Forage Res., **50**(2) : pp. 176-182 (2024) **http://forageresearch.in**

NITROGEN MANAGEMENT AND FOLIAR NUTRITION IN FODDER SORGHUM

SABAVAT SANDHYA SREE[1]*, SHARU S. R.[1], USHA C. THOMAS[1] AND GAYATHRI G.[2]

[1]Department of Agronomy, College of Agriculture, Vellayani, Thiruvananthapuram (Kerala), India
[2]Department of Genetics and Plant Breeding, College of Agriculture, Vellayani, Thiruvananthapuram (Kerala), India
**(e-mail: sandhyasandy62477@gmail.com)*

(Received: 20 September 2024; Accepted: 28 September 2024)

SUMMARY

The present study entitled "Nitrogen management and foliar nutrition in fodder sorghum" was undertaken at College of Agriculture, Vellayani, during 2023-24. The main objective of the study was to evaluate the effect of different concentrations of nano urea on growth, yield and economics of fodder sorghum. The field experiment carried out from December 2023 – February 2024, was laid out in Randomised Block Design with 13 treatments, replicated thrice. The treatments comprised of nitrogen management and foliar nutrition. The treatments were T_1 : 75% Recommended dose of nitrogen RDN + nano urea (0.2%); T_2 : 75% RDN + nano urea (0.4%); T_3: 75% RDN + nano urea (0.6%); T_4: 100% RDN + nano urea (0.2%); T_5: 100% RDN + nano urea (0.4%); T_6: 100% RDN + nano urea (0.6%); T_7: 75% RDN + urea spray (2%); T_8: 100% RDN + urea spray (2%); T_9: nano urea (0.2%) alone; T_{10}: nano urea (0.4%) alone; T_{11}: nano urea (0.6%) alone; T_{12}: KAU POP; T_{13}: control (without nitrogen). The fertilizer recommendation followed was 60:40:20 kg NPK ha^{-1}, along with the recommended dose of farm yard manure (10 t ha^{-1}). Foliar spray of nano urea and urea were applied each at 20 DAS and 40 DAS. Full P and K were applied as basal. The results revealed that 100% RDN along with foliar spray of nano urea 0.4% (T_5) recorded higher growth and yield attributes such as plant height, number of leaves per plant, leaf length, leaf breadth, leaf area per plant, leaf area index, number of internodes per plant, length of internode, 50 per cent flowering, green fodder yield, dry fodder yield and per day productivity. Similarly, higher gross return, net return and BCR were also recorded in T_5 and were on par with 100% RDN along with foliar spray of nano urea 0.6% (T_6).

Key words: Fodder sorghum, nitrogen management, foliar nutrition, nano urea and green fodder yield

Sorghum, a member of the *Poaceae* family, is an important cereal fodder crop, especially grown in arid and semi-arid regions due to its drought resistance. Commonly known as jowar and it is mainly cultivated for fodder, grain and ethanol production (Devi *et al*., 2018). Single cut sorghum accounts for 23.1 % of overall sorghum production (Prabhakar Babu, 2018). The short growing season together with substantial biomass yield enhance its significance as a key crop (Satpal *et al*., 2020). As an annual grass that thrives in warm season through the C_4 photosynthetic pathway. Besides its grains, sorghum offers nutritious and palatable fodder that can be preserved as silage or hay for future use. Though India having highest livestock population of 535.6 million (Anonymous, 2020) faces a green fodder shortage of 11.3 % (Roy *et al*., 2019). However, the improper use of fertilizers significantly limit fodder productivity and quality in various climatic regions of the country (Tokas *et al*., 2021). The balance use of fertilizers to provide essential nutrients to crops is a crucial agronomic practice that can significantly enhance cereal yield under moisture stress conditions. As a result, creating location-specific production strategies to provide high-quality fodder offers a valuable opportunity to support the increasing livestock population.

Over 70 percent of the conventional urea applied to soil is not absorbed by plants and is lost, which can result in soil acidification and water pollution. To boost crop production, applying nutrients via foliar spray as a complement to soil application is regarded as an effective practice (Alam *et al*., 2010). Foliar feeding enables quick and efficient nutrient absorption, reduces losses from leaching and soil fixation and helps to regulate nutrient uptake by plants (Rahman *et al*., 2014). Applying essential nutrients through foliar spray during critical growth stages is vital for maximizing their effectiveness and improving crop yield (Anandhakrishnaveni, 2004). At present, nano fertilizers are gaining importance in agriculture as they enhance crop yield, increase nutrient use efficiency and reduce the excessive reliance on chemical fertilizers.

Nano fertilizers are designed to supply nutrients in a controlled manner that matches crop need, thereby enhancing nutrient use efficiency without negative impacts (Naderi and Shahraki, 2013). Nano fertilizers release nutrients over 40-50 days, compared to just 4-10 days for synthetic fertilizers. Moreover, the use of nano fertilizers has increased plant tolerance to both biotic and abiotic stresses (Mejias *et al*., 2021).

Kantwa and Yadav (2022) found that nano urea comprises 4 per cent nitrogen by weight in its nano form, effectively meeting the nitrogen requirement of crops. It has a nutrient use efficiency of over 80 percent, which is higher than that of conventional urea (IFFCO, 2022). With a particle size of less than 50 nm, nano urea is well-suited for foliar application due to its effective penetration into plant systems. Its large surface area enables a slow and steady release of nutrients, aligning with crop needs (Sadhukan *et al*., 2021).

MATERIALS AND METHODS

The experiment was conducted at the Instructional Farm, attached to the College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India. The experimental field was geographically located at 8°42′ latitude and 76°98′ longitude, at an altitude of 24.13 m above the mean sea level. The field experiment was laid out in randomized block design with 13 treatments replicated thrice, as follows: T_1:75% recommended dose of nitrogen (RDN) + nano urea (0.2%); T_2:75% RDN+ nano urea (0.4%); T_3:75% RDN + nano urea (0.6%);T_4:100% RDN + nano urea (0.2%); T_5:100% RDN + nano urea (0.4%); T_6:100% RDN + nano urea (0.6%); T_7:75% RDN + urea spray (2%); T_8:100% RDN + urea spray (2%); T_9: nano urea alone (0.2%); T_{10}: nano urea alone (0.4%); T_{11}: nano urea alone (0.6%); T_{12}: KAU POP (60:40:20 NPK kg ha^{-1}) T_{13}: Control (without nitrogen). Both the nano urea and urea spray were applied at 20 DAS and 40 DAS. Nitrogen will be applied in three splits -50% as basal, 25% at 20 DAS and 25% at 40 DAS. Full P and K were applied as basal. The experimental soil was sandy clay loam in texture, moderately acidic (5.63) in reaction, low in organic carbon (0.56%), medium in available nitrogen (413.95 kg/ha) and available potassium (278.38 kg ha^{-1}) and high in available phosphorus (62.44 kg/ha). Single cut variety of fodder sorghum 'CNFS-1' was used in the experiment. The seeds were sown with a spacing of 30 cm X 15 cm. All other agronomic practices were followed uniformly in all the treatments as per the package of practices for Kerala Agricultural University, India (KAU POP). Yield attributing parameters were recorded at the time of maturity. Five plants were selected randomly from each treatment to record the observations of yield attributing characters. Harvesting of the crop was done at 50 per cent flowering stage in all the treatments. The weight of harvested green fodder from each plot was measured on-site (kg $plot^{-1}$) and then converted to t ha^{-1}. A random sample of 500 g of green fodder was collected from each plot at harvest. After sun drying, the samples were oven-dried until they reached a constant weight. Using the weight of these samples, the green fodder yield was converted to dry fodder yield (t ha^{-1}). The data generated from the field experiment was statistically analyzed using analysis of variance technique (ANOVA) as applicable to randomized block design (Panse and Sukhatme, 1985) and the significance was tested using F test. Wherever the f value was found significant, critical difference was worked out at five per cent and one per cent probability levels.

RESULTS AND DISCUSSION

Growth parameters

Data on plant height showed that at harvest, T_6 (100 per cent RDN + nano urea 0.6 per cent) resulted in taller plants, and was found to be 25.42 per cent higher compared to T_{12} (KAU POP). The increase in plant height may be due to better nutrient uptake by the plant. This enhanced uptake likely facilitated optimal growth of plant structures and metabolic processes like photosynthesis, resulting in maximum accumulation and movement of photosynthates to the economic parts. This can be linked to increased source and sink strength (Midde *et al*., 2021). Similar findings were observed by Abdel-Aziz *et al*. (2018) in wheat and Prakash *et al*. (2020) in maize. The use of foliar nutrition significantly affected the number of leaves at all stages, except at 15 days after sowing (DAS). The maximum number of leaves was observed with T_5 and was 25.73 per cent higher compared to T_{12}.This might be due to ample supply of nitrogen which might have increased protoplasmic constituents, accelerated cell division and elongation processes, consequently resulted in more leaves. The present findings confirm with that of Al-Juthery *et al*. (2018) in wheat, Ajithkumar *et al*. (2021) and Jadav *et al*. (2022) in

TABLE 1

Effect of nitrogen management and foliar nutrition on growth attributes of fodder sorghum

Treatments	Plant height (cm)	No. of leaves/ plant	Leaf length (cm)	Leaf breadth (cm)	Leaf area/plant (cm^2)
T_1–75% RDN+nano urea (0.2%)	174.52	7.16	63.82	4.22	2144.11
T_2–75% RDN+nano urea (0.4%)	175.17	7.19	68.05	4.26	2165.45
T_3–75% RDN+nano urea (0.6%)	181.57	7.53	72.39	4.36	2300.04
T_4–100% RDN+nano urea (0.2%)	191.48	7.22	69.95	4.33	2254.27
T_5–100% RDN+nano urea (0.4%)	208.58	8.99	89.00	5.61	2569.54
T_6–100% RDN+nano urea (0.6%)	226.62	8.70	82.67	5.23	2682.69
T_7–75% RDN+urea spray (2%)	171.56	7.01	68.33	4.18	2004.24
T_8–100% RDN+urea spray (2%)	181.55	7.21	69.34	4.32	2196.97
T_9–Nano urea (0.2%) alone	166.71	6.79	59.94	4.05	1930.25
T_{10}–Nano urea (0.4%) alone	167.33	6.87	61.29	4.06	1975.93
T_{11}–Nano urea (0.6%) alone	170.15	6.93	63.71	4.08	1999.76
T_{12}–KAU POP	180.69	7.15	65.37	4.21	2150.92
T_{13}–Control (without nitrogen)	136.30	5.43	50.67	3.13	1549.90
S. Em.±	11.39	0.47	4.17	0.31	141.47
C. D. (P=0.05)	33.237	1.366	12.159	0.918	412.928

RDN- Recommended dose of nitrogen.

maize. Similarly, leaf length and leaf breadth were observed higher with T_5 and was found to be on par with T_6. The reason for maximum leaf length and breadth might be due to adequate supply of nitrogen, which might have enhanced the photosynthetic area of the leaf by proportionately widening the leaf and improving its length compared to the control. The results are in agreement with Al-Juthery *et al*. (2018) in wheat and Rathnayaka *et al*. (2018) in rice. Leaf area has a major impact on total biomass of crop and fodder efficiency. The leaf area per plant was maximum in T_6 at harvest and was 24.72 per cent higher when compared to T_{12}. This could be attributed to production of tryptophan amino acids, which promoted cell elongation and subsequently expanded leaf area. The larger leaf area led to increased leaf area index Mallikarjuna (2021) in maize. Furthermore, early application of nano urea might have contributed to enhanced movement of metals and organic elements within plants, in addition to its nutritional benefits. This led to increased plant height, more number of functional leaves and leaf area. These observations are consistent with findings reported by Rajesh *et al*. (2021) in sweet corn and Srivani *et al*. (2022) in fodder maize. The maximum leaf area index (LAI) was recorded in the treatment T_6 at harvest which was statistically comparable with T_5. This might be due to the effect of foliar spray of nano urea which boosted their nutrient content, which in turn enhanced meristematic activity and cell elongation. Furthermore, these improvements support protein synthesis in the leaves, which in turn led to the production of more number of leaves and prolonged photosynthetic activity, ultimately resulted in higher LAI in corn as reported by Alyasari *et al.* (2019). Moreover, the higher LAI might be due to an increase in nitrogen content which resulted in higher leaf area, with both biomass and photosynthetic rate positively linked to leaf nitrogen due to effect of nano urea, known for its higher absorption rate and effectiveness, which in turn increased LAI. The maximum number of internodes per plant was recorded in T_5 at harvest and was found to be on par with T_6. Nitrogen is a critical nutrient for plant growth, and its availability can enhance the overall growth and development of plants. This often led to increase in number of nodes per plant. More number of nodes promoted branching and leaf development which contributed to increased plant height. Furthermore, increase in node density, contributed to higher biomass yield and improved fodder quality as reported by Smith *et al*. (2021) in alfalfa. Similarly, higher length of internode was recorded by T_5 and was comparable with T_6. The increase in length of internode might be due to promotive effect of nitrogen as it is a key element in amino acids, proteins, vitamins, hormones and enzymes. Also, these compounds directly impact cell division and growth, both longitudinally and transversely, which might have enhanced meristematic activity and resulted in higher

TABLE 2
Effect of nitrogen management and foliar nutrition on growth attributes of fodder sorghum

Treatments	LAI	Number of internodes/ plant	Length of internode (cm)	Days to 50% flowering
T_1–75% RDN+nano urea (0.2%)	4.59	7.48	13.44	57.77
T_2–75% RDN+nano urea (0.4%)	4.77	7.56	14.00	57.29
T_3–75% RDN+nano urea (0.6%)	5.01	7.89	14.55	54.84
T_4–100% RDN+nano urea (0.2%)	5.07	7.88	15.28	50.03
T_5–100% RDN+nano urea (0.4%)	5.83	9.67	19.95	45.55
T_6–100% RDN+nano urea (0.6%)	6.14	9.37	17.06	46.97
T_7–75% RDN+urea spray (2%)	4.52	7.31	13.43	60.93
T_8–100% RDN+urea spray (2%)	4.80	7.63	14.04	53.82
T_9–Nano urea (0.2%) alone	4.42	6.71	12.45	60.95
T_{10}–Nano urea (0.4%) alone	4.47	6.92	12.68	59.63
T_{11}–Nano urea (0.6%) alone	4.50	7.01	12.82	60.28
T_{12}–KAU POP	4.60	7.41	13.71	55.88
T_{13}–Control (without nitrogen)	3.46	5.10	9.67	62.79
S. Em.±	0.34	0.64	1.05	3.75
C. D. (P=0.05)	1.001	1.875	3.059	NS

NS- Not significant; RDN- Recommended dose of nitrogen.

length of internode and overall plant height Samui *et al*. (2022) in maize. This is supported by the findings of Reddy *et al*. (2022) in maize.

TABLE 3
Effect of nitrogen management and foliar nutrition on yield attributes of fodder sorghum

Treatments	Green fodder yield (t/ha)	Dry fodder yield (t/ha)	Per day productivity (t/ha/d)
T_1–75% RDN+nano urea (0.2%)	20.33	3.40	0.34
T_2–75% RDN+nano urea (0.4%)	21.95	4.14	0.35
T_3–75% RDN+nano urea (0.6%)	24.33	4.53	0.44
T_4–100% RDN+nano urea (0.2%)	23.17	4.40	0.36
T_5–100% RDN+nano urea (0.4%)	32.03	5.81	0.53
T_6–100% RDN+nano urea (0.6%)	30.00	5.51	0.48
T7–75% RDN+urea spray (2%)	21.00	3.92	0.33
T_8–100% RDN+urea spray (2%)	23.00	4.22	0.36
T_9–Nano urea (0.2%) alone	19.33	2.00	0.30
T_{10}–Nano urea (0.4%) alone	19.50	3.08	0.31
T_{11}–Nano urea (0.6%) alone	20.00	3.13	0.32
T_{12}–KAU POP	22.33	4.21	0.34
T_{13}–Control (without nitrogen)	14.00	1.77	0.24
S. Em.±	2.08	0.38	0.03
C. D. (P=0.05)	6.055	1.110	0.086

RDN-Recommended dose of nitrogen.

TABLE 4
Effect of nitrogen management and foliar nutrition on economics of fodder sorghum

Treatments	Gross return (Rs./ha)	Net return (Rs./ha)	BCR
T_1–75% RDN+nano urea (0.2%)	101666	34544	1.51
T_2–75% RDN+nano urea (0.4%)	109766	42164	1.62
T_3–75% RDN+nano urea (0.6%)	121666	53584	1.79
T_4–100% RDN+nano urea (0.2%)	115833	48384	1.72
T_5–100% RDN+nano urea (0.4%)	160150	92221	2.36
T_6–100% RDN+nano urea (0.6%)	150000	81591	2.19
T_7–75% RDN+urea spray (2%)	105000	38347	1.58
T_8–100% RDN+urea spray (2%)	115000	48021	1.72
T_9–Nano urea (0.2%) alone	96666	30522	1.45
T_{10}–Nano urea (0.4%) alone	97500	30875	1.46
T_{11}–Nano urea (0.6%) alone	100000	32895	1.49
T_{12}-–KAU POP	111666	44698	1.67
T_{13}–Control (without nitrogen)	70000	4335	1.07
S. Em±	9833.87	9833.87	0.15
C. D. (P=0.05)	28703.05	28703.05	0.425

RDN- Recommended dose of nitrogen.

Yield Parameters

The treatment (T_5) resulted in higher green fodder yield of 32.03 t/ha and was 43.43 per cent higher compared to T_{12}. This enhancement was attributed to the rapid absorption and assimilation of nano nutrients, which contributed to improved growth characteristics, including increased plant height and leaf area. The yield increase can be associated with the prolonged presence of nanomaterials in the plants, which led to greater productivity. Additionally, the combined effect of nano fertilizers improved the effectiveness of conventional fertilizers, likely enhancing nutrient absorption by plant cells. This optimization resulted in better growth of plant structures and metabolic processes such as photosynthesis, which increased the accumulation and transport of photosynthetic products to the economic parts of the plants, ultimately leading to higher yields. Similar results were also reported by Bhoya *et al.* (2013) in fodder sorghum, Bochare *et al.* (2015) and Sewhag *et al.* (2021) in fodder maize. Dry fodder yield was higher with T_5 and was 38.00 per cent more than T_{12}. This increase in dry fodder yield can be primarily attributed to the enhanced efficiency and absorption of nano urea within the plant, which is associated with its large surface area and small particle size. This likely contributed to increased biomass production, leading to higher green fodder and dry fodder yields in sorghum. These results align with findings of Singh *et al.* (2012) in fodder sorghum and Sewhag *et al.* (2021) in fodder maize. The maximum per day productivity was recorded with T_5 and was found 55.88 per cent higher compared to T_{12}. This might be due to nano particles less than 5 nm in the cuticles of leaves that can enter through stomatal pores and move through vascular systems, affecting efficacy, chemical composition and shape of nano particles, which led to fresh and dry matter yield of fodder crops, which enhanced per day productivity.

ECONOMICS

Nano fertilizers improve growth and yield parameters of the crops, increase nutrient use efficiency, reduce fertilizer wastage and minimize cost of cultivation. The maximum gross return (Rs.160150/ha), net return (Rs. 92221/ha) and BCR (2.36) were found with T_5 and was comparable with T_6. This might be due to increase in green fodder yield which contributed towards higher net return and BCR in sorghum. Combined application of conventional urea along with foliar spray of nano urea delivered adequate nutrients and resulted in increased yield, which fetched higher net return Chavan *et al.* (2023) in sorghum. Mishra *et al.* (2018) found that foliar spray of nano urea produced higher net return and benefit-cost ratio than conventional fertilizers. The variation in benefit-cost ratio was due to difference in crop yield and expense related to various methods of fertilizer application. Moreover, using a combination of nano fertilizers and conventional fertilizers led to even higher profitability.

CONCLUSION

The findings indicated that using different nitrogen-based formulations as foliar spray improved the growth, yield and economics of fodder sorghum. Notably, higher yield of green fodder and dry fodder were observed with the foliar application of nano urea 0.4 % at 20 DAS and 40 DAS which was on a par with nano urea spray @ 0.6% at 20 DAS and 40 DAS where RDF was also applied in these treatments. The maximum net return and benefit cost ratio was obtained with the application of RDF along with foliar spray of nano urea @ 0.4% at 20 DAS and 40 DAS which was on a par with nano urea 0.6%. Thus, the result of the research work revealed that foliar spray of nano urea 0.4% in addition to soil application of 100 % RDF (60:40:20 NPK kg ha^{-1}) is advantageous for cultivating fodder sorghum in terms of growth, yield and economics during *rabi* season.

ACKNOWLEDGEMENT

Authors are thankful to Kerala Agricultural University, Kerala for providing necessary facilities to conduct the experiment.

REFERENCES

Abdel-Aziz, H., M. N. Hasaneen and A. Omar, 2018 : Effect of foliar application of nano chitosan NPK fertilizer on the chemical composition of wheat grains. *Egyptian J. Bot.*, **58**(1): 87-95.

Ajithkumar, K., Y. Kumar, A. S. Savitha, M. Y. Ajayakumar, C. Narayanaswamy, R. Raliya, M. R. Krupashankar and S. N. Bhat, 2021 : Effect of IFFCO nanofertilizer on growth, grain yield and managing turcicum leaf blight disease in maize. *Int. J. Plant Soil Sci.*, **33**: 19-28.

Alam, S. S., A.Z. M. Moslehuddin, M.R. Islam and A.M. Kamal, 2010 : Soil and foliar application of nitrogen for Boro rice (BRRI dhan 29). *J. Bangladesh Agric. Univ.*, **8**(2): 199-202.

Al-Juthery, H.W., K.H. Habeeb, F.J.K. Altaee, D.K. AL-Taey and A.R.M. Al-Tawaha, 2018 : Effect of foliar application of different sources of nano-fertilizers on growth and yield of wheat. *Biosci. Res*., **4**(3): 976-3985.

Alyasari, J.W., Safi, M.Q., Alamery, A.A., Abudahi, Y.M., Jawad, N.N. and Almosawy, H.M. 2019. Role of nano particles fertilizers on growth of corn (*Zea mays* L.) c.v. 5018. IOP Conf. Series: *Earth Environ. Sci*. 388p. *doi:10.1088/1755-1315/388/1/012087.*

Anandhakrishnaveni, S., A. Palchamy, and S. Mahendran, 2004. Effect of foliar spray of nutrients on growth and yield of green gram (*Phaseolus radiatus*). *Legume Res*. **27**(2): 149-150.

Anonymous 2020: 20th Livestock Census - 2019, All India Report. Department of Fisheries, Animal Husbandry & Dairying, Department of Animal Husbandry & Dairying, Statistics Division, Krishi Bhawan, New Delhi. *http://dadf.gov.in.*

Bhoya, M., Chaudhari, P. P., Raval, C.H. and Bhati, P.K. 2013. Effect of nitrogen and zinc on yield and quality of fodder sorghum (*Sorghum bicolor* L. Moench) varieties. *Forage Res*. **39**(1): 24-26.

Bochare, A.D., 2015 : Effect of nutrient management on green forage yield of maize (cv. African tall), Ph.D. (Ag) thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri.

Chavan, P. M., Y. M. Waghmare, S. D. Maindale and B. K. Chaudhari, 2023 : Studies on effect of foliar application of nano N fertilizer on yield and economics of sorghum (*Sorghum bicolor* L). *Pharma Innov. J*., **12**(3): 1498-1500.

Devi S., Satpal, H. S. Talwar, Ramprakash, V. Goyal, M. Goyal and N. Kumar, 2018: Physiological variability of sorghum [*Sorghum bicolor* (L.) Moench] under salt stress. *Forage Res*, **44**(2):101-104.

IFFCO, 2022: Environment-friendly IFFCO Nano-urea (liquid) fertilizer for precision and sustainable agriculture. (Website: https://nano-urea.in/en/nano-urea retrieved on dated 04-01-2022).

Jadhav, V. D., S. P. Bainade and S. M. Birunagi, 2022 : Chlorophyll meter (SPAD) based nano urea fertilization in maize (*Zea mays* L.) *Pharma Innov. J*., **11**(12): 5617-5619.

Kantwa, S. and L.R. Yadav, 2022 : Nano urea: applications and significance. *Just Agric*., **2**: 1-6.

KAU [Kerala Agricultural University]. 2016 : *Package of Practices Recommendation*: *Crops* 2016. (15th Ed.). Kerala Agricultural University, Kerala, Thrissur, 393p.

Mallikarjuna, P. R., 2021 : Effect of nano nitrogen and nano zinc nutrition on nutrient uptake, growth and yield of irrigated maize during summer in the southern transition zone of Karnataka. M. Sc. (Ag) thesis, University of Agriculture and Horticulture Science, Shivamogga. 71.

Mejias, J.H., F. Salazar, L. Perez Amaro, S. Hube, M. Rodriguez and M. Alfaro, 2021: Nano fertilizers: A Cutting-Edge Approach to Increase Nitrogen Use Efficiency in Grasslands. Frontiers in Environmental Science, **9**: 635114.

Midde, S. K., Perumal, M. S., Murugan, G., Sudhagar, R., Mattepally, V. S. and Bada, M. R. 2021 : Evaluation of nano urea on growth and yield attributes of rice (*Oryza Sativa* L.). *Chem. Sci. Rev. Lett*. **11**(42): 211-214.

Mishra, P., A. Singh, R.R. Mishra, S. Ong, and S.M. Prasad, 2018 : Application of nanotechnology to enhance the nutrient quality of food crops and agricultural production. In *Nanomaterials in Plants, Algae and Microorganisms* (pp. 453-472). Academic Press.

Naderi, M.R. and D. A. Shahraki, 2013 : Nano fertilizers and their roles in sustainable agriculture. *Int. J. Agric. Crop Sci*., **5**(19): 2229-2232.

Panse, V.G. and P.V. Sukhatme, 1985 : Statistical Methods for Agricultural Workers (4 Ed.). Indian Council of Agricultural Research, New Delhi. 347.

PrabhakarBabu, 2018 : Forage crop research contribution to the Indian fodder production: Business opportunities for seed industry. *https://www.millets.res.in/aicsip18/presentations/ S ta k e h o ld e r s in t e r a c t io n -D a y 1 / Fo r a g e opportunities.pdf.*

Prakash, G., Mudalagiriyappa, K. S. Somashekar and S. Goudra, 2020 : A novel approach for increasing productivity under precision nitrogen management in maize (*Zea mays* L.) through crop sensors. *J. Pharmacogn. Phytochem*. **9** (5): 97-103.

Rahman, I.U., Aftab, R.A., Zafar, I. and Shafiul, M. 2014 : Foliar application of plant mineral nutrients on wheat: A Rev. RRJAAS. **3**(2): 19-22.

Rajesh, H., Yadahalli, G., Chittapur, B. M., Halepyati, A. S. and Hiregoudar, S. 2021 : Growth, yield and economics of sweet corn (*Zea mays* L. Saccarata) as influenced by foliar sprays of nano fertilisers. *J. Farm Sci*., **4**: 381-385.

Rathnayaka, R.M., Iqbal, Y.B. and Rifnas, L.M. 2018 : Influence of urea and nano nitrogen fertilizers on the growth and yield of rice (*Oryza sativa* L.) cultivar 'Bg 250'. *Int. J. Res*. **5**: 7-7.

Reddy, B.M., S. Elankavi, S.K. Midde, V.S. Mattepally and D.V. Bhumireddy, 2022 : Effects of conventional and nano fertilizers on growth and yield of maize (*Zea mays* L.). *Bhartiya Krishi Anusandhan Patrika*. **37**(4): 379-382.

Roy, A. K., R. K. Agrawal, N. R. Bhardwaj, A. K. Mishra and S. K. Mahanta, 2019: In: Indian Fodder Scenario: Redefining State Wise Status (eds. A. K. Roy, R. K. Agrawal, N. R. Bhardwaj). ICARAICRP on Forage Crops and Utilization, Jhansi, India, pp. 1-21.

Sadhukhan, R., Sharma, L.D., Sen, S., Karmakar, S., Banerjee, K. and Baral, K. 2021. Enhancing the productivity of field crops through nano fertilizer. *Agric. Dev. Asia Potential Use Nano Mater. Nano Technol.*10.

Samui, S., L. Sagar, T. Sankar, A. Manohar, R. Adhikary, S. Maitra and S. Praharaj, 2022 : Growth and productivity of rabi maize as influenced by foliar application of urea and nano-urea. *Crop Res*., **57**(3): 136-140.

Satpal, B. Gangaiah, N. Kumar, S. Devi, N. Kharor, K.K. Bhardwaj, P. Kumari, D.S. Phogat, and Neelam. 2020 : Performance of single-cut forage sorghum cultivars at different fertilizer levels. *Forage Res*., **46**(2): 202-207.

Sewhag, M., Shweta, S. Kumar, R. Kumar, J. Tokas, Neelam, U. Devi, and Satpal, 2021: Response of spring planted fodder maize to nitrogen and phosphorus levels. *Forage Res.,* **46**(4): 363-367.

Singh, P., Sumeriya H.K., Solanki N.S., Murdia A.Z.A.D. 2012 : Productivity, economics and quality of fodder sorghum under varying levels of nitrogen and phosphorus. *Annals. Plant. Soil. Res*., **14**(2):127-129.

Smith, J., R. Williams, and M. Taylor, 2021 : Effects of nitrogen application on alfalfa growth and quality. *Forage Res*., **33**(2): 112-126.

Srivani, M., P. Satish, S.A. Hussain and K. Shailaja, 2022 : Response of fodder maize (*Zea mays* L.) to urea and nano urea on growth, yield and economics. *Biol. Forum,* **14**(3): 766-769.

Tokas, J., H. Punia, A. Malik, Satpal, S. Sangwan, S. Devi and S. Malik, 2021 : Growth performance, nutritional status, forage yield and photosynthetic use efficiency of sorghum [*Sorghum bicolor* (L.) Moench] under salt stress. *Range Mgmt. Agrofor.,* **42**(1): 59-70.