EFFECT OF NITROGEN RATES AND SEEDING DENSITY ON THE GREEN FODDER YIELD AND NUTRITIONAL QUALITY OF OATS (*AVENA SATIVA* L)

M. Rashid[*], A. Yaseen[*], M. Rizwan[**], S. Rahim [**], Z. Habib[**], A. Manan[**], K. Abbas[**]and M. A. Khan[**]

[*]Research Officers, Livestock Production Research Institute Bahadurnagar (Okara).
[**]Instructors Livestock Service and training Centre Bahadurnagar (Okara),
[**] Research Officers Livestock Production Research Institute Bahadurnagar District Okara & Research Officers, Buffalo Research Institute Pattoki (Kasur).
Corresponding author email. (mruaf1969@gmail.com).

ABSTRACT: *A field experiment "Effect of Nitrogen rates and seeding density on the green fodder yield and Nutritional quality of oats (Avena sativa L)" was conducted in the Research area of Livestock Production Research Institute Bahadurnagar (Okara) during rabi season 2024-25. The soil selected was analyzed for its Physical & chemical properties. The soil was loam in texture with EC 2.6 dSm^{-1}, pH 8.9, $CaCO_3$, 6%, Organic matter 0.65%, Available P & K were 6.5 ppm and 180 ppm respectively. The experiment was laid out in RCBD design with three seed rates 60, 80 & 110 $Kgha^{-1}$ and five rates of Nitrogen (0, 60, 80, 120, and 150 kg N ha^{-1}) along with all possible combinations. The oats crop was sown when the field attains the moisture contents at field capacity during the 2nd week of December 2024, through hand drill by adjusting 23X23 cm RXR distance. The green forage yield obtained was 30 t ha^{-1}, germination count 95% m^{-2}, number of tillers 15 m^{-2}, plant height 90 cm, number of leaves 08 per plant , fresh weight 30 t ha^{-1}, Dry matter yield (11.09 t ha^{-1}), dry matter contents 36.98, crude protein 8.18, crude fiber 27.70, ether extract 1.7 & total ash13.24 % respectively were recorded for the interactive effect of seed rate 110 and Nitrogen 150 $kgha^{-1}$. The Physical & Chemical data were analyzed statically by using Proc GLM procedure of SAS version 9.4 (SAS. 2017) and significant mean differences were tested using Fisher's protected least significant difference (LSD) test at α = 0.05.*

Key words: *- Oats crop, Seeding density, Nitrogen fertilizer rates, Fodder yield, Plant height & Fodder Quality.*

(Received 02.07.2025 Accepted 15.09.2025)

INTRODUCTION

Green forage is a valuable and the cheapest source of energy and provides excellent feed for livestock. A sustainable supply of green forage in Pakistan is a major constraint to achieve the desired livestock production of milk, butter, and other milk derivatives for human consumption (Iqbal *et al*, 2009). Livestock contributes 60.84% towards agriculture and 14.63% towards the gross domestic product of Pakistan during 2024 (Economic Survey of Pakistan, 2024). Livestock is usually underfed in Pakistan, which results in a low animal population. Imbalanced and low soil fertility, low organic matter content, and nitrogen deficiency are the major factors responsible for the low forage yield globally (Ulysses, 1992).

Oat is locally known as "jai" or "jodar" in Pakistan and belongs to the family Poaceae. Pakistan is facing a 52-54% deficiency in the domestic fodder requirements (Bhatti, 1992). Globally, oat is grown for grain, green forage, silage and fodder for livestock. It is the most important and cheapest source of cereal fodder crops grown during the winter season throughout the Pakistan under rain-fed and irrigated conditions. Oat fodder is nutritious, palatable and succulent in growth. The nutritive value of oat fodder can be increased by combining it with legumes, like Alfalfa, Persian clover, Berseem and Pea (Thomson *et al*, 1990). It contains high amount of minerals, including phosphorus, iron, fat, vitamin B_1 and protein. Oat is a high-yielding crop in temperate climates and exhibits low tolerance to water logging (Iqbal *et al*, 2009). Oat grains are a rich nutritive feed for dairy cows, sheep, horses, and young breeding animals (Hussain *et al*., 2002). Oat forage contains 30.44% crude fiber, 9.3% crude protein, 3.56% fat, and 0.27% phosphorus. It can be directly grazed to feed animals before seed setting and can be grown for grain purposes (Chaudhry, 1994). Its good quality grains and leaves are a rich source of carotene and carbohydrates. Oat requires 16-32°C temperature and 400 mm rainfall during the growing season for optimum growth and development (Bhatti, *et al*, 2002)

The forage yield of oat in Pakistan is too low than other countries. The main reasons for low forage production are changing climate, low soil fertility, non-availability of high-yielding varieties, socio-economic factors, shortage of irrigation water, poor seeding techniques, and mismanagement of fertilizer application (Ibraheem, 2012).

Genus *Avena* consists of seventy species. *Avena byzantine* and *Avena sativa* are mainly cultivated for green forage and fodder purposes. There is a dire need to improve the forage yield of oat, which can be achieved by adopting improved agronomic practices (Bhatti, 2002). Oat ranks 6th as a cereal crop worldwide after wheat, maize, rice, barley and sorghum crops. Oat is a multicut fodder crop and achieves maximum green fodder yield with appropriate crop management. It should be harvested at 50% flower blooming (Alipatra *et al*, 2014).

Sowing fodder crops with an optimum seed rate is important to get sufficient plant population, which ultimately contributes towards high grain and fodder production. Plant population has a direct impact on fodder, grain yield and quality. Low and high plant population reduces the yield and quality of forages. The seed rate must be kept optimum. The seed rate of legumes could be decreased when these are sown in a mixture with other fodder crops such as Alfaalfa, Berseem, Ryegrass etc. (Basit *et al*, 2021 & Karar *et al*, 2021) The use of low or high seed rate exerts negative impacts on grain, fodder yield and quality (Abate D. & Wegi T., 2014). A lower seed rate increases plant height, while a high seed rate reduces plant height due to less space, antagonism for light, and other resources. The plant height of forage crops decreases with increasing seeding rate, which indicates competition for light (Reddy, 1976).

Kakol *et al*, 2002, recorded the highest green forage yield of oat with a 100 kg ha^{-1} seed rate compared to 125 kg ha^{-1}, while the quality of forage remained unaffected. Jan and Jan, 1994, have also reported a non-significant impact of seed rates on green and dry forage yields of oat. Abate and Wegi, 2014., concluded that optimum seed rate and fertilizer level have a significant effect on green forage yield of oat and dry matter production.

Nitrogen plays a vital role in crop production (Olson *et al*, 2015). It is an essential ingredient of plant cell constituents like green pigments, amino acids, enzymes, and nucleic acids. Plant uptake N in solution form and partition it into different plant tissues/organs. Nitrogen exerts significant impacts on tillering, stem length, heading, cell division, booting and grain filling. Nitrogen also affects crop morphology (Amanullah *et al*, 2009). It is the most deficient nutrient in soil; thus it is required in heavy amounts for cereal and fodder crops (Havlin *et al*, 1999). Several factors including soil pH, moisture contents, and temperature significantly affect N losses (Malakar *et al*, 2009). However, the application of optimum dose is important to fetch high yield and good quality (Jan & Jan, 1999). Higher N application improves forage yield. Green fodder yield of oat was significantly affected by 80 kg N $ha^{-1}$and it was higher than control, 40 and 120 kg ha^{-1} (Ratan, 2016). However, the optimum N dose significantly varies among locations and agroclimatic conditions. Therefore, it is mandatory to optimize the N application rate and seed rate for high forage production. It was hypothesized that increasing the N dose significantly affected the fodder yield and quality. Similarly, different seed rates have a significant impact on fodder yield and quality of oat.

MATERIALS AND METHODS

Experimental Site: A field experiment was conducted during Rabi seasons of 2024-25 in the field area of Livestock Production Research Institute Bahadurnagar (Okara). The latitude of Okara, Punjab, Pakistan is 30.808500, and the longitude is 73.459396. Okara, Punjab, Pakistan is located at Pakistan country in the Cities place category with the GPS coordinates of 30° 48' 30.6000" N and 73° 27' 33.8256" E. The coldest months were from December to February, when temperatures dropped to 3°C (37°F), with moderate rainfall. The hottest months were May to July, when temperatures reached 45 C (113 °F). The annual average rainfall in the city was approximately 509 mm (20.0 inch) (www.google /com/search/ geographical/ okara/ Pakistan.). Composite soil samples (five random core samples from each plot, thoroughly mixed together) were collected from the surface layer (0–30 cm) before sowing the crop for its Physico-chemical soil properties i.e., Texture, Organic Matter %, available Phosphorus (ppm), available Potassium (ppm), $CaCO_3$ %, EC (dS m^{-1}) and pH (U.S. Salinity Lab. Staff, 1954), which were as under.

Table:-1 Physico-Chemical properties of soil.

Property	Soil sampling Depth 0-30 cm
EC (d Sm^{-1})	2.6
pH	8.9
$CaCO_3$ (%)	6
O.M (%)	0.65
Available P (ppm)	6.5
Available K (ppm)	180
Sand (%)	45
Silt (%)	35
Clay (%)	20
Textural Class	Loam

Experimental Details: The experiment was conducted on a fallow land, leveled and cultivation was done to prepare the fine seed bed. Roni irrigation of 10 cm was applied and the field was cultivated two times with the help of a cultivator followed by planking, when the soil attained the moisture at field capacity. The approved oat cultivar for forage production (SG-2022) was used in the experiment. Three seed rates, i.e., 60, 80 & 110 Kg/ha^{-1} and five N rates (0, 60, 80, 120, and 150 kg N ha^{-1}) with each possible combination were included in the study i.e. (Fifteen treatments). Each treatment/experimental plot (20 X 30 ft^2) consisted upon three replications. The details of treatments was as below.

The oats crop was sown during 2nd week of December 2024 with the help of hand drill by adjusting RXR distance of 23X23 cm. Urea and Diammonium Phosphate (DAP) were used as the source of Nitrogen and Phosphorus, respectively. The whole quantity of recommended Phosphorus @ 100 kg ha^{-1} was applied as a basal dose, while N was applied in two equal splits according to the treatments. The first dose of N was applied at the time of sowing, whereas the second dose was given with first irrigation. Three irrigations were given during the entire growth period of the crop. The crop was harvested manually at ground level with the help of a sickle at milking stage of growth.

Table:-2 Detail of treatments and its possible combinations.

Treatment #	Treatments & its combination	Seed rate (Kg/ha.)	P_2O_5 kg /ha
T_1	$S_{60}N_0$	60	0
T_2	$S_{60}N_{60}$	60	60
T_3	$S_{60}N_{80}$	60	80
T_4	$S_{60}N_{120}$	60	120
T_5	$S_{60}N_{150}$	60	150
T_6	$S_{80}N_0$	80	0
T_7	$S_{80}N_{60}$	80	60
T_8	$S_{80}N_{80}$	80	80
T_9	$S_{80}N_{120}$	80	120
T_{10}	$S_{80}N_{150}$	80	150
T_{11}	$S_{110}N_0$	110	0
T_{12}	$S_{110}N_{60}$	110	60
T_{13}	$S_{110}N_{80}$	110	80
T_{14}	$S_{110}N_{120}$	110	120
T_{15}	$S_{110}N_{150}$	110	150

Picture: - 1 preparation of layout plots for oats and weighing of seed & fertilizers.

Picture: - 2 Drill sowing of oats and standing oats crop.

Data recording: Standard procedure was used for data recording which was kept uniform for all treatments. The number of seed germination (germination count m^{-2}) of experimental plots was monitored daily until the last seed emerged. The number of seeds germinated on the final day of the count were recorded as germination count. The crop was harvested at milking stage of growth. The data relating to plant height (cm), number of leaves (per plant), number of tillers (plant), fresh weight ($kg\,m^{-2}$) & green fodder yield ($t\,ha^{-1}$) were recorded. The plant samples were sent to Animal Nutrition Laboratory for the Approximate Analysis /determination of dry weight ($g\,m^{-2}$), dry matter yield ($t\,ha^{-1}$). The harvested sample were dried in an oven at 70°C, the dry weight (gm^{-2}) and dry matter yield were measured. This yield was then converted into $t\,ha^{-1}$ by a standard unitary method. Crude protein (%), crude fiber (%), ether extract and total ash (%) were determined.

Picture: - 3 Crop stand of oats and its harvesting.

Picture: - 4 weighing of oats for green fodder yield.

Picture: - 5 Data Recording.

RESULTS AND DISCUSSION

It was revealed from the data recorded that treatment T_{14} (Seed 110 & N 120 Kg ha^{-1}) gave maximum plant height (90) cm, number of tellers per plant (15), Number of leaves per plant (8), green fodder yield (29 tons ha^{-1}.), dry matter yield (11.09 tons ha^{-1}.), Moisture % (70), Ash% (13), Crude Fiber % (27.63), Crude Protein % (8.05) which is more than all other treatments but was at par with the treatment T_{15} (Seed 110 & N 150 Kg ha^{-1}) in the experiment and Ether Extract was (1.8%).

The data regarding the germination of seeds showed that there was no effect of treatment on the germination percentage of seed (Table: -3). These findings are in contradiction to the findings of Bray *et al*, (1989) and Arif *et al*, (2005), who reported that priming of seed enhanced germination which may be attributed to repair processes, a buildup of germination metabolites or osmotic adjustments during priming. Aroosa Kanwal *et al*, (2024), reported that the germination count of forage oat was significantly affected by different seed rates, while the main effects of the N level were nonsignificant. Similarly, the interactive effect of the seed rate and N level was also nonsignificant. The highest germination count recorded was (138.77 m^{-2}) for S_3 treatment, whereas the lowest plant population (108.42 m^{-2}) was noted for S_1. The higher germination count is directly corelated with higher seed rate used.

The data given in table:-3 regarding plant height (cm) revealed that maximum Plant height obtained was 90 cm at T_{14} (Seed 110 & N 120 Kg ha^{-1}) and was at par with plant height (cm) achieved at T_{15} (Seed 110 & N 150 Kg ha^{-1}) compared with treatment T_1 control (seed rate 60 Kg ha^{-1}& no Nitrogen fertilizer) with lowest plant height 56 cm. plant height tends to increase with higher Nitrogen fertilizer rates, at least up to a certain point. This is because Nitrogen is a crucial component for plant growth, playing a vital role in cell division, cell enlargement and protein synthesis. However, excessive Nitrogen can lead to issues like delayed maturity and excessive vegetative growth, potentially at the expense of other yield components. Poudel *et al*,(2018), studied to assess the role of five different levels of Nitrogen (100, 150, 200, 250 and 300 $kgha^{-1}$) on growth and yield attributes of Radish. They measured different growth and yield parameters like plant height, number of leaves, root length, root girth, root weight and significant differences were found on root length and plant height. Maximum root length and plant height was observed at 250 and 300 $kgha^{-1}$ reflecting better yield performance at these Nitrogen levels. This indicates that 250 $kgha^{-1}$ Nitrogen was best for better yield (root weight 121.3 g $plant^{-1}$).

The data presented in table:-3 regarding green fodder yield (tha^{-1}) of oats affected by different seed rates and Nitrogen fertilizer rates showed that green fodder yield obtained was 30 tha^{-1} at T_{15} (seed rate 110 and N 150 Kg ha^{-1}) and at treatment T_1 control (seed rate 60 with no Nitrogen fertilizer) with lowest green fodder yield 20 tha^{-1}. Generally applying Nitrogen and adjusting seeding density have a significant impact on green fodder yield of oat. Higher Nitrogen rates increased yield, with optimal rates depending on other factors like variety and climate. Seeding density also plays a vital role and the interaction between Nitrogen and seeding density can affect yield and quality. Aroosa *et al*, (2024), reported that the interactive effect of seeding density and N doses significantly affect green forage yield and quality of oat fodder. The highest green forage yield (54.67 t ha^{-1}) was obtained for the interaction among seed rate 90 and N160 kg ha^{-1}. Similarly, the highest germination count (140 m^{-2}), number of tillers (5.97 m^{-2}), plant height (122.97 cm), number of leaves per plant (24.50 m^{-2}), leaf area per tiller (123.18 cm^2), fresh weight (5.47 kg m^{-2}), dry weight (1692 g m^{-2}), dry matter yield (20.90 t ha^{-1}), crude protein (10.54%), crude fiber (31.62%), and total ash (9.39%) respectively were recorded at seed rate 90 $kgha^{-1}$ and N 160 $kgha^{-1}$.

The data regarding the number of leaves per plant showed that the number of leaves per plant of oats increased with an increasing rate of Nitrogen (Table: -3). Generally, increasing Nitrogen application leads to an increase in the number of leaves, while increasing seeding density tends to decrease the number of leaves per plant. This is because Nitrogen is a crucial nutrient for plant growth and development, particularly leaf production and higher seeding densities can lead to competition for resources among plants, reducing individual leaf counts. Maximum number of leaves $plant^{-1}$ were 08 obtained at T_{12} (seed rate 110 and N 60 Kg ha^{-1}) which were at par with treatment ($T_{13,}$ T_{14} & T_{15}). Minimum number of leaves per plant was 5 at treatment (T_1) which was at par with number of leaves obtained at T_2 to T_5. The results are in conformity with the findings of Aroosa *et al*, (2024), that the interactive effect of seeding density and N doses significantly altered green forage yield and quality attributes of oat.

The data regarding the number of tillers per plant table: - 3 showed that the number of leaves per plant increased significantly with increasing rates of Nitrogen Maximum number of tillers per increased were obtained at T_{13} (seed rate 110 and N 80 Kg ha^{-1}) which was at par with T_{14}& $T_{15.}$ Generally, in oat crops, both Nitrogen (N) fertilizer rates and seeding density significantly influence the number of tillers per plant. Increasing Nitrogen application rates leads to an increase in tillering, while higher seeding densities tend to reduce the number of tillers per plant due to competition for resources. The results are in conformity with the findings of Marwan *et al*, (2019), who reported that Level N_1 gave the highest mean (204.38 $tiller.m^{-2}$) while level N_3 gave the lowest mean (193.12 $tiller.m^{-2}$). This may be due to the role of Nitrogen in the synthesis of cytokine, which was positively reflected on the number of tillers at high level. This result is also in agreement with Harfe, (2017), who found an increase in wheat tillers number by increasing added amount of Nitrogen fertilizer. A significant difference belonged to S_4 which gave the highest mean (328.67 tiller. m^{-2}), while S_1 achieved the lowest a mean (81.50 tillers m^{-2}), this may be due to an increasing number of plants in the area unit, which lead to an increasing number of tillers, this is also in agreement with the findings of Campbell *et al*, (1991).

The data regarding dry matter (%) and dry matter yield (tha^{-1}) table: -4 revealed that maximum dry matter contents (%) and dry matter yield (tha^{-1}) obtained at seeding density of 110 & Nitrogen 150 kg ha^{-1}. Generally, seeding density and nitrogen (N) fertilization both significantly impact dry matter percentage and yield in crops. Generally, increasing seeding density can lead to higher dry matter yield due to increased plant density per unit area, but excessive density can create competition for resources, potentially reducing yield. Nitrogen application, especially when adequate, tends to increase dry matter production and yield, as it is a crucial component for plant growth and development. However, the optimal combination of seeding density and nitrogen level varies depending on the crop, environment, and other factors. There is an optimal combination of nitrogen rate and seeding density that maximizes dry weight. The results in conformity to the finding of Yongli Lu *et al,* (2024), who reported that averaged over the three plant densities, N application rate of 180 kg ha^{-1} resulted in the maximum average aboveground dry matter yield (18.6 t ha^{-1}), crop N accumulation (228.5 kg ha^{-1}), dry matter water productivity (51.9 kg ha^{-1} mm^{-1}), and dry matter precipitation productivity (62.9 kg ha^{-1} mm^{-1}) over the two years in maize crop. Moreover, increasing N application rates significantly increased the soil nitrate-N accumulation (0–200 cm) but reduced the partial factor productivity of applied N fertilizer. Across the three plant densities, the two-year average soil nitrate-N accumulation was 12.6, 32.1, and 75.7 % higher with 90, 180, and 270 kg N ha^{-1} compared to no N treatment, respectively. The highest soil nitrate accumulation under 270 kg ha^{-1} N application rate in 2021 (229.5 kg ha^{-1}) and in 2022 (329.7 kg ha^{-1}) may cause severe nitrate leaching loss and potential soil water contamination, driven by intensive rainfalls. Averaged over the four N rates, planting density of 110000 plants ha^{-1} increased the crop N accumulation and PFP by 21.2 % and 15.8 % in 2021, compared to 70000 plants ha^{-1}, respectively.

The data regarding moisture contents (%) table: -4 showed that maximum moisture contents were found in oats at seeding density 110 & Nitrogen 150 Kg ha^{-1}Generally, seeding density and nitrogen levels can significantly influence a plant's moisture content, both directly and indirectly. Increased seeding density can lead to greater water competition among plants, potentially reducing individual plant moisture content. Nitrogen, an essential nutrient for plant growth, can affect moisture content by influencing plant size, leaf area, and overall water uptake. Nitrogen fertilizer and seeding density significantly influence oat moisture content. Increased nitrogen rates tend to increase moisture content, while higher seeding densities also tend to increase the moisture contents in plants. Optimizing planting density is one of the important cultivation practices to improve yield per unit area and nitrogen use efficiency, Dai, X.L. *et al,* (2013). Planting density largely determines the population dynamics of wheat, thus further affecting environmental factors of light, moisture, and nutrients. Studies have shown that an appropriate increase in planting density can promote root length, root volume, and canopy photosynthetic characteristics, thereby increasing yield and nitrogen use efficiency, Zhang, X.Q. *et al,* (2021). However, too high of a planting density will affect grain filling and reduce yield, Liu, Y .*et al*, (2021). The results are in conformity with the findings of Meixue *et al*, (1998), who reported that the effects of nitrogen (N) application, sowing date, and sowing rate on the quality of the oats were examined. N and late sowing caused a decrease in moisture content.

The data regarding crude protein (%) table: -4 revealed that crude protein 8.18% was found in oats at treatment T_{15} (seed rate 110 Kg $ha^{-1}$and 150 Kg ha^{-1}) which was highest compared with treatments 60 Kg ha^{-1}& no Nitrogen fertilizer) with lowest crude protein 7.06%. The crude protein increased in oats with increasing level of Nitrogen application rates. Higher seeding densities generally lead to increased plant competition, potentially reducing individual plant size and overall forage quality, including crude protein content. Increased nitrogen (N) application rates, on the other hand, typically result in higher crude protein percentages in oat fodder. The interaction between seeding density and nitrogen rates can significantly impact forage yield and quality. Aroosa Kanwal *et al*, 2024, assessed the impact of different seeding densities and nitrogen (N) doses on the forage yield of oat. Three seeding densities (70, 80, and 90 kg ha^{-1}) and five N doses (0, 40, 80, 120, and 160 kg ha^{-1}) were included in the study. The interactive effect of seeding density and N doses significantly altered green forage yield and quality attributes of oat. The highest green forage yield (54.67 t ha^{-1}) was noted for the interaction among 90 kg seed rate ha^{-1} and 160 kg N ha^{-1}. Similarly, the highest germination count (140 m^{-2}), number of tillers (5.97 m^{-2}), plant height (122.97 cm), number of leaves per plant (24.50 m^{-2}), leaf area per tiller (123.18 cm^2), fresh weight (5.47 kg m^{-2}), dry weight (1692 g m^{-2}), dry matter yield (20.90 t ha^{-1}), crude protein (10.54%), crude fiber (31.62%), and total ash (9.39%) were recorded for the interactive effect of 90 kg seed rate ha^{-1} and

160 kg N ha^{-1}. Economic analysis revealed that interaction between 90 kg seed rate ha^{-1} with 120 and 160 kg N ha^{-1} was superior to others with higher benefit: cost ratio and net economic returns. It is recommended that the oat seed rate of forage oat crop must be kept at 90 kg ha^{-1}and it should be supplied 120 kg N ha^{-1} for higher yield & better quality.

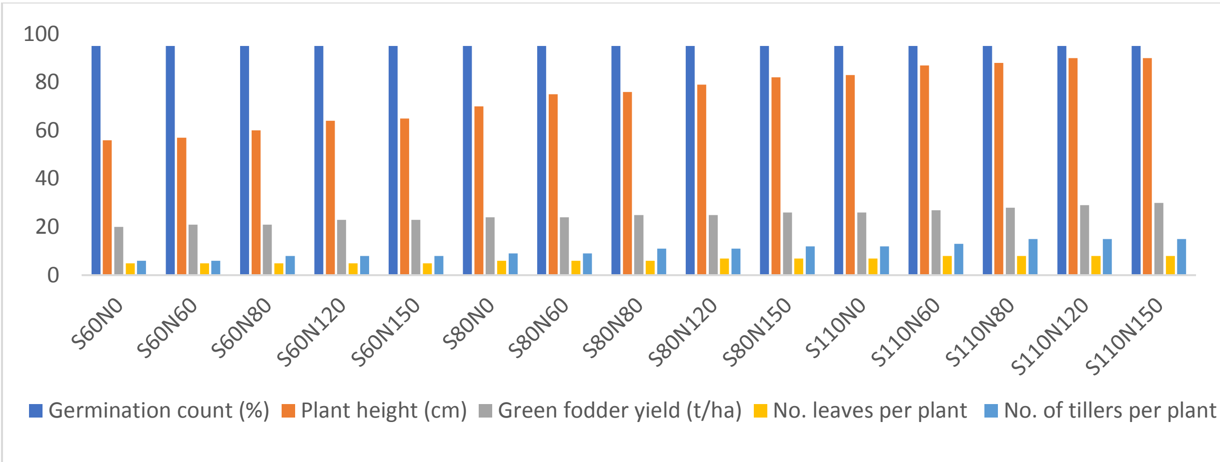
The data regarding crude Fiber (%) table: -4 revealed that crude Fiber 27.70 % was found in oats at treatment T_{15} (seed rate 110 Kg ha^{-1}and 150 Kg ha^{-1}) which was highest compared to treatment T_1 control (seed rate 60 Kg ha^{-1}& no Nitrogen fertilizer) with lowest crude fiber 24.03%. The crude fiber increased in oats with increasing level of Nitrogen application rates. Generally, seeding density and nitrogen application can significantly influence the crude fiber percentage in oats. Higher seeding densities generally lead to a decrease in crude fiber due to increased competition for resources, while nitrogen fertilization can either increase or decrease crude fiber depending on the rate and timing. Ruochen Zhang *et al,* (2021), summarized that the strategic management of sowing density, when coordinated with effective nutrients uptake and utilization practices, can lead to significant improvements in crop productivity and sustainability. Aroosa Kanwal, *et al*, (2024), reported that the variation in seed rate and N level significantly affected the crude fiber percentage. The highest crude fiber percentage was observed for S_3N_5, while S_2 N_1 resulted in the lowest crude fiber percentage.

The data regarding Ether Extract table: -4 revealed that Ether Extract 1.7 % was found in oats at treatment T_{15} (seed rate 110 Kg ha^{-1}and 150 Kg ha^{-1}). Generally, seeding density and nitrogen application significantly affect the ether extract percentage in oat fodder. Higher seeding densities generally lead to a decrease in ether extract, while nitrogen application, particularly at optimal levels, tends to increase it. Vijay Pal *et al,* (2021), reported that the application of Nitrogen to the oat crop has a major effect on plant height, growth and leaf length all increased significantly after Nitrogen was applied. The productivity and quality of fodder oat improves as Nitrogen levels rise. Nitrogen application resulted in higher green and dry fodder yield as well as improved green and dry fodder output efficiency and quality parameters such as ether extract.

The data regarding Ash % (Mineral Matter) Table: -4 revealed that Ash 13.24 % was found in oats at treatment T_{15} (seed rate 110 Kg ha^{-1}and 150 Kg ha^{-1}). Generally, Increasing nitrogen fertilizer levels tends to decrease ash content in oats, while higher seeding densities generally lead to increased ash content, but this effect can be modified by nitrogen levels. Oat performance, including yield and quality, is significantly influenced by both sowing density and nitrogen fertilization levels. Higher sowing densities and nitrogen levels can increase yield, but there's an optimal point beyond which further increases offer diminishing returns or even become detrimental. Tuğçe Karakuzu & Özge Doğanay Erbaş Köse .(2025), reported that the highest grain yield was obtained at sowing densities of 300 and 450 seeds m² as 4.45 t ha^{-1} and 4.56 t ha^{-1}, respectively. Since there was no statistically significant difference in yield between these densities, a sowing density of 300 seeds m^{-2} can be recommended on oat. Additionally, the highest grain yield was achieved with a nitrogen dose of 80 kg per hectare. Based on the results of this study, the combination of nitrogen dose 80 kg and sowing density 450 seeds m² showed the optimal performance in terms of yield and quality.

Table:-3 Effect of seeding density and Nitrogen rates on germination count, plant height, green fodder yield, Number of leaves and Number of tillers per plant

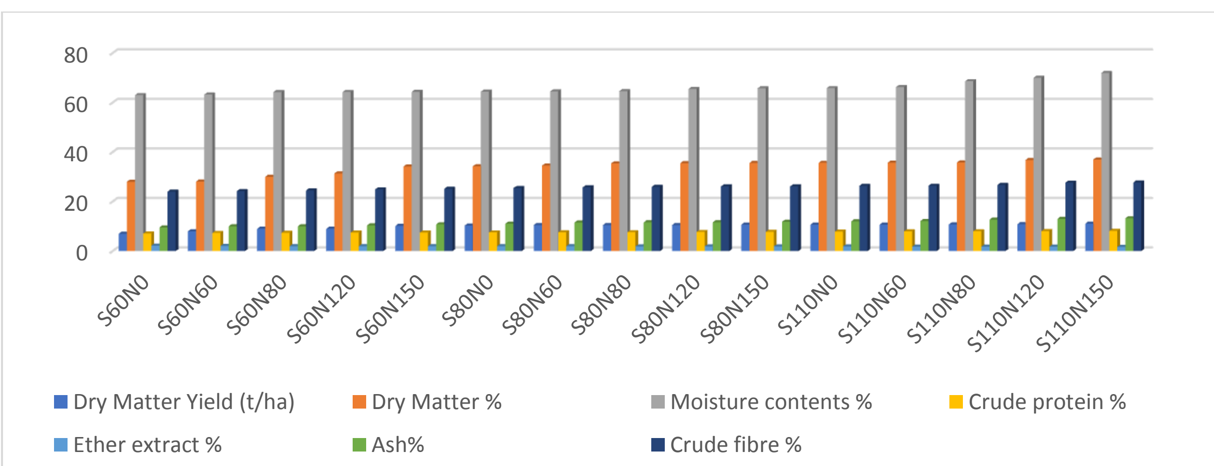
Treatment	Germination count (%)	Plant height (cm)	Green fodder yield (t/ha)	No. leaves per plant	No. of tillers per plant
$S_{60}N_0$	95	56	20	5	6
$S_{60}N_{60}$	95	57	21	5	6
$S_{60}N_{80}$	95	60	21	5	8
$S_{60}N_{120}$	95	64	23	5	8
$S_{60}N_{150}$	95	65	23	5	8
$S_{80}N_0$	95	70	24	6	9
$S_{80}N_{60}$	95	75	24	6	9
$S_{80}N_{80}$	95	76	25	6	11
$S_{80}N_{120}$	95	79	25	7	11
$S_{80}N_{150}$	95	82	26	7	12
$S_{110}N_0$	95	83	26	7	12
$S_{110}N_{60}$	95	87	27	8	13
$S_{110}N_{80}$	95	88	28	8	15
$S_{110}N_{120}$	95	90	29	8	15
$S_{110}N_{150}$	95	90	30	8	15



Picture:- 6 Effect of seeding density and Nitrogen rates on the germination count(%), Plant height (cm), Green fodder yield (t/ha), Number of leaves and Number of tillers per plant.

Table:-4 Effect of seeding density and Nitrogen rates on Nutritional quality of oat fodder.

Treatment	Dry Matter Yield (t/ha)	Dry Matter	Moisture contents	Crude protein	Ether extract	Ash	Crude fiber
		%					
$S_{60}N_0$	7	28.00	63.02	7.06	2.2	9.53	24.03
$S_{60}N_{60}$	8	28.06	63.23	7.34	2.1	10.02	24.20
$S_{60}N_{80}$	9	30.01	64.20	7.39	2.0	10.02	24.47
$S_{60}N_{120}$	9	31.38	64.26	7.46	2.0	10.37	24.94
$S_{60}N_{150}$	10.2	34.19	64.35	7.49	2.0	10.82	25.20
$S_{80}N_0$	10.3	34.26	64.38	7.54	2.0	11.04	25.43
$S_{80}N_{60}$	10.5	34.53	64.49	7.60	2.0	11.52	25.73
$S_{80}N_{80}$	10.5	35.41	64.59	7.63	1.9	11.60	25.93
$S_{80}N_{120}$	10.5	35.51	65.47	7.73	1.9	11.67	26.10
$S_{80}N_{150}$	10.7	35.62	65.74	7.78	1.9	11.83	26.13
$S_{110}N_0$	10.7	35.65	65.81	7.90	1.9	12.01	26.33
$S_{110}N_{60}$	10.7	35.74	66.23	7.96	1.8	12.14	26.37
$S_{110}N_{80}$	10.8	35.8	68.62	8.01	1.8	12.69	26.73
$S_{110}N_{120}$	10.9	36.77	69.99	8.05	1.8	13.00	27.63
$S_{110}N_{150}$	11.09	36.98	71.94	8.18	1.7	13.24	27.70



Picture:- 7 Effect of seeding density and Nitrogen rates on the Nutritional quality of oat fodder

Statistical Analysis: The Physical & Chemical data was analyzed statically by using Proc GLM procedure of SAS version 9.4 (SAS. 2017) and significant mean differences were tested using Fisher's protected least significant difference (LSD) test at α = 0.05.3.

Conclusion: The seed rate 110 kg ha^{-1} and Nitrogen level 120 kg ha^{-1} gave maximum green fodder yield and other yield attributing parameters with good quality fodder.

REFERENCES

Abate D. & Wegi T. (2014). Determination of optimum seed and fertilizer rate for fodder oat in Bale Highland Southeastern Ethiopia. International Journal of Soil and Crop Sciences. 2(7):73–76.

Alipatra A., Kundu C. K., Mandal M. K. and Banerjee H. (2014). Bandopadhyay P. Yiels and quality improvement in fodder oats (Avena sativa L.) through split application of fertilizer and cutting management. J. of Crop and Weed. 9(2):193–195.

Amanullah R. A. K. & Khalil S. K. (2009). Plant density and nitrogen Effects on Maize phenology and Grain yield. J. of Plant Nutri. 32(2):246–260. doi: 10.1080/01904160802592714.

Arif, M., S. Ali, A. Shah, N. Javeed and A. Rashid. (2005). Seed priming maize for improving emergence and seedling growth. Sarhad J. Agric., 21: 539-543.

Aroosa Kanwal, Dawood Zubair, Rao Mehboob ur Rehman, Muhammad Ibrahim, Muhammad Amjad Bashir, Muhammad Mudassar Maqbool, Muhammad Imran, Ubaid ur Rehman, Omaima Nasif and Mohammad Javed Ansari.(2024). The Impact of Seeding Density and Nitrogen Rates on Forage Yield and Quality of Avena sativa L. Biomed Res Int. 9825298 10.1155/2022/8238634

attributing characters of radish. Horticul. Int J. 2 (4): 208–210.

Basit A., Farhan M. & Mo W. D. (2021). Enhancement of resistance by poultry manure and plant hormones (salicylic acid & citric acid) against tobacco mosaic virus. Saudi J. of Biolo. Scie.28(6):3526–3533.

Bhatti B. (1992). Fodder Production in Pakistan. Fodder production in rainfed areas of Punjab; pp. 113–114.

Bhatti M. B., Hussain A. & Mohammad D. (2002). Fodder production potential of different oat cultivars under two cut system. Pakistan J. of Agri. Rese.13:184–190.

Bray, C.M., P.A. Davison, M. Ashraf and R.M. Taylor. (1989). Biochemical changes during osmom-priming of leek seeds. Ann. Bot., 63: 185-193.

Campbell, C.A., F. Selles, R.P. Zentner, J. G. McLeod and F. B. Dyck .(1991). Effect of seeding date, rate and depth on winter wheat grown on conventional fallow in S.W. Saskatchewan. Can. J. Plant Sci., 71: 51-61.

Chaudhry A. R. (1994). Crop production . Nation book foundation Islamabad.

Dai, X.L.; Zhou, X.H.; Jia, D.Y.; Xiao, L.L.; Kong, H.B.; He, M.R. Managing the seeding rate to improve nitrogen-use efficiency of winter wheat. Field Crops Res. 2013, 154, 100–109. [Google Scholar] [CrossRef]

Harfe, M. (2017). Response of bread wheat (Triticum aestivum L.) varieties to N and P fertilizer rates in of a district, Southern Tigary, Ethiopia. African Journal of Agricultural Research, 12(19):1646 – 1660.

Havlin J. L., Beaton J. D., Tisdale S. L. & Nelson W. L. (1999). Soil Fertility and Fertilizers: An Introduction to Nutrient Management . 6th. India: Pearson Education Inc.

Hussain A., Khan S., Mufti M. U. & Bakhsh A. (2002). Introduction and use of oats cultivars in Pakistan. Proceedings of "5th TAPAFON (Temperate Asia Pasture and Fodder Network) meeting/conference held at Renewable Natural Resources Research Center; 2002; Bajo (Wangdue-Bhutan). pp. 159–166.

Ibrahim M. (2012). Determining forage production potential of maize sown as a mixture with different legumes under different nitrogen applications. Ph. D. Thesis, Dept. of Agron., Univ. of Agric., Faisalabad, Pakistan

Iqbal M. F., Sufyan M. A., Aziz M. M., Zahid I. A., Ghani Q. & Aslam S. (2009). Efficacy of nitrogen on green fodder yield and quality of oat (Avena sativa L.) The Journal of Animal and Plant Sciences (Pakistan).19(2):82–84.

Jan T. & Jan M. T. 91994). Effect of sowing dates and seed rates on the forage yields of oats. Sarhad Journal of Agriculture (Pakistan). 10(5):473–476.

Kakol N. B., Alagundagi S. C. & Hosamani S. V. (2002). Effect of seed rate and nitrogen levels on forage yield and quality of oat. Indian J. of Animal Nutrition. 20(2):149–154.

Karar H., Amjad Bashir M., Khaliq A., Jaffar Ali M., Atalla Alajmi R. & Metwally D. M. Stink bug (2021). Agonoscelis spp. (Heteroptera: Pentatomidae) - An emerging threat for seed production in alfalfa crop (_Medicago sativa_ L.) and their successful management. Saudi J. of Biolo. Scie. 28(6):3477–3482.

Liu, Y.; Liao, Y.C.; Liu, W.Z. High nitrogen application rate and planting density reduce wheat grain yield by reducing filling rate of inferior grain in middle spikelets. Crop J. 2021, 9, 412–426. [Google Scholar] [CrossRef]

Malakar B., Mondal S., Bandopadhyay P. and Kundu C. K. (2009). Response of forage oat to nitrogen and phosphorous fertilizer in the new alluvial zone of West Bengal. J. of crop and weed. 5(2):36–38.

Marwan Sami Said, Raja Majeed Hameed and Hassan Ali Majeed. (2019). Effect of Nitrogen fertilizer and seeding rates on growth and grain yield in Oats (*Avena sativa* L.) Plant Archives 19(1):1554-1558.

Meixue Zhou, G. L. Roberts, K. Robards, M. Glennie-Holmes and S. Helliwell. (1998). Effects of sowing date, nitrogen application, and sowing rate on oat quality. Aust. J. Agric. Res., 1998, 49, 845–52.

Olson R. A. & Sander D. J. (2015). Corn production. In: Sprague G. F., Dudley J. W., editors. Corn and Corn Improvement . Madison: American Society of Agronomy/Crop Sci. Society of America/Soil Sci. Society of America;pp. 639–686.

Poudel P, Shrestha A & Shrestha RK. (2018). Effect of nitrogen level on growth and yield attributing characters of radish. Horticult Int J. 2(4):208-210.

Ratan N., Singhand U. N. and Pandey H. C. (2016). Yield and quality of oat as influenced by nitrogen and varieties in Bundelkhand region U. P. India. Agri. Science Rese. J. 6(1):27–30.

Reddy B. S. (1976). Physiological Studies on Oat (Avena sativa) Varieties under Two Cutting Regimes . Pantnagar: M. Sc. (Agri.) Thesis, Govind Ballabh Pant University of Agriculture and Technology.

Thomson E. F., Rihawi S. and Nersoyan N. (1990). Nutritive value and yields of some forage legumes and barley harvested as immature herbage, hay and straw in northwest Syria. Experi. Agri.26(1):49–56.

Tuğçe Karakuzu & Özge Doğanay Erbaş Köse .(2025). Performance of Oat under Different Sowing Densities and Nitrogen Levels Turkish J. of Field Crops 30(1):98-109 DOI:10.17557/tjfc.1636732.

U.S. Salinity Lab. Staff. 1954. Diagnosis and Improvement of Saline and Alkali Soils. USDA Hand Book No. 60, Washington, DC, USA.

Ulysses S. J. (1982). Fertilizers and Soil Fertility . 2nd. Reston, Virginia: Reston Publishing Co; Worku M., Friesen B. E., Diallob O. A. & Horst W. J. 2007. Nitrogen uptake and utilization in contrasting nitrogen efficient tropical maize hybrids. Crop Scie. 47(2):519–528.

Vijay Pal, Dr. Rubina Gill and Ramandeep Singh. (2021). Impact of nitrogen application on fodder quality and yield parameters of oats: A review. The Pharma Innovation J. 10 (5): 1429-1431

Yongli Lu, Renshi Ma, Wei Gao, Yongliang You, Congze Jiang, Zhixin Zhang , Muhammad Kamran and Xianlong Yang. (2024). Optimizing the nitrogen application rate and planting density to improve dry matter yield, water productivity and N-use efficiency of forage maize in a rainfed region. Agri. Water Management 305,109125

Zhang, X.Q.; Du, S.Z.; Xu, Y.J.; Cao, C.F.; Chen, H. (2021). Reducing N Application by Increasing Plant Density Based on Evaluation of Root, Photosynthesis, N Accumulation and Yield of Wheat. Agronomy (11), 1080. [Google Scholar] [Cross Ref].