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Effect of cutting and splitting of nitrogen doses on yield, quality and economics of fodder oat in Indo-Gangetic plains of India

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Abstract
Field study was conducted at Instructional Dairy Farm, Nagla, G. B. Pant University of Agriculture and Technology, Pantnagar from 2019-20 to 2021-22 during *Rabi* season (October-November to March-April) to assess the 'Effect of cutting and splitting of nitrogen doses on yield, quality and economics of fodder oat in Indo-Gangetic plains of India'. The experimental site was located in the Tarai region of Shivalik range of Himalayas in between latitude of 29° N to longitude of 79.3° E and at an altitude of 243.84 meter above the mean sea level. The soil was slightly silty clay loam in texture with granular structure having soil pH 6.70, EC 0.25 dS/m, organic carbon 0.75%, available nitrogen, phosphorus and potassium, 200.4. 19.0 and 226.3 kg/ha, respectively. The experiments results indicated that oat varieties UPO-06-1 and UPO-212 gave the highest green and dry fodder yield, respectively, however both were significantly similar. The crude protein production was found higher in UPO-212 but remained significantly equal to UPO-06-1. The gross and net returns were recorded significantly higher in UPO-06-1 but the B:C ratio was significantly higher in UPO-212. Similarly the plant height, number of tillers/m row length, green and dry fodder yield and its respective productivity, crude protein content, crude protein production and economics were found higher at two cuts with 50% N application as basal followed by 50% N at 1st cut that was significantly similar with two cuts with 60% N application as basal followed by top dressing of 40% N at 1st cut. It is therefore concluded that oat variety UPO-06-1 or UPO-212 could be harvested twice with application of 50% N as basal followed by top dressing of 50% N at 1st cut for higher fodder and crude protein yield and net return in Indo-Gangetic plains of India.

Keywords: Fodder yield, crude protein, cutting management, nitrogen dose, tillers

Introduction
Oat (*Avena sativa* L.) provides high quality green fodder during winter season beside excellent for grazing, hay and silage making (Chakraborty *et al*., 2016) [2]. Globally oat ranks sixth among grain crops in production after corn, wheat, rice, barley and sorghum. Oat is an important dual purpose crop, both fodder and grain, grown mainly in *Rabi* season in whole India. It suits in areas where be seem cannot grow due to scarcity of water, so it requires lower amount of irrigation water. It is a widely grown crop from high hills to tropical plains. Basically oat is originated from Asia and has a fast growth, excellent regeneration capacity, high palatability and nutritive values with 8-10% crude protein, 66% carbohydrates, 11% crude fibre, 65-70% dry matter digestibility and rich in Vitamin A and B_1, phosphorus and iron. Oat is mainly grown for green fodder in India and abroad and its grain is equally excellent for human health as its grains are rich in dietary fiber, especially soluble β-glucans and potassium. Besides, oat gains contain 2.31% ether extract, 9.33% total ash, 0.47% calcium, 0.22% phosphorus, 0.22% magnesium, 0.52% sodium and 2.84% potassium, iron and excellent source of high-quality protein with good amino acid composition. In 2020, the global production of oats was 25.33 million metric tons with 10.65% of growth from 2019 to 2020. The EU is the largest oat producer, followed by Canada, Russia, Australia, the United States and Brazil. The largest oat consumers are the EU, Russia, the United States, Canada, Australia, and China. In India, oat is grown over one lakh ha area mainly in Uttar Pradesh (34%), Punjab (20%), Bihar (16%), Haryana (9%) and Madhya Pradesh (6%). Besides, it is also grown in J & K, HP, and Uttarakhand at higher hills and in dry tracts of India like Gujrat, Rajasthan, Maharashtra, Karnataka, Telangna, A P, North East India, Orisa and West Bengal. Oat requires 20-25 °C temperature at sowing, 80-100mm rainfall and 25-30 °C temperature at harvesting.

Nitrogen is the most important element for growth, yield and quality of oat forage (Subrahmanya *et al*., 2017) [17] and development of crop plants and research findings revealed that fodder yield increased with increasing N levels up to 150 kg/ha (Pravalika and Gaikwad (2021) [12]; Pal and Jain, 2022) [9], however the variations in N the variations in N dose is possible mainly due to differential soil test values of different agro-climatic regions. Similarly oat can be harvested twice and thrice with precise management of nitrogen and water. It has been observed that N dose and time of its application play significant role for crop growth and productivity reported that oat var. JHO-822 gave the highest seed yield when crop was cut at 45DAS for fodder and left for seed production. Kadam *et al*. (2020) [5] revealed that the dual-purpose oats sown on 25th October, cut at 50 DAS and fertilized with 120 kg N ha^{-1} recorded optimum yield and benefit cost ratio. Singh *et al*. (2020) [16] found at the highest green and dry fodder yield of oat at application of 140 kg N/ha i.e. 50% basal +25% at 1st cut +25% at 2nd cut accompanied with 3 cuttings. Above findings indicate that response of N dose, its split application as well as cutting management varied with oat varieties. Recently number of high yielding varieties of oat have been bred and require to standardize its agronomy in relation to its response of nutrient dose and cutting management on growth and yield potentials at different agro-climatic zones for maximizing yield and net profits. Therefore, the present study was carried out to assess the response of N dose, its split application and cutting management on growth, yield and economics of different newly bred oat varieties at Tarai region of Uttarakhand.

Materials and Methods

Field study was conducted at Instructional Dairy Farm, Nagla, G. B. Pant University of Agriculture and Technology, Pantnagar from 2019-20 to 2021-22 during *Rabi* season (October-November to March-April) to assess the 'Effect of cutting and splitting of nitrogen doses on yield, quality and economics of fodder oat in Indo-Gangetic plains of India'. The experimental site was located in the Tarai region of Shivalik range of Himalayas in between latitude of 29° N to longitude of 79.3 °E and at an altitude of 243.84 meter above the mean sea level. The soil was slightly silty clay loam in texture with granular structure having soil pH 6.70, EC 0.25 dS/m, organic carbon 0.75%, available nitrogen, phosphorus and potassium, 200.4. 19.0 and 226.3 kg/ha, respectively. The experiment was consisted of three oat varieties namely RO-10, UPO 06-1 and UPO-212 in main plot and level of cutting management as well as nitrogen management in sub plot were planted in split plot design with three replications. The level of cutting management was two i.e. two cuts and three cuts and level of nitrogen application was four i.e. 60% basal fb 40% at 1st cut, 50% basal fb 50% at 1st cut, 50% basal fb 25% at 1st cut & 2nd cut and 40% basal fb 30% at 1st cut & 30% 2nd cut. The crop was grown with standard agronomy with proper management of irrigation water. Phosphorus and potassium were basal applied at the rate of 60 and 40 kg/ha while nitrogen was applied as per the need of treatments. Pendimethalin @ 1.0 kg ai/ha was applied after one day of sowing uniformly to check the weed population. The growth, foliage yield, crude protein and economics were observed during field experimentation and three year data were pooled for final results and discussion.

Results and Discussion

Effect of varieties

The growth attributes like number of tillers/m row and L:S ratio, green and dry fodder yield and its respective productivity were affected significantly by oat varieties (Table.1). The plant height was recorded significantly similar in all three varieties; however UPO-212 had the tallest plants. The number of tillers and L:S ratio were recorded significantly highest in UPO-06-1 followed by UPO-212. Kanala *et al*. (2014) [6] reported variation in plant height and number of tillers per unit area among forage oat cultivars. Amanullah *et al* (2013) [1] also concluded that number of tillers had direct effect on leaf area and CO_2 assimilation rate. Oat varieties UPO-06-1 and UPO-212 gave the highest green and dry fodder yields, respectively but both were statistically at par with each other. The green and dry fodder productivity was recorded significantly higher in UPO-212 that was at par with UPO-06-1. The higher values of green and dry fodder were attributed to taller plants and more tillers per unit area. Further the higher L:S ratio also contributed to foliage yield because of higher leaf area contributed to more synthesis of photosynthesis resulting in to more fodder yield.. Sharma *et al*. (2018) [14] also reported significant difference in green and dry fodder yield among oat varieties reported that oat var. JHO-822 gave the highest seed yield when crop was cut at 45DAS for fodder and left for seed production.

The crude protein production and economics were significantly by oat varieties (Table.2). The crude protein content did not differ significantly among oat varieties, however the highest value was found in UPO-212 followed by UPO 06-1. The crude protein production was found significantly higher in UPO- 212 that was statistically at par with UPO 06-1. The higher crude protein production was attributed to higher dry fodder yield. Oat varieties differed in crude protein and crude fibers (Kanala *et al*., 2014) [6]. Similarly Sharma *et al*. (2018) [14] reported non-significant difference in crude protein content among oat varieties.

The gross and net return were recorded significantly higher under UPO-06-1 that was significantly similar to UPO-212 but the B:C ratio was found higher under UPO-212 that was significantly equal to UPO-06-1. The RO-19 had lower growth and yield as well economics than UPO-06-1 and UPO-212 varieties. The higher gross returns are the result of higher green fodder yield and low cost of cultivation. Kashyap *et al.* (2022) [7] announced variation in gross returns and B:C ratio among oat entries.

Effect of cutting management and N doses

In general, the plant height, number of tillers/m row length, green and dry fodder yield and its respective productivity (Table.1), crude protein content, crude protein production and economics (Table.2) were found higher at *t*wo cu**ts** with 50% N application as basal followed by 50% N at 1st cut that was significantly similar with two cuts with 60% N application as basal followed by top dressing of 40% N at 1st cut. It is very clear from the results that the fodder yield was 12.7% higher at three cuts with application of 40% N basal +30% N at both 1st and 2nd cuts compared to three cuts +50% N basal fb 25% N at each 1st & 2nd cuts. It is mainly due to better plant growth at application of higher N dose at sowing time as well as after each cut. Amanuulah *et al* (2013) [1] concluded that application N had direct effect of leaf growth and increased number of tillers and leaf area.

Singh *et al*. (2022) [15] described the highest green and dry fodder yield of oat at application of 140 kg N/ha i.e. 50% basal fb 25% at 1st cut & 25% at 2nd cut accompanied with 3 cuttings. Pal *et al*. (2021) reported that application of nitrogen increased plant height, growth, leaf length, fodder yield and quality parameters like ether extracts and crude fibre. Pravalika and Gaikwad (2021) [12] reported that single cut oat at 50% flowering gave the highest plant height, number of tillers and L:S ratio while two cuts i.e. 60 DAS and 50% flowering gave highest green fodder yield, crude protein yield, crude fibre yield and also B:C ratio. Patel *et al*. (2022) found significantly higher green fodder yield, crude protein and fibre content and crude protein yield and also net profit at 140 kg N /ha with 65 days after cutting of forage oat at Sardar Kushinagar (Gujrat). Pal and Jain (2022) [9] reported that growth and fodder yield increased with increasing N dose up to 150 kg/ha.

The crude protein content was recorded significantly higher at three cuts than two cuts, however the highest CP content was measured at three cuts+50% N basal fb 25% N at 1st & 2nd cuts that was significantly at par with three cuts +40% N basal followed by top dressing of 30% N at both 1st & 2nd cuts (Table.2). The crude protein yield was recorded significantly higher at two cuts than three cuts. The maximum crude protein yield was found at two cuts+50% N basal+50% N at 1st cut that was statistically at par two cuts 60% N basal fb 40% N at 1st cut. Sharma *et al*. (2018) [14] also reported higher crude protein content at 1st cut and then decreased with subsequent cuts but it increased with N levels being highest at 120 kg N/ha. Kumar *et al*. (2017) reported that nitrogen content, protein content and protein yield were significantly superior at 160 kg N/ha. Likewise, double cut shows higher protein content than single cut management, single cut resulted into higher protein yield than their respective counterparts like double cutting (60 DAS and 50% flowering). Saklani and Pal (2022) [9] also noted higher crude protein content in green fodder as higher rates of nitrogen application.

The gross and net returns as well as B:C ratio were higher under two cuts than three cuts with significantly higher values at tow cuts along with 50% N as basal and 50% N after cut that was significantly equal with two cuts +60% basal fb 40% N at 1st cut. Between three cuts, the higher gross and net returns and B:C ratio were recorded at application of 50% N as basal+ 25% N at 1st cut & 2nd cuts than 40% N as basal+ 30% N at 1st cut & 2nd cuts. It seems that higher basal and split application of N dose has better impact on foliage yield. Pravalika and Gaikwad (2021) [12] also reported higher B:C ratio at two cuts. The interaction effect was found significant for plant height, L:S ratio and dry fodder yield. The highest net returns was found at application of 120 kg N/ha (Godara *et al*., 2016; Dabhi *et al*., 2017 and Kashyap *et al*., 2022) [7].

Conclusion

Based on 3 years pooled data, it could be concluded that oat variety UPO-06-1 or UPO-212 could be grown for 2 cuts at application of 50% N as basal followed by top dressing of 50% N at 1st cut for higher fodder and crude protein yield and net return in Tarai region of Uttarakhand.

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