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RESPONSE OF NANO FERTILIZERS ON GROWTH AND QUALITY OF FODDER OATS (*AVENA SATIVA* L.)

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ABSTRACT

The experiment was carried out during the *rabi* season of 2023–24 at the Experimental Field (College of Agriculture, Central Agricultural University, Imphal, Manipur) to evaluate the impact of nano urea and nano DAP on fodder oats (*Avena sativa* L. Wilczek) growth and quality. The fodder oat variety 'JHO-822' was taken for experimentation. The experiment was laid out in Randomized Block Design (RBD) with ten treatments replicated thrice. The result of research work revealed that the treatment receiving 75% RNP as basal along with 3 ml/l nano urea spray and 3 ml/l Nano DAP spray recorded maximum fresh weight of plant (21.99 g/plant), dry weight of plant (1.99 g/plant) and number of leaves per plant (14.33). Other parameters such as crude protein content (11.18%) and crude protein yield (24.73 q/ha) were also recorded maximum in the same treatment. The effect of treatments may be evaluated for seed production of oat.
***Keywords*: **Fodder oats, Nano DAP, Nano urea, Growth, Crude protein content, Crude protein yield

The production of forages is the foundation of the livestock sector and is the primary source of revenue for animals. More than 20% of all livestock are produced in India, which is the world's top producer of buffalo (5.5%) and cattle (16%). Just 4.6% of India's total cultivated land is used for fodder crops, which has stayed relatively constant at 8.5–9.0 million hectares over the past ten years. Devi *et al.* (2014) stated that a lack of feed and fodder is one of the most important factors in achieving the desired level of livestock output. An estimated 648 million tons of green fodder were required, whereas only about 491 million tons were produced. The current deficit for the country is 35.6% green fodder, 10.95% dry crop leftovers, and 44% concentrate (Anonymous, 2013). Nevertheless, just 1% of Manipur's total land area is utilized for permanent pasture, fodder crops, and other grazing land; this results in only 549 and 903 t of fresh and dry fodder, respectively (Anonymous, 2008). This is not enough to satisfy the state's feed requirement. As the world's population grows, so does the need for livestock products, principal cereal crops, and pulse crops. As a result, growing green fodder in the cropping system becomes essential (Aulakh *et al.*, 2012). Additional fodder acreage must be planted in order to solve the lack of green fodder needed to sustain India's livestock production.

India produces very little livestock, especially milch animals, in comparison to developed countries. The primary cause of this is the scarcity of animal feed and fodder that is high in nutrients (Patel *et al.*, 2011). The availability of high-quality feed has also been cited as the main barrier to the cattle industry's full potential (Palsaniya *et al.*, 2011). Livestock productivity is low during the winter months because the animals primarily rely on semi-dried standing grasses and rice straw from fallow sites. After rice is grown on fallow areas, oats can be grown successfully to increase the amount of green fodder available throughout the winter.

One of the most significant cereal crops cultivated for its seed, feed, and fodder is oats (*Avena sativa* L.). Because of its many health benefits, oats are widely regarded as a healthy grain and are occasionally referred to as "health foods." The poaceae family includes oats (*Avena sativa* L.). It is a significant crop of Rabi cereal. "Javi" or "Jayi" are the local names for this annual grass species. It is thought that oats originated in Asia. It is a significant grain crop that is farmed in the winter months in central and northwestern India, as well as the eastern region these days. Green fodder from oats (*Avena sativa* L.) is incredibly healthy, tasty, and succulent. It has 60–65% digestibility at 50% flowering state when collected, 10-11.5% crude protein, 55–64% neutral detergent fiber (NDF), 30-32 percent acid detergent fiber (ADF), 22-23% cellulose, and 17–20% hemicelluloses. Currently, 25.48 million tons of oats are produced annually on 9.97 million hectares of land, mostly in temperate regions of the US, Canada, and Europe. In Gujrat, Andhra Pradesh, Telangana, Maharashtra, and hilly areas of the southern plateau, oats are grown on an average of around 1.0 lakh hectares of land. Hay and silage, which are utilized during lean times, can also be made from oats. Furthermore, ß-glucone, antioxidants, minerals, vitamin E, and other health-promoting phytochemicals are abundant in oat grains. Optimizing balanced plant nutrition is a challenging problem for agronomic approaches that aim to maximize production while improving nutrient consumption efficiency and system sustainability. Chemical fertilization, which includes urea, diammonium phosphate, muriate of potash, and complex fertilizers, is the primary source of nutrients for plants. Integrated nutrient management, on the other hand, provides greater sustainability, profitability, and production. Due to increased awareness of the detrimental effects of chemical fertilization and rising demand for organic products, particularly dairy products, dairymen have a significant need for the production of organic fodder. Nano fertilizers, including nano urea, nano DAP, nano Zn, and others, have just been available for commercial crop cultivation. With improved nutrient consumption efficiency, nano fertilizers require less to promote crop yield, N metabolism, protein and carbohydrate synthesis, seed germination, and seedling growth. They are also manageable. Furthermore, nanomaterials improve the general health of plants and their ability to withstand biotic and abiotic stress. Nano fertilizers and their effects on oat fodder production have received very little attention, despite the growing popularity of fodder oats. Maximizing the yield of oat fodder in India requires careful consideration of when to use nano fertilizers.

Keeping the above in view, the experiment “Response of nano fertilizers on growth and quality of fodder oats (*Avena sativa* L.)” was conducted to study the growth and quality fodder oats (*Avena sativa* L.) as influenced by the integration of nano fertilizers and inorganic fertilizers.

Materials and Methods

The experiment was conducted during *rabi* season 2023-24 at the Field, College of Agriculture, Central Agricultural University, Iroisemba, Imphal, Manipur. The experimental site is located at 24°.45’N latitude and 93°.54’ E longitude, with an altitude of 774 m above mean sea level in the Eastern Himalayan Region (II). The rainfall received during the cropping season (December 2023 – March 2024) was 141.62 mm. The mean temperature recorded during the cropping season was 26.3 ^{0}C (max.) and 6.4 ^{0}C (min.) respectively. The average relative humidity in the morning ranged from 86.2 % to 91.9 % and evening ranged from 41.30 % to 55.10 %. The mean wind velocity recorded 3.57 km/hr. A composite soil sample was prepared by collecting soil samples from 0 to 15 cm depth randomly from the experiment plot before sowing and analysed for their chemical and physical properties. The sample was analysed for estimation of pH which was observed to be acidic i.e. 5.35 determined by Systronic glass electrode pH meter(Jackson, 1973), organic carbon content in soil samples was found to be 0.97% determined by Walkley-Black chromic acid wet oxidation method (Walkley and Black, 1934), electrical conductivity (EC) was 0.55 dS/m determined by Systronic range conductivity meter (Jackson, 1973), available nitrogen content of the soil was 289.32 kg/ha determined by Alkaline Permanganate method as described (Subbiah and Asija, 1956), available phosphorus content of soil was 18.20 kg/ha determined by Bray and Kurtz method (Jackson, 1973) and available potassium content of soil was 230.3 kg/ha determined by Flame photometry method (Jackson, 1973).

The experiment was laid out in Randomized Block Design (RBD) with ten treatments replicated thrice. The treatments were: T_1- 100% Recommended dose of Nitrogen and Phosphorous (RNP) @ 60-40 N-P kg/ha, T_2- 25% RNP as basal + nano urea & nano DAP spray @ 1ml/l each at 30 and 50 DAS, T_3- 25% RNP as basal + nano urea & nano DAP spray @ 2ml/l each at 30 and 50 DAS, T_4- 25% RNP as basal + nano urea & nano DAP spray @ 3 ml/l each at 30 and 50 DAS, T_5- 50 % RNP as basal + nano urea & nano DAP spray @ 1 ml/l each at 30 and 50 DAS, T_6- 50 % RNP as basal + nano urea & nano DAP spray @ 2 ml/l each at 30 and 50 DAS, T_7- 50 % RNP as basal + nano urea & nano DAP spray @ 3 ml/l each at 30 and 50 DAS, T_8- 75 % RNP as basal + nano urea & nano DAP spray @ 1 ml/l each at 30 and 50 DAS, T_9- 75 % RNP as basal + nano urea & nano DAP spray @ 2 ml/l each at

30 and 50 DAS, T_{10}- 75 % RNP as basal + nano urea & nano DAP spray @ 3 ml/l each at 30 and 50 DAS. The fodder oat variety 'JHO-822' was used during the course of experimentation. The seeds were line sown in the first week of December i.e. 5th of December 2023 at a row to row distance of 25 cm. The seed rate ranged from 80 kg/ha. Each plot was 2.0 m in length and 2.0 m in width i.e. 4 m^2. In the specified experiment, the plots received P_2O_5 in the form of SSP in a complete dose according to the experimental design. Likewise, for nitrogen application, urea was divided into three separate doses. Half of the total nitrogen was applied as a basal dose during seed sowing based on the layout and treatment. The remaining half was split equally, with the first portion added to the plots at 30 DAS according to the layout and treatment, and the remaining portion added to the plots at 45 DAS. Certain cultural practices such as mulching, irrigation and weeding were performed for optimum plant growth and development. The observations on fresh weight, dry weight and number of leaves/plants were recorded manually on five randomly selected representative plants from each plot of each replication separately. Harvesting occurred on 27th February 2024. After harvesting the data of quality parameters were recorded and calculated thoroughly. The procedure followed for recording different observations are given as follows:

Fresh weight of plant (g/plant)

Five plants were selected and collected from the sampling rows of each plot at the interval of 40 DAS, 60 DAS, 80 DAS and weighed to record the fresh weight (g/plant). The mean value was then calculated.

Dry weight of the plant (g/plant)

The five plants for which fresh weight was taken were oven dried at 70°C to a constant weight separately for the different treatments and then weighed and the average was calculated to get dry weight.

Number of leaves per plant

At the time of harvest, the total number of fully opened green leaves on the main stems of five sample plants were counted, and the average number of leaves per plant was determined.

Crude protein content (%)

To analyse for N content (%), oven dried samples of each plot was grinded to make powder and then tested. After this, N content of produce from each plot converted into crude protein content (%) by multiplying with 6.25 factor.

Crude protein content = N content x 6.25

Crude protein yield (CPY) (q/ha)

The dry matter yield in q ha^{-1} was converted into crude protein yield in quintal per hectare on the basis of crude protein content:

$$CPY\ (q/ha) = \frac{Crude\ protein\ \% \times Dry\ matter\ yield\ (q/ha)}{100}$$

The observed data on crops was statistically analyzed based on the procedure (Gomez and Gomez, 1984). The analysis of variance (ANOVA) for all treatments was carried out in Randomized block design (RBD). Critical difference (CD) at five per cent level of provability was calculated for comparison.

Results and Discussions

Effect of nano urea and nano DAP on growth of fodder oats

The growth parameters are depicted in Table 1. The findings indicated that while fresh weight varied significantly at 60 and 80 DAS, respectively, fresh weight at 40 DAS did not show any significant effect. Maximum fresh weight per plant at 60 DAS (11.31 g) and 80 DAS (21.99 g) were recorded in the treatment where the crop received 75% RNP as basal along with 3 ml/l Nano urea spray and 3 ml/l Nano DAP spray (T_{10}) which was found to be at par with the treatment where the crop received 100% RNP 60:40 N:P_2O_5 kg/ha (T_1) at 60 and 80 DAS. This might be due to greater biomass synthesis caused by uninterrupted photosynthetic activity beyond 50-60 days of growth causing resultant increase in plant height, number of tillers and thereby fresh weight. These results are in close conformity with Samui *et al.* (2022) and Rawate *et al.* (2022). Similarly, it is evident that at 60 DAS maximum dry weight (1.99 g) per plant was observed where 75% RNP as basal along with 3 ml/l Nano urea spray and 3 ml/l Nano DAP spray were applied and at 80 DAS maximum dry weight (3.30 g) per plant was observed where the crop received 100% RNP i.e., 60:40 N:P_2O_5 kg/ha. Whereas, lower dry weight per plant was recorded where only 25% RNP as basal along with 1 ml/l Nano urea spray and 1 ml/l Nano DAP spray were applied. This could be owing to crop's improved growth and development when both conventional fertilizer and nano fertilizer are integrated at higher doses. These results are in close conformity with Samui *et al.* (2022) and Rawate *et al.* (2022).

The number of functional leaves per fodder oat plant was found to be influenced by different treatments. The highest number of leaves per plant (14.33) were produced when 75% RNP as basal along with 3 ml/l Nano urea spray and 3ml/l Nano DAP spray were applied. The lowest leaves per plant (10.33) were produced when 25% RNP as basal along with 1 ml/l Nano urea spray and 1 ml/l Nano DAP spray were applied per hectare. This might be due to adequate supply of nitrogen and phosphorous through conventional and nano fertilizers at right concentration that helped in production of more number of leaves. These findings were in line with Chinappa *et al.* (2023) who recorded higher number of leaves per plant with the application of 75% RNP as basal + nano urea & DAP spray @ 1.5 ml/l each at 30 and 45 DAS.

Table 1: Mean performance of different treatments on growth characteristics in fodder oats

Treatment		Fresh weight of plant (g/plant)			Dry weight of plant (g/plant)			Number of leaves/plant
		40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS	At harvest
T1	100% RNP (60:40 NP) kg/ha	13.96	10.84	0.45	1.87	1.87	3.30	5.67
T2	25% RNP as Basal + nano urea & nano DAP spray @ 1 ml/l	6.68	9.05	0.18	1.48	1.48	2.30	4.33
T3	25% RNP as Basal + nano urea & nano DAP spray @ 2 ml/l	8.76	9.40	0.37	1.57	1.57	2.46	4.67
T4	25% RNP as Basal + nano urea & nano DAP spray @ 3 ml/l	7.08	10.00	0.43	1.62	1.62	2.90	4.33
T5	50% RNP as Basal + nano urea & nano DAP spray @ 1 ml/l	7.84	9.21	0.31	1.50	1.50	2.37	4.33
T6	50% RNP as Basal + nano urea & nano DAP spray @ 2 ml/l	9.99	9.68	0.30	1.58	1.58	2.52	4.67
T7	50% RNP as Basal + nano urea & nano DAP spray @ 3 ml/l	10.85	10.03	0.35	1.71	1.71	3.00	5.00
T8	75% RNP as Basal + nano urea & nano DAP spray @ 1 ml/l	8.44	10.36	0.31	1.75	1.75	3.06	5.33
T9	75% RNP as Basal + nano urea & nano DAP spray @ 2 ml/l	8.85	10.57	0.32	1.83	1.83	3.14	5.33
T10	75% RNP as Basal + nano urea & nano DAP spray @ 3 ml/l	11.15	11.31	0.43	1.99	1.99	3.25	6.00
S Em (±)[a]		2.27	0.43	0.57	0.07	0.06	0.08	0.30
CD (P=0.05)[b]		NS	1.27	1.69	NS	0.17	0.24	0.89

[a]SE(m)- Standard Error of mean [b]CD- Critical difference

Effect of nano urea and nano DAP on quality parameters

The quality parameters are depicted in Table 2. It is evident from the results that the maximum crude protein content (11.18 %) was obtained in the treatment T_{10} where 75% RNP as basal along with 3 ml /l Nano urea spray and 3 ml/l Nano DAP spray were applied. This increase in crude protein with integrated use conventional fertilizer and nano fertilizer may be due to improvement of the nutrient uptake efficiency including nutrient nitrogen and phosphorous which is a key component of ATP acting as an energy carrier for metabolic processes. This might have directly contributed to large photosynthetic activity and thus synthesis of higher protein content. These results are in line with the findings of Choudhary *et al.* (2023). Similarly, various treatments had a significant impact on the crude protein yield. It is observed that application of 75% RNP as basal along with 3 ml/l Nano urea spray and 3 ml/l Nano DAP spray (T_{10}) recorded maximum crude protein yield (24.73 q/ha) followed by T_1 (24.70 q/ha), T_9 (24.51 q/ha) while minimum crude protein yield (17.39 q/ha) was recorded where only 25% RNP as basal along with 1 ml/l Nano urea and 1 ml/l Nano DAP spray (T_2). These results are in line with the findings of Choudhary *et al.* (2023).

Table 2: Effect of Nano urea and Nano DAP on crude protein content and crude protein yield of fodder oat

Treatment		Crude protein content (%)	Crude protein yield (q/ha)
T1	100% RNP (60:40 NP) kg/ha	10.74	24.70
T2	25% RNP as Basal + nano urea & nano DAP spray @ 1 ml/l	8.03	17.39
T3	25% RNP as Basal + nano urea & nano DAP spray @ 2 ml/l	8.15	17.85
T4	25% RNP as Basal + nano urea & nano DAP spray @ 3 ml/l	8.24	18.60
T5	50% RNP as Basal + nano urea & nano DAP spray @ 1 ml/l	8.06	17.43
T6	50% RNP as Basal + nano urea & nano DAP spray @ 2 ml/l	8.40	17.84
T7	50% RNP as Basal + nano urea & nano DAP spray @ 3 ml/l	8.81	19.01
T8	75% RNP as Basal + nano urea & nano DAP spray @ 1 ml/l	9.85	23.62
T9	75% RNP as Basal + nano urea & nano DAP spray @ 2 ml/l	10.73	24.51
T10	75% RNP as Basal + nano urea & nano DAP spray @ 3 ml/l	11.18	24.73
SEm (±)[a]		0.37	0.74
CD (P=0.05)[b]		1.09	2.19

It may be concluded that the combination of both conventional fertilizers and nano fertilizers i.e. 75% RNP as basal along with 3 ml/l nano urea spray and 3 ml/l nano DAP spray was found to be the most effective in terms of growth and quality for fodder oat cultivation as compared to the sole application of conventional fertilizers. Further research is required to confirm the aforementioned findings.

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