. Roy (ed.) Forage Crops Varieties. IGFRI, Jhansi, India, pp. 23-27. http://www.igfri.res.in/pdf/Vision-2030.pdf.

IS/ISO 5983-2 2005: Animal feeding stuffs - Determination of nitrogen content and calculation of crude protein content, Part 2: block digestion/steam distillation method [FAD 5: Livestock Feeds, Equipment and Systems].

Jaipal and S. S. Shekhawat. 2016: Character association studies in oats (*Avena sativa* L.) for green fodder and grain yield. *Forage Research*, 42 (1): 24-29.

Jindal, Y., D. S. Phogat, N. K. Thakral, Satpal and J. Toka. 2024: HFO 427: A single-cut oats variety for south zone of India. *Forage Research,* **50**(2): pp. 228-231.

Kalamkar, S. S., A. Kinjal, S. R. Bhiaya and H. Sharma. 2019: Report on 'Impact assessment and evaluation of fodder seed production and sale activities under national dairy plan-I in selected states of India', AERC Report No. 186, Agro-Economic Research Centre, Sardar Patel University, Vallabh Vidyanagar, Anand, Gujarat. pp. 112. https://www.nddb.coop/ndpi/about/ndpistudies (accessed on July 15, 2025).

Kaur, M. U. S. Tiwana and S. Singh. 2023: Seed yield response of fodder oats varieties to row spacing and seed rate in north-west parts of India. *Range Management and Agroforestry,* **44**(2): 323-328.

Kaur, M., U. S. Tiwana and S. Singh. 2023: Seed yield response of fodder oats varieties to row spacing and seed rate in north-west parts of India. *Range Management and Agroforestry,* **44**(2): 323-328.

Kebede, G., Walelign Worku, Habte Jifar, Fekede Feyissa. 2023: Grain yield productivity, nutrient uptake and use efficiency and profitability of oats (*Avena sativa* L.) as influenced by variety and levels of nitrogen and phosphorus fertilizers in the central highlands of Ethiopia. *Journal of Crop Science and Biotechnology,* https://doi.org/10.1007/s12892-023-00230-3.

Kibite, S. 1997: Ac juniper oats. *Canadian Journal of Plant Science*, **77**(4): 647- 649.

Monika, R. S. Sheoran, K. Singh and Satpal. 2018: Effect of cutting management and phosphorus levels on growth, forage and seed yield of multicut oats (*Avena sativa* L.). *Forage Research*, 44 (1): 8-13.

Ozcan, M. M., A. Bagci, N. Dursun, S. Gezgin, M. Hamurcu, Z. Dumlupýnar, and N. Uslu. 2017: Macro and Micro Element Contents of Several Oats (*Avena sativa* L.) Genotype and Variety Grains. *Iranian Journal of Chemistry & Chemical Engineering,* **36** (3): 73-79.

Ranjan, R., S. Chand, R. K. Singhal, M. Rana, R. Sah, R. Gajghate. 2024: Genetic diversity amongst oats (*Avena sativa*) lines for micronutrients and agro-morphological traits. *Indian Journal of Agricultural Sciences*, **94**: 665-672. doi: 10.56093/ijas.v94i6.139929.

Rasane P., A. Jha, L. Sabikhi, A. Kumar and V. S. Unnikrishnan. 2015: Nutritional advantages of oats and opportunities for its processing as value added foods-A review. *Journal of Food Science and Technology*, **52**(2): 662–675.

Sheoran, O. P., D. S. Tonk, L. S. Kaushik, R. C. Hasija, and R. S. Pannu. 1998: Statistical Software Package for Agricultural Research Workers. In: *Recent Advances in information theory, Statistics & Computer Applications*, D.S. Hooda & R.C. Hasija (eds.). Department of Mathematics Statistics, CCS HAU, Hisar. pp. 139-143.

Singh, Digvijay and Avinash Chauhan. 2017: Evaluation of Oats and Barley varieties for fodder yield, quality and mineral uptake potential under central Gujarat conditions. *Range Management & Agroforestry*, **38** (1): 89-95.

Singh, Digvijay, A. Chauhan and A. Choudhary. 2018a: Relative performance of oats forage varieties for seed production, economics and fodder yield under central Gujarat conditions. *Forage Research*, **44**(3):185-191.

Singh, Digvijay. 2022: Screening of oats varieties for higher seed yields under last sown condition. In: D.R. Palsaniya, M. Rana, A. K. Singh, M. Choudhary, O. M. Limbalkar, A. Ghosh, M. Tomar, T. Singh, R. Srinivasan, B.B. Choudhary, J.B. Singh and S.K. Mahanta (Eds). Innovations in Forage and Livestock Sector for Enhancing Entrepreneurship and Farm Productivity: Souvenir cum abstracts of National Symposium, November 1-3, 2022, Jhansi, India, Range Management Society of India, Jhansi, UP, India pp 175.

Singh, V. K., A. K. Sinha, P. S. Takawle, D. N. Shindey and M. K. Srivastav. 2018b: Evaluation of different oats varieties for green fodder and seed production yields. *International Journal of Recent Advances in Multidisciplinary Research*, **05**(03): 3668-3670.

Veettil, P. C., A. Devi, and I. Gupta, 2018: "Caste, informal social networks and varietal turnover," in 10th International Conference of Agricultural Economists (Vancouver, Canada: agecon search). July 29-August 2. doi: 10.22004/ag.econ.277172.

Verma. R., D. Vijay, C. K. Gupta and D. R. Malaviya, 2014: Seed quality enhancement of oats (*Avena sativa* L.) varieties through priming. *Range Management & Agroforestry*, **35**(1): 144-150.

Wilson, M.L., E. E. Evans, L. Klossner and P. H. Pagliari, 2021: Organic Oats Response to Variety, Seeding Rate, and Mineral Source and Rate. *Agronomy*, **11**: 1418. *https:// doi.org/10.3390/agronomy 11071418*.