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Effect of application of nano urea and nano DAP on growth characters of soybean (*Glycine max* L.)

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Abstract

A field experiment entitled “Studies on application of nano urea and nano DAP on growth and yield of soybean” was conducted at Research farm of All India Co-ordinated Research Project on Integrated Farming System Research, Main Centre, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* season 2023-24. The experiment was laid out in Randomized Block Design with six treatments and four replications. The soil of the experimental site was vertisol. Six treatments include, T₁: Seed priming with nano DAP, T₂: 100% RD of NPK (conventional) at the time of sowing, T₃: T₁ + 25% Conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano DAP at 20 and 40 DAS, T₄: T₁ + 50% Conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS, T₅: T₁ + 75% Conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS and T₆: T₁ + foliar spray of 100% nano urea and nano DAP at 20 and 40 DAS respectively.

The growth of soybean crop in terms of plant height, number of branches, leaf area, dry matter and root biomass per plant were significantly higher due to application of 100% RD of NPK (conventional) at the time of sowing (T₂) which was at par with seed priming with nano DAP + 75% conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS (T₅).

Keywords: Soybean, RDF, conventional, nano urea, nano DAP, foliar application

Introduction

The wonder crop ‘soybean’ (*Glycine max* L. Merrill) is a leguminous crop and belongs to family Leguminosae with sub family Papilionaceae having chromosomes number 2n=40. It is grown in tropical, sub- tropical, and temperate climates. It is also known as “Golden Bean” of the 21st century because of its nutritive value and regarded a substitute or compliment of protein. It is one of the most important protein and oilseed crop throughout the world. Its oil is the largest component of the world’s edible oil production. It is native of China and it was introduced to India in 1968. Soybean is also known as the “Miracle crop” because of its multiple uses. Soybean seed contains 18-20% oil, 40% protein, 30% carbohydrates, 4% saponin and 5% fiber. It is commonly used as pulse, oil seed, vegetarian meat and milk and oil is also used as a raw material in manufacturing antibiotics, paints, varnishes, adhesives and lubricants etc. Soybean has many important roles in human and animal nutrition. Achieving optimum quantity and increasing quality of soybean seeds depend upon many factors among which plant nutrition has critical importance. (Imliwati *et al.*, 2016) [5].

Nano-fertilizers have distinct properties due to their small size and large surface area which leads to an increase in the surface of absorption which is reflected in the increase of photosynthesis rate, thus increased plant productivity. As a result, nanotechnology is used to produce these agriculturally useful nanoparticles and it can be used in increasing the value of agricultural production (Noaema *et al.*, 2020) [11].

Nano-fertilizers play a crucial role in agriculture by enhancing crop growth, yield and quality while minimizing fertilizer wastage and cultivation costs. Through nanotechnology these fertilizers can mitigate nutrient loss via leaching thus reducing water and soil pollution. Their small particle size and large surface area enable better nutrient penetration in to the plant tissue, improving nutrient uptake and efficiency (Dimkpa *et al.*, 2019) [3].

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Nano urea exhibits a slow-release nitrogen pattern, enabling more efficient nutrient utilization with reduced fertilizer application. Nano urea offers cost-effectiveness and requires minimal quantities. Its most significant advantage when used for crop cultivation is its minimal environmental impact.

Nano DAP is an efficient source of available nitrogen (N) and phosphorus (P₂O₅) for all the crops. It corrects the nitrogen & phosphorus deficiencies in standing crops. Nutrient use efficiency is more than 90 percent under optimum field conditions. Beneficial as seed primer for early germination and vigour, enhances crop growth boosts crop yield and quality, boosts crop yield. It is cheaper than conventional DAP and is economical for the farmers and fit for residue free agriculture. (IFFCO, 2023) [4].

Now-a-days nano fertilizer technology is gaining importance for foliar application of nitrogen (N) through nano urea and phosphorus (P) through nano DAP with respect of growth and development, yield, quality and tolerance to abiotic stress in crops. With this background the present study involving nano urea and nano DAP foliar application on vegetative and reproductive growth stages of soybean crop. Therefore, it was proposed to carried out this experiment.

Materials and Methods

The experiment was conducted in kharif season of 2023-24 undertaken at Research farm of All India Co-ordinated Research Project on Integrated Farming System Research, Main Centre, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Soil of experimental plot was clayey in texture and vertisol in nature with low in available Nitrogen (172.07 kg/ha), moderate in phosphorus (14.10 kg/ha) and very high in potash (346.35 kg/ha). The experiment was carried out in a randomized block design, with six treatments and four replications. Six treatments include, T₁: Seed priming with nano DAP, T₂: 100% RD of NPK (conventional) at the time of sowing, T₃: T₁ + 25% Conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano DAP at 20 and 40 DAS, T₄: T₁ + 50% Conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS, T₅: T₁ + 75% Conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS and T₆: T₁ + foliar spray of 100% nano urea and nano DAP at 20 and 40 DAS respectively. The Gross size of experimental plot was 6.00×4.50 m and Soybean cultivar 'PDKV - Amba' was sown with spacing of 45 x 5 cm² apart by dibbling method. Seed of PDKV – Amba was sown @ 62 kg ha⁻¹

¹ on 14th July of 2023. 30:60:30 NPK kg/ha used as RDF i.e., Recommended dose of fertilizers for this variety. Basal application of conventional fertilizers was given at the time of sowing. 100%, 75%, 50% and 25% nano urea and DAP used as 4 ml/l, 3ml/l, 2ml/l and 1ml/l for this experiment. Foliar application of nano urea and DAP was given by knapsack sprayer at 20 and 40 days after sowing. Data was recorded from five plants selected randomly from each replication of treatment. The harvesting of soybean crop was done on 16th October of 2023. Data on growth parameters such as plant height, number of branches, leaf area, dry matter accumulation and root biomass per plant of soybean were analysed statistically using ANOVA.

Results and Discussion

Effect of treatments on growth characters of soybean

Plant height (cm)

Data suggested that at 20 DAS plant height results were found non-significant, while significant variation was noticed regarding plant height at 40, 60, 80 DAS and at harvest.

Plant height at 40, 60, 80 DAS and at harvest was found significant. The mean of plant height was recorded as 31.42, 40.53, 45.63 and 44.11 cm respectively. At these stages significantly maximum plant height was observed in treatment T₂ (100% RD of NPK (conventional) at the time of sowing) and it was found at par with treatment T₅ (Seed priming with nano DAP + 75% conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS). These treatments were found to be superior over treatments T₁, T₃ and T₆ respectively except at 60 DAS where treatment T₅ was found at par with treatment T₃.

However, treatment T₅ (Seed priming with nano DAP + 75% conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS) was found at par with treatment T₄ (Seed priming with nano DAP + 50% conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS) and treatment T₄ at par with treatment T₃ (Seed priming with nano DAP + 25% conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano at 20 and 40 DAS) except at 80 DAS and at harvest treatment T₄ was found at par with treatment T₆ (Seed priming with nano DAP + foliar spray of 100% nano urea and nano DAP at 20 and 40 DAS) at 60 DAS. The lowest plant height was observed in T₁ (Seed priming with nano DAP).

Similar results were reported by Midde S. *et al.* (2022) [10], Jadhav *et al.* (2023) [6] and Vyankatrao *et al.* (2024) [15].

Table 1: Effect of different treatments on plant height (cm) of soybean

Treatments	Plant height (cm)				
	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest
T ₁ : Seed priming with nano DAP	15.65	25.38	33.57	37.46	36.13
T ₂ : 100% RD of NPK(conventional) at the time of sowing	17.69	37.40	48.20	54.56	52.71
T ₃ : T ₁ + 25% Conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano at 20 and 40 DAS	16.46	30.02	39.31	42.46	40.89
T ₄ : T ₁ + 50% Conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS	16.67	32.15	40.47	48.56	46.79
T ₅ : T ₁ + 75% Conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS	17.34	35.63	43.99	49.10	48.19
T ₆ : T ₁ + Foliar spray of 100% nano urea and nano DAP at 20 and 40 DAS	16.29	27.96	37.64	41.66	39.62
S.E (m)+	0.53	1.34	1.55	1.96	1.93
CD at 5%	NS	4.05	4.68	5.91	5.82
GM	16.68	31.42	40.53	45.63	44.11

Number of branches plant⁻¹

The observations suggested that at 20 DAS the number of

branches plant⁻¹ results were found to be non-significant, while significant variation was noticed regarding number of branches

plant⁻¹ at 40, 60 and 80 DAS.

The number of branches plant⁻¹ at 40, 60 and 80 DAS was found significant. The mean of number of branches plant⁻¹ was recorded as 2.87, 4.91 and 5.10 respectively. At these stages significantly maximum number of branches plant⁻¹ was observed in treatment (T₂) 100% RD of NPK (conventional) at the time of sowing. However, treatment T₂ at par with application of seed priming with nano DAP + 75% conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS (T₅), seed priming with nano DAP + 50% conventional urea & DAP basal at sowing + foliar spray of 50%

nano urea & nano DAP at 20 and 40 DAS (T₄), seed priming with nano DAP + 25% conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano at 20 and 40 DAS (T₃) and seed priming with nano DAP + foliar spray of 100% nano urea and nano DAP at 20 and 40 DAS (T₆) except at 60 DAS and minimum number of branches plant⁻¹ found in treatment T₁ (Seed priming with nano DAP) and the rest of the treatments.

The results are in agreement with those reported by Khemshetty *et al.* (2024)^[8] and Balachandrakumar *et al.* (2024)^[2].

Table 2: Effect of different treatments on number of branches plant⁻¹ of soybean

Treatments	Number of branches plant ⁻¹			
	20 DAS	40 DAS	60 DAS	80 DAS
T ₁ : Seed priming with nano DAP	0.85	2.55	4.10	4.18
T ₂ : 100% RD of NPK (conventional) at the time of sowing	1.03	3.15	5.44	5.56
T ₃ : T ₁ + 25% Conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano DAP at 20 and 40 DAS	0.92	2.83	4.88	5.08
T ₄ : T ₁ + 50% Conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS	0.97	2.84	4.91	5.25
T ₅ : T ₁ + 75% Conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS	1.00	3.07	5.30	5.49
T ₆ : T ₁ + Foliar spray of 100% nano urea and nano DAP at 20 and 40 DAS	0.91	2.79	4.82	5.05
S.E (m)+	0.04	0.13	0.20	0.21
CD at 5%	NS	0.38	0.60	0.62
GM	0.94	2.87	4.91	5.10

Leaf area plant⁻¹ (dm²)

Data suggested that at 20 DAS leaf area plant⁻¹ (dm²) results were found to be non-significant, while significant variation was noticed regarding leaf area per plant at 40, 60 and 80 DAS.

It was observed that the mean leaf area (dm²) plant⁻¹ increased rapidly from 40 DAS to 60 DAS and thereafter decreased progressively at 80 DAS due to leaf senescence. The general mean leaf area plant⁻¹ of soybean at 40, 60 and 80 DAS was 10.30, 13.11 and 8.69 dm² respectively.

Application of 100% RD of NPK(conventional) at the time of sowing (T₂) recorded significantly maximum leaf area plant⁻¹ and it was at par with treatments seed priming with nano DAP + 75% conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS (T₅) and seed

priming with nano DAP + 50% conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS (T₄) at 40 and 60 DAS, whereas at 80 DAS treatment T₂ was at par with treatment T₅ and was significantly superior over treatment T₄. Similarly, Treatment T₃ (Seed priming with nano DAP + 25% conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano at 20 and 40 DAS) was at par with treatment T₆ (Seed priming with nano DAP + foliar spray of 100% nano urea and nano DAP at 20 and 40 DAS) and T₁ (Seed priming with nano DAP) at all the growth stages.

Results analogous to this have also been reported by Khemshetty *et al.* (2024)^[8] and Abisankar *et al.* (2024)^[1].

Table 3: Effect of different treatments on leaf area plant⁻¹ (dm²) of soybean

Treatments	Leaf area plant ⁻¹ (dm ²)			
	20 DAS	40 DAS	60 DAS	80 DAS
T ₁ : Seed priming with nano DAP	2.31	9.12	11.62	7.38
T ₂ : 100% RD of NPK (conventional) at the time of sowing	2.87	11.43	14.60	10.06
T ₃ : T ₁ + 25% Conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano DAP at 20 and 40 DAS	2.52	10.07	12.79	8.43
T ₄ : T ₁ + 50% Conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS	2.64	10.35	13.16	8.60
T ₅ : T ₁ + 75% Conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS	2.66	11.15	14.21	9.42
T ₆ : T ₁ + Foliar spray of 100% nano urea and nano DAP at 20 and 40 DAS	2.45	9.70	12.30	8.24
S.E (m)+	0.17	0.43	0.53	0.39
CD at 5%	NS	1.30	1.61	1.18
GM	2.57	10.30	13.11	8.69

Dry matter plant⁻¹ (gm)

At 20 DAS dry matter plant⁻¹ (gm) results were found non-significant, while significant variation was noticed at 40, 60, 80 DAS and at harvest.

Dry matter plant⁻¹ (gm) at 40, 60, 80 DAS and at harvest was found significant. The mean of dry matter plant⁻¹ (gm) was recorded as 3.72, 14.57, 23.98 and 25.79. At these stages maximum dry matter plant⁻¹ (gm) was observed in treatment T₂

(100% RD of NPK (conventional) at the time of sowing). However, it was found at par with treatment T₅ (Seed priming with nano DAP + 75% conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS) at all the growth stages. Similarly, treatment T₅ was at par with treatment T₄ (Seed priming with nano DAP + 50% conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS) at all the growth stages, treatment T₃ (Seed priming with nano DAP + 25%

conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano at 20 and 40 DAS) was at par with treatment T₆ (Seed priming with nano DAP + foliar spray of 100% nano urea and nano DAP at 20 and 40 DAS) at all the growth stages and with treatment T₁ (Seed priming with nano DAP) at 40 and 60 DAS only.

The results obtained in this regard are in close accordance with Srivastava and Singh (2023) ^[14], Saitheja *et al.* (2022) ^[12] and Singh *et al.* (2023) ^[13].

Table 4: Effect of different treatments on dry matter plant⁻¹ (gm) of soybean

Treatments	Dry matter plant ⁻¹ (gm)				
	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest
T ₁ : Seed priming with nano DAP	1.54	3.01	10.82	18.14	20.30
T ₂ : 100% RD of NPK(conventional) at the time of sowing	1.86	4.64	18.82	29.49	31.01
T ₃ : T ₁ + 25% Conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano DAP at 20 and 40 DAS	1.64	3.41	13.64	23.23	24.83
T ₄ : T ₁ + 50% Conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS	1.65	3.72	15.12	24.46	26.55
T ₅ : T ₁ + 75% Conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS	1.75	4.30	16.44	26.49	28.89
T ₆ : T ₁ + Foliar spray of 100% nano urea and nano DAP at 20 and 40 DAS	1.54	3.23	12.59	22.05	23.19
S.E (m)±	0.08	0.22	0.98	1.03	1.24
CD at 5%	NS	0.65	2.82	3.12	3.75
GM	0.24	3.72	14.57	23.98	25.79

Root biomass plant⁻¹(g)

Data suggested that at 20 DAS the root biomass plant⁻¹ result was found to be non-significant, while significant variation was noticed regarding root biomass plant⁻¹ at 40, 60 and 80 DAS.

The number of root biomass plant⁻¹ at 40, 60 and 80 DAS was found to be significant. The mean root biomass plant⁻¹ was recorded 1.40, 4.22 and 3.01 g respectively. At all the stages maximum root biomass plant⁻¹ was observed with application of 100% RD of NPK(conventional) at the time of sowing (T₂).

At 40 DAS application of 100% RD of NPK(conventional) at the time of sowing (T₂) was found at par with treatments T₅ (Seed priming with nano DAP + 75% conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS), T₄ (Seed priming with nano DAP + 50% conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS) and T₃ (Seed priming

with nano DAP + 25% conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano DAP at 20 and 40 DAS).

At 60 DAS application of 100% RD of NPK (conventional) at the time of sowing (T₂) at par with treatment T₅ (Seed priming with nano DAP + 75% conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS) and treatment T₄ (Seed priming with nano DAP + 50% conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS) at par with T₃ (Seed priming with nano DAP + 25% conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano DAP at 20 and 40 DAS).

These views are also supported by Liu and Lal (2021) ^[9] and Kanjilal *et al.* (2023) ^[7].

Table 5: Effect of different treatments on root biomass plant⁻¹(g) of soybean

Treatments	Root biomass plant ⁻¹ (g)			
	20 DAS	40 DAS	60 DAS	80 DAS
T ₁ : Seed priming with nano DAP	0.61	1.27	3.12	2.72
T ₂ : 100% RD of NPK (conventional) at the time of sowing	0.72	1.54	5.10	3.29
T ₃ : T ₁ + 25% Conventional urea & DAP basal at sowing + foliar spray of 75% nano urea & nano DAP at 20 and 40 DAS	0.63	1.38	4.11	2.95
T ₄ : T ₁ + 50% Conventional urea & DAP basal at sowing + foliar spray of 50% nano urea & nano DAP at 20 and 40 DAS	0.66	1.39	4.23	2.96
T ₅ : T ₁ + 75% Conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS	0.69	1.50	4.81	3.21
T ₆ : T ₁ + Foliar spray of 100% nano urea and nano DAP at 20 and 40 DAS	0.62	1.36	3.97	2.92
S.E (m)±	0.03	0.06	0.16	0.12
CD at 5%	NS	0.17	0.50	0.37
GM	0.66	1.40	4.22	3.01

Conclusion

Plant height, number of branches, leaf area, dry matter and root biomass per plant were significantly influenced with different conventional and combination of conventional with foliar

application of fertilizers. Among the different treatments 100% RD of NPK (conventional) at the time of sowing (T₂) shows maximum growth and yield attributing characters which is at par with treatment T₅ (Seed priming with nano DAP + 75%

conventional urea & DAP basal at sowing + foliar spray of 25% nano urea & nano DAP at 20 and 40 DAS).

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