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YIELD AND ECONOMIC OF SOYBEAN (*GLYCINE MAX* L.) AS INFLUENCED BY APPLICATION OF NANO UREA AND NANO DAP

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ABSTRACT

A field experiment was conducted during the *Kharif* season of 2024 at the Experimental Farm, Agronomy Section, College of Agriculture, Latur to study the effect of Nano Urea and Nano DAP on yield attributes, yield and economics of soybean (*Glycine max* L.). The soil was well-drained with uniform topography, providing favourable conditions for crop growth. The experiment was laid out in a Randomized Block Design (RBD) with eight treatments replicated three times *viz*., T_1 -Control (no fertilizer), T_2 -100% Recommended Dose of Fertilizer (RDF) (30:60:30 NPK kg ha^{-1}), T_3 -100% RDF + two foliar sprays of Nano Urea at 30 and 45 Days After Sowing (DAS), T_4 -100% RDF + two foliar sprays of Nano DAP at 30 and 45 DAS, T_5 -75% RDF + two sprays of Nano Urea at 30 and 45 DAS, T_6 -75% RDF + two sprays of Nano DAP at 30 and 45 DAS, T_7 -75% RDF + one spray of Nano Urea at 30 DAS and one spray of Nano DAP at 45 DAS and T_8 -75% RDF + one spray of Nano DAP at 30 DAS and one spray of Nano Urea at 45 DAS. The results indicated that application of 100% RDF + two sprays of Nano Urea at 30 and 45 DAS (T^3) recorded the highest yield parameters viz., number of seeds plant^{-1} (173.80), pod weight plant^{-1} (30.97 g), seed yield plant^{-1} (16.57 g), seed index (12.51 g), seed yield (3286 kg ha^{-1}), biological yield (8637 kg ha^{-1}) and harvest index (38.08%), gross monetary returns (Rs. 161,014 ha^{-1}), net returns (Rs. 104,568 ha^{-1}) which were statistically comparable with the application of 100% RDF (T_2) and 100% RDF + two foliar sprays of Nano DAP at 30 and 45 DAS (T_3).

***Key words*:** Soybean, RDF, nano urea, nano DAP, foliar application

Introduction

Soybean (*Glycine max* L.), often called the “Golden Bean,” is an annual legume belonging to the Fabaceae family and plays a crucial role worldwide as both a pulse and oilseed crop. Originating from East Asia, soybean was introduced to India via the ancient Silk Road around 1000 AD. The black-seeded variety ‘Kalitur’ sparked the soybean revolution in India, which further accelerated with the development of high-yielding varieties adapted to Indian agro-climatic conditions. Today, soybean is the fifth most important crop globally in terms of production and contributes approximately 20% to India’s edible oil supply. In addition to oil, India generates over ¹ 40,000 million from soya-meal exports Anonymous, (2024). Soybean seeds are a rich source of vegetable protein (40–45%), edible oil (18–20%), carbohydrates (24–26%), and essential vitamins Kaul and Das (1986). India ranks fifth globally in soybean production, following Brazil, the USA, Argentina, and China Anonymous (2023). According to the 2023–24 Economic Survey, India cultivates soybean on 132.54 lakh hectares, yielding 130.62 lakh tonnes at an average productivity of 985 kg/ha. Maharashtra leads production with 51.148 lakh hectares under soybean cultivation, 52.58 lakh tonnes production, and a yield of 1028 kg/ha. Specifically, in the Marathwada region, soybean covers 2.6 million hectares with a productivity of 1328.49 kg/ha in the 2023–24 season.

Proper nutrient management, particularly of macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), is essential to realize the crop’s full yield potential. In this scenario, nano fertilizers like nano urea and nano DAP have gained significant attention due to

Table 1: Yield attributes of soybean as influenced by different treatments.

Treatments	No. of seeds plant^{-1}	Pod yield plant^{-1}(g)	Seed yield plant^{-1}(g)	Seed index (g)
T1- Control (No Fertilizer)	120.60	16.27	9.14	10.13
T2 - 100 % RDF	163.80	29.67	15.80	11.87
T3 - 100% RDF + Two spray of Nano urea @ 30 DAS & 45 DAS	173.80	30.97	16.57	12.51
T4 - 100 % RDF + Two spray of Nano DAP @ 30 DAS & 45 DAS	164.53	30.10	15.80	12.28
T5 - 75% RDF + Two spray of Nano urea @ 30 DAS & 45 DAS	130.00	19.80	11.46	10.83
T6 - 75% RDF + Two spray of Nano DAP @ 30 DAS & 45 DAS	119.27	18.00	10.23	10.64
T7 -75% RDF + One spray of Nano urea @ 30 DAS + One spray of Nano DAP @ 45 DAS	141.50	25.83	14.13	11.17
T8 -75% RDF + One spray of Nano DAP @ 30 DAS + One spray of Nano Urea @ 45 DAS	139.00	23.43	12.27	11.01
SE (m) ±	9.10	1.50	0.80	0.74
CD at 5%	27.61	4.55	2.44	NS
General mean	144.06	24.26	13.17	11.31

their unique physical and chemical properties. Their extremely small particle size (20–50 nm) and high surface area improve nutrient absorption and utilization by plants. Foliar application of these nano formulations ensures better nutrient delivery directly through leaves, allowing for enhanced nutrient uptake efficiency and quicker physiological responses compared to soil application. Foliar treatment is more effective than traditional fertilizers as it directly targets the leaves, allowing quicker uptake and response. Nano fertilizers enhance this by penetrating the cuticle for controlled release. This method improves nutrient efficiency, yield, and reduces soil pollution. Even though leaves allow for gas exchange, their cuticle prevents things from penetrating Schwab *et al*., (2016). This leads to improved growth, higher yield, and better economic returns, while reducing the overall quantity of fertilizers needed, thus lowering input costs for farmers.

Research has shown that nano urea surpasses conventional urea in promoting plant growth, nutrient uptake, and yield Manikandan and Subramanian (2015). Additionally, nano fertilizers offer controlled and sustained nutrient release, reducing environmental pollution associated with excess fertilizer use. They also help plants better withstand abiotic stresses such as drought and heat, which are increasingly prevalent due to climate change. In summary, integrating nano urea and nano DAP into soybean nutrient management strategies can significantly enhance crop productivity and profitability by maximizing nutrient efficiency and reducing fertilizer inputs. This not only contributes to increased soybean yield but also improves farmers' economic returns, thereby supporting sustainable and environmentally friendly agricultural practices.

Materials and Methods

The field experiment was conducted during the *Kharif* season of 2024 at the farm of the Agronomy Section, College of Agriculture, Latur (Maharashtra). The soil of the experimental plot was medium and black in colour with good drainage. The topography of the experimental field was uniform and fairly level. Representative soil samples from a depth of 0 to 30 cm were collected from randomly selected plots across the experimental field before laying out the experiment. The soil was clay loam with moderate alkalinity (pH 7.4), low available nitrogen (112.9 kg ha^{-1}), medium phosphorus (7.46 kg ha^{-1}), and high potassium (1145.60 kg ha^{-1}). The region experiences a semi-arid tropical climate with an average annual rainfall of 795.3 mm, while during the crop period, total precipitation was 1017.9 mm, supporting favourable growth conditions for soybean. The field experiment was laid out in a Randomized Block Design (RBD) with three replications and eight treatments *viz*., T_1 -Control (no fertilizer), T_2 -100% Recommended Dose of Fertilizer (RDF) (30:60:30 NPK kg ha^{-1}), T_3 -100% RDF + two foliar sprays of Nano Urea at 30 and 45 Days After Sowing (DAS), T_4 -100% RDF + two foliar sprays of Nano DAP at 30 and 45 DAS, T_5 -75% RDF + two sprays of Nano Urea at 30 and 45 DAS, T_6 -75% RDF + two sprays of Nano DAP at 30 and 45 DAS, T_7 -75% RDF + one spray of Nano Urea at 30 DAS and one spray of Nano DAP at 45 DAS and T_8 -75% RDF + one spray of Nano DAP at 30 DAS and one spray of Nano Urea at 45 DAS. The gross and net plot sizes of each experimental unit were 5.4 m × 4.5 m and 4.2 m × 3.9 m, respectively. Soybean variety MAUS-158 was sown on 30th June 2024 using a spacing of 45 cm × 5 cm at a seed rate of 65 kg ha^{-1}. The recommended dose of fertilizer was 30:60:30 NPK kg ha^{-1}. Nano urea and nano DAP were applied as per the treatments. The crop was harvested on 3rd November 2024. Standard protocols

were followed for data collection, including plant growth analysis and nutrient status assessment, to evaluate the effects of nano fertilizer treatments on soybean performance. The statistical technique of analysis of variance was employed to analyse the recorded data Panse and Sukhatme (1967).

Methodology

1. **Number of Pods Plant^{-1}:** The total number of pods per plant was recorded by counting the pods from five randomly selected plants from each net plot at the time of harvest.
2. **Pod Yield Plant^{-1}(g):** Matured pods were collected from the five randomly selected plants and weighed. The pod yield per plant was recorded in grams.
3. **Seed Yield Plant^{-1}(g):** Seeds from the same five tagged plants were cleaned and dried after harvest. The seed yield per plant was then measured in grams (g).
4. **Seed Yield (kg ha^{-1}):** After harvest, plants from each net plot were threshed, and seeds were cleaned by winnowing. The cleaned seeds were weighed in kilograms and the value was converted to seed yield per hectare (kg ha^{-1}) using the appropriate hectare conversion factor.
5. **Biological Yield (kg ha^{-1}):** The biological yield was calculated using the following formula:

   Biological yield = Seed yield + Straw yield
6. **Harvest Index (%):** The Harvest Index (HI) represents the plant's efficiency in converting photosynthates into economic yield. It was calculated using the formula:

$$\text{Harvest Index} = \frac{\text{Grain Yield}}{\text{Biological Yield}} \times 100\%$$

   Where:

   Biological yield = Seed yield + Straw yield
7. **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 soybean during the experimental year.
8. **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.
9. **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.
10. **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.

Result and Discussion

Yield attributes

The perusal data in Table 1 showed that the yield attributing characters of soybean *viz.*, number of seeds plant^{-1}, pod weight plant^{-1} and seed yield plant^{-1}, were influenced significantly due to various treatments. The application of 100% RDF + two sprays of Nano Urea @ 30 DAS + 45 DAS (T_3) recorded significantly higher values of umber of seeds plant^{-1} (173.80), pod weight plant^{-1} (30.97 g) and seed yield plant^{-1} (16.57 g) which was at par with the application of 100% RDF (T_2) and 100% RDF + two foliar sprays of Nano DAP at 30 and 45 DAS (T_3) and found significantly superior over rest of the treatment. Highest seed index (12.51 g) was recorded with the application of 100% RDF + two sprays of Nano Urea @ 30 DAS + 45 DAS (T_3). The improvement in seeds per plant is attributed to enhanced nutrient use efficiency through nano fertilizer application, which promoted better vegetative growth, increased photosynthesis, and efficient assimilate translocation to developing pods. This strengthened the source-sink relationship, ensuring better seed filling and increased seed number per plant. The increase in pod yield may be due to the sustained nitrogen supply from nano urea, which

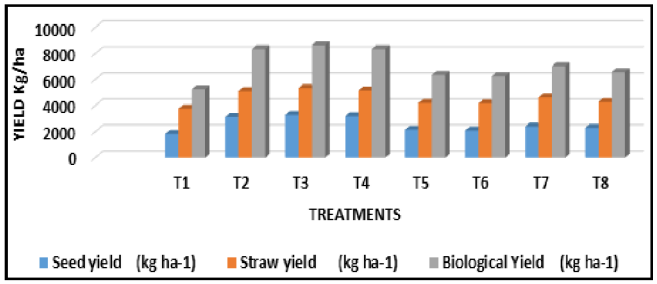

Fig. 1: Effect of different treatments on yield of soybean.

Table 2: Economics of soybean cultivation as influenced by different treatments.

Treatment	Seed yield (kg ha^{-1})	Biological Yield (kg ha^{-1})	Harvest index (%)	Gross monetary returns (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	B:C ratio
T1-Control (No Fertilizer)	1833	5267	35.44	89817	40917	1.8
T2 -100 % RDF	3130	8348	37.49	153359	98673	2.8
T3 -100% RDF + Two spray of Nano urea @ 30 DAS & 45 DAS	3286	8637	38.08	161014	104568	2.9
T4 -100 % RDF + Two spray of Nano DAP @ 30 DAS & 45 DAS	3186	8351	37.80	156098	96612	2.6
T5 -75% RDF + Two spray of Nano urea @ 30 DAS & 45 DAS	2158	6371	33.93	105758	50758	1.9
T6 -75% RDF + Two spray of Nano DAP @ 30 DAS & 45 DAS	2100	6272	33.51	102884	44844	1.8
T7 -75% RDF + One spray of Nano urea @ 30 DAS + One spray of Nano DAP @ 45 DAS	2398	7026	35.03	117502	60982	2.1
T8 -75% RDF + One spray of Nano DAP @ 30 DAS + One spray of Nano Urea @ 45 DAS	2293	6582	34.08	112373	55853	2.0
SE (m) ±	156	334	-	**7649**	**7649**	-
CD at 5%	473	1013	-	**23199**	**23199**	-
General mean	2548	7107	35.67	**124851**	**69151**	**2.20**

supported prolonged vegetative growth, better branching, and higher flower retention. The combination with RDF ensured balanced nutrient availability, improving pod initiation and development. Similar results were reported by Islam *et al*., (2023) in black gram and Peddinti *et al*., (2023) in safflower, Vasanth *et al*., (2024) in maize, Arya *et al*., (2022) Bhakher *et al*., (2023).

Yield

The application of 100% RDF + two sprays of Nano Urea @ 30 DAS + 45 DAS (T_3) recorded significantly higher seed yield (3286 kg ha^{-1}) and biological yield (8637 kg ha^{-1}) which was at par with the application of 100% RDF (T_2) and 100% RDF + two foliar sprays of Nano DAP at 30 and 45 DAS (T_3) and found significantly superior over rest of the treatment. The increased seed yield may be due to improved nutrient use efficiency from nano nitrogen, which provided a sustained nitrogen supply, enhancing photosynthesis, assimilate translocation, and seed filling. Similar findings were reported by Veeramani *et al*., (2023), Bhedela *et al*., (2024), Peddinti *et al*., (2023), and Samui *et al*., (2023) Dabhi *et al*., (2025). Highest harvest index was also observed with the application of 100% RDF + two sprays of Nano Urea @ 30 DAS + 45 DAS (T_3). This suggests improved partitioning of assimilates towards economic yield, likely due to enhanced nutrient efficiency and better reproductive growth supported by Nano Urea application, resulting in the highest harvest index.

Economics

Gross Monetary Returns and Net Monetary Returns of soybean were influenced significantly due to various treatments. The application of 100% RDF + two sprays of Nano Urea @ 30 DAS + 45 DAS (T_3) recorded significantly GMR (Rs. 161,014 ha^{-1}) and NMR (Rs. 104,568 ha^{-1}) which was at par with the application of 100% RDF (T_2) and 100% RDF + two foliar sprays of Nano DAP at 30 and 45 DAS (T_3) and found significantly superior over rest of the treatment. The observed increase in gross income is attributed to improved nutrient use efficiency, better pod development, and higher seed output, all contributing to enhanced marketable yield. Highest B:C ratio (2.9) was also observed with the application of 100% RDF + two sprays of Nano Urea @ 30 DAS + 45 DAS (T_3).

Conclusion

On the basis of present field investigation, it can be concluded that application of 100% RDF + Two spray of Nano urea @ 30 DAS & @ 45 DAS (T_3) recorded highest yield attributes, yield and economic returns of soybean, which was closely followed by the application of 100% RDF + two spray of Nano DAP @ 30 DAS & @ 45 DAS (T_4) and 100 % RDF (T_2).

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