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SEED YIELD POTENTIAL OF FODDER OATS (*Avena sativa* L.) TO THE DATE OF SOWING AND DEFOLIATION MANAGEMENT

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ABSTRACT

Optimizing sowing date and assessing defoliation responses are crucial for enhancing the seed yield of fodder oats (Avena sativa L.), particularly in the case of both seed and straw yields. A two-year field study on fodder oats was done at the National Pasture and Fodder Research Program, Khumaltar, Lalitpur, Nepal, to determine optimum date of sowing and the effect of defoliation on seed production. In the first experiment, the fodder oats cultivar Netra was sown on six dates (October 1, October 15, November 1, November 15, December 1 and December 15) using recommended agronomical practices. The experiment was conducted in Randomized Complete Block Design (RCBD) The second experiment was done to evaluate seed yield of two defoliation regimes, Zero-cut and One-cut at 45 days after sowing by using four fodder oat cultivars) in RCBD. The results revealed that the date of sowing significantly ($p<0.001$) influenced growth and seed yield parameters. Accordingly, sowing on November 1 produced the highest ($p<0.001$) seed yield, associated with superior ($p<0.05$) tillering, indicating early November as the optimum sowing time for seed production. Defoliation significantly ($p<0.05$) reduced plant height, number of effective tillers plant^{-1} and seed yield across all cultivars.

Keywords: Cultivar, Defoliation management, Number of effective tillers, Number of leaves, Straw yield

INTRODUCTION

Oat (*Avena sativa* L.) is an important multipurpose cereal crop globally, valued not only for its grain but also as a highly nutritious fodder for livestock. Within crop-livestock systems, high quality roughage like oat fodder is vital for sustainable animal production (Russelle *et al.*, 2007). Although, it is primarily cultivated for grain, its utility as a dual-purpose crop, where early growth can be grazed or cut for forage before the crop is left to regenerate for grain harvest, offers an effective strategy to enhance farm profitability and resource use efficiency (Bharati *et al.*, 2023; Ghimire, 2025).

The successful cultivation of oat, whether for single or dual purposes, is highly dependent on agronomic management, and the sowing date being a critical determinant of productivity. The phenological development of oat is exquisitely sensitive to environmental parameters such as temperature and photoperiod (Ghimire *et al.,* 2026). Sowing at an optimal time ensures

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that critical growth stages, including tillering, panicle initiation and grain filling; coincide with favourable climatic conditions thereby maximizing yield potential. On the otherhand, suboptimal sowing dates can expose the crop to abiotic stresses like terminal heat or moisture deficit that leads to significant yield reduction (Basu *et al.*, 2009). Identifying the appropriate date of sowing is therefore essential for optimizing seed yield, particularly in specific agro-ecological zones like the mid-hills of Nepal. For dual-purpose systems, defoliation management is another important factor. The practice of harvesting oat for fodders at a vegetative stage, followed by regrowth for seed, involves a multifaceted phenomenon. In general, while it provides the forage the defoliation acts as a physiological stressor, removing photosynthetic tissue and apical meristems, which can compromise the ability of the plant to accumulate biomass and ultimately reduce grain yield (Zhang *et al.*, 2021). The magnitude of yield reduction is influenced by the timing and severity of defoliation, as well as the genetic potential of the cultivar for regrowth and compensatory growth (Ferraro & Oesterheld, 2002). Cultivars with greater tolerance to defoliation, capable of maintaining satisfactory seed yields after a cutting are crucial for the economic viability of dual-purpose systems (Baron *et al.*, 1994).

In the context of growing importance of oat as the winter forage crop and the increasing research emphasis on optimizing its seed production in Nepal, the information particularly on the date of sowing and the feasibility of dual-purpose use remains limited. Therefore, the study was done to determine the optimum sowing dates for seed production of oats and to assess the effect of defoliation on the seed yield production of promising fodder oat cultivars.

MATERIALS AND METHODS

Experimental site

The study was conducted at the research field of the National Pasture and Fodder Research Program under Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur (27°39'18" N 85°19'29" E, altitude 1335 masl) during September 2018 to May 2020. The site experiences a humid subtropical climate. The weather parameters recorded at the station during the study period are presented in Figure 1.

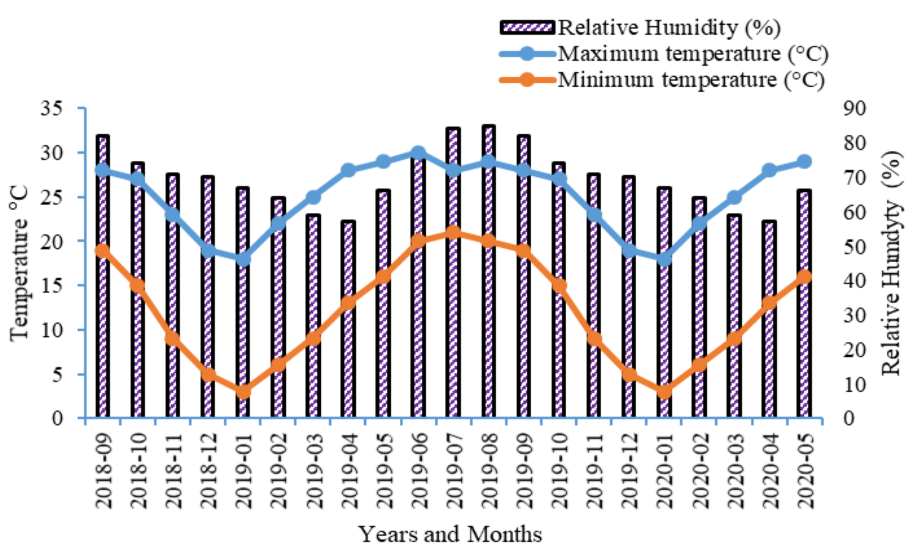

Figure 1. Monthly temperatures and Relative Humidity during September, 2018 to May 2020 at Khumaltar, Lalitpur, Nepal

The soil physicochemical properties of the experimental fields for both experiments were analysed prior to sowing (Table 1). The soil was moderately acidic with medium to high levels of organic matter, nitrogen, phosphorus and potassium contents (Table 1).

Table 1. Physicochemical properties of the soil at the experimental sites at Khumaltar, Lalitpur, Nepal

Parameters	Date of sowing experiment (Mean±SD)	Defoliation management experiment (Mean±SD)
pH	5.4±0.04	5.8±0.98
Total N (%)	0.2±0.01	0.2±2.02
P2O5 (kg ha^{-1})	79.0±7.22	80.4±0.71
K2O (kg ha^{-1})	317.36±40.86	338.56±32.84
OM (%)	3.12±0.38	3.37±0.39

Experimental details

The first-year experiment on date of sowing was laid out using Randomized Complete Block Design (RCBD) with four replications for each treatment compromising six dates of sowing (October 1, October 15, November 1, November 15, December 1 and December 15). Netra cultivar of fodder oats was used and the plot size was maintained for 12 square-meter as an experimental unit. The seed rate of 80 kg ha^{-1} was used. Fertilizer was applied at 80:60:40 kg ha^{-1} N:P_2O_5:K_2O. A basal dose of 40 kg ha^{-1} N along with the full dose of P and K was applied at the time of sowing. The remaining 40 kg ha^{-1} N was top-dressed after irrigation at 45 days after sowing (DAS). Weeding, irrigation and other crop management practices were carried out as per the recommendations of Nepal Agricultural Research Council (NARC).

The second-year experiment on defoliation management was done using a RCB Design with five replications for each treatment. The treatments were Zero-cut (not defoliated) and One-cut (defoliated once at 45 DAS) in four fodder oat cultivars were evaluated. Each experimental plot measured 12 m^2. The defoliation height was maintained at 5 cm above ground level. The seed rate of 80 kg ha^{-1} and a fertilizer dose of 80:60:40 kg ha^{-1} N:P_2O_5:K_2O was applied. Basal dose of 40 kg ha^{-1} N and the full dose of P and K was applied at the time of sowing and the remaining nitrogen was top-dressed. The top-dressings for the Zero-cut plots were done after an irrigation application at 45 DAS, while it was applied after the defoliation followed by irrigation in case of the defoliated plots. Weeding, irrigation and other crop management practices were uniformly maintained for all plots as per the NARC recommendation.

Data Collection

For both experiments, agronomic data were collected at seed maturity. Plant height, number of leaves tiller^{-1} and number of effective tiller plant^{-1} were measured from five randomly selected plants in every plot. The seed yield and straw yield were collected by harvesting the central three rows of each plot. The harvested materials were threshed, winnowed and dried to 12% moisture content for seed yield determination. The yields were calculated to kg m^{-2} by using the following equation, and then converted to t ha^{-1}.

$$\text{Seed yield, kg m}^{-2} = \frac{\text{Seed yield of three central rows, kg}}{\text{Row to row distance, m} \times \text{Row length, m} \times \text{Number of sample rows}}$$

Similarly, the following equation was used to estimate the straw yield per m^2 and converted to t ha^{-1}.

$$\text{Seed yield, kg m}^{-2} = \frac{\text{Seed yield of three central rows, kg}}{\text{Row to row distance, m} \times \text{Row length, m} \times \text{Number of sample rows}}$$

Statistical Analysis

The data from date of sowing experiment conducted during first year were analysed using one-way Analysis of Variance under RCBD. The treatment means were separated by using the Tukey's HSD Test at a 5% level of significance. For the defoliation experiment conducted in second year, the primary objective was to assess the effect of defoliation on seed yield components, seed yield and straw yield within each cultivar. Therefore, a paired sample t-test (2-tailed) was employed to evaluate the effects of defoliation on these parameters for each cultivar separately. The statistical analyses were performed using the jamovi™ (The jamovi project, 2020) software.

RESULTS

Date of sowing

Sowing date had a significant influence ($p<0.001$) on all measured growth and yield parameters of fodder oats (Table 2). Plant height differed markedly across sowing dates, with crops sown from October 1 to November 15 producing statistically similar ($p>0.05$) and comparatively taller plants (128.85-139.68 cm). In contrast, plant height declined substantially when sowing was delayed to December, with the reduced plant height (78.19 cm) recorded on December 15 (Table 2).

The number of effective tillers plant^{-1} was also affected by sowing date. The highest tiller number (7.45 plant^{-1}) was obtained from the November 1 sowing, which was significantly higher ($p<0.001$) to all other treatments. Tiller production declined with both earlier (October) and later (December) sowings.

Seed yield followed a similar trend, with November 1 sowing producing the maximum seed yield (4.576 t ha^{-1}), which was significantly higher than all other dates ($p<0.001$). Sowing on November 15 followed the November 1 for seed yield, while the lowest yield was recorded for December 15 sowing. Straw yield showed comparable responses, with the highest value (13.352 t ha^{-1}) from the early November sowing and pronounced reductions in December sowings.

The results showed that optimal crop growth, tillering and seed production were achieved when oat was sown in early November, while substantial yield penalties occurred with delayed sowing.

Table 2. Seed yield and yield components of fodder oats (cv. Netra) under different dates of sowing at Khumaltar Lalitpur, Nepal

Date of sowing	Plant height (cm)	No of leaves tiller^{-1}	No of effective tillers plant^{-1}	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})
October 1	139.68^{a}	6.28^{b}	5.22^{cd}	2.306^{d}	11.317^{bc}
October 15	136.60^{a}	5.88^{bc}	6.25^{b}	3.084^{c}	12.083^{ab}
November 1	128.85^{a}	6.83^{a}	7.45^{a}	4.576^{a}	13.352^{a}
November 15	131.60^{a}	5.63^{c}	6.50^{b}	3.671^{b}	11.951^{b}
December 1	107.63^{b}	5.67^{c}	5.69^{c}	2.835^{c}	10.654^{c}
December 15	78.19^{c}	4.85^{d}	5.10^{d}	1.508^{e}	7.523^{d}
Significance (F-test)	***	*	***	***	***

Defoliation management

Defoliation at 45 DAS had a significant impact on plant height, tillering, seed and straw yield across all four oat cultivars evaluated (Tables 3 and 4). Plant height was consistently reduced ($p<0.05$) in defoliated plants of each cultivar, with decreases ranging from 18 to 31 cm depending on cultivar. Significant reductions ($p<0.05$) in the number of leaves tiller^{-1} were observed in Amritdhara and Kamadhenu, while the effect was non-significantly different ($p>0.05$) in Ganesh and Parbati (Table 3).

Defoliation significantly decreased the number of effective tillers plant^{-1} in all cultivars. Zero-cut plants produced 6.80-8.56 tillers plant^{-1}, whereas one-cut plants produced only 6.00-6.16 tillers plant^{-1}, reflecting their incomplete compensatory ability after removal of photosynthetic and meristematic tissues.

Seed yield was significantly reduced in all cultivars following defoliation ($p<0.01$). Under zero-cut management, seed yield ranged from 3.63 t ha^{-1} (Amritdhara) to 4.62 t ha^{-1} (Parbati). Defoliation reduced seed yield by 43%, 24%, 37% and 31% in the case of Amritdhara, Kamadhenu, Ganeshand Parbati cultivars, respectively. Straw yield exhibited similar declines ($p<0.05$) across cultivars. Among the tested cultivars, Kamadhenu showed the least proportional reduction in seed yield, indicative of its comparatively higher tolerance to defoliation and better suitability for dual-purpose use (Table 4), although the statistical significances of the reduction in seed yield were yet to be analyzed.

Table 3. Seed components of different fodder oats cultivars under defoliation treatments at Khumaltar, Lalitpur, Nepal

Defoliation	Amritdhara			Kamadhenu			Ganesh			Parbati		
	Plant height (cm)	No of leaves $tiller^{-1}$	No of effective tillers $plant^{-1}$	Plant height (cm)	No of leaves $tiller^{-1}$	No of effective tillers $plant^{-1}$	Plant height (cm)	No of leaves $tiller^{-1}$	No of effective tillers $plant^{-1}$	Plant height (cm)	No of leaves $tiller^{-1}$	No of effective tillers $plant^{-1}$
Zero-cut	136.26	3.93	6.80	130.20	4.46	8.56	122.33	3.73	6.64	102.20	3.60	6.93
One-cut	104.73	3.53	6.00	103.53	3.86	6.13	102.53	3.93	6.16	87.53	3.20	6.00
Significance$^{\lambda}$	**	*	*	*	*	**	*	ns	**	**	ns	*

$^{\lambda}$Paired differences significance in t-test (2-tailed), * significance at $p<0.05$, ** significance at $p<0.01$.

Table 4. Seed and straw yield (t ha^{-1}) of different fodder oat cultivars under defoliation treatments at Khumaltar, Nepal

Defoliation	Amritdhara		Kamadhenu		Ganesh		Parbati	
	Seed yield	Straw yield	Seed yield	Straw yield	Seed yield	Straw yield	Seed yield	Straw yield
Zero-cut	3.625	14.636	4.163	13.350	3.930	13.600	4.617	15.702
One-cut	2.068	9.297	3.182	10.583	2.480	11.245	3.182	12.887
Significance$^{\lambda}$	**	**	**	**	**	*	**	*

$^{\lambda}$Paired differences significance in t-test (2-tailed), * significance at $p<0.05$, ** significance at $p<0.01$.

DISCUSSION

The marked variation in growth and yield components across different sowing dates demonstrates the strong influence of seasonal temperature and photoperiod on fodder oat phenology. The superior seed yield obtained from the November 1 sowing is consistent with the well-established principle that fodder oat performs best when vegetative growth, panicle initiation and grain filling coincide with moderate temperatures and favorable day lengths. Although early October sowings produced taller plants, they generated comparatively fewer effective tillers and lower seed yields, likely because crop establishment occurred under relatively warmer conditions and less favorable photoperiods during the initial stages of development (Ko *et al*., 2022; Trevaskis *et al*., 2022). In contrast, delayed sowing, particularly in December, exposed seedlings to low temperatures and shortened day lengths, conditions that can accelerate phenological development, reduce tillering, shorten the vegetative growth period and ultimately limit biomass accumulation and reproductive potential (Devi *et al*., 2023). The substantial decline in seed yield under December sowing agrees with the findings of Dhakal *et al*. (2023), who reported considerable yield penalties when oat sowing was delayed beyond mid-November under mid-hill environments of Nepal.

The results clearly indicate that early November provides the most suitable combination of environmental conditions for oat seed production at Khumaltar condition. Sowing during this period allows adequate vegetative growth, optimal tiller development and grain filling under favorable temperatures, thereby avoiding both early-season heat stress and late-season cold stress. Consequently, sowing oat around November 1 can be considered as the optimum planting date for seed production in agro-ecological conditions similar to those of central Nepal.

Previous studies have consistently demonstrated the effects of forage defoliation on growth and seed yield potential in oat genotypes (Devkota *et al*., 2015; Ghimire *et al*., 2026). The second experiment was designed to evaluate the effects of defoliation on the seed production performance of recently developed oat cultivars rather than to re-establish the response of a widely adopted check cultivar used in sowing date experiment. Therefore, the emphasis of the second experiment was on assessing whether newly released cultivars possess comparable or superior tolerance to defoliation stress. From a breeding and cultivar evaluation perspective, understanding the relative resilience of new cultivars is more important than repeatedly validating responses that have already been well established in a benchmark cultivar.

The significant reduction in seed yield following forage harvesting in all cultivars highlights the inherent compromise associated with dual-purpose oat management. Removal of photosynthetically active biomass during the stem elongation stage (45 DAS) reduces the assimilatory capacity of the crop and limits the accumulation and translocation of carbohydrates required for floret development, grain set and grain filling (Ferraro & Oesterheld, 2002; Bell *et al*., 2020; Ko *et al*., 2022). Although partial compensatory growth through additional tillering was observed, it was insufficient to fully offset the loss of assimilate-producing tissues, resulting in a measurable decline in final seed yield. Similar responses have been reported in oats and other small-grain cereals, where defoliation after the commencement of stem elongation generally reduces reproductive productivity because the capacity for compensatory growth becomes progressively restricted (Bell *et al*., 2020; Ferraro & Oesterheld, 2002). Studies conducted in Nepal have likewise shown that forage harvesting can substantially increase total biomass production while causing varying levels of seed yield reduction, depending on genotype, cutting stage and environmental conditions (Devkota *et al*., 2015; Ghimire *et al*., 2026).

Notably, cultivars differed in their response to defoliation. Kamadhenu exhibited the least proportional reduction in seed yield (24%) following forage harvest, indicating comparatively greater tolerance to defoliation stress. However, the statistical significance of cultivar differences in defoliation response was not evaluated in this study. Such genotypic variation in response to defoliation has been widely reported in fodder oat, with yield losses ranging from approximately 20% to 45% depending on cultivar characteristics and timing of defoliation (Yang *et al*., 2019). The comparatively superior performance of Kamadhenu, although statistically not tested, suggests greater regrowth capacity, enhanced recovery following biomass removal, and more efficient partitioning of assimilates to reproductive structures after stress. These attributes are particularly desirable for dual-purpose cultivars because they allow the production of valuable forage without incurring excessive reductions in seed yield (Baron *et al*., 1994). Future studies incorporating economic analyses that compare the value of harvested forage with the associated reduction in seed yield would provide a more comprehensive assessment of the profitability and practical feasibility of dual-purpose oat production systems in Nepal.

CONCLUSION

The findings demonstrated that both sowing date and defoliation management significantly influence seed yield of fodder oat under the mid-hill valley conditions of Nepal. For maximizing seed production, early November sowing (November 1) without defoliation was the most effective strategy, producing the highest seed yield and superior yield components. A single defoliation at 45 DAS reduced seed yield by 24-43% across cultivars, indicating a clear trade-off between forage harvest and seed production. However, where both forage and seed are desired from the same crop, further comprehensive study incorporating biological and economic analysis of forage and seed yields following a single forage harvest are needed to assess the feasibility and profitability of dual purpose production system.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICAL STATEMENT

The manuscript is original work of the authors and has not been published previously, nor submitted, nor is it under consideration for publication elsewhere.

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