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EFFECT OF NANO AND PRILLED UREA ON PRODUCTIVITY AND PROFITABILITY OF FODDER OAT (*AVENA SATIVA* L.) UNDER SUB-TEMPERATE CLIMATIC CONDITIONS

SHIVANGI KAITH[1]*, NAVEEN KUMAR[1] AND SUPRIYA[2]

Department of Agronomy, College of Agriculture
[1]CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176062 (H.P.), India
[2]ICAR- National Dairy Research Institute, Karnal-132 001 (Haryana), India
**(e-mail: shivkaith30@gmail.com)*

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SUMMARY

A field experiment was conducted during *rabi* 2022-23 at Fodder Research Farm, CSK HPKV, Palampur (H.P.) to evaluate the performance of nano urea in oat (*Avena sativa* L.) under field conditions and examine how well it can be combined with other N source. Eleven treatments comprised of combinations of three levels of nitrogen (100, 75 and 50 per cent recommended dose of nitrogen), three doses of nano urea (2, 4 and 6ml/l of water) along with the recommended dose of nitrogen (RDN) 100 kg/ha, RDN + water spray at the time of nano urea spray and control (No N) were evaluated in the randomized block design with three replications in soils having acidic soil pH, low in available nitrogen and medium in available phosphorus and potassium. Application of 75 per cent recommended nitrogen + nano urea @ 6 ml/l of water resulted in significantly taller plant heights. The number of shoots was significantly increased through a conventional source as well as nano urea spray, where higher shoot numbers were recorded with the RDN; 100kg/ha which was remained at par with RDN + water spray and 75 per cent recommended nitrogen + nano urea @ 6 ml/l of water. Significantly, higher green (171.04 q/ha) and dry fodder (62.34 q/ha) yield, and monetary returns *viz.*, gross return (88089 Rs./ha), net return (51487 Rs./ha) and benefit-to-cost (1.41) ratio were recorded with the application of a recommended dose of nitrogen 100kg/ha. The results established that the use of nano urea in combination with conventional urea can improve the growth contributing characters to some extent whereas it could not establish the superiority of getting higher yields and profitability in fodder oat.

Key words: Conventional urea, nano urea, fodder oats, net return and yield

Agriculture and livestock play an important role in maintaining the livelihood security of the majority of the farmers in the country. The contribution of livestock to family income is more important among small and marginal farmers but its production potential in the country is not harnessed up to the optimum level due to a lack of quality fodder (Maneesha *et al.*, 2024). Among different sources of cultivated fodders, Oats (*Avena sativa* L.) is an important winter season fodder crop of the world and hold an important position in supplying quality fodder. It occupies an area of 27 million ha with an annual production of 40 million tons. In India, the state of Uttar Pradesh accounts for the highest area under oats cultivation followed by Punjab, Bihar, Haryana and Madhya Pradesh (Kumar *et al.,* 2017). At present country faced a net deficiency of 35.6% green fodder, 10.9% dry fodder and 44% concentrate feed materials in the country (IGFRI Vision, 2050). The productivity of livestock often remains low in Indian conditions, which is 20 to 60% lower than the global average. The major reason perceived is deficiency of feed and fodder followed by poor health and management. Fodder feed issues need to be addressed because the feed alone constitutes 60 to 70% of the milk production cost. Thus, any attempt towards enhancing livestock productivity should consider feed availability. In the hill zone deficit of 24.9% in green fodder availability has been estimated but a surplus has been mentioned in the aspect of Himachal Pradesh uneven distribution of forage resources and production in a few months tends to create fodder deficiency during the lean months (Kumar *et al*., 2023; Roy *et al*., 2019). The only way to bridge the gap between the demand and supply of fodder is to ameliorate the forage resources through better nutrition. After the green revolution, injudicious and excessive use of nitrogen fertilizer especially urea had a detrimental effect on the quality of the air, soil and water (Rawat *et al.*, 2024). Despite all efforts put together, under field conditions the nitrogen use

efficiency (NUE) rarely exceeds 40%. The (NUE) can be enhanced by split application, deep placement, and use of slow-release fertilizers along with enzymes and nitrification inhibitors (Bahuguna *et al*., 2024). It is an efficient approach for increasing crop yields as it reduces total N losses and increases its uptake. The foliar application of nutrients shortens the time lag between the application and uptake of plant nutrients by improving their availability during crucial growth stages (Upadhyay *et al.*, 2023; Rawat *et al.*, 2024). Nano urea is a liquid formulation manufactured by Nano Biotechnology Research Center in association with Indian Farmers Fertilizers Cooperative Limited (IFFCO). The 500 ml of nano urea is equivalent to a 45 kg urea fertilizer. It contains nano-scale nitrogen particles (55,000 nanoparticles) with a high surface area (10,000 times over 1mm Urea prilled. On foliar application, these small particles are delivered directly to the plant cell, thereby releasing nitrogen inside the cells as per the requirement in a phased manner which ensures low and targeted efficient release for providing the nutrients to the crop and thus increases nutrient use efficiency (Attri *et al.*, 2022). Hence, in consideration of the above facts and very contradictory results shown by various researchers on nano-urea, an experiment was undertaken to assess the effect of prilled and nano urea on the productivity and profitability of fodder oats under sub-temperate climatic conditions.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* 2022-23 at Fodder Research Farm of CSK HPKV, Palampur (H.P.) India. The soil of the field experimentation was silty clay loam in texture having pH 5.43, low in available nitrogen (223.7 kg/ha), medium in available phosphorus (14.5 kg/ha) and available potassium (174 kg/ha). Eleven treatments comprised of combinations of three levels of nitrogen (100, 75 and 50% recommended dose of nitrogen), three doses of nano urea (2, 4 and 6 ml/l) along with the recommended dose of nitrogen (RDN) 100kg/ha, RDN+ water spray at the time of nano urea spray and control (No-N) were evaluated in the randomized block design with three replications. The land preparation was done with the application of pre-sowing irrigation to the field followed by tractor-driven disc plough, harrowing and planking to obtain a good soil tilth before sowing fodder oats. Kent variety of oats was sown using 100 kg seed per hectare by maintaining a spacing of 20 cm from row to row. Five plants were selected randomly and tagged in each plot. The growth parameters observations were recorded in those tagged plants. The average of five plants was expressed as mean plant height and shoot number of each crop in respective treatments. The standard procedure was followed to compute the fodder yield. For computing net returns, the cost of cultivation of individual treatment was subtracted from the gross returns of the respective treatments. Benefit to cost ratio was calculated by dividing net returns by cost of cultivation. All data recorded was analyzed by adopting the ANOVA (Analysis of variance) techniques (Gomez and Gomez, 1984) using t-test at a significance level of 5 %. CD (critical difference) to determine the significant difference between the treatments with the help of analysis of variance at a 5% level of significance ($P<0.05$).

RESULTS AND DISCUSSION

Effect of Nano and prilled urea on growth and yield attributes

On pursual of the data regarding the emergence count (m^2), plant height, shoot numbers and leaf-to-stem ratio of oats shown in Table 1. The emergence count (m^2), under various treatments, did not reveal any significant impact on the crop's emergence count. The data indicated that the integrated application of prilled urea with nano urea spray significantly influenced the plant height of fodder oats. Significantly higher plant height (128.80 cm) was recorded with 75 per cent recommended dose of N through prilled urea + nano urea @ 6ml/l of water over control (without N). This remained at par with the recommended dose of N 100 kg/ha (126.7cm), 75 per cent recommended dose of N + 2 per cent urea spray (126.4cm), RDN + water spray (124.3cm), 50 per cent recommended dose of N + 2 per cent urea spray (116.9 cm). The plant height of the oats crop increased with the increasing doses of nitrogen, up-to the recommended dose of N (100 kg N/ha). Nano urea contains nitrogen in nano forms which might have helped to improve the plant height of crop with the increasing dose of nano urea as nitrogen is known to have positive effects on the vegetative growth of crops, also due to increased tryptophan in meristematic cells which provoke auxins to enhance the growth of plant (Abd Alqdader *et al*., 2020).

Similarly, significantly higher shoot numbers were recorded with the recommended dose of nitrogen 100 kg N/ha (103.33/m). However, it was at par with

TABLE 1
Effect of variable nitrogen sources and doses on growth and yield attributes of fodder oats

Treatment	Emergence count (no.)	Plant height (cm)	Shoot number	Leaf-stem ratio
Control (No N)	205.6	78.6	45.00	0.26
Recommended dose of nitrogen (RDN) 100 kg N/ha	206.6	126.7	103.33	0.28
75% recommended dose of N + nano urea @ 2 ml/l of water	211.3	107.3	95.33	0.21
50% recommended dose of N + nano urea @ 2 ml/l of water	206.0	99.5	81.67	0.21
75% recommended dose of N + nano urea @ 4 ml/l of water	211.3	114.1	97.67	0.25
50% recommended dose of N + nano urea @ 4 ml/l of water	221.0	102.1	81.33	0.26
75% recommended dose of N + nano urea @ 6 ml/l of water	205.3	128.8	99.33	0.21
50% recommended dose of N + nano urea @ 6 ml/l of water	202.6	112.4	86.67	0.26
75% recommended dose of N + 2% urea spray	214.0	126.4	97.00	0.30
50% recommended dose of N + 2% urea spray	209.5	116.9	87.33	0.31
RDN + Water spray	211.0	124.3	101.33	0.27
S. Em±	8.6	4.2	1.71	0.02
C. D. (P=0.05)	NS	12.5	5.05	0.05

RDN + water spray (101.33) and 75 per cent recommended N + nano urea @ 6ml/L of water (99.33). The shoot number of oats was obtained highest with the application of urea due to an abundant supply of nitrogen there might have been increased protoplasmic constituents which accelerated the process of cell division, cell elongation resulted in luxuriant vegetative growth and more numbers of shoots of oats crop (Devi *et al.*, 2009). The similar results were reported by Velmurugan *et al.* (2021).

Analysis of the data indicated that the application of nano urea resulted in a notably higher leaf-to-stem ratio in oats. Specifically, the data showed that using 50% of the recommended nitrogen dose along with a 2% urea spray produced the highest leaf-to-stem ratio (0.30). This increase was attributed to the lower plant height and the presence of succulent stems, which likely contributed to the higher leaf-to-stem ratio. This outcome was consistent with treatments involving different nitrogen doses, water sprays, and varying concentrations of nano urea. Brar (2015) also observed that in conditions of balanced nutrition, an increased number of shoots per plant could lead to an improved leaf-to-stem ratio. This effect may arise from decreased stem thickness caused by heightened intra-specific competition within the plant.

Effect of Nano and prilled Urea on yields and economics of oats

Significantly higher green and dry fodder yield (Table 2) was recorded with the application of the recommended dose of N 100kg/ha (271.04 q/ha) which remained at par with the RDN + water spray (254.82q/ha) and 75 per cent recommended N + nano urea @ 6ml/l of water (241.80 q/ha). An increment in yield was observed with the increased levels of nitrogen from 50% to 75% as well as with the increased doses of nano urea. Similarly, the dry fodder yield was significantly influenced by the application of nitrogen sources through prilled urea @100 kg/ha (62.34 kg/ha) which also remained at par with the RDN + water spray (60.48 kg/ha) and 75 per cent recommended N + nano urea @ 6ml/L of water (55.62 kg/ha). The improved fodder yield with the application of nitrogen might be ascribed to adequate availability of nitrogen to the crop which is the constituent of amino acid and chlorophyll thus enhancing the photosynthesis activity and growth attributes and ultimately the yield of the crop (Abd Alqdader *et al.*, 2020).

Data in the table 2 shown revealed that the highest gross returns (Rs. 88089/ha), net returns (Rs. 51487/ha) and benefit-to-cost ratio (1.41) were recorded with the application of the recommended dose of nitrogen 100kg/ha while RDN + water spray proved to be the second-best treatment in terms of higher gross return (Rs. 82816/ha), net returns (Rs. 45594/ha) and benefit to cost ratio (1.22). The cumulative effect of the cost of cultivation and gross returns highlighted their effect on net returns and benefit-to-cost ratio in each treatment. The sustainability of any crop/cropping system was measured by economic returns and in the present

TABLE 2
Effect of variable nitrogen sources and doses on yields (q/ha) and economics of fodder oats

Treatments	Green fodder yield	Dry fodder yield	Gross returns (Rs./ha)	Net returns (Rs./ha)	Benefit-cost ratio
Control (No N)	91.73	22.02	29811	2211	0.08
Recommended dose of nitrogen (RDN) 100 kg N/ha	271.04	62.34	88089	51487	1.41
75% recommended dose of N + nano urea @ 2 ml/l of water	219.88	50.57	71461	32728	0.84
50% recommended dose of N + nano urea @ 2 ml/l of water	212.56	47.62	69083	30640	0.80
75% recommended dose of N + nano urea @ 4 ml/l of water	230.31	50.67	74849	34317	0.85
50% recommended dose of N + nano urea @ 4 ml/l of water	229.30	52.74	74521	35666	0.92
75% recommended dose of N + nano urea @ 6 ml/l of water	241.80	55.62	78585	37814	0.93
50% recommended dose of N + nano urea @ 6 ml/l of water	226.05	51.99	73466	32811	0.81
75% recommended dose of N + 2% urea spray	237.43	53.66	77164	41566	1.17
50% recommended dose of N + 2% urea spray	232.58	53.49	75589	40281	1.14
RDN + Water spray	254.82	60.48	8 2816	45594	1.22
S. Em±	11.10	2.50	-	-	-
C. D. (P=0.05)	32.74	7.37	-	-	-

experiment, the higher cost of nano urea spray resulted in increased cost of cultivation and lower yield in nano urea spray treatments as compared to prilled urea application. These results are supported by the findings of Rajesh *et al.* (2022).

CONCLUSIONS

Based on a year of study it is concluded that for better yield and economic returns of oats cultivation for fodder purposes, the application of a recommended dose of nitrogen 100 kg N/ha is a better option. However, the study also, could not establish the superiority of nano urea in terms of monetary benefits as higher gross returns, net returns and benefit-cost ratio were also obtained with the recommended dose of nitrogen *i.e.* 100 kg N/ha.

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