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Full length article

Cold Tolerant Oats as Summer Forage in Temperate Environment of Bhutan

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ABSTRACT

The number of oat varieties used in extension program is limited and there is a need to provide more options to the dairy farmers by identifying additional oat varieties with good yield and quality. Therefore, an experiment was conducted to evaluate forage yield and nutrient content of new oat [*Avena sativa L.*] varieties in comparison with the varieties currently used in extension. The new oat varieties were: Gansu oat 1, Gansu oat 2, Gansu oat 3, Lina oat, and Qingyin oat. The experiment was laid out in randomized complete block design with six replications and measuring plot size of 4.5 m^2 [1.5×3 m]. The variety Gansu oat 2 and Qingyin oat produced significantly higher green forage and dry matter yield than variety stampede. However, there was no significance difference in essential nutrient [Crude protein] content between new and existing oat varieties. The study concluded that variety Gansu 2 and Qyingyin oat can be suitable for forage production in summer under temperate climatic condition of Bhutan.

1. INTRODUCTION

Oats [*Avena sativa* L], belonging to the family Poaceae, originate from Mediterranean region and ranks 5th in cereal production in the world [Numan et al. 2016]. Oat is a succulent winter fodder crop with excellent growth habit, quick recovery after cutting, good quality herbage, and good palatability [Khanal et al. 2017]. Temperate and cool subtropical environments are considered favorable for better growth and productivity of oats. Oat contains large amount of digestible crude protein, total digestible nutrients [TDN], vitamin B1, minerals and fat, and soft straw that make oat superior to wheat and barley [Saleem et al. 2015]. Oat tolerates a wide range of soil conditions but requires adequate fertility for good dry matter production and quality [Gyeltshen et al. 2017].

In Bhutan, oat is used as fodder and managed under cut and carry system in temperate and subtropical regions, whereas in alpine region it is used as conserved fodder in the form of hay [Gyeltshen et al. 2017]. At present, two oat varieties Stampede and FOB are recommended for winter fodder production. The number of oat varieties used in extension program is limited and there is a need to provide more options to the dairy farmers. Thus, there is a need to identify additional oat varieties with good forage yield, quality, and winter hardiness. Five cold tolerant varieties of oat, known to provide high forage yield in high altitude areas were introduced in 2017. These are varieties grown on Tibetan plateau and were imported from Nepal. These varieties were experimented at the National Research and Development Center for Animal Nutrition [NRDCAN]. The study objectives were to assess growth, dry matter production and nutritional quality of oat varieties under temperate summer condition of Bhutan.

2. MATERIALS AND METHOD

2.1 Experimental site

A field experiment was conducted from March to October, 2017 at the National Research and Development Center for Animal Nutrition, Bumthang. The center is located at an altitude of 2650 m above sea level with geographical location between 27.54° North latitude and 90.75° East longitude. The area falls under temperate climate characterized by cool wet summer and cold dry winter. The annual mean rainfall is recorded around 63.82 mm [NCHM 2018].

2.2 Experimental design and treatment

A Randomized Complete Block Design was used with six replications and seven treatments. The treatments were five cold tolerant oat varieties [Gansu oat 1, Gansu oat 2, Gansu oat 3, Qingyin and Lina oat] and two existing oats varieties [Stampede and Fodder Oat of Bhutan [FOB]]. Stampede and FOB were used as control. Individual plot measured 4.5 m^2

[3×1.5m] and there was a total of 42 plots. Each replication had seven plots. Spacing followed were 50 cm between plots and 70 cm between replications.

2.3 Management and treatment application

Seed was sown at the rate of 50 kg per acre. Fertilizer Single Superphosphate [SSP] was applied at the rate of 150 kg per acre. Irrigation was totally dependent on rainfall as it was sown in summer when light rains were frequent.

2.4 Field measurement and data collection

The crop was harvested at booting stage, 75 days after sowing. The second harvest was 60 days after first cut. The data recorded were; fresh and dry matter yield, number of tillers, plant height, and leaf to stem ratio. Similar measurements were carried out in the second cut. For the fresh yield, the entire plot was harvested and fresh plant materials were weighed with weighing scale. For the plant height, ten plants were randomly selected from each plot and plant heights were measured with measuring scale. Ten plants were selected at random and plants parts were segregated into leaf and stem and then weighed separately to calculate leaf to stem ratio. The tiller numbers per plant were counted from ten plants randomly selected from each plot and tiller numbers were recorded.

2.5 Laboratory analysis

Plant materials were thoroughly mixed after harvest and a representative sample weighing 250 gm was collected from each plot. The total samples collected were 42 in first cut and 35 in second cut. These samples were used to estimate dry matter content and nutrients. The laboratory tests for dry matter and nutrient content were performed at the Animal Nutrition Laboratory, Bumthang. Samples were dried in a hot air oven at 65℃ for 48 hours. Crude protein was determined with Kjeldahl method. AOAC method was followed to determine Crude fat and crude fiber content.

2.6 Data analysis

Data were entered in Microsoft Excel program and exported to SPSS version 23. The dataset was checked for outliers, followed by Shapiro Wilk's and Levene's tests for normality of data and homogeneity of variance, respectively. The Generalized Linear Model with Multivariate ANOVA was used to compare the mean differences on various parameters between new and existing oat varieties. Means between treatments were compared with Tukey Pairwise comparison test. Differences in means were considered significant when p-value was less than 0.05.

3. RESULTS AND DISCUSSION

3.1 Morphological characteristics: plant height

The mean plant height, tiller numbers and leaf to stem ratio for the first and second cuts are presented in Table 1. Plant height is a major factor contributing towards forage yield of different crops [Ansar et al. 2010]. In the first cut, the tallest plants [61cm] were from Qingyin oat, followed by FOB [58 cm] and Gansu oat 1 [56 cm] among seven varieties. The plants of variety Qingyin oat and Gansu oat 1 were significantly [$p<0.05$] taller than Stampede oat in the first cut. In the second cut, maximum plant height [68.50 cm] was from Gansu oat 2, followed by Gansu oat 1 [68.17 cm]. However, there was no significance difference on plant height between new oat varieties and FOB. The significant effect of variety on plant height in the present study is in agreement with previous findings of Chohan et al. [2004]. Lodhi et al. [2009] also reported significant differences among oat varieties in plant height. The main cause of difference in height is due to environmental condition and difference in genetics of varieties [Singh et al. 2018].

3.2 Morphological characteristics: number of tillers per Plant

In the first cut, the tiller numbers per plant were same among five oat varieties [Lina oat, Gansu oat 2, Qingyin oat, Gansu oat 1 and FOB] and between Gansu oat 3 and Stampede. The tiller number per plant in the second cut was similar among Gansu oat 1, Gansu oat 3, Gansu oat 1 and FOB and among Lina oat, Qingyin oat and Stampede. Statistically, there was no significance difference in average tiller number per plant between Tibetan oat and existing oat varieties [Stampede and FOB] in the first and second cuts. This finding is in line with the result reported by Zaman et al. [2006]. However, in contrast, significant variations among oat varieties in number of tillers per plant have been reported by Arif et al. [2002] and Naeem et al. [2002]. Differences in number of tillers among the varieties may be attributed to variation in genetics of varieties [Muhhamad et al. 2011].

3.3 Morphological characteristics: leaf stem ratio

The highest leaf to stem ratio [0.73] was observed in Gansu oat 2, followed by Gansu oat 1 [0.69] and Lina oat [0.67] in the first cut. In the second cut, the highest leaf to stem ratio [0.73] was observed in Lina oat, followed by Gansu oat 1 [0.72]. The leaf to stem ratio of Tibetan oat varieties Gansu oat 2, Gansu oat 3 and Lina oat were significantly [$p<0.01$] higher than the existing variety FOB in first cut. In the second cut, there was no significance difference between new [Tibetan] and existing oat varieties. Saleem et al. [2015] reported similar result. The leaf to stem ratio in fodder crops decreased with advancement of crop growth stage and maturity.

3.4 Morphological characteristics: Fresh fodder biomass and dry matter yield

Fodder yield is the most important trait and ultimate product of fodder variety. Table 2 elucidates the mean green fodder biomass production and dry matter yield from seven oat varieties. The fresh fodder biomass production and dry matter yield from variety Gansu oat 2 and Qingyin oat was found significantly [$p<0.05$] higher than the existing variety stampede oat in the first cut. But statistically, there was no significant difference in fresh biomass production and dry matter yield between new [Tibetan] and existing oat varieties in the second cut. Nawaz et al. [2004] reported significant differences among oat cultivars regarding green forage yield. These results are in conformity with Ayub et al. [2011] and Naeem et al [2006] who found significant variations among different oat varieties in total dry matter yield. Amanullah et al. [2004] stated that higher yields of fodder in oat varieties can be possibly attributed to their greater leaf area, responsible for more photosynthetic activities having high capacity to store assimilative products of photosynthesis.

Table 1: Mean plant height, tiller count and leaf stem ratio for seven varieties of oats.

Oat variety	First cut			Second cut		
	Plant height [cm]	Tiller No	Leaf stem ratio	Plant height [cm]	Tiller No	Leaf stem ratio
Lina oat	40	3	0.67	57	4	0.73
Gansu oat 2	54	3	0.73	68	3	0.29
Qingyin oat	61	3	0.57	62	4	0.31
Gansu oat 3	48	4	0.69	62	3	0.32
Gansu oat 1	57	3	0.56	68	3	0.72
FOB	58	3	0.45	59	3	0.55
Stampede	46	4	0.61	63	4	0.38
Total	52	3	0.61	63	3	0.45
Significance	**	ns	**	ns	ns	*

*p≤0.05, **p≤0.01, ns: nonsignificant

3.5 Fodder quality parameters: crude protein content

Crude protein is an important factor, which affects the quality of forage. Table 3 presents the nutrient content, mainly crude fiber, crude fat, crude fiber and total ash of seven oat varieties. In the first cut, the highest crude protein [14.47%] was observed in Gansu oat 3. In contrast, the highest crude protein content was observed in Lina oat [9.70%] and lowest in Stampede oat [6.21%] in second cut. But statistically, there was no significant variation in crude protein content between new [Tibetan] and existing [Stampede and FOB] oat varieties in both first and second cuts. The result is in line with the finding of Habib et al. [2003]. However, these results are contradictory to those of Muhammad et al. [2011] and Adeel et al. [2014] who reported that crude protein content varied significantly among oat varieties. These conflicting results can be attributed to variation in soil fertility status and climatic conditions in different agro-ecological zone.

Table 2: Mean biomass [Fresh] production and dry matter yield from seven varieties of oats

Oat variety	First cut		Second cut	
	Biomass per acre [MT]	DM yield per acre [MT]	Biomass per acre [MT]	DM yield per acre [MT]
Lina oat	7.68	1.69	1.92	0.41
Gansu oat 2	9.10	2.05	1.62	0.33
Qingyin oat	8.80	1.88	1.76	0.37
Gansu oat 3	7.07	1.50	2.04	0.43
Gansu oat 1	7.16	1.61	1.80	0.38
FOB	7.15	1.52	1.48	0.30
Stampede	5.75	1.23	2.26	0.48
Total	7.53	1.64	1.82	0.38
Significance	*	*	ns	ns

*p≤0.05, **p≤0.01, ns: nonsignificant

3.6 Fodder quality parameters: crude fat

The maximum crude fat content [3.21%] was obtained from variety Gansu oat 1 and minimum crude fat content from variety stampede ain the first cut [Table 3]. But in the second cut, variety Lina oat showed the highest concentration of crude fat content with 3.5% and lowest crude fat content in Gansu oat 1 with 1.41%. However, there was no significant variation in crude fat content of new [Tibetan] oat varieties from the existing oat varieties. Staudenmeyer et al. [2017] obtained the similar result. But this result is in contradictory to the finding of Saleem et al. [2015] who reported significance difference in crude fat composition among oat varieties. The crude fat content of oat varieties depends on genetic and environmental factors.

3.7 Fodder quality parameters: crude fiber

In the first cut, the highest crude fiber content [24.75%] was observed in Qingyin oat and lowest [18.66%] in Lina oat. In the second cut, variety Gansu oat 3 gave the highest crude fiber content [28.50%] and FOB gave the lowest crude fiber content [23.16%]. The data regarding the crude fiber percentage presented in Table 3 clearly shows that crude fiber percentage did not vary significantly between new [Tibetan] and existing oat varieties in both first and second cuts. But the result showed that crude fiber content increased during the second cut. Crude fiber contents greatly increased with maturity and delay in harvesting, which ultimately reduced its digestibility. The result agrees with the findings of Hussain et al. [1993] and Mohammad et al. [2004] who reported similar results.

3.8 Fodder quality parameters: total ash

The highest total ash content of 9.14% was observed in variety stampede in the first cut and 5.75% in variety Gansu oat 2 in the second cut. The minimum total ash content of 6.31% was observed in variety Lina oat and 4.25% in variety FOB. Statistically, the total ash content did not differ significantly between new [Tibetan] and existing oat varieties. But Sharma [2009] reported significance difference in total ash content among oat varieties. Higher ash content in oat varieties is an indicative of higher level of micro-nutrients present [Liu and Mahmood 2015] [10.47%] and that varieties varied in efficiency to absorb nutrients, which may be due to variable rooting depth and rooting pattern.

4. CONCLUSIONS

The varieties Gansu oat 2 and Qyingyin oat performed better than the existing variety stampede in both green forage production and dry matter yield. These two new varieties are suitable for forage production in Bhutan under temperate climatic conditions. However, further assessment needs to be carried out for winter fodder production with the same oat varieties at different elevations.

Table 3: Nutrient content for seven varieties of oats.

	First cut			Second cut		
Oat variety	CP [%]	CF [%]	Ash [%]	CP [%]	CF [%]	Ash%
Lina oat	13.18	2.66	6.31	9.70	3.50	4.40
Gansu oat 2	14.56	2.50	8.35	9.22	2.08	5.75
Qingyin oat	12.29	2.80	7.61	9.22	2.66	4.49
Gansu oat 3	14.47	2.71	8.14	7.98	2.16	4.96
Gansu oat 1	13.91	3.21	8.54	7.82	1.41	4.51
FOB	13.86	2.66	8.10	7.70	3.25	4.25
Stampede	13.40	1.79	9.14	6.21	2.80	4.37
Total	13.66	2.62	8.02	8.33	2.54	4.37
Significance	ns	ns	ns	ns	ns	ns

ns: nonsignificant

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