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EFFECT OF ORGANIC AND INORGANIC SOURCES OF NITROGEN ON GROWTH, YIELD AND ECONOMICS OF SINGLE CUT OAT (*AVENA SATIVA* L.)

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SUMMARY

A field experiment was carried out during *rabi* season, 2019-20 at Forage Section Research Farm Department of G&PB, CCS Haryana Agricultural University, Hisar (India) to study the effect of organic and inorganic sources of nitrogen on growth, yield and economics of single cut oat. The experiment was laid out in randomized block design with 11 treatments (organic, inorganic and integrated nitrogen sources) replicated thrice. Among the different combination of nitrogen sources, T_2 [100% N through inorganic source (Urea)] resulted into significantly higher growth parameters at harvest *i.e.* number of tillers/m.r.l. (73.6), plant height (140.8 cm), no. of leaves/plant (76.7), leaf stem ratio (0.54) and dry matter accumulation/plant (109.8 g); lesser days to 50% flowering (105 days); significant higher LAI (3.49) and CGR (12.20 g/m^2/day); higher yield *i.e.* green fodder yield (50.39 t/ha) and dry matter yield (10.54 t/ha). The maximum net returns (Rs. 26,486/ha) and B: C (1.73) were fetched with the application of 100% N through inorganic source (Urea) followed by 75% N through inorganic source (Urea) + 25% N through FYM (Rs. 21,202/ha and 1.55, respectively) and 75% N through inorganic source (Urea) + 25% N through Vermicompost (Rs. 17,095/ha and 1.39, respectively). The B: C of single-cut oats (Variety OS 403) improved 51.8% with the application of 80 kg N/ha (100% RDN through urea containing 46% N) over no nitrogen (Control).

Key words: Single cut, oat, nitrogen sources, fodder, yield and economics

According to 20th Livestock Census, India is home to 535.78 million livestock; over a 4.6 percent increase in livestock population compared to Livestock Census-2012. Also there is 1.0 percent increase of total bovine population, comprising of buffalo, cattle and yak which was 302.79 million in 2019 compared to previous census (Anonymous, 2019). Despite huge cattle and buffalo population, milk productivity of the country is much lower than world average because of the green and dry fodder scarcity of 14.1 % and 2.4 %, respectively (ICAR, 2026). The availability of nutritive fodder and feed is a decisive factor that controls the productivity of livestock. Availability of improved varieties of fodder crop along with better nutrient management can be the key to the problem. Among different *rabi* fodder crops, oat fodder is an energy-rich crop with good regeneration ability and high dry matter content (Kumar *et al.*, 2010).

Oat (*Avena sativa* L.) is a cool-season annual cereal that is well adapted to diverse soil and climatic conditions. Its forage is highly palatable, nutritious, and digestible, making it an ideal feedstuff for ruminants. It has several uses, including the preparation of hay, silage, and concentrate feed grain, and is considered the most crucial cereal fodder suitable for the Haryana region, with a crude protein content ranging from 10 to 14 percent. Additionally, its quick-growing nature, high-yielding potential, palatability with nutritious value make it popular. The yield and quality of oat forage are influenced by several factors, including suitable climatic conditions, variety, and agronomic practices (Kumar *et al.*, 2023). Among these, nutrient management plays a crucial role in determining the productivity of the crop. Out of 17 essential plant nutrients, N being a macronutrient play a key role in plant growth and development, and its availability in the soil is a major limiting factor for crop yields (Wang *et al.*, 2023). Adequate N supply can significantly increase forage yields and improve the quality of the crop by increasing crude protein content and reducing fibre concentrations. As nitrogen is a crucial component of chlorophyll and protein, gives plant deep green colour, encourages vegetative growth and improves the quality of fodder (Patel *et*

al., 2007). The majority of soils in the Haryana are low in nitrogen, and if the necessary amount of nitrogen is not supplied to crops, this deficiency would be reflected in the fodder yield and quality.

The reason for low fodder production is the poor fertility status of soil (Iqbal *et al.,* 2009) which is due to the consequence of continuous use of inorganic sources of nutrient. Integration of inorganic and organic sources of nutrient can be possible solution to overcome the current deficit in fodder demand. Organic sources like farmyard manure (FYM), poultry manure (PM) and vermicompost, etc. are not only environment friendly but also supply balanced form of nutrients to improve the soil health (Kuepper and Gegner, 2004). The nutrient value of organic and inorganic sources is low and high, respectively, that is why the suitable combination of organic and inorganic sources can serve the purpose of better nutrient supply which may be a sustainable alternative for soil health as well as for fodder production point of view. Keeping all these facts in view, the present investigation entitled "Effect of organic and inorganic sources of nitrogen on forage yield and quality of single cut oat" was carried out.

MATERIALS AND METHODS

A field was conducted during *rabi* season, 2019-20 at Forage Section Research Farm of CCS Haryana Agricultural University, Hisar (Haryana), India (located 29°10' N latitude, 75°46' E longitude, at an average elevation of 215.2 m above mean sea level). The climate of site was semi-arid and sub-tropical with hot dry summers and severe cold winters. Average annual rainfall is about 450 mm, of which 75 per cent is received in three months, from July to September during South-West monsoon. Weekly weather parameters *i.e.* temperature (°C), relative humidity (%) and rainfall (mm) during the crop period are depicted in Fig 1. The soil of the experimental site was sandy loam with a pH of 7.8, EC 0.28 dS/m, with a low of available nitrogen (146.5 kg/ha), medium available phosphorus (12.5 kg/ha) and potassium content (265.4 kg/ha). The experiment was conducted in randomized block design wherein 11 treatments (organic, inorganic and integrated nitrogen sources) were replicated thrice. The detail of the treatments is given in Table 1. As per treatment, oat variety OS 403 seeds were sown manually on November 30, 2019 in opened furrows spaced 25 cm apart using a seed rate of 100 kg/ha. All the other standard agronomic practices for the cultivation of oat were followed uniformly in all the treatments. Single cut oat was harvested just after 50% flowering. The leaf area index (LAI) was calculated by dividing the leaf area per plant by the land area occupied by the plant. The relative growth rate (RGR) of crop at the time instant (t) is defined as the increase of plant material per unit weight per unit time. It is expressed in g/g/day.

$$RGR = \frac{(InW_2 - InW_1)}{(t_2 - t_1)}$$

Where, W_1 and W_2 are plant dry weight at time t_1 and t_2, respectively.

Crop growth rate (CGR) represents dry weight gained by a unit area of crop in a given time. It is expressed in g/ m^2/day.

$$CGR = \frac{W_2 - W_1}{(t_2 - t_1)\ S}$$

TABLE 1
Details of the treatments

Notation	Treatment
T_1	Control
T_2	100% N through inorganic source (Urea)
T_3	100% N through organic source (FYM)
T_4	100% N through organic source (Vermicompost)
T_5	75% N through inorganic source (Urea) + 25% N through FYM
T_6	75% N through inorganic source (Urea) + 25% N through Vermicompost
T_7	50% N through inorganic source (Urea) + 50% N through FYM
T_8	50% N through inorganic source (Urea) + 50% N through Vermicompost
T_9	50% N through FYM + 50% N through Vermicompost
T_{10}	25% N through inorganic source (Urea) + 75% N through FYM
T_{11}	25% N through inorganic source (Urea) + 75% N through Vermicompost

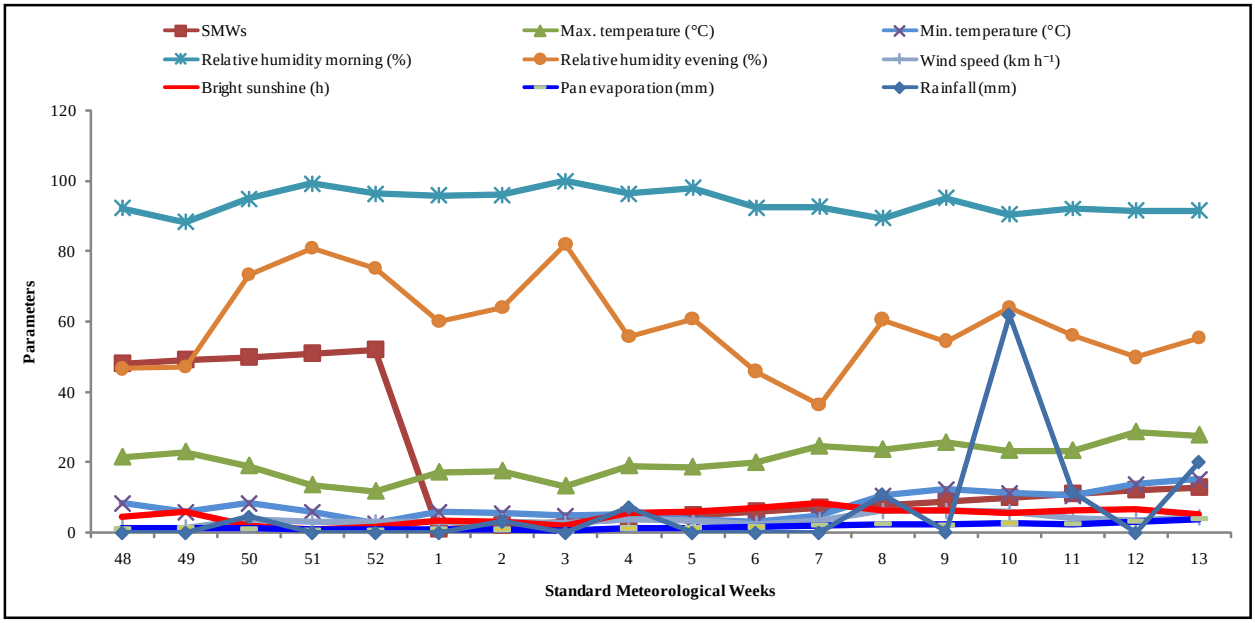


Fig. 1. Weekly weather parameters during *rabi* 2019-20 at the experimental site.

Where, W_1 and W_2 are plant dry weight (g) at time t_1 and t_2, respectively. S is the land area (cm^2) over which dry matter was recorded.

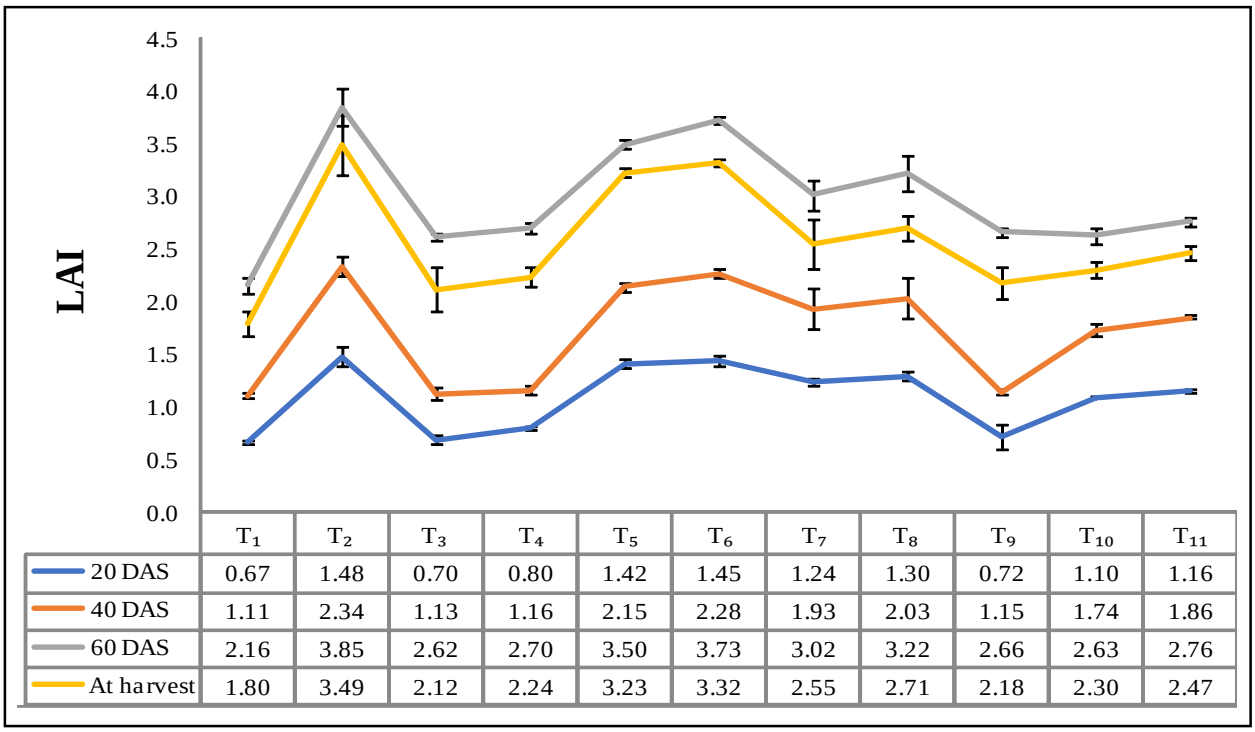
The harvested green fodder from each plot was weighed in situ in kg/plot and then converted into q/ha. A 500 g sample was taken randomly from each plot at the time of green fodder at harvest, chopped well and put into paper bag. These bags were aerated by making small holes all over. The samples were first dried in the sun for 15 days and then transferred in an electric hot air oven for drying at a temperature of 60±5°C till constant weight was achieved. Based on these samples, the green fodder yield was converted into dry matter yield (q/ha). The local market's prevailing input and product prices were used to calculate economics. The trial data were analyzed by using OPSTAT software (Sheoran *et al.*, 1998).

RESULTS AND DISCUSSION

Growth parameters

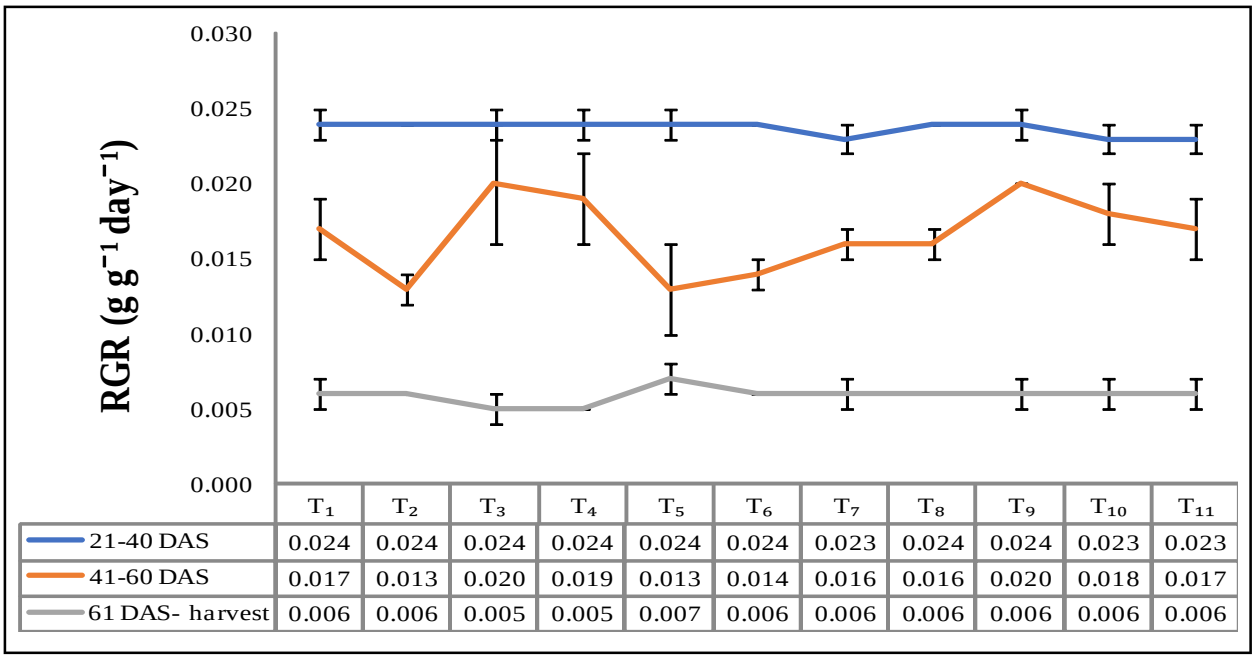
Data presented in Table 2 revealed that all of the fertilized treatments recorded a significantly higher number of tillers/m.r.l. at harvest over the unfertilized control. However, the highest number of tillers/meter row length at harvest (73.6) was recorded with T_2 [100% N through inorganic source (Urea)] that was significantly higher than unfertilized control (62.3). According to Sheoran *et al.* (2017), raising nitrogen levels from 40 to 120 kg/ha had a substantial impact on the number of tillers/m row length. Significantly taller plants (140.8 cm) were observed in T_2 [100% N through inorganic source (Urea)] than the rest of treatments except T_6 and T_5 at harvest. This might be attributed to sustained nutrient supply, which increased the growth parameters. Also, integration of 25% nitrogen through FYM or vermicompost with 75% nitrogen through urea had a stimulatory effect on the efficiency of chemical fertilizer resulted in higher availability of nitrogen which accelerated the process of cell division, enlargement and elongation. Biswas *et al.* (2019) also reported the beneficial effect of integration of 25% nutrient through organic manure and 75% through inorganic fertilizer. The significantly higher leaf stem ratio (0.54 at harvest) was observed in T_2 [100% N through inorganic source (Urea)] than unfertilized control (T_1) and organic sources alone (T_3, T_4 and T_9). Significantly highest dry matter accumulation $plant^{-1}$ (109.8 g) was recorded in T_2 than the rest of treatments except T_6 and T_5. As nitrogen is an important constituent of protein and chlorophyll. It imparts dark green colour to the plants, promotes vegetative growth and rapid early growth (Godara *et al.*, 2016). This will lead to better crop growth with increased availability of nitrogen.

The perusal of data presented in Table 2 showed that days to 50% flowering of single cut oat was not affected significantly by the organic sources of nitrogen alone (T_3, T_4 and T_9) and integrated sources of nitrogen where 75% nitrogen was supplied through organic sources (T_{10} and T_{11}). The highest days to 50%



	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}
20 DAS	0.67	1.48	0.70	0.80	1.42	1.45	1.24	1.30	0.72	1.10	1.16
40 DAS	1.11	2.34	1.13	1.16	2.15	2.28	1.93	2.03	1.15	1.74	1.86
60 DAS	2.16	3.85	2.62	2.70	3.50	3.73	3.02	3.22	2.66	2.63	2.76
At harvest	1.80	3.49	2.12	2.24	3.23	3.32	2.55	2.71	2.18	2.30	2.47

Fig. 2. Leaf area index of single cut oat as influenced by organic and inorganic sources of nitrogen.



	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}
21-40 DAS	0.024	0.024	0.024	0.024	0.024	0.024	0.023	0.024	0.024	0.023	0.023
41-60 DAS	0.017	0.013	0.020	0.019	0.013	0.014	0.016	0.016	0.020	0.018	0.017
61 DAS- harvest	0.006	0.006	0.005	0.005	0.007	0.006	0.006	0.006	0.006	0.006	0.006

Fig. 3. Relative growth rate of single cut oat as influenced by different organic and inorganic sources of nitrogen.

flowering (109.0 days) were observed in the unfertilized control (T_1). The inorganic treatment (T_2) and integrated treatments (T_5, T_6, T_7 and T_8), where 50% or more nitrogen was supplied through inorganic sources, recorded a significantly lower number of days to 50% flowering than unfertilized control (T_1). This may be due to the application of fertilizers with any source (organic or inorganic), regardless of their doses which accelerated days to heading as compared to no fertilizer application. Krushnaiah *et al*. (2018) also recorded the lower number of days to 50% flowering in treatment where the application of nitrogen was solely done with inorganic sources over 50% integration of nitrogen through organic sources *viz*., FYM or vermicompost.

TABLE 2
Effect of organic and inorganic sources of nitrogen on growth parameters of single cut oat

Treatment	No of tillers/ mrl	Plant height (cm)	No. of leaves/ plant	Leaf to stem ratio (L:S)	DMA/ plant	Days to 50% flowering
T1–Control	62.3	111.7	44.7	0.40	80.0	109.0
T2–100% N through inorganic source (Urea)	73.6	140.8	76.7	0.54	109.8	105.0
T3–100% N through organic source (FYM)	68.2	122.1	52.0	0.45	87.5	108.3
T4–100% N through organic source (Vermicompost)	70.9	124.2	54.7	0.46	89.0	107.7
T5–75% N through inorganic source + 25% N through FYM	72.1	133.6	73.9	0.51	103.5	106.0
T6–75% N through inorganic source + 25% N through vermicompost	73.6	136.7	75.9	0.53	107.4	106.0
T7–50% N through inorganic source + 50% N through FYM	71.6	127.3	67.3	0.49	93.9	106.3
T8–50% N through inorganic source + 50% N through vermicompost	72.8	129.7	69.6	0.50	95.1	106.0
T9–50% N through FYM + 50% N through vermicompost	69.3	124.1	52.6	0.46	88.7	108.0
T10–25% N through inorganic source + 75% N through FYM	71.1	126.5	58.1	0.47	90.1	107.0
T11–25% N through inorganic + 75% N through vermicompost	71.8	128.0	60.7	0.48	92.5	106.7
SE(m)+	1.9	3.2	1.9	0.01	2.3	0.8
C.D. at 5%	5.7	9.4	5.6	0.04	6.9	2.3

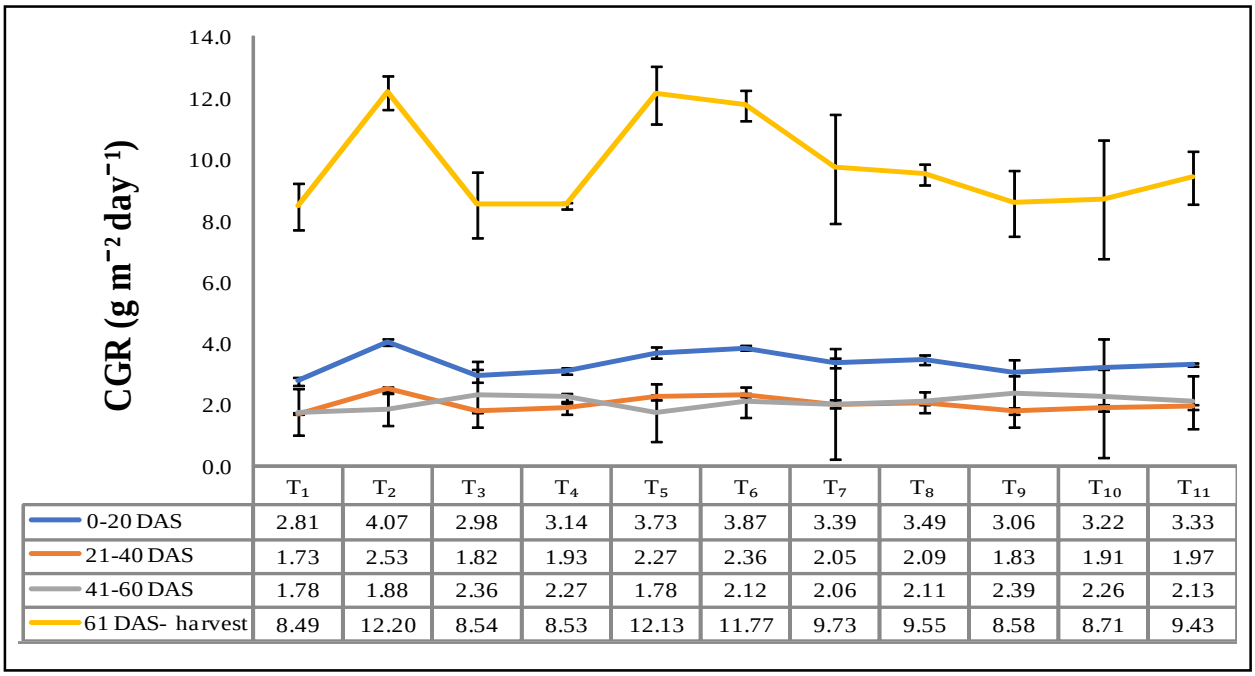
The organic or inorganic sources of nitrogen either applied alone or in combinations significantly influenced the growth indices *i.e.* leaf area index, relative growth rate and crop growth rate of single cut oat over control except T_3 (100% N application through FYM). The perusal of data presented in Fig. 2 depicted that highest values of LAI were observed at 60 DAS which decreased thereafter. Significantly higher LAI (1.48, 2.34, 3.85 and 3.49) at different growth stages (20 DAS, 40 DAS, 60 DAS and at harvest), respectively was recorded in T_2 [100% N through inorganic source (Urea)] over the rest of treatments except T_6 and T_5. The perusal of data presented in Fig. 3 depicted that none of the treatments significantly influenced the relative growth rate (RGR) of single cut oat during different crop growing periods. The highest values of RGR were observed from 21 to 40 DAS, which decreased thereafter. The perusal of data presented in Fig. 4 depicted that the highest values of crop growth rate (CGR) were observed from 61 DAS to harvest. From 0 to 20 DAS and 21 to 40 DAS, significantly higher CGR (4.07 and 2.53 g/m^2/day) was recorded in treatment T-$_2$ [100% N through inorganic source (Urea)] over the rest of treatments except T_5 and T_6. At later stages, CGR was not influenced significantly by different treatments. The lowest crop growth rate (2.81, 1.73, 1.78 and 8.49 g/m^2/day) at different growth periods (0 to 20 DAS, 21 to 40 DAS, 41 to 60 DAS and 61 DAS to harvest, respectively) was recorded in the unfertilized control (T_1). This might be due to better nutritional availability in the crop root zone and plant system, where 75% or more nitrogen was supplied through inorganic sources. These results confirm the findings of Paikara and Pandey (2018) who found statistically at par CGR with 25% substitution of nitrogen through FYM or vermicompost with sole application of nitrogen through inorganic sources.

Fodder yield

The entire organic or inorganic sources of nitrogen either applied alone or in combinations significantly affects the green fodder yield (GFY) and dry matter yield (DMY) of single cut oat over unfertilized control (T_1). The data presented in Table 3 indicate that significantly lower green fodder and dry matter yield (32.20 and 6.64 t/ha, respectively) of single cut oat were recorded in the unfertilized control (T_1). Among the fertilized treatments, significantly higher green fodder and dry matter yield (50.39 and 10.54 t/ha, respectively) were recorded in T_2 [100% N through inorganic source (Urea)] over the rest of treatments except T_6 (49.03 and 10.26 t/ha, respectively) and T_5 (47.83 and 9.91 t/ha, respectively). The green fodder yield (GFY) of oats significantly improves with application of recommended dose of nitrogen over no nitrogen (Kumar *et al*., 2021 and Satpal *et al*., 2018). The GFY of single-cut oat (Variety OS 403) improved 56.5% with the application of 80 kg nitrogen/ha (100% RDN through urea fertilizer containing 46%N) over no nitrogen (Control). As nitrogen is one of the most important nutrient it occupies prominent role in plant metabolism. It increases physiological indices by improving leaf production and expansion rate that ultimately achieve more interception of photo synthetically active radiation and consequently more total biomass accumulation (Kumar *et al.*, 2017).

TABLE 3
Effect of organic and inorganic sources of nitrogen on yield and economics of single cut oat

Treatment	GFY (t/ha)	DMY (t/ha)	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C
T_1–Control	32.20	6.64	35,260	40,253	4,993	1.14
T_2–100% N through inorganic source (Urea)	50.39	10.54	36,500	62,986	26,486	1.73
T_3–100% N through organic source (FYM)	37.47	8.04	44,860	46,840	1,980	1.04
T_4–100% N through organic source (Vermicompost)	40.28	8.16	67,260	50,347	-16,913	0.75
T_5–75% N through inorganic source + 25% N through FYM	47.83	9.91	38,590	59,792	21,202	1.55
T_6–75% N through inorganic source + 25% N through vermicompost	49.03	10.26	44,190	61,285	17,095	1.39
T_7–50% N through inorganic source + 50% N through FYM	43.50	8.72	40,680	54,375	13,695	1.34
T_8–50% N through inorganic source + 50% N through vermicompost	45.72	8.93	51,580	57,156	5,576	1.11
T_9–50% N through FYM + 50% N through vermicompost	38.81	8.11	56,060	48,507	-7,553	0.87
T_{10}–25% N through inorganic source + 75% N through FYM	39.72	8.55	42,770	49,653	6,883	1.16
T_{11}–25% N through inorganic + 75% N through vermicompost	41.11	8.63	59,570	51,389	-8,181	0.86
SE(m)+	1.36	0.44	-	-	-	-
C.D. at 5%	4.04	1.30	-	-	-	-



	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}
0-20 DAS	2.81	4.07	2.98	3.14	3.73	3.87	3.39	3.49	3.06	3.22	3.33
21-40 DAS	1.73	2.53	1.82	1.93	2.27	2.36	2.05	2.09	1.83	1.91	1.97
41-60 DAS	1.78	1.88	2.36	2.27	1.78	2.12	2.06	2.11	2.39	2.26	2.13
61 DAS- harvest	8.49	12.20	8.54	8.53	12.13	11.77	9.73	9.55	8.58	8.71	9.43

Fig. 4. Crop growth rate of single cut oat as influenced by organic and inorganic sources of nitrogen

ECONOMICS

Data presented in Table 3 revealed that highest cost of cultivation (Rs. 67,260/ha) with lowest B: C (0.75) were recorded in T_4 (100% N applied through Vermicompost) because of higher cost of vermicompost (Rs. 4/kg). Whereas, maximum net returns (Rs. 26,486/ha) and B: C (1.73) were computed in T_2 (100% N applied through urea), followed by T_5 (Rs. 21,202/ha) and T_6 (Rs. 17,095/ha) in terms of net returns and T_5 (1.55) and T_6 (1.39) in terms of B: C. Further, Urea as N fertilizer played critical role in fetching higher remunerations in single cut oats. The B: C of single-cut oats (Variety OS 403) improved 51.8% with the application of 80 kg N/ha (100% RDN through urea) over no N (Control). Application of sufficient nitrogen helps to fetch maximum B: C along with sustaining higher fodder yield of oats (Satpal *et al*., 2024).

CONCLUSION

Based on the research findings, it can be concluded that among different nitrogen management options integrated use of inorganic and organic sources of nitrogen (75% nitrogen through urea and 25%

nitrogen through vermicompost or FYM) can be a better substitute to inorganic sources (100% N through urea) to obtain the comparative results *i.e*. growth characters and yield of single cut oat. Whereas, with the application of 100% nitrogen through urea, highest net returns and B: C of forage oat can be obtained. It is also concluded that FYM proved to be an economical viable nitrogen source over vermicompost when 25, 50 and 75 % N was supplied with FYM or vermicompost in combination with 75, 50 and 25% N through urea fertilizer (46% N).

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