Influence of Nano urea and nano DAP on growth and productivity of sunflower (*Helianthus annuus* L.) during *kharif* season

ABSTRACT

A two years field experiment was conducted at AICRP on sunflower, Zonal agricultural research station, UASB, GKVK, Bengaluru during *kharif,* 2022 and 2023 to study the effect of nano urea and nano DAP on growth and productivity of sunflower. The experiment was laid out in Randomized Complete Block Design with thirteen treatments (50 % RDN+ Nano N @ 4 ml, 50 % RDN+ Nano N @ 6 ml, 75 % RDN+ Nano N @ 4 ml, 75 % RDN+ Nano N @ 6 ml, 50 % RDNP + Nano N & P @ 4 ml, 50 % RDNP + Nano N & P @ 6 ml, 75 % RDNP + Nano N & P @ 4 ml, 75 % RDNP + Nano N & P @ 6 ml, RDF + Normal urea spray @ 1%, RDF+ DAP spray @ 1%, RDF+ FYM, RDF and absolute control) each replicated thrice. The results revealed that significantly higher plant height (199.89 cm), number of leaves per plant (30.26), leaf area (5557 cm^2 $plant^{-1}$), leaf area index (3.09), total dry matter production (146.70 g $plant^{-1}$), capitulum diameter (19.06 cm), no. of seeds per capitulum (1147), seed yield (2026 kg ha^{-1}) and stalk yield (4395 kg ha^{-1}) were recorded with the application of RDF+ FYM and it was found on par with application of 75 % RDN+ Nano N @ 6 ml.

Keywords: *Sunflower, RDF, nano urea, nano DAP, yield*

1. INTRODUCTION

Sunflower is one of the seven edible oilseeds under cultivation. Sunflower (*Helianthus annuus* L.) was domesticated as a food crop in North America, as early as 3000 BC, which was successfully developed as an oilseed in Russia in the early 1800s. Sunflower is a major source of vegetable oil in the world. Its seed contains around 48 – 53 per cent edible oil and 16 per cent proteins making it both an oil and protein species. The sunflower oil which is light yellow in colour with high linoleic acid (64% - a poly-unsaturated fatty acid that helps in washing out cholesterol deposition in the coronary arteries of the heart), no linolenic acid, good flavour and the high smoke point is considered as premium oil compared to other vegetable oils. The oil is also used for manufacturing hydrogenated oil. Sunflower also makes a nutritious meal for birds and animals, as it is a source of lecithin, tocopherols, and furfural. It is also used in the preparation of cosmetics and pharmaceuticals.

Globally, sunflower is cultivated on an area of 28.72 m ha and it is the third oilseed produced (57.27 m t), with a productivity of 1990 kg ha^{-1} representing 9 per cent of the total oilseeds production, preceded by soybean (60%) and rapeseed (12%) (1); fourth in vegetable oils market with 9.20 per cent (19 m t $year^{-1}$), after palm oil (36.50%), soybean oil (27.40%) and rapeseed oil (12.50%) (2). India accounts for about 15-20 per cent of global oilseeds area, 6-7 per cent of vegetable oil production, and 9-10 per cent of the total edible oil consumption (3). In India sunflower is grown in an area of 2.26 lakh ha with a production of 2.50 lakh tonnes and showcasing a productivity of 1011 kg ha^{-1} (4).

Sunflower is a day neutral and short-season crop, that allows the crop to be grown over a wide range of latitudes and year-round (*kharif, rabi,* and summer) compared to other oilseed crops. Besides they have got wider adaptability to different soils, agro-climatic conditions and varied soil moisture levels. However, the reasons for the low productivity of sunflower in India are due to unavailability of adequate soil moisture and nutrients especially during winter and summer, erratic rainfall, imbalanced nutrient management, untimely weed management, low solar radiation, and bud necrosis during the rainy season. Currently, the oilseeds production in India is not meeting the local demands and heavily dependent on imports. However, agricultural land area is inelastic, and hence enhancement of productivity is the only alternative. Hence, special attention is needed to achieve the goal of increasing and stabilizing agricultural production.

Nutrient management plays an important role in enhancing crop yield, but the conventional application of fertilizers to increase productivity and profitability has brought about higher consumption of the nutrients, which ultimately leads to low nutrient use efficiencies, lower profits, and increased environmental issues (5). Conventional fertilizers offer nutrients in chemical forms that are not often fully accessible to plants. Additionally, the inversion of these chemical fertilizers to sparingly soluble forms in soil is the reason for the less utilization of most of the added macronutrients (6). These problems make it imperative to go in for the repeated use of fertilizers. It is fairly well known that the yields of many crops have begun to drop as a result of imbalanced fertilization and a decrease in soil organic matter. In addition to the irreparable damage that the excess use of chemical fertilizers causes to the soil structure and mineral cycles, excessive (often indiscriminate) and imbalanced application of fertilizers spoils the soil microflora, plants, and consequently, the food chains across ecosystems, leading to heritable mutations in future generations of consumers.

To deal with such situation, it is very important to develop smart materials that can systematically release nutrients to specific targeted sites in plants which could be beneficial in controlling their deficiencies in agriculture, while keeping intact the natural soil structure.

Nano fertilizers possess unique features that enhance plants' performance in terms of ultrahigh absorption, increase in production, rise in photosynthesis, and significant expansion in the leaves' surface area. Besides, the controlled release of nutrients contributes in preventing eutrophication and pollution of water resources. Replacement of traditional fertilizer by nanofertilizer is beneficial as upon application, it releases nutrients into the soil steadily and in a controlled way, thus preventing the water pollution (7). Nanoporesand stomatal openings in plant leaves facilitate nanomaterial uptake andtheir penetration deep inside leaves leading to higher nutrient use efficiency(NUE) (8).

Nano urea (Liquid) contains 4 per cent (40000 ppm) nitrogen by weight in its nano form, is a source of nitrogen which is a major essential nutrient required for proper growth and development of a plant. Nano urea liquid particles are 20 to 50 nanometers in size which have more surface area (10000 times over 1 mm urea prill) and number of particles (55000 nitrogen particles over 1 mm urea prill) which makes it more effective (9). The availability of Nano Urea to crops increases by more than 80 per cent due to its small size (10). Nano DAP (liquid) is source of nitrogen and phosphorus. It contains about 8 per cent (80000 ppm) of nitrogen and 16 per cent (160000 ppm) of phosphorus.

2. MATERIAL AND METHODS

The field experiment was conducted during *kharif* 2022 and 2023 at AICRP on Sunflower, University of Agricultural Sciences, Bangalore, GKVK, Karnataka, in E7 block, ZARS, situated at $13^0$05' N latitude, $77^0$34' E longitude and at an altitude of 924 m above mean sea level. The research station comes under the Eastern Dry Zone (Zone-V) of Karnataka. The actual rainfall received throughout the cropping period at the experimental site was 627.4 and 556.8 mm during 2022 and 2023, respectively. The soil was red sandy loam in texture that comes under *Alfisol* soil order. Soil was acidic in reaction (pH 6.1), low in organic carbon content (4.5 mg kg^{-1}) with an electrical conductivity of 0.23 dS m^{-1}. The soil was initially medium in fertility status with respect to available nitrogen (275.7 kg ha^{-1}), phosphorous (38.73 kg ha^{-1}) and potassium (258.42 kg ha^{-1}). Sunflower seeds were sown @ 5 kg ha^{-1}, using KBSH-85 hybrid at a spacing of 60×30 cm. The experiment was laid out in Randomized Complete Block Design with thirteen treatments and three replications. The thirteen treatments were, T_1:50 % RDN+ Nano N @ 4 ml, T_2:50 % RDN+ Nano N @ 6 ml, T_3:75 % RDN+ Nano N @ 4 ml, T_4:75 % RDN+ Nano N @ 6 ml, T_5:50 % RDNP + Nano N & P @ 4 ml, T_6:50 % RDNP + Nano N & P @ 6 ml, T_7:75 % RDNP + Nano N & P @ 4 ml, T_8:75 % RDNP + Nano N & P @ 6 ml, T_9:RDF + Normal urea spray @ 1%, T_{10}:RDF+ DAP spray @ 1%, T_{11}:RDF+ FYM, T_{12}:RDF and T_{13}: Absolute control. FYM for the treatment T_{11} was applied at the rate of 8 t ha^{-1} and RDF 90-90-60 N-$P_2O_5K_2O$ kg ha^{-1}whichwasapplied as per the treatments. Rest of the agronomic practices were followed as per the recommendation for all the treatments in common.

Five plants from each plot were randomly selected from the net plot and tagged. These plants were used for recording growth and yield attributes observations. The plant height was measured from the ground level to base of the top leaf. The number of green leaves per plant were recorded from the tagged plants. The plants from the gross plot were cut above the ground and leaves were fed to leaf area meter for estimating the photosynthetically active area (leaf area). The same plants were oven dried at 65-70^{0}C and the dry weight per plant was noted. The plants from the net plot were harvested and threshed separately and the seed and stalk yield were recorded and expressed on hectare basis. The average of all the replications was is expressed as mean values of the respective treatments. The data recorded on various parameters were subjected to Fisher's method of analysis of variance and interpretation of the data was made as given by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was P = 0.05. Whenever F-test was significant for comparison amongst the treatments means the critical differences (CD) was worked out. Otherwise against CD values abbreviation 'NS' (Non-significant) is indicated.

3. RESULTS AND DISCUSSION

The data pertaining of nano urea and nano DAP application on growth parameters of sunflower is presented in Table 1 & 2. The pooled data analysis revealed that application of RDF + FYM recorded significantly higher plant height (199.89 cm) and total dry matter production (146.70 g plant^{-1}) at harvest and it was found on par with application of 75% RDN + Nano N @ 6 ml lit^{-1} (190.39 cm and 133.00 g palnt^{-1}), respectively. Whereas, the lower plant height (144.28 cm) and total dry matter production (49.43 g plant^{-1}) was recorded in absolute control. Significantly higher number of green leaves (30.26), leaf area (5557 cm^2 plant^{-1}) and leaf area index (3.09) at 60 DAS were recorded with the application of RDF + FYM and found on par with 75% RDN + Nano N @ 6 ml lit^{-1} (29.19, 5127 cm^2 plant^{-1} and 2.85), respectively. Significantly lower number of green leaves (20.26), leaf area (2972 cm^2 plant^{-1}) and leaf area index (1.65) at 60 DAS were recorded in absolute control. The increase in growth parameters with increase in the fertilizer application might be due to the synergistic effect of nano fertilizers on the efficiency of chemical fertilizer for greater absorption of nutrients by plant cells, resulting in maximum growth of plant parts and metabolic activities such as photosynthesis (11, 12). Increased growth parameters might be due to increased number of nodes resulting from cell growth and cell elongation, which in turn produce more number of leaves (13). Increase in dry matter production per plant might be attributed to better growth parameters *viz.,* increased photosynthetic rate and higher leaf area. Soil application of conventional fertilizers along with foliar spray of Nano-N helped in increased nitrogen uptake which would have promoted robust plant growth, as nitrogen is essential for chlorophyll, amino acids, and proteins, resulting in higher dry matter production of the plant. Similar results were found by Rawate*et al.* (2022) and Rajesh (2021) (14,15). Further, higher growth parameters were recorded during *kharif* season of 2023 as compared to *kharif* season of 2022, which might be due to prevalence of congenial conditions for the growth and development of the crop.

The data related to yield and yield parameters of sunflower is presented in the Table 3. Pooled data of two seasons revealed that significantly higher capitulum diameter (19.06 cm), no. of seeds per capitulum (1147), seed yield (2026 kg ha^{-1}) and stalk yield (4395 kg ha^{-1}) were recorded with the application of RDF + FYM and found on par with the application of 75% RDN + Nano N @ 6 ml lit^{-1} (18.18 cm, 1005, 1896 kg ha^{-1} and 3999 kg ha^{-1}), respectively. Whereas, significantly lower capitulum diameter (12.13 cm), no. of seeds per capitulum (527), seed yield (698 kg ha^{-1}) and stalk yield (2145 kg ha^{-1}) were recorded in absolute control.

The increase in yield parameters can be attributed to increased root growth and development, improved crop's growth performance, particularly the enhanced dry matter production and efficient translocation of photosynthates from source to sink. This increased photosynthetic activity leads to a greater accumulation and translocation of photosynthates to the plant's economic parts, such as grains, resulting in higher yields, which canbe attributed to both enhanced source and sink strength (12, 16). Nitrogen influences floret development, increasing the potential number of seeds per capitulum, promotes larger and heavier grains through the accumulation of starch and storage compounds (17). Adequate fertilizer application promotes healthy crop growth and development leading to improved crop performance and productivity.

In the present study, the seed yield increased to the tune of 36.8 per cent and 53.6 per cent increase in stalk yield was observed with the application of 75% RDN+ Nano N @ 6 ml lit^{-1} over the absolute control. This experiment showed that using nano urea as a nitrogen source can reduce the sunflower crop's nitrogen requirement by 25 per cent, without compromising yields, as the nano urea treatment achieved yields comparable to the RDF + FYM application. Foliar application of nano urea offers several advantages over conventional urea, including enhanced plant uptake, minimized nitrogen losses, and increased nutrient availability, ultimately leading to improved crop yield and productivity. The tiny particle size of nano fertilizers offers a significantly higher surface area, enabling increased metabolic activity and facilitating enhanced photosynthesis, leading to boosted photosynthate production and improved plant growth when applied through foliar spray. The nutrient use efficiency of foliar applied nano urea is significantly higher (>80%) compared to soil-applied conventional urea (<40%) in crop plants.

As a result, even with a 25 per cent reduction in nutrient supply, similar yield levels were achieved with 75 per cent recommended dose of nitrogen (RDN) with nano urea applied in two foliar sprays. The results are in conformity with the findings of Mahantesh (2023) (18) and Vyankatrao*et al.* (2024) (19). Further, the crop in *kharif* season of 2022 recorded slightly lower yield than the *kharif*-2023 crop which might be due to receipt of higher rainfall during the flowering stage in the month of October (361.0 mm) during the *kharif*- 2022 crop resulting in decreased seed setting and pollination ultimately resulting in yield reduction.

Table 1: Influence of nano urea and nano DAP on plant height and total dry matter production of sunflower at harvest

Treatment	**Plant height**			**Total dry matter production**		
	2022	**2023**	**Pooled**	**2022**	**2023**	**Pooled**
T_1	180.00	190.4	185.22	96.8	111.3	104.08
T_2	180.56	191.3	185.94	100.0	114.7	107.37
T_3	184.11	192.7	188.39	111.7	132.3	122.04
T_4	184.33	196.4	190.39	128.6	137.4	133.00
T_5	177.00	190.0	183.50	87.4	95.4	91.42
T_6	178.44	190.2	184.33	92.6	104.3	98.48
T_7	181.67	191.4	186.56	103.1	119.3	111.24
T_8	182.89	192.0	187.44	106.7	128.2	117.46
T_9	185.78	201.0	193.39	134.8	145.0	139.92
T_{10}	186.78	202.4	194.61	137.3	148.2	142.75
T_{11}	195.89	203.9	199.89	139.5	153.9	146.70
T_{12}	184.78	199.2	192.00	131.6	141.0	136.30
T_{13}	142.44	146.1	144.28	48.5	50.3	49.43
S.Em.±	7.80	8.13	6.01	4.63	6.25	4.27
CD at 5%	22.76	23.74	17.54	13.53	18.25	12.46

Table 2: Influence of nano urea and nano DAP on no. of green leaves, leaf area and leaf area index of sunflower at 60 DAS

Treatment	No. of green leaves plant^{-1}			Leaf area (cm^2 plant)			Leaf area index		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
T_1	27.13	29.22	28.18	4426	4419	4422	2.46	2.45	2.46
T_2	27.20	29.22	28.21	4577	4564	4570	2.54	2.54	2.54
T_3	28.00	30.00	29.00	4854	5163	5008	2.70	2.87	2.78
T_4	28.27	30.11	29.19	5039	5214	5127	2.80	2.90	2.85
T_5	27.07	28.22	27.64	3968	4098	4033	2.20	2.28	2.24
T_6	27.80	28.33	28.07	4219	4217	4218	2.34	2.34	2.34
T_7	27.33	29.44	28.39	4611	4782	4696	2.56	2.66	2.61
T_8	27.80	29.78	28.79	4682	4936	4809	2.60	2.74	2.67
T_9	28.27	30.22	29.24	5471	5399	5435	3.04	3.00	3.02
T_{10}	27.93	31.00	29.47	5454	5451	5452	3.03	3.03	3.03
T_{11}	28.40	32.11	30.26	5500	5615	5557	3.06	3.12	3.09
T_{12}	28.27	30.22	29.24	5349	5298	5323	2.97	2.94	2.96
T_{13}	18.73	21.78	20.26	2946	2999	2972	1.64	1.67	1.65
S.Em.±	1.11	1.36	0.91	269.67	254.79	198.19	0.13	0.12	0.09
CD at 5%	3.25	3.98	2.64	787.10	743.67	578.49	0.39	0.36	0.25

Table 3: Influence of nano urea and nano DAP on yield and yield parameters of sunflower

Treatment	Capitulum diameter (cm)			No. of seeds per capitulum			Seed yield (kg ha^{-1})			Stalk yield (kg ha^{-1})		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
T_1	17.00	17.77	17.38	908	921	915	1716	1841	1779	3468	3608	3610
T_2	17.30	18.03	17.67	920	942	931	1733	1858	1796	3493	3748	3663
T_3	17.58	18.17	17.87	988	991	990	1799	1937	1868	3805	3942	3831
T_4	17.70	18.67	18.18	1001	1008	1005	1831	1960	1896	3869	4061	3999
T_5	16.90	17.40	17.15	883	892	888	1672	1794	1733	3204	3169	3181
T_6	16.90	17.47	17.18	895	903	899	1695	1825	1760	3363	3421	3402
T_7	17.43	18.07	17.75	942	963	953	1765	1886	1826	3551	3744	3679
T_8	17.57	18.10	17.83	965	978	972	1783	1913	1848	3635	3945	3842
T_9	18.02	18.90	18.46	1096	1092	1094	1876	2028	1952	4096	4190	4158
T_{10}	18.20	18.97	18.58	1077	1105	1091	1901	2057	1979	4193	4340	4290
T_{11}	18.61	19.50	19.06	1125	1168	1147	1957	2095	2026	4314	4537	4395
T_{12}	17.83	18.70	18.27	1018	1023	1021	1847	1983	1915	3990	4124	4080
T_{13}	10.33	13.93	12.13	576	478	527	734	661	698	2238	2100	2145
S.Em.±	0.77	0.93	0.61	43.96	42.96	35.26	77.81	79.84	69.48	153.44	187.15	143.67
CD at 5%	2.26	2.73	1.78	128.31	125.40	102.93	227.12	233.02	202.80	447.86	546.25	419.34

4. CONCLUSION

Basal dose of conventional urea application can be replaced to the tune of 25 per cent without significant yield reduction. Further, application of nano urea through foliar spray holds a good practice under rainfed conditions, where farmers merely applies fertilizers due to lack of sufficient moisture in the soil.

REFERENCES

1. USDA [United States Department of Agriculture], World agriculture production: Sunflower seed area, yield and production. 2023, https://apps.fas.usda.gov/psdonline/circulars/production.pdf
2. Pilorge E. Sunflower in the global vegetable oil system: situation, specificities and perspectives. *OCL*. 2020; 27: 34.
3. Kumar V. Tiwari A. Sparking yellow revolution in India again. *Rural Pulse,* 2020;34: 1-4.
4. Anonymous, Department of Agriculture and Farmer's welfare. Available on \http://agricoop.gov.in/en/Oilseeds#gsc.tab=0, 2023.
5. Pampolino MF, Witt C, Pasuquin JM, Johnston A. Fisher MJ, Development approach and evaluation of the nutrient expert software for nutrient management in cereal crops. *Comput Electron Agric.* 2012;**88**: 103-110.
6. Kumar Y, Tiwari KN, Nayak RK, Abhimanyu R, Singh SP, Singh AN, Kumar Y, Tomar H, Singh T, Raliya R, Nanofertilizers for increasing nutrient use efficiency, yield and economic returns in important winter season crops of Uttar Pradesh. *Indian J Fert.*2020;**16**(8): 772-786.
7. Naderi MR. Danesh-shahraki, A., Nanofertilizers and their roles in sustainable agriculture. *Int J Agric Crop Sci*. 2013;**5**(19): 2229–2232.
8. Iqbal, Nano-fertilizers for sustainable crop production under changing climate: A global perspective. *Sustain. crop prod.*, 2019;1-12. DOI: http://dx.doi.org/10.5772/intechopen.89089.
9. Wu H, Li, Z, Recent advances in nano enabled agriculture for improving plant performance. *Crop J.* 2022; **10**: 1–12.
10. Tiwari, K., Kumar, Y., Nayak, R, Rai, A, SINGH, J, SRIVASTAVA S. S. A, Nano-Urea for enhancing yield and farmers profit with potato in Uttar Pradesh. *Ann Plant Soil Res.* 2021; **23**(4): 495-500.
11. Midde SK, Saravana M, Perumal G, Murugan R, Sudhagar VS, Mattepally Bada M. R, Evaluation of nano urea on growth and yield attributes of rice (*Oryza Sativa* L.). *Chem Sci Rev Lett,* 2022;**11**(42): 211-214.

12. Ajitkumar K, Yogendra K, Savitha AS, Ajayakumar MY, Narayanaswamy C, Ramesh, R, Krupashankar MR, BHAT SN, Effect of IFFCO nanofertilizer on growth, grain yield and managing turcicum leaf blight disease in maize*. Int J Plant Soil Sci.* 2021;**33**(16): 19-28.
13. Devi S, Kalita J, Borkotoki B, Baruah N, Choudhury H, Comparative evaluation of nano urea versus conventional urea for nitrogen management in rainfed sunflower (*Helianthus annuus* L.) cultivation in acid sandy loam soils of Assam. *Asian Res J Agric.* 2024;**17**(1): 22-32.
14. Rawate D, Patel JR, Agrawal AP, Agrawal HP, Pandey D, Patel CR, Effect of nano urea on productivity of wheat (*Triticum aestivum* L.) under irrigated condition. *J Pharm Innov,* 2022;**11**(9): 1279-1282.
15. Rajesh H, Studies on foliar application of nano nitrogen (N) and nano zinc (Zn) in sweet corn (*Zea mays* L. saccharata). *M. Sc. (Agri.)Thesis*, Univ. Agril. Sci. Raichur, Karnataka, India, 2021.
16. Rajput JS, Thakur AK, Nag, NK, Chandrakar T, Singh DP, Effect of nano fertilizer in relation to growth, yield and economics of little millet (*Panicum sumatrense* Roth) under rainfed conditions. *Pharm Innov J.* 2022;**11**(7): 153-156.
17. Leghari SJ, Wahacho NA, Laghari GM, Laghari AH, Bhabhan GM, Talpur KH, Ahmed T, Wahocho SA, Lashari AA, Role of nitrogen for plant growth and development: A review. *Adv Environ Biol*. 2016;**10**(9): 209-218.
18. Mahantesh BN, Studies on mitigation of nitrogen losses and greenhouse gases emission in aerobic rice. *Ph.D Thesis*, Univ. Agric. Sci., Bengaluru, Karnataka, India, 2023.
19. Vyankatrao KS, Baburao AP, Amrut RP, Jaipal KP, Ashroba IO, Effect of foliar application of nano urea on growth, nutrient uptake, yield and quality of sunflower. *Int. J. Plant Soil Sci.,* 2024;**36**(4): 184-190.