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Studies on the performance of promising varieties of oat (*Avena sativa* L.) under different cutting regimes in mid hill conditions of Himachal Pradesh

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Abstract
A field experiment was conducted to study the performance of promising varieties of oat under different cutting regimes. Amongst the oat varieties tested, Palampur-1 recorded significantly higher tiller number per metre row length and better leaf stem ratio compared to other varieties. Tiller number also increased with each delay in harvesting stage and highest tiller number was recorded at 50 per cent flowering stage, however, significantly highest leaf stem ratio was in fodder harvested at 30 cm plant height. Significantly higher total green (329 q ha^{-1}) and dry (185 q ha^{-1}) fodder yields were obtained with Palampur-1 harvested at 50 per cent flowering stage compared to other varieties with different cutting regimes. Comparatively better net returns and net returns per rupee invested were obtained with variety Palampur-1 and cutting at 50 per cent flowering stage. However, cutting at 45 cm height fetched better green fodder yield than cutting at 60 cm height which gave regular fodder supply with good green fodder yield thus suggesting it good for small and marginal farmers.

Keywords: oat, yield, fodder and cutting

Introduction
Oat (*Avena sativa* L.) is the most important winter cereal fodder crop, which is highly palatable, nutritious and energy rich fodder with average crude protein and crude fibre content of 6.8 and 39.5-40.0 per cent, respectively (Dar *et al*. 2007) [4]. Increased nutritional demand for optimal animal performance has challenged oat producers to select superior oat varieties and to combine good management practices to produce crop with high yield and favourable quality characteristics (Kim *et al*. 2006) [8]. The need of farmers for forage production of nutritious fodder crop like oat can be made possible by introducing varieties which are having the potential of providing higher green forage yield regularly even during the lean winter months. Multi-cut nature of the crop ensures continuous supply of fodder during the entire season. A good number of varieties of oat have been recommended for cultivation in Himachal Pradesh. However, growth behaviour in terms of crop growth rate, regeneration rate after cutting, production potential and quality characteristics of a particular variety under different agro-climatic conditions mainly depend upon the genetic makeup of a variety. A particular variety may respond differentially to the management practices like cutting management under different agro-climatic conditions. The availability of green fodder over the cropping season may, therefore, be regulated by cutting management and as regeneration of a crop after frequent cutting may be governed by the genetic makeup of a particular genotype. Therefore, it will be worthwhile to know the response of the promising varieties to different cutting regimes and to identify the most suitable variety that can supply green fodder regularly during winter months.

Material and Methods
A field experiment was conducted at Research Farm of the Fodder unit of the Department of Crop Improvement, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (H.P.) laid out during *rabi* 2014-2015. Soil of the experimental site was silty clay loam in texture, acidic (5.6) in reaction, medium in organic carbon (0.62 %), available nitrogen (323.0 kg/ha) and available phosphorus (22.8 kg/ha) and high in available potassium (286.4 kg/ha). Twelve treatment combinations comprising of three varieties *viz.* Palampur-1, Kent and JHO-99-1 and four cutting regimes *viz.* C_1-30, C_2-45, C_3-60 cm and C_4-50 % flowering stage replicated thrice in a factorial randomized block design.

The harvested green forage was weighed plot wise using hanging scale balance of 50 kg capacity. Thereafter, it was converted into q ha^{-1} from kilogram per plot. For crude protein, the nitrogen contents of sample was determined using methods given by AOAC (1970) [1] and the value recorded for nitrogen was then multiplied with 6.25. Neutral detergent fibre and Acid detergent fibre were estimated by the method suggested by Van Soest *et al.* (1991), respectively.

Results and Discussion

Days taken to attain cutting stage

Days taken to attain cutting stage were significantly affected by varieties and cutting management (Table 1). Kent took significantly minimum number of days to attain different stages required for cutting which might be due to faster growth, while, JHO-99-1 took significantly maximum number of days to attain plant height due to its slow growth than other two varieties. The differential growth was expected due to their varietal characteristics (Vashishatha 1993) [19]. Fodder cut at 50 per cent flowering and 30 cm height took significantly maximum and minimum numbers of days to attain their respective cutting stages.

Number of tillers per metre row length

Number of tillers was significantly affected by varieties and cutting regimes (Table 1). The number of tillers were significantly higher in Palampur-1 (129) followed by Kent (123) and JHO-99-1 (116). Among different cutting regimes, significantly maximum and minimum number of tillers was observed when crop was cut at 50 per cent flowering (146) and 30 cm (106) plant height, respectively. However, the effect of 45 cm (120) and 60 cm (121) plant height was found at par with each other in terms of number of tillers.

Leaf stem ratio

Varieties and cutting regimes significantly affected the leaf stem ratio (Table 1). Palampur-1 resulted in significantly higher leaf stem ratio (0.88) than variety Kent and JHO-99-1. Whereas, minimum leaf stem ratio (0.73) was observed in variety JHO-99-1. Siloriya *et al*. (2014) [14] also found a significant variation in leaf stem ratio among different varieties. Among cutting regimes, fodder cut taken at 30 cm plant height recorded significantly higher leaf stem ratio (1.11) than other cutting treatments. However, the effect of 45 cm (0.78) and 60 cm (0.74) plant height was found at par with each other. The reduction in leaf stem ratio with delay in fodder cut might be due to increase in stem biomass owing to continuous vegetative growth of the plants which resulted in more dry matter accumulation in stem than leaves. These results are in conformity with the findings of Sharma *et al*. (2001) [12] and Castaganara *et al*. (2014).

Green and dry fodder yield

Green and dry fodder yields were affected significantly by varieties and cutting management (Table 1). The variety Palampur-1 exhibited significantly higher green (262 q ha^{-1}) and dry (47.87q ha^{-1}) fodder yields and found to be the best among the rest of cultivars. JHO-99-1 produced minimum green (218 q ha^{-1}) and dry (39.3q ha^{-1}) fodder yields. The magnitude of increase in green fodder yield of Palampur-1 over Kent and JHO-99-1 was 6.1 and 20.3 per cent, respectively. The respective increase in dry fodder yield of Palampur-1 over Kent and JHO-99-1 was 7.7 and 21.9 per cent, respectively. Dubey *et al*. (1995) [5] also reported that oat varieties differed significantly in their forage production potential owing to significant variation in yield contributing parameters. These findings are in conformity with the findings of Haile (1984) [6], Hassan *et al*. (1995) [7], Singh and Singh (1995) [16] and Tiwana (2002). Among cutting management practices, fodder cut taken at 50 per cent flowering recorded significantly higher green (300.7 q ha^{-1}) and dry (59.0 q ha^{-1}) fodder yields followed by fodder cut taken at 45 cm plant height. Fodder cut taken at 60 cm height remaining at par with 45cm height resulted in significantly higher green fodder yield compared to 30 cm height stage. The minimum green (200 q ha^{-1}) and dry (29 q ha^{-1}) fodder yields were obtained when fodder was harvested at 30 cm height. The growth of oat varieties with advancement of growth period might have resulted in better accumulation of dry matter. Various workers have also observed a significant positive correlation of plant growth on green forage yield and ultimately on dry forage yield (Midha *et al*. 1999) [10].

The interaction effect between varieties and cutting management practices was significant on forage yields (Table 2). Palampur-1 exhibited the significant effect on green (329 q ha^{-1}) and dry (185 q ha^{-1}) fodder yields when harvested at 50 per cent flowering stage.

Quality

Crude protein content and Crude protein yield

Crude protein content and crude protein yield was significantly affected by varieties and different cutting schedules (Table 1). Palampur-1 recorded significantly higher crude protein content (10.04%) and crude protein yield (2.00 q ha^{-1}) followed by variety Kent. JHO-99-1 recorded significantly lower crude protein content (9.54 %) and crude protein yield (1.58 q ha^{-1}). Varietal variation in crude protein content has also been reported by Kumar *et al*. (2001) [9] and Bahadur and Chaubey (2009) [3]. The higher crude protein yield in Palampur-1 was due to higher dry fodder yield of variety Palampur-1 (Table 1).

Among different cutting regimes, fodder cut taken at 30 cm height recorded significantly higher crude protein content (10.04 %) and crude protein yield (2.00 q ha^{-1}) and decreased significantly and gradually when cutting stage was delayed from 30 cm to 50 per cent flowering. The cutting stage of 50 per cent flowering recorded lowest values of crude protein content (9.02 %). However, fodder cut at 50 per cent flowering resulted in significantly higher crude protein yield (2.71 q ha^{-1}) than fodder cut at 30, 45 and 60 cm plant height. The increase in crude protein yield with fodder cut at 50 per cent flowering over fodder cut at 30, 45 and 60 cm height was 222.6, 90.8 and 36.9 per cent, respectively.

Acid detergent fiber (ADF) and Neutral detergent fiber (NDF) content

Varieties and cutting management practices significantly affected the acid detergent and neutral detergent fiber contents (Table 1). JHO-99-1 recorded significantly highest acid detergent fibre (59.80 %) and neutral detergent fiber (55.26 %) contents followed by Palampur-1. Kent recorded significantly lowest value of ADF content (57.11 %) than Palampur-1 (58.19 %) and JHO-99-1 (59.80 %). However, minimum NDF content was observed in Kent (54.04 %) but it remained at par with Palampur-1 (54.28 %).

Among cutting regimes, fodder cut taken at 50 per cent flowering observed significantly higher ADF (64.56 %) and NDF (59.82 %) contents followed by 60, 45 and 30 cm plant height. ADF and NDF concentration in fodder increased consistently and significantly with delay in cutting stage from

30 cm plant height to 50 per cent flowering stage. Whereas, fodder cut taken at 30 cm plant height contained significantly lowest values of ADF (52.55 %) and NDF (49.09 %) contents.

Economics

Palampur-1 recorded significantly higher net returns (Rs. 29808 ha^{-1}) and net returns per rupee invested (1.4) followed by variety Kent. JHO-99-1 observed lower values of net returns (Rs. 21599 ha^{-1}) and net returns per rupee invested (1.0). Such differences in net returns and benefit cost ratio among different varieties were also observed by Siloriya *et al*. (2014) [14]. Fodder cut at 50 per cent flowering resulted in highest net returns (Rs. 35989 ha^{-1}) and net returns per rupee invested (1.6), which can be ascribed to the higher fodder productivity in this treatment. Pradhan and Mishra (1994) [11] also reported higher profitability of oat when cut was taken at 50 per cent flowering stage.

Conclusions

Palampur-1 gave significantly higher green and dry forage yields and higher crude protein yield as well as economic returns. Kent appeared next suitable variety after Palampur-1. Forage cut at 50 per cent flowering resulted in higher herbage yield and crude protein yield. However, to ensure better seasonal distribution and availability of green forage, cutting of variety Palampur-1 at 45 cm height appeared suitable.

Table 1: Effect of varieties and cutting regimes on different treatments of oat (q ha^{-1})

Treatment	Days taken to attain cutting stage	Number of tillers	Leaf stem ratio	Green fodder yield	Dry fodder yield	Crude protein content	Crude protein yield	Acid detergent fibre (ADF)	Neutral detergent fibre (NDF)	Net returns	Net returns per rupee invested
Variety											
Palampur-1	70	129	0.88	262	48	10.04	2.00	58.19	54.28	29808	1.4
Kent	68	123	0.82	247	45	9.78	1.63	57.11	54.04	27738	1.3
JHO-99-1	72	116	0.73	218	39	9.54	1.58	59.80	55.26	21599	1.0
SE m±	0.2	0.8	0.02	1.8	0.5	0.07	0.02	0.30	0.25	650.6	0.03
CD(P=0.05)	0.6	2.3	0.05	5.2	1.4	0.21	0.07	0.87	0.74	1908.4	0.09
Cutting at											
30cm height	8	105	1.11	200	29	10.81	0.84	52.55	49.09	18634	0.9
45cm height	42.2	121	0.78	235	41	9.95	1.42	55.64	52.80	25297	1.2
60cm height	53.0	120	0.74	235	46	9.36	1.98	60.72	56.40	25607	1.2
50% flowering	148	146	0.60	301	59	9.02	2.71	64.56	59.82	35989	1.6
SE m±	0.2	0.9	0.02	2.0	0.5	0.08	0.03	0.34	0.29	751.3	0.03
CD(P=0.05)	0.7	2.6	0.06	6.0	1.6	0.24	0.08	1.01	0.86	2203.6	0.10

Table 2: Interaction effect of varieties and cutting regimes on total green fodder and dry fodder yield of oat (q ha^{-1})

Cutting at	Variety					
	Green fodder yield			Dry fodder yield		
	Palampur-1	Kent	JHO-99-1	Palampur-1	Kent	JHO-99-1
30 cm height	216	199	185	32	28	27
45 cm height	255	237	213	45	42	37
60 cm height	251	242	212	50	47	42
50% flowering stage	329	311	263	65	61	51
SE m±	3.5			0.9		
CD (P=0.05)	10.3			2.7		

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