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Research article

Growth and quality parameters of oat (*Avena sativa* L.) cultivars as influenced by different cutting management in irrigated subtropical conditions

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Abstract

An investigation was conducted at SKUAST, Jammu, during *Rabi* 2018-19 and 2019-20 to assess the effect of different cutting managements on the growth and quality of multicut oat cultivars. The experiment was laid out in a randomized block design with 14 treatments and three replications. A severe drop in plant height and number of tillers/m^2 was observed in double cut management system at maturity. Higher fresh and dry weight was recorded at the second cut than at the first cut, resulting in a higher forage yield. However, in the case of quality parameters, no significant difference among the treatments was recorded on the cuttings. Fodder oats harvested at 60 days after sowing (DAS) recorded higher crude protein and lower acid detergent fiber, neutral detergent fiber, and hemicellulose when compared to those harvested at 105 DAS. Thus, on the basis of two years of experimentation, it was concluded that a single cut provides superior quality fodder. However, if an additional cut is taken at 105 DAS, there is a slight reduction in the quality of fodder, but higher fresh and dry weights of fodder are obtained. However, single-cut treatments recorded superior plant height, number of tillers, grain as well as straw weight. Among cultivars, JHO-2000-4 stood out in both the cutting managements in almost all the parameters.

Keywords: Dry weight, Fresh weight, Growth parameters, Oat cultivars, Quality parameters, Yield

Introduction

India is a country that is severely deficient in fodder production. Statistics reflect that the country has deficits of 11.24% in green fodder and a substantial 23.4% in dry fodder resources (Roy *et al*., 2019). However, it is expected that the deficit of green fodder will upsurge even further in the foreseeable future (Kumar *et al*., 2023). In order to bridge the gap between fodder demand and supply, fodder production needs to be elevated. Oat (*Avena sativa* L.) is an imperative winter fodder crop. Among cereal crops, oat possesses exceptional properties and it holds sixth rank globally among the highest cereal production after wheat, maize, rice, barley and sorghum (Priyanka *et al*., 2022). Owing to its exceptional growth and hasty regeneration, it can be grown in irrigated as well as rainfed conditions (Rajesh *et al*., 2022). Apart from this, oat is also an economic source of dietary energy which offers succulent and extremely palatable fodder up to three cuttings. It delivers numerous advantages such as early fodder availability, high yield potential, nutritive fodder, quick regenerating capability and higher dry matter content (Rana *et al*., 2022). Its fodder is rich in vitamin B, energy, protein, phosphorus and iron. Adequate and unremitting supply of fodder is the major issue faced by Indian dairy farmers (Singh *et al*., 2020; Chaudhary *et al*., 2021). To counter this issue, oat fodder can be well-preserved as silage and hay for nourishing livestock during the scarcity period of fodder availability (Kumar, 2012; Poonia *et al*., 2020).

The choice of oat cultivars and their cutting management during the vegetative stage have pronounced effects on the forage as well as grain yield. The selection of cultivars and cutting management depends on the specific objectives. Traditionally, oats were primarily cultivated under the single-cut regime, limiting their availability to a short period. However, nowadays, oats are widely adopted under the multicut regime, extending the availability of green fodder (Poonia *et al*., 2020). Similarly,

genetic buildup of all the cultivars is different and their response varies differently for every cultural operation. Hence, the present study was taken up to evaluate the quality and quantity of forage from various oat cultivars under two cutting regimes.

Materials and Methods

Crop growing conditions: A two-year study on seven different multi-cut oat cultivars was carried out at Research Farm, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Main Campus Chatha (32°40¢ N, 74°82¢ E and 293-meter altitude above mean sea level) in *Rabi* seasons of the year 2018-19 and 2019-20. The soil of the experimental field was sandy clay loam, slightly alkaline in reaction (7.87) and electrical conductivity in safer range (0.17). The soil was low in organic carbon (4.57 g/kg) and available nitrogen (227.65 kg/ha), while medium in available phosphorus (12.81 kg/ha) and available potassium (131.22 kg/ha). Rainfall of 332.4 mm and 463.2 mm was received during the crop growing period in both years, respectively (Fig. 1).

Sowing was done using *kera* method with 20 cm row-to-row spacing. A seed rate of 100 kg/ha was used for sowing along with a fertilizers rate of 100kg N + 40 kg P_2O_5 and 40 kg K_2O per ha. 1/3rd of nitrogen and a full dose of phosphorus and potassium were applied at the time of sowing. 1/3rd of nitrogen was applied in the first split at 30 DAS. The remaining nitrogen was applied treatment-wise in equal amounts after every cut. After every cut at the vegetative stage, green fodder was sold to the Farming System Research Centre, SKUAST Jammu, at market prevailing rates. After the last vegetative cut according to treatments, the crop was left for seed production. Harvesting at both the vegetative stage and final maturity was done manually with a sickle.

***Experimental design*:** The experiment was laid out in a randomized block design with 14 treatments and replicated thrice. The gross plot area of the experimental plots was 3.4 m×4.5 m = 15.30 m^2, while the net plot area was 2.6 × 3.5 m = 9.10 m^2. Seven oat cultivars which were released by IGFRI Jhansi *viz.* JHO-99-1, JHO-822, JHO-2010-1, JHO-2009-1, JHO-851, JHO-2000-4 and JHO-992 were cultivated under two cutting managements *viz.* single cut at 60 DAS, and double cut at 60 DAS and 105 DAS.

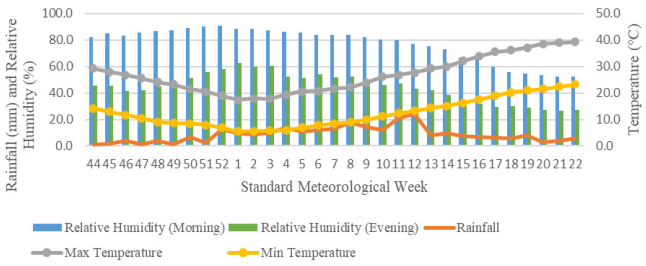

Fig 1. Meteorological data of the experimental site during crop growth period

***Data collection*:** At each cutting of fodder, random samples were taken by quadrate and weighed immediately for fresh weight using a standard procedure (Rana *et al.*, 2014). These samples were sun-dried for 2-3 days and then oven-dried at 72°C to calculate dry weight. However, at the time of maturity, dry weight was calculated directly by using a quadrate. Apart from it, plant height and number of tillers/m^2 were also recorded at each cutting. Samples taken for dry weight were then ground and used for the estimation of quality parameters *viz.* acid detergent fiber (ADF), neutral detergent fiber (NDF), hemicellulose and crude protein. NDF and ADF were analyzed as per the method suggested by Van Soest *et al.* (1991) in which a known quantity of ground sample (1.0 g) was taken in a spout-less beaker and a known quantity of neutral detergent solution for NDF and acid detergent solution for ADF (100 mL) was added to it. The beaker, along with the contents, was heated to boil and refluxed for 60 minutes. The contents were filtered through a pre-weighed Gooch crucible under vacuum with 3 to 4 washings of hot distilled water and a final washing of acetone. The crucibles were dried to a constant weight at 100°C and weighed. Hemicellulose was calculated by subtracting ADF (%) from NDF (%), while crude protein was calculated by multiplying nitrogen content (%) by the factor of 6.25.

Statistical analysis: Experimental data of both years were pooled for final statistical analysis according to the procedure outlined by Cochran and Cox (1963).

Results and Discussion

Plant height: Both cutting management and cultivars had a profound impact on plant height of oats (Table 1). At 60 DAS, JHO-2010-1 recorded significantly higher plant height (59.9 cm), while statistically, at par, plant height was recorded by JHO-99-1, JHO-822, JHO-2009-1, JHO-2000-4 and JHO-992. However, significantly lower plant height was recorded by JHO-851. Similarly, at 105 DAS, JHO-2010-1 recorded significantly higher plant height (85.5 cm). However, only JHO-822 and JHO-2009-1 were recorded statistically at par plant height. At maturity, plant height was severely impeded in double cut treatments, which might be attributed to the progressive loss of vigor of the plants due to repetitive cuttings, which resulted in reduced plant height at maturity. Similar results were also reported by Karki and Banstola (2003) where every increase in cut resulted in a gradual decrease in plant height of oats at maturity. Similarly, Jehangir *et al.* (2017) reported significantly lower plant height upon additional cuts taken in oat crops. Among single-cut

Table 1. Effect of cutting managements on plant height and number of tillers of multi cut oat cultivars

Oat cultivars	Plant height (cm)			Number of tillers/m^2		
	60 DAS	105 DAS	Maturity	60 DAS	105 DAS	Maturity
JHO-99-1(SC)	54.2	-	122.4	487.0	-	253.3
JHO-822 (SC)	52.9	-	124.1	474.8	-	171.3
JHO-2010-1 (SC)	53.5	-	127.8	463.0	-	199.3
JHO-2009-1 (SC)	59.1	-	134.6	485.4	-	177.0
JHO-851 (SC)	27.2	-	133.7	788.0	-	377.3
JHO-2000-4 (SC)	52.9	-	138.0	571.8	-	256.4
JHO-992 (SC)	56.1	-	126.8	396.2	-	202.6
JHO-99-1 (DC)	57.0	66.0	74.8	514.1	286.7	90.7
JHO-822 (DC)	54.0	84.0	76.2	443.5	209.4	84.2
JHO-2010-1 (DC)	59.9	85.5	79.7	474.7	237.8	92.0
JHO-2009-1 (DC)	58.5	85.4	88.8	492.3	258.2	87.1
JHO-851 (DC)	26.1	53.3	68.3	799.9	502.0	226.7
JHO-2000-4 (DC)	55.6	77.5	75.5	564.1	393.9	155.1
JHO-992 (DC)	53.3	77.4	77.8	418.2	209.1	65.2
SEM	2.5	2.6	5.3	18.7	11.4	8.1
CD (p <0.05)	7.3	8.0	15.6	54.4	35.1	23.6

*DAS : Days after sowing; SC: Single cut; DC: Double cut

treatments, JHO-2000-4 recorded significantly higher plant height (138.0 cm). However, there was no significant difference among single-cut treatments. On the other hand, among double-cut treatments, significantly higher plant height was recorded in JHO-2010-1 (88.8 cm), which was statistically at par with all the single-cut treatments except JHO-851 (68.3 cm).

***Number of tillers/m^2*:** A reduction in number of tillers/m^2 was observed with each cut in fodder oats. The first cut at 60 DAS recorded the highest number of tillers/m^2 followed by the second cut at 105 DAS and lastly at maturity (Table 1). This might be attributed to reduced regeneration of tillers after cutting, resulting in a gradual decrease in the number of tillers after every cut. These findings were similar to earlier findings as reported by Jahangir (2012) where double-oat-cut treatments recorded a significantly reduced number of tillers/m^2 as compared to single-cut treatments. Among cultivars, JHO-851 recorded significantly the highest number of tillers/m^2 among all the treatments irrespective of cutting.

***Fresh weight*:** Fresh weight was recorded at 60 DAS and 105 DAS when cuts were taken. It was observed that at 60 DAS, oat cultivar JHO-2010-1 recorded significantly higher fresh weight (16.6 t/ha), which was statistically at par with JHO-2000-4 and JHO-99-1. Significantly lowest fresh weight was recorded by JHO-851 (6.3 t/ha). During the second cut at 105 DAS, JHO-2000-4 recorded statistically highest fresh weight (23.2 t/ha). It was also observed that during the second cut, all the varieties had considerably higher fresh weight than at the first cut, which might be attributed to the quick regeneration of the crop and fast accumulation of photosynthates during the period in between two harvestings. However, JHO-99-1 was an exception as it recorded reduced fresh weight at the second cut owing to its poor regeneration in contrast to other cultivars (Table 2).

***Dry weight*:** Data pertaining to dry weights were also recorded (Table 2). An almost similar trend as of fresh weight was observed in dry weight as well at both the first and second cut. At 60 DAS, JHO-2010-1 recorded significantly higher dry weight (1.575 t/ha), which was statistically at par with JHO-2000-4 and JHO-99-1. Significantly lowest dry weight was recorded in JHO-851 (0.610 t/ha). At 105 DAS, JHO-2000-4 recorded a significantly highest value of dry weight. The considerable gain in dry weight at the second cut was also observed as in fresh weight along with JHO-99-1, which was an exception as its dry weight decreased at the second cut. Poor accumulation and translocation of photosynthates might be responsible for the reduced dry weight of JHO-99-1 at the second cut. Data pertaining to dry weight at maturity was considerably affected by both cultivars and cuttings. JHO-2000-4 recorded significantly higher dry

Table 2. Effect of cutting managements on fresh weight and dry weight of multicut oat cultivars

Oat cultivars	Fresh weight (t/ha)		Dry weight (t/ha)			Grain weight (t/ha)	Straw weight (t/ha)
	60 DAS	105 DAS	60 DAS	105 DAS	Maturity		
JHO-99-1(SC)	14.1	-	1.35	-	3.04	0.58	2.40
JHO-822 (SC)	12.9	-	1.30	-	2.85	0.78	2.02
JHO-2010-1 (SC)	14.9	-	1.37	-	3.81	0.90	2.91
JHO-2009-1 (SC)	12.3	-	1.19	-	3.95	0.70	3.28
JHO-851 (SC)	6.4	-	0.58	-	3.54	1.11	2.41
JHO-2000-4 (SC)	16.0	-	1.57	-	3.98	0.76	3.16
JHO-992 (SC)	11.2	-	1.05	-	3.83	0.74	3.02
JHO-99-1 (DC)	16.3	11.6	1.51	1.44	2.70	0.28	2.42
JHO-822 (DC)	13.9	16.6	1.28	2.07	1.53	0.33	1.13
JHO-2010-1 (DC)	16.6	18.4	1.58	2.26	2.84	0.37	2.49
JHO-2009-1 (DC)	15.0	16.1	1.46	1.99	3.16	0.39	2.67
JHO-851 (DC)	6.3	19.7	0.61	2.34	2.77	0.43	2.35
JHO-2000-4 (DC)	15.6	23.2	1.56	2.68	3.41	0.39	2.98
JHO-992 (DC)	13.5	14.3	1.31	1.79	0.91	0.21	0.69
SEM	0.6	0.9	0.04	0.10	0.14	0.02	0.11
CD (p <0.05)	1.7	2.7	0.10	0.32	0.42	0.07	0.32

*DAS : Days after sowing; SC: Single cut; DC: Double cut

weight in both single and double-cut treatments (3.977 and 3.408 t/ha, respectively). However, statistically at par, dry weight was recorded in JHO-2009-1 among single-cut treatments. It was also observed that dry weight was considerably lower in double-cut treatments than single-cut treatments, owing to a reduction in vigor after an increased number of cuts.

***Grain weight*:** Data pertaining to grain weight was recorded at maturity of the crop and it was observed that an increase in cutting numbers severely affected grain weight in all the cultivars. Double-cut treatments had a noteworthy reduction in grain weight in comparison to single-cut treatments (Table 2), which might be attributed to more time period available to the crop for sufficient vegetative growth, which resulted in attaining more degree days for completing its life cycle, ultimately leading to higher grain weight. This reduction in grain weight with increased cuttings was in accordance with the findings of Kumawat *et al.* (2016) where no-cut pearl millet treatments recorded the highest grain yield, followed by single-cut treatments and lastly, double-cut treatments. Thamer and Al-Refai (2019) also recorded that no cut oat treatments had significantly higher grain weight than single and double-cut treatments. Differences in grain weight among the cultivars were also observed and JHO-851 recorded significantly higher grain weight among both single-cut (1.11 t/ha) and double-cut (0.43 t/ha) managements. The quick and fast regeneration capacity of the cultivar JHO-851 as compared to other cultivars might be attributed for its higher grain weight in both cutting managements.

Straw weight: Straw weight was recorded upon maturity of the crop and a remarkable difference in cutting managements was observed in single cut and double cut treatments. Double cut treatments recorded lower straw weight than single cut treatments which might be attributed to poor regeneration of the crop after second cut at 105 DAS. Oat cultivar JHO-2009-1 (3.28 t/ha) and JHO-2000-4 (2.98 t/ha) recorded the highest straw weights in single and double cutting managements, respectively (Table 2). These findings were in close conformity with the findings of Thamer and Al-Refai (2019) who reported significantly higher biological yield in no cut oat treatments followed by single and double cut treatments.

***Quality*:** Data with respect to acid detergent fiber (ADF), neutral detergent fibre (NDF), hemicellulose and crude protein did not show any significant effect on any of the quality parameters at both cuttings (Table 3). This might be attributed to homogeneity in the genetic makeup of the cultivars. However, it was observed that there was an intensification of ADF, NDF and hemicellulose contents of the crop at the second cut. In ADF, 5.06-6.70%

Table 3. Effect of cutting managements on quality parameters of multicut oat cultivars

Oat cultivars	ADF (%)		NDF (%)		Hemicellulose (%)		Crude protein (%)		
	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	Grains
JHO-99-1(SC)	34.2	-	61.7	-	27.5	-	11.75	-	1.89
JHO-822 (SC)	35.3	-	62.5	-	27.2	-	11.87	-	1.90
JHO-2010-1 (SC)	34.8	-	62.8	-	28.0	-	11.84	-	1.88
JHO-2009-1 (SC)	34.8	-	60.7	-	25.8	-	11.66	-	1.84
JHO-851 (SC)	35.2	-	61.3	-	26.2	-	11.63	-	1.88
JHO-2000-4 (SC)	34.7	-	61.5	-	26.8	-	11.81	-	1.89
JHO-992 (SC)	34.3	-	61.7	-	27.3	-	11.81	-	1.88
JHO-99-1 (DC)	35.0	36.3	62.3	65.0	27.3	28.7	11.90	11.52	1.89
JHO-822 (DC)	35.3	37.3	63.3	66.0	28.0	28.7	11.81	11.34	1.93
JHO-2010-1 (DC)	35.5	37.0	62.2	64.5	26.7	27.5	11.72	11.35	1.93
JHO-2009-1 (DC)	34.8	37.2	61.7	65.7	26.8	28.5	11.90	11.41	1.93
JHO-851 (DC)	34.3	36.5	61.3	64.3	27.0	27.8	11.69	11.42	1.90
JHO-2000-4 (DC)	35.3	37.2	61.5	64.7	26.2	27.5	11.90	11.43	1.92
JHO-992 (DC)	33.7	36.2	61.3	65.3	27.7	29.2	11.69	11.40	1.92
SEM	0.7	0.5	0.7	1.1	1.0	1.3	0.12	0.13	0.02
CD (p <0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

*DAS : Days after sowing; SC: Single cut; DC: Double cut; ADF: Acid detergent fibre; NDF: Neutral detergent fibre

intensification was recorded in the second cut, while intensification in NDF and hemicellulose was to the tune 3.20 to 7.36% and 0.6 to 8.23%, respectively. This might be attributed to the higher deposition of hemicellulose, cellulose and lignin, resulting in higher values of ADF, NDF and hemicellulose. On the other hand, a decline in crude protein content was observed after the second cut to the tune 2.61 to 4.25%, which might be attributed to the heavy deposition of cellulosic fiber and increasing bulk of forage. Moreover, with advancement in maturity, protein utilization in the plant body increases as nutrients are translocated to the reproductive organs and are utilized in their formation and development, resulting in the decrease of protein content in stems and leaves. The trend of increase and decrease of quality parameters were in conformity with the findings of Kumar (2012), who performed five cutting managements in oats, which involved three cutting regimes and two treatments with delayed cut. It was reported that with every increase and delay in cut, crude protein content decreased gradually while ADF, NDF and hemicellulose contents increased, thus concluding a reduction in the quality of fodder at every successive cut.

Conclusion

The performance of oat crops was significantly shaped by the combined effects of cutting management practices and the selection of multi cut oat cultivars. The study revealed that the manner in which oats were managed, whether through a single cut or double cut approach, had a significant influence on their overall crop productivity and quality of forage. In the case of single cut treatments, oats exhibited superior plat height, number of tillers, grain as well as straw yield. Conversely, double cut treatments demonstrated their effectiveness in terms of producing higher dry weight and fresh-weight of fodder. It was also observed that the second cut of fodder at 105 DAS recorded a higher forage yield as compared to first cut at 60 DAS. However, fodder received at the second cut was low in crude protein but high in ADF, NDF and hemicelluloses contents, indicating the reduced quality of the forage when compared to the first cut. Among the cultivars, the multi cut oat variety JHO-2000-4 distinguished itself as an exceptional performer, clearly demonstrating its proficiency under both single and double-cut management strategies. It consistently achieved the highest levels of both fresh and dry forage yields in both cutting management scenarios while also producing commendable grain and straw production.

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