Evaluation of the foliar application of nano urea on the performance of *Rabi* Sunflower (*Helianthus annuus* L.)

ABSTRACT

A study was conducted on clayey soils (*vertisols*) of southern Telangana zone(India) characterized by low soil organic carbon, low available nitrogen and medium available phosphorous (P) and high available potassium (K). The experiment involving seven nitrogen (N) management practices (T_1 to T_7) involving recommended dose of fertilizers (RDF) as soil application, varied rates of foliar application of nano urea (liquid) was laid out in randomized block design replicated thrice. All the treatments were supplied with basal 50% of soil applied urea fertilizer at the time of sowing except in T_1 (No nitrogen application) treatment. Results revealed that application of recommended dose of fertilizers in three splits as soil application resulted into significantly highest growth, yield (1774 kg) and yield attributes of sunflower, and was found profitable (Benefit:Cost ratio = 3.47) over foliar application of varied rates of nano- urea spray. Foliar application of nano urea @ 2-4 ml L^{-1} in T_3 to T_7 treatments could significantly improve growth and yield of sunflower (by 546 to 744 kg) when compared to no nitrogen application treatment. However foliar application of nano urea showed significantly lesser growth and yield compared to soil application of RDF in three splits in *rabi* sunflower.

Key words: Neem-coated urea, nano technology, split application, nitrogen management, oilseeds.

1. INTRODUCTION

Oilseeds sector contributes for around 3% of the India's gross national product and 10% of the value of all agricultural products. Ministry of Agriculture & Farmers Welfare [1].

Sunflower is India's fourth most popular oilseed crop which was grown on 0.225 million hectares. Telangana State has got potential to expand area from existing 7000 hectares, and productivity from 2342 kg per hectare. Indiastat [2].

Nitrogen is the most important nutrient, which determines the growth of the oilseed crops and increases the amount of protein and the yield. Further, N fertilizer application affects drymatter production as well as N accumulation and partitioning into various parts of crop plants for the growth, development and other processes. Khaliq and Cheema [3].

Conventional fertilizers are claimed to demand more manpower to be applied (especially as top dressing) and to alter the soil chemical properties if used indiscriminately. This indicated the need to explore new means to supply N to the crop with higher nitrogen use efficiency.

Nanotechnology to supply nutrients is being tested globally in crop production with various compositions. Nanotechnology is defined as understanding and control of matter at dimensions of roughly 1-100nm, where unique physical properties make novel application possible. Foliar application of nano N has been found promising in supplying N to field crops by various researchers. Kumar et al. [4]. Most of the researches on application of nanotechnology in the form of nano nitrogen (N) to the crops was largely emphasizing commercial crops. However, there is a need of research on evaluation of nano N on oilseed crops such as sunflower which has great potential to yield more on supplement with N under irrigated situation in semi-arid tropics.

2. MATERIALS AND METHODS

A field experiment was conducted during *rabi* (post rainy winter season) 2021-22 on vertisols of Agricultural Research Institute of Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India (17º 19' 44" N latitude, 78º 23' 55" E longitude and 523 m above mean sea level) which is characterized as semi-arid tropic region (SAT). The soil (pH=7.9) was low in soil organic carbon (0.32%) and available N (145 kg ha^{-1}), medium in P (27.31 kg ha^{-1}) and high in K (395 kg ha^{-1}). During the crop growth period, the weekly mean maximum temperature ranged from 27.4°C to 38.4°C with an average of 30.59°C and mean minimum temperature ranged from 9.6°C to 22.2°C with an average of 16.91°C (Fig 1). The experiment involving seven nitrogen management practices was laid out in randomized block design replicated thrice. The treatments included, T_1 : No Nitrogen application; T_2: 50% Recommended Dose of Nitrogen (RDN) at sowing + 25% RDN at star bud stage+ 25% RDN at 50% flowering; T_3: 50% RDN at sowing + foliar spray of nano-N @ 2 ml L^{-1} at star bud stage and at 50 % flowering; T_4: 50% RDN at sowing + foliar spray of nano-N @ 2.5 ml L^{-1} at star bud stage and at 50 % flowering; T_5: 50% RDN at sowing +foliar spray of nano-N @ 3 ml L^{-1} at star bud stage and at 50 % flowering; T_6: 50% RDN at sowing +foliar spray of nano-N @ 3.5 ml L^{-1} at star bud stage and at 50 % flowering; T_7: 50% RDN at sowing +foliar spray of nano-N @ 4 ml L^{-1} at star bud stage and at 50 % flowering. The recommended dose of fertilizer (RDF) was 75:90:30 N:P:K kg ha^{-1} . Since it is mandatory for all indigenous urea producers in India to coat the urea granules with neem

(*Azadirachtin*) to achieve slow release of N, such neem coated urea was used in the experiment. In this study, nano N was supplied through Nano-Urea (liquid) which was released by Indian Farmers Fertilizer Cooperative Limited (IFFCO) for commercial basis in the year 2021. It is claimed by the manufacturer that nano urea liquid contains 4% of N with a shelf life of about 2 years and sprayed @ 2-4 ml L^{-1} of water depending on the crop N requirement and crop canopy. It is also claimed that 500ml which costs INR 240 (approx. 3$) could substitute 1 bag (equivalent to soil application of 45kg of commercially available urea with 46%N). IFFCO [5]. Quantity of water used for spray in all relevant treatments was @ 312 L^{-1} /ha at each spraying. Knapsack sprayer was used for foliar spray of nano N at each spray. Urea, single super phosphate (SSP) and muriate of potash (MOP) were used as sources of N, P and K, respectively through soil application. Full dose of P and K were applied at the time of sowing. The experimental data obtained were statistically analysed using the ANOVA procedure and the results presented using alphabet notations after analysis by DMRT Gomez and Gomez [6].

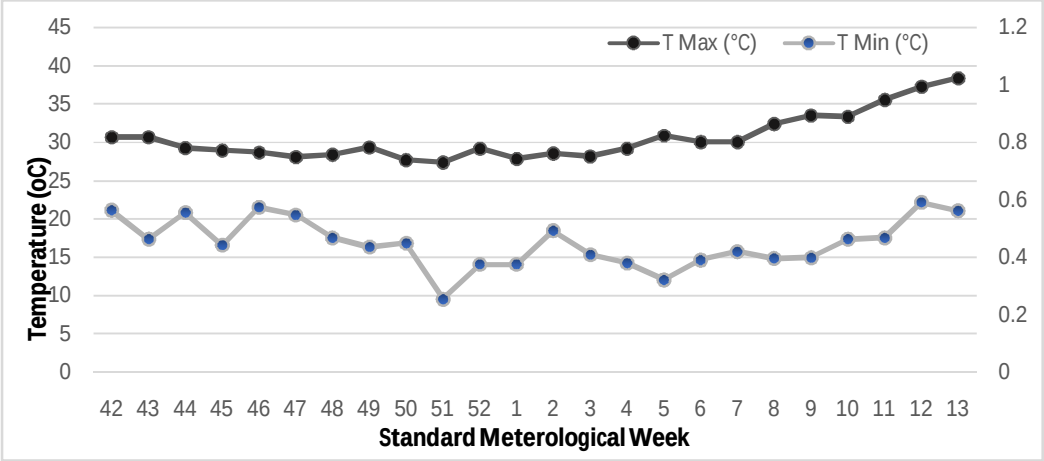

Fig 1. Weekly maximum and minimum temperatures (^{0}C) during the crop growth period

3. RESULTS AND DISCUSSION

3.1 Growth attributes:

It was observed that supplementation of crop with N has significantly boosted the growth irrespective of the source of N during crop growth period (Table 1). The experimental data revealed that the application of 75kg N ha^{-1} through soil application of urea induced significant increment in growth attributes (plant height, leaf area index and drymatter

accumulation at critical growth stages) of sunflower over other N management combinations which included foliar application of nano urea (liquid) at various dosages.

At flowering and harvest stages, soil application of urea in three splits i.e. T_2 resulted into taller plants by 24cm, higher leaf area index by 18%, higher drymatter accumulation by 13.6 g over T_7 respectively. This finding could be the reflection of improved absorption and transport of nutrients that enhanced the cell division and growth owing to supply of higher amount of N at critical growth stages like starbud stage and 50% flowering stage. Further, slow release of N from neem coated urea for extended period eventually resulted in taller plants with broader leaf area. These findings were in close agreement with the findings of Adhikary et al. [7], Siddiqui et al. [8], Dambale et al. [9].

This might be due to slow release nature of neem coated urea and plant assimilated more with the conventional urea Waqar et al. [10]. This has led to more leaf area and drymatter. These results are in accordance with Pattanayak et al. [11] and Ahmad et al. [12].

It is to be noted here that, among nano urea involving treatments, its application @ 4ml L^{-1} showed numerically higher growth response than other nano urea treatments. However, this increment was at par with other nano urea dosage treatments from 50% flowering till harvest. This indicated that increase in nano urea application rate from 2ml L^{-1} to 4ml L^{-1} could not induce significant plant growth. This could be due to higher N requirement of the sunflower crop and nano urea supplied 4% N i:e., probable less application rates of nano urea.

3.2 Yield and Yield attributes:

Soil application of RDF in three splits resulted into significantly larger sunflower heads and more grain weight per head by 3.5cm to 8.9cm and 9.4g to 23.7g, respectively over T_7 and T_1 (Fig. 2 and Table 2). Our finding is supported by Dayananda and Nissanka [13] who presented significantly less growth and yield with nano form of nitrogen in N demanding crop like finger millet. Highest harvest index was recorded with T_2. This increased yield is attributable to significant increase in growth, yield attributes and better partitioning of photosynthates from source to sink. Strong and positive relationships between grain yield and growth & yield attributes were estimated (Fig.3 and Table.3). Higher seed yield with recommended dosage of nitrogen in three splits was associated with an increase in seed

number capitulam^{-1}, which ultimately leads to higher seed weight capitulam^{-1}. Further, improved photosynthate translocation and accumulation improved yield characteristics and chlorophyll content resulting in higher seed production. Mollashahi et al. [14] and Munir et al. [15] also reported that the application of RDF affects the development and growth of both source and sink.

Interestingly, application of 50% RDN through soil application of urea at sowing followed by foliar application of nano urea at various rates has led into significant increase in grain yield over no N application by 546 kg ha^{-1} (T_3) to 744 kg ha^{-1} (T_7). Further, T_3 to T_7 have recorded significantly higher stalk yield over no N application by 386 kg ha^{-1} to 531 kg ha^{-1}, respectively. There is promising relevance of including foliar application of nano urea (liquid) in N management under low input agriculture Velmurugan et al. [16] and the areas where adequate quantity of conventional urea could not reach due to various reasons. Nevertheless, response of sunflower to foliar application of nano urea at varied rates i.e., @ 2ml, 2.5ml, 3ml, 3.5ml and 4ml L^{-1} was found to be insignificant with respect to growth and yield indicating that if farmers need to adopt foliar application of nano urea liquid in sunflower cultivation, they could go for application rate of 2ml L^{-1} to save N management cost.

3.3 Economics:

Variations in seed yield and stalk yield owing to imposed treatments impacted monetary returns (Table 2). Economic indicators viz., Gross return (INR 1,09,055 ha^{-1}), net return (INR 77,638 ha^{-1}) as well as benefit to cost ratio (B:C) (3.47) were significantly highest with soil application of RDF in three splits. It was also noticed that cultivation of sunflower involving nano urea (irrespective of dosage) was costlier than soil application of conventional urea which is available to the farmers at subsidized price owing to government subsidy policy. However, it would be worthy to point out that, including foliar application of nano urea along with soil applied 50% RDN fetched significantly higher profits (net return) by INR 32,129 to INR 43,603 ha^{-1} compared to no application of N to sunflower crop. This implied that in the situations of shortage of urea foliar application of nano urea could be profitable when used after application of 50% as basal. Transport and storage of liquid nano urea is simple and easy to any part of the country in short time. These results are in accordance with the findings of Rasool et al. [17] and Ashoka and Shashadhar [18].

Table 1. Influence of foliar application of nano urea on growth attributes of sunflower.

Treatments	Plant Height(cm)				LAI				Drymatter (g) per plant			
	Vegetative stage	Starbud stage	50% Flowering stage	At Harvest	Vegetative stage	Starbud stage	50% Flowering stage	At Harvest	Vegetative stage	Starbud stage	50% Flowering stage	At Harvest
T_1	9.3[b]	62.3[b]	75.7[c]	82.7[c]	0.30[b]	0.55[b]	2.09[c]	1.74[c]	1.3[b]	23.5[b]	50.0[c]	59.0[c]
T_2	14.7[a]	78.7[a]	135.0[a]	153.0[a]	0.50[a]	0.80[a]	3.47[a]	3.03[a]	1.6[a]	31.3[a]	81.7[a]	91.6[a]
T_3	15.5[a]	83.0[a]	101.7[b]	113.1[b]	0.55[a]	0.88[a]	2.65[b]	2.26[b]	1.7[a]	33.2[a]	62.5[b]	74.1[b]
T_4	15.0[a]	78.0[a]	106.3[b]	115.2[b]	0.49[a]	0.82[a]	2.78[b]	2.28[b]	1.8[a]	32.4[a]	63.8[b]	75.6[b]
T_5	17.0[a]	85.0[a]	109.0[b]	119.0[b]	0.56[a]	0.86[a]	2.84[b]	2.34[b]	1.7[a]	32.8[a]	65.0[b]	75.7[b]
T_6	14.5[a]	81.0[a]	112.3[b]	122.3[b]	0.49[a]	0.83[a]	2.90[b]	2.42[b]	1.6[a]	27.6[a]	66.6[b]	76.3[b]
T_7	15.4[a]	82.3[a]	114.7[b]	129.0[b]	0.52[a]	0.85[a]	2.93[b]	2.55[b]	1.9[a]	27.1[a]	67.4[b]	78.0[b]
SEm±	0.9	3.9	6	6.2	0.02	0.04	0.17	0.13	0.1	2	4	4
CV%	10.9	8.6	9	9.2	7.76	8.65	10.28	9.49	11.8	11	10	9

Table 2. Influence of foliar application of nano urea on yield and economics of sunflower.

Treatments	Yield			Economics			
	Stalk yield kg ha^{-1}	Grain yield kg ha^{-1}	Harvest index (%)	Cost of cultivation (INR ha^{-1})	Gross Returns (INR ha^{-1})	Net Returns (INR ha^{-1})	B:C
T_1	1450^{c}	750^{c}	34.2^{b}	30433	46550^{c}	16117^{c}	1.53^{c}
T_2	2349^{a}	1774^{a}	43.6^{a}	31417	109055^{a}	77638^{a}	3.47^{a}
T_3	1836^{b}	1296^{b}	41.4^{a}	31525	79771^{b}	48246^{b}	2.53^{b}
T_4	1853^{b}	1343^{b}	42.1^{a}	31675	82614^{b}	50939^{b}	2.61^{b}
T_5	1885^{b}	1389^{b}	42.5^{a}	31825	85413^{b}	53588^{b}	2.68^{b}
T_6	1927^{b}	1426^{b}	42.6^{a}	31975	87701^{b}	55726^{b}	2.74^{b}
T_7	1981^{b}	1494^{b}	42.7^{a}	32125	91845^{b}	59720^{b}	2.86^{b}
SEm±	112	80	2.4	0	4782	4782	0.2
CV%	10.3	10.2	10.3	0	10	16	10

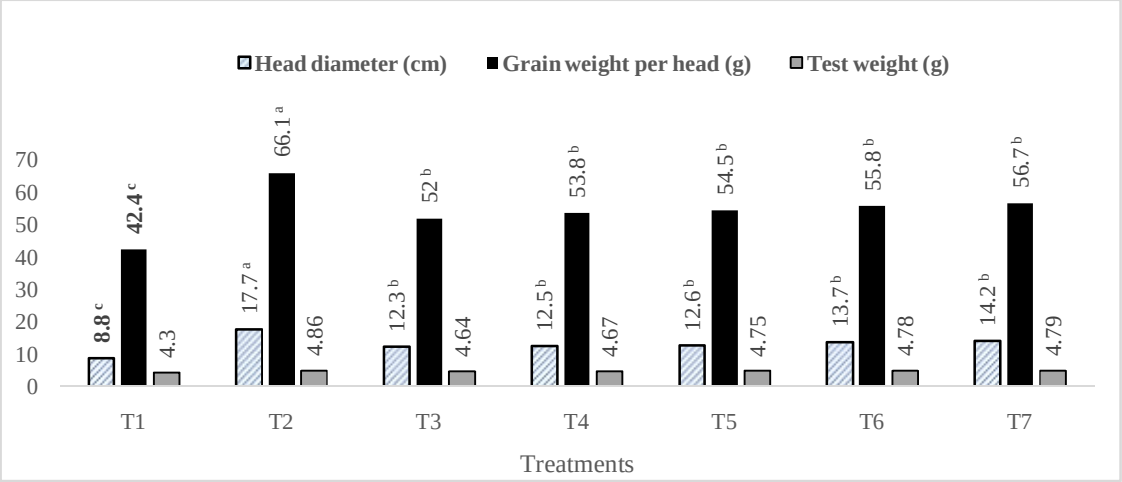

Fig 2. Influence of foliar application of nano urea on head diameter(cm), grain weight per head(g) and test weight (g) in sunflower.

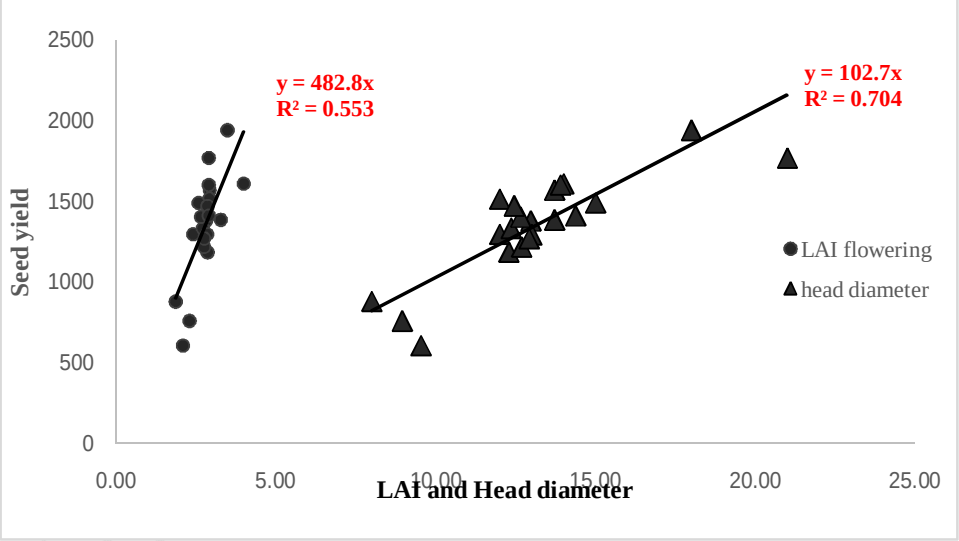

Fig 3. Relationship between leaf area, head diameter and seed yield.

Table 3: Relationship between seed yield and growth &yield attributes of sunflower.

Parameter(x)	Regression equation	Coefficient of determination (R^2)
Plant height(harvest)	y = 11.39x	0.98
Grain weight per head	y = 25.025x	0.98
Head diameter	y = 102.77x	0.98
LAI(flowering)	y = 482.85x	0.97

4. CONCLUSION

Results of this short-term experiment revealed that soil application of 50% recommended dose of nitrogen followed by twice foliar application of nano urea (liquid) at critical growth stages viz. star bud stage and at 50% flowering @ 2-4ml L^{-1} could be a wise N management practice in rabi sunflower cultivation in the situation of inadequate reach of conventional urea as far as growth, yield and monetory benefits are emphasized. However, this strategy could not substitute complete half of the N requirement of the crop. Soil application of recommended dose of fertilizers at time of sowing coupled with top dressing with urea at starbud stage and at 50% flowering was high yield giver and profitable strategy of N management in rabi sunflower.

REFERENCES

1. Ministry of Agriculture & Farmers Welfare. Directorate of Oilseeds Development. 2021. https://oilseeds.dac.gov.in
2. Indiastat. Area, production and productivity of sunflower. 2021. https://www.indiastat.com
3. Khaliq A and Cheema ZA. Influence of irrigation and nitrogen management on some agronomic traits and yield of hybrid sunflower. International Journal of Agriculture and Biology. 2005;7(6): 915-919.
4. Kumar Y, Tiwari KN, Singh T, Sain NK, Laxmi S, VERMA R, Sharma GC and Raliya R. Nanofertilizers for enhancing nutrient use efficiency, crop productivity and economic returns in winter season crops of Rajasthan. Annals of Plant and Soil Research. 2020;22(4): 324-335.
5. IFFCO Nano Urea.2021. https://nanourea.in/en/nano-urea.

6. Gomez KA and Gomez AA. Statistical procedures for agricultural research (2 ed.). John Willey and Sons, New York. 1984; 680.
7. Adhikary P, Patra PS, Reja H, Saren S and Tudu B. Response of sunflower to different ratios of nitrogen, phosphorus, potassium fertilizer. Journal of Pharmacognosy and Phytochemistry, 2018;7(4):2898-2901.
8. Siddiqui MH, Oad FC, Abbasi MK and Gandahi AW. Effect of NPK, micronutrients and N-placement on the growth and yield of sunflower. Sarhad Journal of Agriculture. 2009;25(1): 45-52.
9. Dambale AS, Ghotmukale AK, Khandekar SD, Suryawanshi SB, Suryararshi VP and Shinde RS. Influence of integrated nutrient management on growth, yield, quality and economics of sunflower (*Helianthus annuus* L.). International Journal of Current Microbiology and Applied Sciences. 2018;6:1226-1233.
10. Waqar M, Habib-ur-Rahman M, Hasnain MU, Iqbal S, Ghaffar A, Iqbal R, Hussain MI and Sabagh AE. Effect of slow release nitrogenous fertilizers and biochar on growth, physiology, yield, and nitrogen use efficiency of sunflower under arid climate. Environmental Science and Pollution Research 2022; 1-14.
11. Pattanayak S, Behera A, Jena SN, Das P and Behera S. Growth and yield of sunflower (*Helianthus annuus* L.) hybrids under different nutrient management practices. International Journal of Bio-resource and Stress Management. 2016;7(4): 845-850.
12. Ahmad MI, Ali A, Khan A, Sher A, Rashid A, Jamro SA and Ahmad S. Nitrogen Management of Diverse Sunflower (*Helianthus annuus* L.) Hybrids Production under Agro-Climatic Conditions of Sargodha, Pakistan. American Journal of Plant Sciences, 2017;8(6): 1357-1367.
13. Dayananda JAMS and Nissanka SP. Effect of Nano-Urea on Growth, Development, Yield and Quality Variation of Finger Millet [*Eleusine coracana* (L.) *Gaertn.*]. Proceedings of the Faculty of Agriculture Undergraduate Research Symposium, 2014; 50.
14. Mollashahi M, Ganjali H and Fanaei H. Effect of different levels of nitrogen and potassium on yield, yield components and oil content of sunflower. International Journal of Farming & Allied Sciences. 2013;2: 1237-1240.
15. Munir MA, Malik MA and Yaseen M. Performance of sunflower in response to nitrogen management at different stages. Pakistan Journal of Agricultural Sciences. 2007;44: 12-15.

16. Velmurugan A, Subramani T, Bommayasamy S, Ramakrishna, Manoj Kumar and Swarnam TP. The effect of foliar application of nano urea (liquid) on rice (*Oryza sativa* L). Journal of Andaman Sciences Association. 2021;26(2): 76-81.
17. Rasool FU, Hasan B, Jahangir IA, Ali T and Mubarak T. Nutritional yield and economic responses of sunflower (*Helianthus annuus* L.) to integrated levels of nitrogen, sulphur and farmyard manure. The Journal of Agricultural Sciences. 2013;8: 17-27.
18. Ashoka P and Shashadhar G. Yield, water use and economics of sunflower (*Helianthus annuus*) as influenced by irrigation and integrated nutrient management. Journal of Pharmacognosy and Phytochemistry, 2020;9(3): 1757-1759.