Forage Res., **51**(4) : pp. 492-496 (2026) **http://forageresearch.in**

EFFECT OF FOLIAR APPLICATION OF NANO DAP ON THE PERFORMANCE OF FORAGE SORGHUM UNDER SUMMER SEASON

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(Received : 21 February 2026; Accepted : 21 March 2026)

SUMMARY

The present investigation entitled "Effect of foliar application of nano DAP on the performance of forage sorghum under summer season" was conducted at the Research Farm, Department of Agronomy, CCS Haryana Agricultural University, Hisar during 2024. The soil of experimental field was sandy loam in texture, low in available N (126.5 kg/ha) and medium in P (13.5 kg/ha) & K (248.8 kg/ha). The experiment was laid out in a randomized block design with seventeen treatments *i.e.* T_1: Control (No RDF), T_2: RDF (75 kg N + 30 kg P_2O_5 30 kg K, O/ha), T_3: 75% N and P + foliar spray of nano DAP at 30 DAS, T_4: 75% N and P + foliar spray of nano DAP at 45 DAS, T_5: 75% N and P + two foliar spray of nano DAP at 30 and 45 DAS, T_6: 50% N and P + foliar spray of nano DAP at 30 DAS, T_7: 50% N and P + foliar spray of nano DAP at 45 DAS, T_8: 50% N and P + two foliar spray of nano DAP at 30 and 45 DAS, T_9: 75% N and P + foliar spray of conventional DAP at 30 DAS, T_{10}: 75% N and P + foliar spray of conventional DAP at 45 DAS, T_{11}: 75% N and P + two foliar spray of conventional DAP at 30 and 45 DAS, T_{12}: 50% N and P + foliar spray of conventional DAP at 30 DAS, T_{13}: 50% N and P + foliar spray of conventional DAP at 45 DAS, T_{14}: 50% N and P + two foliar spray of conventional DAP at 30 and 45 DAS, T_{15}: RDF + foliar spray of water at 30 DAS, T_{16}: RDF + foliar spray of water at 45 DAS and T_{17}: RDF + two foliar spray of water at 30 and 45 DAS and replicated thrice. The crop was sown on 20th March, 2024 and harvested at 80 DAS. The variety of forage sorghum was CSV - 41. Among the different treatments, T_{17} recorded significantly higher growth parameters *i.e.* plant height (204.32 cm), number of leaves/plant (13.0), dry matter accumulation/plant (131.47 g) and LAI (6.85). This treatment also recorded highest green fodder (431.2 q/ha) & dry fodder yield (112.0 q/ha) and was statistically at par with the treatments T_5, T_{16}, T_{15} and T_2. The highest crude protein content (9.19%), N (1.47%), P (0.202%) and nutrient uptake of N (163.9 kg/ha), P (22.5 kg/ha) were estimated with 75% N & P combined with two foliar sprays of nano DAP @ 4 ml/ L at 30 and 45 DAS (T_5). The highest gross (Rs. 86240/ha) and net returns (Rs. 48080/ha) were computed with T_{17}. The highest B:C obtained with T_2 (2.28) which was followed by T_{15}, T_{16} (2.27), T_{17} (2.26) and T_5 (2.04).

Key words: Sorghum, nano DAP, green fodder yield, dry fodder yield and B:C

India, now the most populous nation globally relies heavily on agriculture with animal husbandry playing a critical role in the rural economy. The livestock sector alone contributes 30.23% to the agricultural GDP (Anonymous, 2024a). India has a livestock population of over 535.8 million, making it one of the largest in the world (FAO, 2023). But, has a low average milk yield per animal (1,777 kg/year), well below the global average of 2,699 kg (NDDB, 2023) due to the inadequate supply of quality fodder. The country deficits of 11.24% green fodder, 23.4% in dry fodder, and 29% in concentrates (Roy *et al.*, 2019). These shortages worsen in summer and drought periods, disrupting livestock feed supply. India had 4.08 million hectares under sorghum cultivation in 2023-24 and produced 4.74 million tonnes, attaining an average grain yield of 1162 kg ha^{-1}. The total sorghum area in Haryana is 0.147 million hectare (CARP, 2024). Out of which only 0.01 million hectare area is under grain sorghum, with an average productivity of 527 kg/ha (Anonymous, 2024b).

Sorghum is a versatile crop known as the "camel crop" with multiple uses across the globe. It serves as a source of fodder, grain, biofuels and alcoholic beverages. The succulency, dry matter, crude protein and other quality parameters of fodder are

affected by moisture stress, nutrient availability and the harvesting stage of the crop. The scarcity of water especially during the summer months, exacerbates this issue making moisture stress a significant problem in obtaining high-quality fodder.

Managing water availability through irrigation or foliar application of nutrients/water at critical crop stages is essential for maintaining fodder quality. Nano fertilizers have been identified as an effective solution to improve nutrient use efficiency in agriculture. Nano DAP (Liquid) is indigenous and non-subsidised fertiliser. Nutrient use efficiency is more than 90% under optimum field conditions that provides a balanced nutrient ratio of phosphorus and nitrogen (2.5:1). When applied as a foliar spray, Nano DAP readily infiltrates into plant tissues through stomata allowing for better nutrient uptake and utilization (Maloth *et al*., 2024). Addressing the nutritional needs of fodder crops like sorghum through innovative practices such as nano fertilizer applications could play a crucial role in enhancing fodder availability and quality ultimately supporting the productivity of India's livestock sector (Anil *et al*., 2023). Keeping the above facts in view, present study has been planned to evaluate the effect of foliar spray of nano DAP on productivity of forage sorghum.

MATERIALS AND METHODS

A field experiment was conducted during the *summer* season of 2024, at Research Farm, Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana (India). Hisar is situated at 29°10' N latitude and 75° 46' E longitude at an altitude of 215.2 m above mean sea level. During crop growing period, the average weekly maximum and minimum temperatures during the crop growing season were observed from 30.1°C to 45.6°C and from 14.1°C to 28.4°C, respectively. The experiment was laid out in a randomized block design with seventeen treatments *i.e*. T_1: Control (No RDF), T_2: RDF (75 kg N + 30 kg P_2O_5 + 30 kg K, O/ha), T_3: 75% N and P + foliar spray of nano DAP at 30 DAS, T_4: 75% N and P + foliar spray of nano DAP at 45 DAS, T_5: 75% N and P + two foliar spray of nano DAP at 30 and 45 DAS, T_6: 50% N and P + foliar spray of nano DAP at 30 DAS, T_7: 50% N and P + foliar spray of nano DAP at 45 DAS, T_8: 50% N and P + two foliar spray of nano DAP at 30 and 45 DAS, T_9: 75% N and P + foliar spray of conventional DAP at 30 DAS, T_{10}: 75% N and P + foliar spray of conventional DAP at 45 DAS, T_{11}: 75% N and P + two foliar spray of conventional DAP at 30 and 45 DAS, T_{12}: 50% N and P + foliar spray of conventional DAP at 30 DAS, T_{13}: 50% N and P + foliar spray of conventional DAP at 45 DAS, T_{14}: 50% N and P + two foliar spray of conventional DAP at 30 and 45 DAS, T_{15}: RDF + foliar spray of water at 30 DAS, T_{16}: RDF + foliar spray of water at 45 DAS and T_{17}: RDF + two foliar spray of water at 30 and 45 DAS and replicated thrice. The soil of experimental field was sandy loam in texture, low in available N (126.5 kg/ha) and medium in P (13.5 kg/ha) & K (248.8 kg/ha). The crop was sown on 20th March, 2024 and harvested at 80 DAS. The variety of forage sorghum was CSV - 41. Yield attributing parameters were recorded at the time of maturity. Three plants were selected randomly from each treatment to record the observations of yield attributing characters. The weight of harvested green fodder from each plot was taken in situ (kg/plot) and then converted into q/ha. Random sample of green fodder of 500 g was taken separately from each plot at the time of harvesting, after sun drying it was oven dried till constant weight is achieved, on the basis of weight of these samples, the green fodder yield converted into dry fodder yield (q/ha). The data were analyzed using appropriate analysis of variance (ANOVA). OPSTAT software was used to carry out statistical analysis.

RESULTS AND DISCUSSION

Growth parameters

The data presented in Table 1 revealed that the highest plant height was recorded at harvest (204.32 cm) in T_{17} (RDF alongwith two foliar spray of water @ 500 L ha^{-1} at 30 DAS and 45 DAS) which was statistically at par with T_5, T_{16}, T_{15} and T_2. The superior performance of T_{17} may be attributed to the combined effect of adequate basal nutrients and timely water sprays particularly under moisture stress or scanty rainfall which likely enhanced internal nutrient mobility, hydration and physiological efficiency during active vegetative stages. Treatment T_5 (75% N & P alongwith two foliar spray of nano DAP @ 4 ml L^{-1} at 30 DAS and 45 DAS) also showed higher plant height at harvest (204.07 cm) demonstrating the efficiency of nano DAP in improving nutrient uptake even with 25% reduction in N and P dose. These results align with the findings of Patil *et al*. (2024). T_{17} (100% RDF alongwith two foliar sprays of water @ 500 L ha^{-1} at 30 DAS and 45 DAS) recorded highest number

of leaves and it was statistically at par with T_5 and T_{16} (at harvest). This improved performance was attributed to the combined effect of balanced fertilization and foliar sprays of water which could have enhanced the hydration, nutrient mobility and cell division during the vegetative growth period. T_5 (75% N & P alongwith two foliar spray of nano DAP @ 4 ml/L at 30 DAS and 45 DAS) produced 12.8 leaves per plant indicating the efficiency of nano DAP in improving leaf count even with 25 % reduction in nitrogen and phosphorous dose. These findings are consistent with those of Chinnappa *et al*. (2023). The highest DMA (131.47 g/ plant) was recorded in T_{17} (RDF alongwith two foliar sprays of water @ 500 L/ha at 30 DAS and 45 DAS) at harvest which was statistically at par with T_5, T_{16}, T_{15} and T_2. Application of 75% N & P alongwith two foliar spray of nano DAP @ 4 ml/L at 30 DAS and 45 DAS (T_5) also accumulated higher dry matter (131.31 g/plant) indicating nano DAP's efficiency in nutrient delivery even at reduced basal dose. Similar results were reported by Maloth *et al*. (2024). In contrast, the control (T_1) without any fertilizer application resulted in lowest dry matter accumulation, indicating severe nutrient deficiency. The highest LAI was observed in T_{17} (RDF alongwith two foliar sprays of water @ 500 L/ha at 30 DAS and 45 DAS) with value of 6.85 at harvest and was statistically at par with T_5, T_{16}, T_{15} and T_2 confirming the combined benefit of RDF and foliar applications of water or nano DAP. Increased LAI in forage sorghum likely resulted from a higher leaf number per plant, enhancing light interception and boosting photosynthesis, which contributed to increased leaf length and width and ultimately, larger leaf area. Furthermore, this improvement likely resulted from adequate nutrients supply, timely foliar spray of nano DAP and water during summer season (Ajithkumar *et al*., 2021).

Green fodder and dry fodder Yield

The data regarding green and dry fodder yield as influenced by foliar application of nano DAP or conventional DAP or water is presented in Table 1. Data revealed that significantly higher green fodder yield of 431.2 q/ha was recorded with the application of treatment T_{17} where, RDF were applied alongwith two foliar spray of water @ 500 L/ha at 30 and 45 DAS, which was found statistically at par with T_5, T_{16}, T_{15} & T_2 treatments and 55.4% higher over the control. This significant improvement can be attributed to the synergistic interaction between basal fertilizer application, top dressing of remaining nitrogen dose and foliar application of water. The basal application of recommended dose of fertilizer ensured early supply of essential macronutrients such as nitrogen, phosphorous and potassium which were critical for early vegetative growth of crop, leaf expansion and overall biomass production (Chamush *et al*., 2023).

TABLE 1
Green fodder and dry fodder yield of forage sorghum as influenced by the different treatments

Treatments	Plant height (cm)	No. of leaves/ plant	DMA (g/plant)	LAI	Green fodder yield (q/ha)	Dry fodder yield (q/ha)
T_1: Control (No RDF)	128.74	9.3	98.67	4.77	277.4	70.0
T_2: RDF (75 kg N + 30 kg P_2O_5 + 30 kg K_2O/ha)	201.90	12.3	129.89	6.76	422.8	109.0
T_3: 75% N and P + foliar spray of nano DAP at 30 DAS	189.05	11.9	123.68	6.53	356.6	93.8
T_4: 75% N and P + foliar spray of nano DAP at 45 DAS	194.47	12.2	125.35	6.59	369.5	96.2
T_5: 75% N and P + foliar spray of nano DAP at 30 and 45 DAS	204.07	12.8	131.31	6.82	431.0	111.5
T_6: 50% N and P + foliar spray of nano DAP at 30 DAS	174.82	10.5	110.55	6.24	326.3	86.1
T_7: 50% N and P + foliar spray of nano DAP at 45 DAS	175.71	10.6	111.26	6.26	330.8	87.9
T_8: 50% N and P + foliar spray of nano DAP at 30 and 45 DAS	181.34	11.5	119.47	6.36	348.9	91.6
T_9: 75% N and P + foliar spray of DAP at 30 DAS	176.08	10.8	112.27	6.27	330.8	89.0
T_{10}: 75% N and P + foliar spray of DAP at 45 DAS	179.19	11.2	116.34	6.33	338.3	90.6
T_{11}: 75% N and P + foliar spray of DAP at 30 and 45 DAS	184.79	11.7	120.94	6.47	350.8	91.9
T_{12}: 50% N and P + foliar spray of DAP at 30 DAS	165.82	10.2	101.30	6.15	309.7	77.8
T_{13}: 50% N and P + foliar spray of DAP at 45 DAS	167.34	10.3	104.56	6.18	314.1	80.5
T_{14}: 50% N and P + foliar spray of DAP at 30 and 45 DAS	170.60	10.5	107.94	6.21	320.0	82.5
T_{15}: RDF + foliar spray of water at 30 DAS	203.11	12.5	130.02	6.79	426.9	109.2
T_{16}: RDF + foliar spray of water at 45 DAS	203.89	12.7	130.98	6.80	427.5	110.7
T_{17}: RDF + foliar spray of water at 30 and 45 DAS	204.32	13.0	131.47	6.85	431.2	112.0
SE (m)±	3.12	0.2	1.90	0.11	4.7	1.6
C.D. (p=0.05)	9.04	0.4	5.51	0.31	13.6	4.5

TABLE 2
Economics of different treatments as influenced by foliar application of nano DAP in forage sorghum

Treatments	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C
T_1: Control (No RDF)	33550	55480	21930	1.65
T_2: RDF (75 kg N + 30 kg P_2O_5 + 30 kg K_2O/ha)	37160	84560	47400	2.28
T_3: 75% N and P + foliar spray of nano DAP at 30 DAS	39432	71320	31888	1.81
T_4: 75% N and P + foliar spray of nano DAP at 45 DAS	39432	73900	34468	1.87
T_5: 75% N and P + foliar spray of nano DAP at 30 and 45 DAS	42332	86200	43868	2.04
T_6: 50% N and P + foliar spray of nano DAP at 30 DAS	38805	65260	26455	1.68
T_7: 50% N and P + foliar spray of nano DAP at 45 DAS	38805	66160	27355	1.70
T_8: 50% N and P + foliar spray of nano DAP at 30 and 45 DAS	41705	69780	28075	1.67
T_9: 75% N and P + foliar spray of DAP at 30 DAS	37292	67160	29868	1.80
T_{10}: 75% N and P + foliar spray of DAP at 45 DAS	37292	67660	30368	1.81
T_{11}: 75% N and P + foliar spray of DAP at 30 and 45 DAS	38052	70160	32108	1.84
T_{12}: 50% N and P + foliar spray of DAP at 30 DAS	36665	61940	25275	1.69
T_{13}: 50% N and P + foliar spray of DAP at 45 DAS	36665	62820	26155	1.71
T_{14}: 50% N and P + foliar spray of DAP at 30 and 45 DAS	37425	64000	26575	1.71
T_{15}: RDF + foliar spray of water at 30 DAS	37660	85380	47720	2.27
T_{16}: RDF + foliar spray of water at 45 DAS	37660	85500	47840	2.27
T_{17}: RDF + foliar spray of water at 30 and 45 DAS	38160	86240	48080	2.26

Application of 75% N and P alongwith two foliar spray of nano DAP @ 4 ml/L at 30 DAS and 45 DAS (T_5) improved 55.4% green fodder yield over the control (T_1) which was even 1.9% higher over RDF (T_2). Through this treatment, 25% of N and P could also be saved. This targeted delivery of nutrients through foliar spray combined with a reduced rate of conventional basal fertilizers, optimized nutrient use efficiency and crop metabolism. The application timing at 30 and 45 DAS likely coincided with critical growth stages where the demand of nutrients for tillering and biomass accumulation is at its peak. This combination of basal and foliar application along with the higher efficiency of nano-fertilizers directly contributed to increased plant height, number of leaves and overall physiological growth contributing in the higher green fodder yield. These results were in concordance with Dobariya *et al.* (2025). Foliar sprays were more effective during summer season as there was low relative humidity and prevalence of moisture stress. Application of 75% N and P alongwith two foliar sprays of DAP @ 2% at 30 DAS and 45 DAS (T_{11}) improved green fodder yield by 26.5% over the control, but it was still 17.0% lower than the RDF (T_2) treatment. Application of RDF alongwith a foliar spray of water @ 500 L/ha at 30 DAS or 45 DAS (T_{15} or T_{16}) could improve green fodder yield by 53.9% and 54.1%, respectively, over the control (T_1). The highest dry fodder yield of 112.0 q/ha was recorded with the treatment T_{17} where RDF were applied alongwith two foliar spray of water @ 500 L/ha at 30 & 45 DAS, which was found statistically at par with T_5, T_{16}, T_{15} & T_2 treatments and 60.0% higher over the control. However, application of 75% N and P alongwith two foliar spray of nano DAP @ 4 ml/L at 30 DAS and 45 DAS (T_5) improved 59.3% dry fodder yield over the control which was even 2.3 % higher over RDF (T_2). Nano-fertilizers are known for their high surface area to volume ratio which enhances nutrient uptake and reduces nutrient loss through leaching or volatilization. These findings are consistent with those of Kumar *et al.* (2022).

ECONOMICS

The data related to cost of cultivation, gross returns, net returns and B:C influenced by different treatments in forage sorghum is summarized in Table 2. Economic evaluation is essential in determining the profitability and viability of agricultural practices. In this study, the economics of forage sorghum under different treatments were assessed through cost of cultivation, gross returns, net returns and B:C. The cost of cultivation differed among treatments, with the highest expenditure recorded under T_5 (Rs. 42332/ ha). This was attributed to the application of 75% N & P combined with two foliar sprays of nano-DAP @ 4 ml/L, applied at 30 and 45 DAS, which increased both input and labour cost. In contrast, the lowest cultivation cost (Rs. 33550/ha) was recorded in T_1 (control) due to the absence of fertilizers or foliar applications.

The highest gross (Rs. 86240/ha) and net returns (Rs. 48080/ha) were recorded with the application of RDF alongwith two foliar spray of water

@ 500 L/ha at 30 DAS and 45 DAS (T_{17}) indicating that full basal fertilizers coupled with dual water sprays was most effective in profitability. These results suggest that the physiological benefits from foliar hydration including enhanced nutrient uptake and photosynthetic activity, translate into higher biomass and economic gains. The highest B:C (2.28) was fetched with T_2 which is followed by T_{15} (2.27), T_{16} (2.27), T_{17} (2.26) and T_5 (2.04) indicating that some foliar spray of water slightly increases yields and gross returns, the added cost of foliar sprays can reduce the overall benefit-cost ratio. T_1 (control) recorded the lowest gross returns (Rs. 55480/ ha), net returns (Rs. 21930/ha) and B:C (1.65) due to the poor crop performance in the absence of nutrient support confirming the necessity of external nutrient application for profitable forage sorghum cultivation. Bhanudas (2023) who concluded that net returns and B:C was significantly higher when 100% RD of NPK were applied. Corroborative findings were also reported by Kumar *et al*. (2022) and Suryawanshi *et al*. (2024).

CONCLUSION

In summer forage sorghum, application of RDF alongwith two foliar sprays of water @ 500 L/ ha at 30 and 45 DAS resulted in higher growth parameters and fodder yield which were comparable with the application of 75% N and P + foliar spray of nano DAP @ 4 ml/L at 30 and 45 DAS, RDF + foliar spray of water@ 500 L/ha at 30 DAS/45 DAS and 100% RDF alone. Maximum B:C (2.28) was fetched with the application of 100% RDF which was comparable with the treatments having water spray (either one or two) in combination with RDF and application of 75% N and P + foliar spray of nano DAP @ 4 ml/L at 30 and 45 DAS.

REFERENCES

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. *International Journal of Plant & Soil Science*, **33**(16): 19-28.

Anil, 2023 : Effect of foliar application of nitrogen based formulations on quality and yield of fodder sorghum during summer season under semi-arid condition. M.Sc. thesis, CCS HAU, Hisar, Haryana.

Anonymous, 2024a : Statistics at a Glance, National Dairy Development Board.

Anonymous, 2024b : Agricultural Statistics at a Glance, 2024.

Bhanudas, K. R., 2023 : Yield, nutrient uptake, availability of soybean as influenced by foliar application of nano-DAP. M.Sc.Thesis, Mahatma Phule Krishi Vidyapeeth, Ahmednagar.

CARP, 2024 : Crop outlook report-Centre for Agriculture & Rural development policy research (CARP), ANGARU, Guntur – 522034.

Chamuah, S., S. Gogoi, D. Bhattacharjee, D. Barman, S. Dutta, S. Sharma and K. Das, 2023 : Effect of nano-DAP on soil characteristics and qualities of cabbage. *International journal of plant soil science*, **35**(13): 52-59.

Chinnappa, S. A., D. Krishnamurthy, M. Y. Ajaykumar, Y. M. Ramesha and S. Ravi, 2023 : Effect of nano fertilizers on growth, yield, nutrient uptake and soil microbiology of *Kharif* Sorghum. *International Journal of Environment and Climate Change*, **13**(10): 2339-2348.

Dobariya, M. P., H. M. Bhuva, S. N. Goplani and A. K. Khunt, 2025 : Impact of nano DAP on growth, yield and economics of summer pearl millet. *Journal of Agronomy and Crop Science*, **8**(6): 1-7.

FAO, 2023 : *World food and agriculture: Statistical yearbook/ 2023* (Statistical Yearbook;/ ISSN/ 2225 7373).

Kumar, N., S. Manuja, N. K. Sankhyan, P. Kumar, A. Kumar, and T. Sharma, 2022 : Effect of application of nano-DAP and conventional fertilizers on rice yield. *Sustainable Agricultural Innovations for Resilient Agri-Food Systems*, 373.

Maloth, A., R. Thatikunta, B. K. Parida, D. S. Naik and N. Varma, 2024 : Evaluation of nano-DAP on plant growth, enzymatic activity and yield in paddy (*Oryza sativa* L.). *International Journal of Environment and Climate Change*, **14**(1): 890-897.

NDDB, 2023: https://beta.nddb.coop. Accessed on December 2, 2025.

Patil, M., S. Ravi, H. Veeresh, A. K. Gaddi and D. Krishnamurthy, 2024 : Response of pearl millet (*Pennisetum glaucum*) to foliar spray of nano DAP. *International Journal of Research in Agronomy*, **7**(10): 995-999.

Roy, A. K., R. K. Agrawal, N. R. Bhardwaj, A. K. Mishra and S. K. Mahanta, 2019 : Revisiting National Forage Demand and Availability Scenario. In: Indian Fodder Scenario: Redefining State Wise Status. ICAR-AICRP on Forage Crops and Utilization, Jhansi, India. pp. 1-21.

Suryawanshi, S. S., Y. M. Waghmare, P. N. Karanjikar, S. S. Sukne, A. P. Sabale, 2024 : Studies on foliar application of nano urea and nano dap on growth and yield of sorghum (*Sorghum bicolor* (L.) Moench). *International Journal of Research in Agronomy*, **7**(11): 33-38.