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EFFECT OF NANO DAPON YIELD AND ECONOMICS OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) IN KHARIF SEASON

J.S. Gaikwad[1*], V.P. Suryavanshi[2], S.B. Suryawanshi[1], R.R. Abhale[1] and A.U. Wankhede[1]

[1]Department of Agronomy, College of Agriculture, Latur-413512, (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani), Maharashtra, India

[2]Extension Agronomist, RAEEC, Latur-413512, (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani), Maharashtra, India

*Corresponding author E-mail: jayesh2000gaikwad@gmail.com

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ABSTRACT

A field experiment was conducted during *kharif*, 2024 at Experimental Farm of Agronomy section, College of Agriculture, Latur to study the effect of nano-DAP on yield attributes, yield and economics of sunflower (*Helianthus annuus* L.) in *kharif* season. The soil of experimental field was clayey in texture. The experiment was laid out in Randomized Block Design (RBD) with eight treatments replicated thrice. The treatments were T_1 - Control (No Fertilizer), T_2 - 100 % RDF, T_3 - 100 % RDF + Two spray of 2 % DAP, T_4 - 100 % RDF + Two spray of 0.4 % Nano DAP, T_5 - 75 % RDF + Two spray of 2 % DAP, T_6- 75 % RDF + Two spray of 0.4 % Nano DAP, T_7 - 75 % RDF + One spray of 2 % DAP @ 30 DAS + One spray of 0.4 % Nano DAP @ 45 DAS and T_8 - 75 % RDF + One spray of 0.4 % Nano DAP @ 30 DAS + One spray of 2 % DAP @ 45 DAS. The result revealed that the application of 100 % RDF + Two spray of 0.4 % Nano DAP (T_4) recorded significantly highest yield attributes and economics viz.,number of filled seeds plant^{-1} (972), number of unfilled seeds plant^{-1} (147), seed yield plant^{-1} (41.27 g), test weight (65.81 g), seed yield (2443 kg ha^{-1}), stalk yield (4895 kg ha^{-1}), biological yield (7337 kg ha^{-1}), gross monetary return (1,77,826 ₹/ha), net monetary return (1,22,343 ₹/ha) being at par with the application of 100 % RDF + Two spray of 2 % DAP (T_3) over rest of the treatments. Highest Harvest index (33.29) and B:C ratio (3.21) was also observed with the application of 100 % RDF + Two spray of 0.4 % Nano DAP (T_4).

***Key words*: Sunflower, RDF, DAP, nano DAP, foliar spray**

Introduction

Sunflower (*Helianthus annuus* L.) popularly known as “surajmukhi” is an annual oilseed crop. It is a member of the Asteraceae (Compositae) family. It was formerly an ornamental plant in India, but it is now a significant source of edible oil. It is photo and thermo-insensitive crop having wide range adaptability to different cropping pattern and also for different soil and climatic conditions, drought tolerance, lower seed rate, higher seed multiplication ratio. It is native of North America. It was introduced to India in 1969 as an addition to the introduction of oilseed crops to fill the gap left by the nation’s ongoing edible oil scarcity (Shankergoud *et al.*, 2006). The sunflower seeds contain approximately 45-50% oil content, 14-19% protein, 21-27% hull, 7-9% soluble sugars, and 30-35% carbohydrates. In India, sunflower cultivation covers an area of 0.28 million hectares, producing 0.25 million tonnes with an average productivity of 905 kg per hectare (Anonymous, 2023a). Maharashtra ranks fourth position in both area and production, following Karnataka, Haryana, and Odisha. In Maharashtra during 2023-24 sunflower grown on 6.14 thousand hectares area with a production of 2.37 thousand tonnes with productivity 387 kg per hectare (Anonymous, 2023b). Current oilseed production of India falls short to meet local demands, leading to excessive dependence on imports. Despite limited potential for expanding oilseed cultivation areas, meeting future demand depends largely on enhancing productivity. This can be achieved by applying resource- and land- use efficient practices like using optimized nutrient management and nano fertilizers. Effective nutrient management focuses on primary nutrients like nitrogen, phosphorus, and potassium whichimproves sunflower optimal growth and yield. Nano fertilizers are required in less amount, thereby adopting nano fertilizers in sunflower cultivation holds great potential for sustainable agriculture, boosting productivity while minimizing the adverse effects of excessive conventional fertilizer usage on the environment. These nano fertilizers (NFs) decrease overall fertilizer requirements in agriculture while enhancing nutrient use efficiency and reducing fertilizer losses due to runoff and leaching. Accordingly, nano fertilizers present a superior alternative to conventional fertilizers due to their eco-friendly nature, cost- effectiveness, and capacity to sustain soil fertility and promote plant health. Synthetic phosphorus fertilizers exhibit low uptake efficiency due to rapid fixation in the soil, resulting in significant nutrient losses, whereas nano-phosphorus formulations enhance nutrient use efficiency by accelerating direct absorption by plants. Among phosphatic fertilizers, diammonium phosphate (DAP) is widely used due to its high nutrient content and favorable physical properties Therefore, applying DAP fertilizer in nano form offers additional benefits (Chamuah *et al.*, 2023). Nano DAP consists of nano size particles that improves phosphorus availability, enhanced root development, increased flowering, and better seed formation. Therefore, the present study was undertaken to study the effect of nano-DAP on yield and economics of sunflower.

Materials and Methods

The field experiment was carried out at Experimental farm of Agronomy Section, College of Agriculture, Latur, Maharashtra during the *kharif* season of 2024. The soil of experimental site was clayey in texture, well drained which was favourable for optimum growth of the crop. The soil samples from 0 to 30 cm depth were taken from randomly selected plots all over the experimental field before laying out the experiment. The soil was slightly alkaline in reaction having pH (7.31), low in available nitrogen (137.98 kg ha^{-1}), low in available phosphorous (9.65 kg ha^{-1}) and very high in available potassium (522.8 kg ha^{-1}). The field experiment was laid out in a Randomized Block Design (RBD) with three replications and eight treatments. The treatments were T_1 - Control (No Fertilizer), T_2 - 100 % RDF, T_3 - 100 % RDF + Two spray of 2 % DAP, T_4 - 100 % RDF + Two spray of 0.4 % Nano DAP, T_5 - 75 % RDF + Two spray of 2 % DAP, T_6- 75 % RDF + Two spray of 0.4 % Nano DAP, T_7 - 75 % RDF + One spray of 2 % DAP @ 30 DAS + One spray of 0.4 % Nano DAP @ 45 DAS and T_8 - 75 % RDF + One spray of 0.4 % Nano DAP @ 30 DAS + One spray of 2 % DAP @ 45 DAS. Each plot had a gross size of 5.4 m × 4.5 m and a net size of 4.2 m × 3.9 m. Sunflower hybrid LSFH-171 was planted on 1st July, 2024 with spacing of 60 cm × 30 cm using the dibbling method and a seed rate of 5 kg ha^{-1}. The recommended cultural practices and plant protection measures were undertaken. The recommended dose of fertilizer 90:45:45 NPK kg ha^{-1} was applied as per treatments through urea, SSP and MOP. The foliar application of DAP and nano DAP was taken as per the treatments. The crop was harvested on 5th October, 2024. Data on various variables were statistically analysed by analysis of variance (Panse and Sukhatme, 1967).

Methodology

Number of filled and unfilled seeds plant^{-1}

The five sampled plants selected at random from net plot for recording observations were used for recording the number of filled and unfilled seeds plant^{-1}.

Seed yield plant^{-1}(g)

Weight of seed plant^{-1} was recorded after harvest. The samples constituted of five randomly tagged plants from each net plot were cleaned and dried. Weight was recorded in grams.

Test weight(g)

After drying, one thousand seeds were counted from each net plot and their weight was recorded in g.

Seed yield (kgha^{-1})

Sunflower heads from each net plot were cut, rubbed against ground and seeds were separated and cleaned by winnowing. Weight of sundried seed kg net plot^{-1} was recorded and presented in kg ha^{-1}.

Stalk yield (kg ha^{-1})

Sunflower stalks harvested from each net plot were sun dried for a week and weight was recorded and converted into kg ha^{-1}.

Biological yield (kg ha^{-1})

The biological yield per plot was calculated by adding stalk yield per plot and head weight per plot and converted into hectare basis and expressed in kg ha^{-1}.

Biological yield = Headweight+ Stalk yield

Harvest Index(%)

Harvest index indicates the efficiency of plant material to convert the photosynthate in to the economic yield and it is worked out as

$$\text{Harvest Index}(\%) = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield of respective plot (kg ha}^{-1})} \times 100$$

Where,

Table 1: Yield attributes and yield of sunflower as influenced by different treatments.

Treatments	FSP	USP	SYP	TW	SY	St. Y	BY	HI
T_1- Control (No Fertilizer)	546	204	25.67	59.23	1288	2902	4190	30.75
T_2- 100 % RDF	817	171	36.51	64.48	1952	3970	5921	32.96
T_3- 100 % RDF + Two spray of 2 % DAP	887	159	39.35	65.04	2185	4505	6690	32.66
T_4- 100 % RDF + Two spray of 0.4 % Nano DAP	972	147	41.27	65.81	2443	4895	7337	33.29
T_5- 75 % RDF + Two spray of 2 % DAP	620	191	30.09	61.99	1631	3599	5229	31.18
T_6- 75 % RDF + Two spray of 0.4 % Nano DAP	745	178	34.02	64.10	1850	3914	5763	32.09
T_7- 75 % RDF + One spray of 2 % DAP @ 30 DAS + One spray of 0.4 % Nano DAP @ 45 DAS	682	185	32.67	65.29	1749	3752	5501	31.79
T_8- 75 % RDF + One spray of 0.4 % Nano DAP @ 30 DAS + One spray of 2 % DAP @ 45 DAS	777	174	35.25	63.57	1902	3890	5792	32.84
SE	**39**	**7**	**1.41**	**3.14**	**113**	**214**	**245**	**-**
C.D.at 5%	**117**	**22**	**4.28**	**NS**	**344**	**649**	**744**	**-**
G.Mean	**756**	**176**	**34.35**	**63.69**	**1875**	**3928**	**5803**	**32.20**

FSP: Filled seedplant^{-1}; **USP:** Unfilled seed plant^{-1}; **SYP:** Seed yield plant^{-1} (g); **TW:** Test weight (g); **SY:** Seed yield(kg/ha); **St. Y:** Stalk yield(kg/ha); **BY:** Biologicalyield (kg/ha); **HI:** Harvest Index(%)

Biologicalyield = Headweight + stalkyield

Stalk yield= Stalks + leaves

Gross monetary returns (Rs./ha^{-1})

The gross monetary returns occurred due to different treatments in the present study, were worked out by considering the market prices of seed yield of sunflower during the experimental year.

Cost of cultivation (Rs./ha^{-1})

The cost of cultivation of each treatment was worked out by considering the prices of variable inputs *viz.*, labour, fertilizer, seed, bullock charges, machinery charges and plant protection.

Net monetary returns (Rs./ha^{-1})

The net monetary returns of each treatment were worked out by deducting the cost of cultivation of each treatment from the gross monetary returns gained from the respective treatments.

Benefit: Cost ratio

The benefit: cost ratio of each treatment was calculated by dividing the cost of cultivation to gross monetary.

Statistical analysis and interpretation of data

Data obtained on various variables were analyzed by "Analysis of variance method" (Panse and Sukhatme, 1967). The total variance (S^2) and degree of freedom (n-1) were partitioned into different possible sources. The variance of treatments and replications were calculated and compared with error variance for finding out 'F' value and ultimately for testing the significance at P=0.05. Wherever, the results were found significant, critical differences were calculated for comparison of treatment mean at 5 % level of significance.

Results and Discussion

Yield attributes

Number of filled seeds plant^{-1}

Among various treatments, the application of 100 % RDF + Two spray of 0.4 % Nano DAP (T_4) recorded maximum number of filled seeds plant^{-1} (972) which was at par with the application of 100 % RDF + Two spray of 2 % DAP (T_3) (887) and found significantly superior over rest of the treatments (Table 1). However, the minimum number of filled seeds plant^{-1} was recorded in control (No Fertilizer) (T_1) (546). It might be due to better nutrient availability and uptake, particularly nitrogen and phosphorus during critical reproductive stage. This improved nutrient supply promotes better pollen viability, fertilization and effective seed development resulting in higher number of filled seed per plant. The nano DAP ensures quicker and more effective nutrient absorption through the leaves, resulting in improved metabolic activity and efficient translocation of assimilates towards developing seeds. These finding were in confirmative with

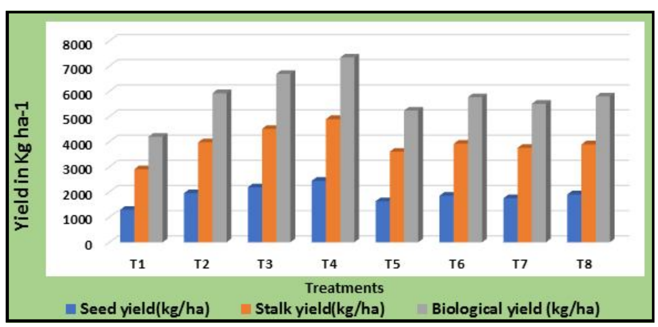

Fig. 1: Seed yield, stalk yield, biological yield (kg ha^{-1}) of sunflower as influenced by different treatments at harvest.

Table 2: Economics of sunflower as influenced by different treatments.

Treatments	GMR (Rs/ ha^{-1})	COC (Rs/ ha^{-1})	NMR (Rs/ ha^{-1})	B:C Ratio
T_1- Control (No Fertilizer)	93791	41240	52551	2.27
T_2- 100 % RDF	142081	47683	94398	2.98
T_3- 100 % RDF + Two spray of 2 % DAP	159044	51223	107821	3.10
T_4- 100 % RDF + Two spray of 0.4 % Nano DAP	177826	55483	122343	3.21
T_5- 75 % RDF + Two spray of 2 % DAP	118713	49612	69101	2.39
T_6- 75 % RDF + Two spray of 0.4 % Nano DAP	134656	53872	80784	2.50
T_7- 75 % RDF + One spray of 2 % DAP @ 30 DAS + One spray of 0.4 % Nano DAP @45 DAS	127303	51742	75561	2.46
T_8- 75 % RDF + One spray of 0.4 % Nano DAP @ 30 DAS + One spray of 2 % DAP@ 45 DAS	138490	51742	86748	2.68
SE(m) ±	**8252**	**-**	**8252**	**-**
C.D.at 5%	**25029**	**-**	**25029**	**-**
General Mean	**136488**	**50325**	**86163**	**2.70**

those reported by Rajanikanth reddy *et al.*, (2024).

Number of unfilled seeds plant^{-1}

Among various treatments, the application of 100 % RDF + Two spray of 0.4 % Nano DAP (T_4) recorded lowest number of unfilled seeds plant^{-1} (147) which was found at par with the application of 100 % RDF + Two spray of 2 % DAP (T_3) (159) and found significantly superior over rest of the treatments (Table 1). However, the highest number of unfilled seeds plant^{-1} was recorded in control (No Fertilizer) (T_1). It might be due to better nutrient availability and uptake this promotes the photosynthesis, ATP production and assimilate transport from source (leaves) to sink (developing seeds). As a result, the improved nutrient supply contributes to proper seed development, reducing the number of unfilled seeds per plant and resulting in higher production of crop.

Seed yield plant^{-1}(g)

Among various treatments, the application of 100 % RDF + Two spray of 0.4 % Nano DAP (T_4) recorded maximum seed yield plant^{-1} (41.27 g) which was found at par with the application of 100 % RDF + Two spray of 2 % DAP (T_3) (39.35 g) and found significantly superior over rest of the treatments (Table 1). However, the minimum seed yield plant^{-1} was recorded in control (No Fertilizer) (T_1) (25.67 g). Seed yield plant^{-1} is depending on various factors but majorly on number of seeds and test weight. The higher the number of seeds in plant and test weight, higher is the seed yield plant^{-1}.

Test weight(g)

Among various treatments, the application of 100 % RDF + Two spray of 0.4 % Nano DAP (T_4) recorded maximum test weight (65.81 g) over rest of the treatments (Table 1). However, the minimum test weight was recorded in control (No Fertilizer) (T_1) (59.23 g).

Yield

Data showed in Table 1 reveals that yield of sunflower *viz.*, seed yield, stalk yield, biological yield and harvest index was significantly influenced by different treatments. Application of 100 % RDF + Two spray of 0.4 % Nano DAP (T_4) recorded maximum seed yield (2443 kg ha^{-1}), stalk yield (4895 kg ha^{-1}), biological yield (7337 kg ha^{-1}) which was found at par with the application of 100 % RDF + Two spray of 2 % DAP (T_3) and found significantly superior over rest of the treatments. Maximum harvest index (33.29 %) was recorded with the application of 100 % RDF + Two spray of 0.4 % Nano DAP (T_4) compared to other treatments. However, the minimum yield attributes were recorded in control (No Fertilizer) (T_1). Higher seed yield might be attributed to higher yield parameter *viz.*, head diameter, seed yield plant^{-1}, test weight and harvest index. Moreover, the combined application of conventional fertilizer and nano DAP promotes optimal and balanced nutrient availability throughout the crop growth period. This effectiveness is due to smaller size and greater effective surface area of nanoparticles, which can easily penetrate into plant leaves and enhanced nitrogen and phosphorus uptake. The

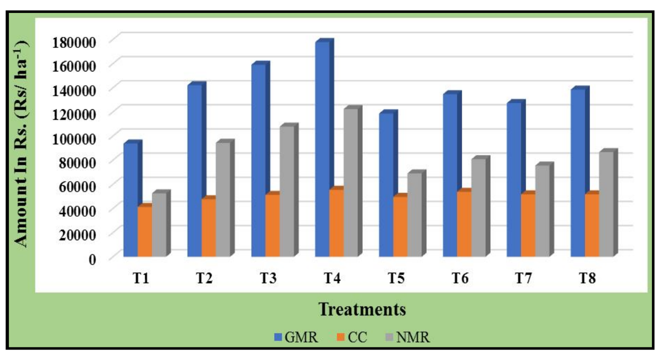

Fig. 2: Economics (Rs/ ha^{-1}) of sunflower as influenced by different treatments.

increased uptake promotes the healthy growth of plant parts and improves metabolic activities such as chlorophyll synthesis, photosynthesis that increases translocation and accumulation of photosynthates to the economically productive parts of the plant. As a result, this process increases biomass production, yield attributing characters and finally yield. Similar results were reported by Prakash *et al.*, (2023), Girigoud *et al.*, (2023), Borana *et al.*, (2024), Nandeesh *et al.*, (2024), Rajani kanth reddy *et al.*, (2024), Rajpurohit *et al.*, (2024), Sanjayakumar *et al.*, (2024) and Kumar *et al.*, (2025).

Economics

Data presented in Table 2 reveals that gross monetary return and net monetary return differed significantly among different treatments. The maximum gross monetary return (Rs 1,77,826 ha^{-1}) and net monetary return (Rs 1,22,343 ha^{-1}) was obtained with the application of 100 % RDF + Two spray of 0.4 % Nano DAP(T_4) which was found at par with the application of 100 % RDF + Two spray of 2 % DAP(T_3) and found significantly superior over rest of the treatments. The highest B:C ratio (3.21) was also obtained with the application of 100 % RDF + Two spray of 0.4 % Nano DAP(T_4). The minimum GMR, NMR and B:C ratio was obtained in control (No Fertilizer) (T_1). The observed increase in gross income is attributed to improved nutrient use efficiency and better seed development, all contributing to enhanced marketable yield. These results are in confirmative with the findings of Prakash *et al.*, (2023) in soybean and Kumar *et al.*, (2025) in sunflower.

Conclusion

Based on experimental results, it can be concluded that application of 100 % RDF + Two spray of 0.4 % Nano DAP (T_4) recorded highest yield attributes, yield and economic returns of sunflower which was followed by the application of 100 % RDF + Two spray of 2 % DAP (T_3).

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