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Short communication

Diverse nitrogen fertilization effects on fodder yield and quality of oat

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Abstract

A field experiment was conducted during the *rabi* season of 2020-21, to assess the effect of diverse nitrogen fertilization on growth, yield and quality of fodder oat. The experiment consisted of seven treatments *viz*., control (no N); a recommended dose of N (RDN); 50% N through fertilizer + 50% N through FYM; 50% N through fertilizer + 50% N through vermicompost; 50% N through fertilizer + two sprays of nano-urea; two sprays of nano-urea; site-specific nitrogen management (SSNM). Results showed that diverse nitrogen fertilization brought considerable improvement in the growth, productivity and fodder quality of oats. Application of 50% RDN through fertilizer + 50% N through vermicompost produced significantly the highest green (61.1 t/ha) and dry fodder yields (10.19 t/ha), which were at par with all other treatments except two sprays of nano urea and control. The increase in green and dry fodder yield was 92.8 and 87.2% over control. Furthermore, the highest CP content (12.1%) and CP yield (1212 kg/ha) were obtained under SSNM, which was at par with all other treatments except control and two sprays of nano-urea. However, a reverse trend was observed in acid detergent fiber. The study suggested that integrated use of fertilizer and organic manure could be applied in oats to get higher fodder yield and quality.

Keywords: Fodder yield, Nano-urea, Organic manure, Quality

Oat *(Avena sativa* L.*)* is a major winter season fodder crop in India. It is locally known as a '*Jai* or *Javi.*' It is widely grown in northwestern and central India and now it is extending to the eastern region. In many parts of the world, it is cultivated as a multipurpose crop for grain, pasture, forage, or as a rotational crop. It provides soft, palatable and nutritive fodder to all categories of livestock in different forms like green, dry fodder, silage, and hay. Nitrogen (N) is the most important nutrient for forage crops. It has great significance due to its role in enhancing luxuriant vegetative growth, higher biomass and quick regeneration following cutting or defoliation (Choudhary *et al*., 2018). Further, optimum N nutrition improves leaf-to-stem ratio, succulence and palatability of forage crops. Nitrogen fertilization also influences nutritional value in forages. The majority of farmers apply N through urea since it is an easy to use, cost-effective and quick nutrient supplier. Conventional fertilizers offer nutrients in chemical forms that are not often fully accessible to plants. Despite the excessive use of mineral N fertilizer, a huge amount is lost and/or unavailable to plants. Moreover, sole mineral fertilization enhances the decomposition of soil organic matter, which leads to degraded soil structure and decline in soil aggregation and loss of nutrients through leaching, fixation, and greenhouse gas emission (Iqbal *et al*., 2019). Additionally, the use of inorganic fertilizers on soils over long periods of time may affect their capability to maintain healthy crop growth and productivity (Singh, 2018). In contrast to inorganic fertilizer application, organic manure has multiple benefits due to a balanced supply of both macro and micronutrients. This can enhance soil nutrients due to enhanced soil microbial activity, improving soil physical and chemical properties (Choudhary *et al*., 2023). Furthermore, manure application not only provides soil organic carbon, but the residual effect of manure fertilization is higher soil nutrient availability for crop growth and development. However, organic fertilizers are quite low in nutrient contents and their nutrient-releasing ability is also low to meet crop requirements in a short time. Hence, the sole application of manure could not meet the usual intensity of agricultural production. Organic manure coupled with synthetic fertilizers has been confirmed to be a better approach to improving

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and sustaining soil fertility and crop production than the sole application of mineral or organic manure (Kumar *et al*., 2017).

Several innovations have been made in the area of plant nutrition in order to improve nutrient use efficiency by reducing nutrient loss. The development of nano-fertilizers is one of the important innovations among them. Some beneficial effects include an increase in nutrient use efficiency, better yield and reduced soil pollution. Applying nano-fertilizers can also reduce environmental pollution than traditional chemical fertilizers applied at high rates. Nano-fertilizers possess unique features that enhance plants' performance in terms of ultra-high absorption, increase in production, rise in photosynthesis and significant expansion in leaves' surface area (Kumar *et al.,* 2020). One-fourth of the N requirement of oats can be replaced through nano-urea (Kumar *et al*., 2022). Despite having numerous advantages of using nanomaterials in agriculture, the application and popularity of such inputs are very less. Thus, keeping these facts in view, an experiment was carried out to assess the effect of diverse nitrogen fertilization on fodder yield and quality of oats.

A field experiment was carried out at Central Research Farm of Indian Grassland and Fodder Research Institute Jhansi, India (25°27′ N, 78°33′ E and 270 m a.m.s.l) during *rabi* 2020-21. The study area was characterized by a semi-arid climate, with extreme temperatures during summer (43–46°C) and winter (as low as 2°C). The soil of the experimental site was clay loam in texture, neutral in reaction (pH 7.2), medium in organic carbon (6.3 g/kg soil), low in available nitrogen (206 kg/ha) and medium in available P (11.4 kg/ha) and K (230 kg/ha).

The experiment was laid out in a randomized block design with three replications. The experiment comprised seven treatments T1- control (No N); T2- 100% recommended dose of N (100 kg/ha through fertilizer in 2 splits, half of the dose at the time of sowing and the remaining dose at first irrigation as top dressing); T3- 50% RDN through fertilizer + 50% N through FYM; T4- 50% RDN through fertilizer + 50% N through vermicompost; T5- 50% RDN through fertilizer + two spray of nano-urea; T6- two spray of nano-urea (2 ml/l at 30 and 50 DAS); T7- site-specific nitrogen management. In T7, 30 kg N was applied at the time of sowing, 30 kg at first irrigation, and 30 kg N was applied when the SPAD meter reading reached below 37. SPAD meter readings were taken before irrigations. Organic manure was applied at the time of field preparation as per treatments. A uniform dose of 60 kg P_2O_5 and 40 kg K_2O per hectare was applied at the time of sowing. Oat variety 'JHO-822' was sown at 25 cm row spacing at about 3 to 4 cm depth through a seed drill using a seed rate of 100 kg/ha. The oat crop was harvested at 50% flowering stage from net plot area (10 m^2) and weighed for green fodder yield. Random chopped samples of green fodder were sun-dried and placed in an oven at 65°C for 72 hours to estimate dry matter percentage and then it was multiplied with respective green fodder yield to calculate dry fodder yield.

The forage samples were collected at the time of harvesting and were subjected to drying in an oven at 65°C for 48 h. Such oven-dried samples were ground to pass through 40 mesh-sieve in a Macro-Wiley Mill. Total N, P and K concentrations in plant samples were analyzed by Kjeldahl, Vanado-molybdate yellow color and Flame-photometric method, respectively as per the procedure described by Jackson (1973). The crude protein (CP) concentration was calculated by multiplying N concentration by 6.25. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) in dry matter were estimated in the laboratory as described by Van Soest *et al*. (1991). Crude protein yield was calculated by multiplying crude protein content with dry fodder yield. Data were subjected to analysis of variance (ANOVA) using Proc-GLM in SAS 9.3 (SAS Institute, Cary, NC, USA). Fischer's protected least significant difference (LSD) test was used to test the differences between treatment means at $p < 0.05$.

Plant height, tillers and dry matter accumulation were influenced significantly due to diverse nitrogen fertilization at 60 days after sowing (DAS) and at harvest (Table 1). However, these parameters were not influenced statistically at 30 DAS. At 60 DAS, plant height varied from 54.3 cm in the control plot to 62.3 cm in RDN. A similar trend was observed at harvest. All the treatments had increased plant height over the control plot. In general, the number of tillers increased up to 60 DAS (Table 1). Further increment was very less or no increment in some of the treatments. The highest number of tillers per m^2 (624) was observed under RDN, which was at par with all other treatments except control. Furthermore, the number of tillers was statistically at par in control and two sprays of nano-urea at 60 DAS. Plants accumulated very less dry matter up to 30 DAS and increased very fast in later stages (Table 1). In 30 to 60 days, dry matter increased about more than 10 times than 30 DAS. However, the increase in DM from 60 DAS to harvest was only about two times. At harvest, the highest DM was accumulated in RDN which was 80.7% higher than the control plot, but at par with all other treatments except two sprays of nano-urea. The positive response of nitrogen fertilization in combination with organic manure on growth parameters could be ascribed to a better nutritional environment, enabling the plant to absorb more nutrients (Dhaliwal *et al*., 2019). An increased uptake of nutrients empowered plants to manufacture more quantity of photosynthates.

The crop growth rate (CGR) of oat did not influence significantly during the initial stage (0–30 DAS). CGR was progressively increased up to harvest in almost all treatments (Table 2). In the control plot, it decreased

Table 1. Effect of diverse nitrogen fertilization on growth of oat at various stages

Treatments	Plant height (cm)			Tillers (nos./m^2)			DMA (g/m^2)		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T1	26.1^{a}	54.5^{c}	133.3^{c}	382^{a}	476^{d}	483^{de}	29.0^{a}	354^{c}	592^{c}
T2	29.0^{a}	62.3^{a}	145.5^{ab}	451^{a}	587^{a}	624^{a}	34.2^{a}	487^{ab}	1070^{a}
T3	27.8^{a}	58.7^{abc}	142.1^{ab}	426^{a}	559^{bc}	568^{bc}	32.0^{a}	521^{a}	965^{a}
T4	29.4^{a}	60.5^{ab}	147.0^{a}	473^{a}	535^{ab}	592^{ab}	35.3^{a}	490^{ab}	1050^{a}
T5	27.0^{a}	57.5^{ab}	138.2^{ab}	448^{a}	571^{ab}	586^{ab}	33.6^{a}	481^{ab}	990^{a}
T6	28.7^{a}	60.0^{bc}	142.5^{bc}	420^{a}	506^{cd}	529^{cd}	30.3^{a}	425^{bc}	802^{b}
T 7	28.2^{a}	61.2^{ab}	146.2^{ab}	410^{a}	579^{bc}	556^{bc}	31.5^{a}	503^{a}	1055^{a}
P value	0.42	0.041	0.033	0.18	0.002	0.003	0.06	0.007	0.0001

T1: Control (no N); T2: 100% recommended dose of N; T3: 50% RDN through fertilizer + 50% N through FYM; T4: 50% RDN through fertilizer + 50% N through vermicompost; T5: 50% RDN through fertilizer + two spray of nano-urea; T6: Two spray of nano-urea; T7: Site-specific nitrogen management; Means followed by a similar lowercase letter within a column are not significantly different (p <0.05) according to LSD test; RDN: Recommended dose of nitrogen; DAS: Days after sowing; DMA: Dry matter accumulation

Table 2. Effect of diverse nitrogen fertilization on crop growth indices of oat at various stages

Treatments	CGR(g/m^2/day)			RGR (mg/g/day)	
	0–30 DAS	30–60 DAS	60-Harvest	30–60 DAS	60-harvest
T1	0.97^{a}	10.8^{c}	7.9^{c}	83.2^{a}	17.1^{a}
T2	1.14^{a}	15.1^{ab}	19.4^{a}	88.4^{a}	26.2^{a}
T3	1.07^{a}	16.3^{a}	14.8^{ab}	93.0^{a}	20.6^{a}
T4	1.18^{a}	15.1^{ab}	18.7^{ab}	87.6^{a}	25.4^{a}
T5	1.12^{a}	14.9^{ab}	17.0^{ab}	88.7^{a}	24.1^{a}
T6	1.01^{a}	13.1^{bc}	12.6^{bc}	87.8^{a}	21.5^{a}
T 7	1.05^{a}	15.7^{ab}	18.4^{ab}	92.3^{a}	24.8^{a}
P value	0.051	0.009	0.017	0.20	0.44

Means followed by a similar lowercase letter within a column are not significantly different (P< 0.05) according to LSD test. RDN: Recommended dose of nitrogen; CGR: Crop growth rate; RGR: Relative growth rate; DAS: Days after sowing

after 60 DAS. However, different treatments had no significant effect on the RGR of oats. Higher CGR might have occurred due to an adequate and balanced nutrient supply, resulting in better utilization of carbohydrates to form more protoplasm. It is quite obvious that the continued and balanced supply of nutrients right from an early stage of growth resulted in vigorous plant growth and higher leaf area, which eventually caused an increase in dry matter accumulation and crop growth rate (Manzer *et al*., 2008).

Green and dry fodder yields of oat were significantly influenced by diverse nitrogen fertilization practices (Fig 1). Application of 50% RDN through fertilizer + 50% N through vermicompost produced significantly the highest green (61.1 t/ha) and dry fodder yields (10.19 t/ha) followed by SSNM. This treatment improved the yields by 92.8 and 87.2% over control, respectively. Least yields were recorded in control, followed by two sprays of nano-urea. All other treatments produced statistically similar fodder yield. Organic manure (FYM and vermicompost) acted as a substrate for microorganisms, which brought about the transformation of the unavailable form of nutrients present in soil and applied as fertilizer in available form, which were readily utilized by growing plants and also improved soil condition, favorable for the availability of nutrients to crop (Choudhary *et al*., 2018a; Dhandayuthapani *et al*., 2023). Therefore, a synergistic effect of organic manure with fertilizer resulted in higher fodder yield. The improvement in fodder yield with the combined application of fertilizer and organic manure was also reported earlier (Biswas *et al*., 2020; Jhonsonraju *et al*., 2023).

The nutritive value of forage is a measure of proximate composition, digestibility and nature of digested products and, thereby its ability to maintain or promote growth, milk production or other physiological functions in the animal body. Diverse nitrogen fertilization had a significant effect on nitrogen content, crude protein (CP)

Table 3. Effect of diverse nitrogen fertilization on the nutritive value of oat at 50% flowering stage

Treatments	N (%)	P (%)	K (%)	CP (%)	CPY (kg/ha)	ADF (%)	NDF (%)
T1	1.70^{c}	0.32^{a}	1.43^{a}	10.6^{c}	558^{c}	37.2^{a}	58.6^{a}
T2	1.89^{a}	0.28^{a}	1.50^{a}	11.8^{a}	1166^{a}	33.8^{c}	55.0^{a}
T3	1.81^{abc}	0.30^{a}	1.47^{a}	11.3^{abc}	1027^{ab}	31.5^{c}	54.3^{a}
T4	1.85^{ab}	0.30^{a}	1.45^{a}	11.6^{ab}	1180^{a}	32.0^{c}	56.0^{a}
T5	1.88^{ab}	0.29^{a}	1.52^{a}	11.7^{ab}	1105^{a}	34.1^{bc}	53.3^{a}
T6	1.74^{bc}	0.28^{a}	1.44^{a}	10.9^{bc}	811^{b}	36.6^{ab}	55.4^{a}
T 7	1.93^{a}	0.26^{a}	1.49^{a}	12.1^{a}	1212^{a}	32.3^{c}	52.5^{a}
P value	0.026	0.12	0.48	0.027	0.0004	0.0026	0.34

Means followed by a similar lowercase letter within a column are not significantly different (P< 0.05) according to LSD test.

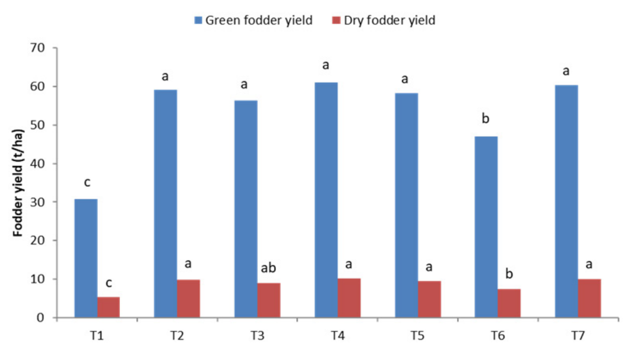

Fig 1: Effect of diverse nitrogen fertilization on green and dry fodder yields of oat [bars with a similar lowercase letter are not significantly different ($p < 0.05$) according to LSD test]

content, CP yield and acid detergent fiber, while P and K content and neutral detergent fiber (NDF) remained statistically similar under all the treatments (Table 3). Maximum N concentration was observed under SSNM treatment followed by RDN and 50% RDN + two sprays of nano-urea. Least N content in DM of oat was found in the control plot. The marked improvement in N content in DM of oats seems to be on account of its greater availability in the soil and enhanced translocation in the plant system. Further, it was reported that shoot and root growth mutually enhanced the efficiency of a plant, as evidenced by higher yield, which might have supplied metabolites. Similarly, the highest CP content (12.1%) and CP yield (1212 kg/ha) were recorded under SSNM, which was at par with all other treatments except control and two sprays of nano-urea (Table 3). However, a higher value of ADF was recorded in plants growing without nitrogen fertilization. The improvement in the CP content of oats might be due to increased N content in DM attributed to increased availability of nitrogen in the soil. Higher nitrogen in DM was directly responsible for higher CP content because it is a primary component of amino acids, which constitute the basis of protein. It was also reported that the application of N fertilizer increased the synthesis of polyphenolic precursors of tyrosine and phenylalanine, enzymes required for protein synthesis and lignification (Margna *et al*., 1989). CP yield is a function of CP content and DM yield. Both attributes increased with nitrogen fertilization, resulting in a significant increase in CP yield. Many researchers reported higher CP content and yield with nitrogen fertilization (Choudhary *et al*., 2018; Kaplan *et al*., 2019). The study revealed that integrated use of fertilizer and organic manure (FYM/vermicompost) resulted in significant improvement in fodder productivity and quality of oats. It also observed a reduction in fodder productivity under two sprays of nano-urea. Since soil type is one of the determinants of crop yield response, recommendations on manure and inorganic fertilizer application rates should take a soil-specific approach and also consider the yield potential of the crop.

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