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**VP Bhone**

PG Student, Department of  
 Soil Science, Dr. Panjabrao  
 Deshmukh Krishi Vidyapeeth,  
 Akola, Maharashtra, India

**VV Gabhane**

Professor (CAS), AICRP for  
 Dryland Agriculture,  
 Dr. Panjabrao Deshmukh  
 Krishi Vidyapeeth, Akola,  
 Maharashtra, India

**Monika S Bhavsar**

Ph.D Research Scholar,  
 Department of Soil Science and  
 Agricultural Chemistry,  
 Dr. Panjabrao Deshmukh  
 Krishi Vidyapeeth, Akola,  
 Maharashtra, India

**MS Yerme**

PG Student, Department of  
 Soil Science, Dr. Panjabrao  
 Deshmukh Krishi Vidyapeeth,  
 Akola, Maharashtra, India

**SD Jadhao**

Professor (CAS), Department  
 of Soil Science, Dr. Panjabrao  
 Deshmukh Krishi Vidyapeeth,  
 Akola, Maharashtra, India

**Mohammad Sajid**

Assistant Professor, College of  
 Agriculture, Dr. Panjabrao  
 Deshmukh Krishi Vidyapeeth,  
 Akola, Maharashtra, India

**MM Ganvir**

Assistant Professor, AICRP for  
 Dryland Agriculture,  
 Dr. Panjabrao Deshmukh  
 Krishi Vidyapeeth, Akola,  
 Maharashtra, India

**Corresponding Author:****Monika S Bhavsar**

Ph.D Research Scholar,  
 Department of Soil Science and  
 Agricultural Chemistry,  
 Dr. Panjabrao Deshmukh  
 Krishi Vidyapeeth, Akola,  
 Maharashtra, India

## Effect of foliar application of nano-urea on yield, nutrient uptake and biochemical properties of rainfed cotton in Vertisols

**VP Bhone, VV Gabhane, Monika S Bhavsar, MS Yerme, SD Jadhao, Mohammad Sajid and MM Ganvir**

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**Abstract**

A field study entitled, "Effect of foliar application of nano-urea on yield, nutrient uptake and biochemical properties of rainfed cotton in Vertisols" was conducted at research field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during the year 2023-24 in *Kharif* season. The experiment was laid out in randomized block design with nine treatment and three replications. Nine treatments comprised of control (no fertilizer), 100% RDF (60:30:30 NPK kg ha<sup>-1</sup>), 100% RDF and spraying of Nano-urea (once-60 DAS), 100% RDF and spraying of Nano-urea (twice-60 & 90 DAS), 100% RDF and spraying of Nano-urea (thrice-45, 60 & 90 DAS), 75% RDN + Recommended PK, 75% RDN + Recommended PK and spraying of Nano-urea (once-60 DAS), 75% RDN + Recommended PK and spraying of Nano-urea (twice-60 & 90 DAS), 75% RDN + Recommended PK and spraying of Nano-urea (thrice-45, 60 & 90 DAS). The results indicated that the application of 100% recommended NPK and spraying of Nano-urea @ 4 ml/liter resulted in higher nutrient uptake and yield of cotton and was on par with 100% RDF. However, application of 100% recommended NPK and spraying of Nano-urea @ 4 ml/liter resulted in higher improvement in biochemical properties of cotton in Vertisols under rainfed conditions.

**Keywords:** Biochemical properties, nano-urea, nutrient uptake, seed cotton yield, Vertisol

**Introduction**

In India, cotton (*Gossypium hirsutum*), known as "white gold", is one of the most important commercial products. It earns a lot of money by using resources from its valuable products. As a major fiber product, it earns a lot of money by subsidizing the property and oil industries. A primary supply of protein (30-40%) for animal feed. Cotton employs 350 million people across the sector in production, manufacturing, transportation and storage. The top three cotton-producing countries are China, India and the United States, followed by Pakistan, Brazil, Australia, Uzbekistan, Turkey, Turkmenistan, Burkina, Mali, Greece and Burma (Aslam *et al.*, 2020) [3].

India dominates the area under cotton cultivation, with 130 thousand hectares of cotton growing, which is 40% of the world's cotton area. Globally, although India accounts for 40% of the area, it can produce only 21% of the world's cotton production. While in China, it has 30 lakh hectares of land and produces 59.80 lakh tonnes of cotton. Globally, cotton production is high in Australia, followed by China, Turkey, Brazil, Mexico and the United States. India's yield is 400 kg/ha (Anonymous, 2023) [1]. Cotton production in India in 2022-23 is estimated to produce 337.23 lakh bales from 130.49 lakh hectares with a yield of 439 kg lint per hectare. In India, Gujarat, Maharashtra and Telangana are the major cotton growing states of the country. Maharashtra leads with 42.29 lakh hectares, accounting for 32.53% of the nation's total cotton growing area (130.60 lakh hectares). However, in production, it ranks second, yielding 84.13 lakh bales, which is 17% of the total production, with Gujarat taking the top spot with 91.83 lakh bales. Maharashtra stands 9<sup>th</sup> in productivity, with 338.19 kg/ha.

Nano-urea as a foliar spray in small quantities helps the easy absorption of nitrogen through the stomata, which improves the growth of the product, delivery and reduces production costs. Foliar application of nano-nitrogen at critical stages of growth such as flower initiation, bud initiation and bud development increases growth and yield.

(Gousia *et al.* 2023) [12]. Nano fertilizers have a higher surface area due to their smaller particle size, which gives them more space to regulate various metabolic processes in the plant system, thus increasing photosynthesis. Due to its high surface area and smaller size, it reacts with other compounds very well. It is very soluble in various solvents such as water. The particle size of nano fertilizers ranges from 1-100 nm that support the nutrition of the plants (Avila-Quezada *et al.* 2022) [6].

## Materials and Methods

A field experiment on the effect of foliar application of nano-urea on yield and nutrient uptake by rainfed cotton in Vertisols was initiated during 2023-2024 under the All India Coordinated Research Project for Dryland Agriculture, Dr. PDKV, Akola, Maharashtra. Most of the rainfall in this region is received from June to September from the southwest monsoon. Experimental soil was nearly neutral to slightly alkaline in nature.

The experiment was laid out in randomized block design with nine treatment and three replications. Nine treatments comprised of control (no fertilizer), 100% RDF(60:30:30 NPK kg ha<sup>-1</sup>), 100% RDF and spraying of Nano-urea @ 4 ml/l (once-60 DAS), 100% RDF and spraying of Nano-urea (twice- 60 & 90 DAS), 100% RDF and spraying of Nano-urea

(thrice-45, 60 & 90 DAS), 75% RDN + Recommended PK, 75% RDN + Recommended PK and spraying of Nano-urea (once-60 DAS), 75% RDN + Recommended PK and spraying of Nano-urea (twice- 60 & 90 DAS), 75% RDN + Recommended PK and spraying of Nano-urea (thrice-45, 60 & 90 DAS).

## Results and Discussion

### Cotton yield

The data on seed cotton and stalk yield of cotton (Table 1) as influenced by various treatments was found to be significant. The mean seed cotton yield ranged between (704.09 to 1096.10 kg ha<sup>-1</sup>). However, significantly higher seed cotton yield (1096.10 kg ha<sup>-1</sup>) was observed in treatment 100% RDF and spraying of Nano-urea (thrice-45, 60 & 90 DAS) (T<sub>5</sub>) and was on par with treatment 100% RDF and spraying of Nano-urea (twice- 60 & 90 DAS) (T<sub>4</sub>), 100% RDF and spraying of Nano-urea (once-60 DAS) (T<sub>3</sub>) and 100% RDF (T<sub>2</sub>). The lowest seed cotton yield (704.09 kg ha<sup>-1</sup>) was recorded in treatment control (no fertilizer) (T<sub>1</sub>). The increase in seed cotton yield in treatment 100% RDF and spraying of Nano-urea (thrice-45, 60 & 90 DAS) (T<sub>5</sub>) was 55.6% and 11% higher as compared to control (no fertilizer) (T<sub>1</sub>) and 100% RDF (T<sub>2</sub>) respectively.

**Table 1: Effect of foliar application of nano urea on cotton yield**

Treatments		Cotton yield (kg ha <sup>-1</sup> )	
		Seed cotton	Stalk
T <sub>1</sub>	Control (no fertilizer)	704.09	1209.4
T <sub>2</sub>	100% Recommended NPK	987.45	1697.1
T <sub>3</sub>	100% Recommended NPK and spraying of Nano-urea (once-60 DAS)	973.18	1672.4
T <sub>4</sub>	100% Recommended NPK and spraying of Nano-urea (twice- 60 & 90 DAS)	991.60	1705.2
T <sub>5</sub>	100% Recommended NPK and spraying of Nano-urea (thrice-45, 60 & 90 DAS)	1096.10	1885.0
T <sub>6</sub>	75% Recommended N + Recommended PK	824.08	1279.4
T <sub>7</sub>	75% Recommended N + Recommended PK and spraying of Nano-urea (once-60 DAS)	885.21	1372.1
T <sub>8</sub>	75% Recommended N + Recommended PK and spraying of Nano-urea (twice- 60 & 90 DAS)	904.77	1403.8
T <sub>9</sub>	75% Recommended N + Recommended PK and spraying of Nano-urea (thrice-45, 60 & 90 DAS)	902.41	1410.3
SE (m) ±		60.40	101.8
CD at 5%		181.09	305.20
CV		11.39	11.64

The mean stalk yield of cotton ranged from 1209.4 to 1885.0 kg ha<sup>-1</sup>. The higher stalk yield (1885.0 kg ha<sup>-1</sup>) was recorded in treatment 100% RDF and spraying of Nano-urea (thrice-45, 60 & 90 DAS) (T<sub>5</sub>). The lowest cotton stalk yield (1209.4 kg ha<sup>-1</sup>) was recorded with treatment control (no fertilizer) (T<sub>1</sub>). The increase in cotton stalk yield in treatment 100% RDF and spraying of Nano-urea (thrice-45, 60 & 90 DAS) (T<sub>5</sub>) was 55.8% and 11% higher as compared to control (no fertilizer) (T<sub>1</sub>) and 100% RDF (T<sub>2</sub>) respectively. Application of RDF along with spraying of Nano-urea resulted increase in seed cotton and stalk yield. This might be due to increasing nutrient levels as nano form of nitrogen is more easily absorbed by the plants. The foliar application of nano nitrogen helps to increase the photosynthetic rate of the plants, which can lead to increased plant dry matter accumulation, which may have served as a source of photosynthates for reproductive bolls, leading to increased weight of bolls, boll production which in turn have lead to higher seed cotton yield. The results are in conformity with the findings Attri *et al.* (2022) [5], Arya *et al.* (2022) [2], Goud *et al.* (2022) [11], Hemanth *et al.* (2022) [14], Rawate *et al.* (2022) [18], Samanta *et al.* (2022) [20] and Gousia *et al.* (2023) [12].

## Nutrients uptake

### Nitrogen uptake

The data on effect of nano urea on total N uptake by cotton (Table 2) indicate that significantly higher total N uptake (51.14 kg ha<sup>-1</sup>) by cotton was observed with treatment 100% RDF and spraying of Nano-urea (thrice-45, 60 & 90 DAS) (T<sub>5</sub>) and was on par with 100% RDF and spraying of Nano-urea (twice- 60 & 90 DAS) (T<sub>4</sub>), 100% RDF and spraying of Nano-urea (once-60 DAS) (T<sub>3</sub>) and 100% RDF (T<sub>2</sub>). The lowest total N uptake by cotton (31.14 kg ha<sup>-1</sup>) was observed in treatment control (no fertilizer) (T<sub>1</sub>). The increase in total N uptake by cotton was 64.2% and 15.7% in treatment (T<sub>5</sub>) as compared to treatment T<sub>1</sub> and T<sub>2</sub> respectively. The increase in N uptake in cotton after spraying of nano urea is due to fact that Nano-fertilizers have large surface area and particle size, less than the pore size of root and leaves of the plant which can increase penetration into the plant from applied surface and improve uptake and nutrient use efficiency of the nano-fertilizer. Reduction of particle size results in increased specific surface area and number of particles per unit area of a fertilizer that provide more opportunity to contact of nano-fertilizer which leads to more penetration and uptake of the nutrient and thus results in high

nutrient use efficiency. The results are in conformity with the findings of Kanno *et al.* (2022) <sup>[15]</sup>, Gousia *et al.* (2023) <sup>[12]</sup>, Parve *et al.* (2023) <sup>[17]</sup> and Sahu *et al.* (2022) <sup>[19]</sup>.

### Phosphorus uptake

The data on effect of nano urea on total P uptake by cotton (Table 2) indicate that significantly higher total P uptake by cotton (11.87 kg ha<sup>-1</sup>) was observed in treatment 100% RDF and spraying of Nano-urea (thrice-45, 60 & 90 DAS) (T<sub>5</sub>) and was on par with application of 100% RDF (T<sub>2</sub>), 100% RDF and spraying of Nano-urea (once-60 DAS) (T<sub>3</sub>) and 100% RDF and spraying of Nano-urea (twice- 60 & 90 DAS) (T<sub>4</sub>). The lowest total P uptake by cotton (7.58 kg ha<sup>-1</sup>) was

observed in treatment control (no fertilizer) (T<sub>1</sub>). The increase in total P uptake by cotton was 56.6% and 3% in treatment (T<sub>5</sub>) as compared to treatment T<sub>1</sub> and T<sub>2</sub> respectively. The increase in P uptake in cotton after spraying of nano urea might be due to fact that, increase in the nitrogen uptake increase the root growth and uptake capacity for phosphorus by plant. Linear increase in nitrogen concentration due to application of nano urea helps to root proliferation of the cotton which leads to higher content and uptake of the phosphorus by cotton. The results are in conformity with the findings of Sahu *et al.* (2022) <sup>[19]</sup>, and Gousia *et al.* (2023) <sup>[12]</sup>, NamaSharma *et al.* (2023) <sup>[16]</sup>, and Parve *et al.* (2023) <sup>[17]</sup>

**Table 2:** Effect of foliar application of nano urea on nutrient uptake by cotton

Treatments		Nutrient uptake (kg ha <sup>-1</sup> )		
		N	P	K
T <sub>1</sub>	Control (no fertilizer)	31.14	7.58	23.38
T <sub>2</sub>	100% Recommended NPK	44.20	11.52	34.17
T <sub>3</sub>	100% Recommended NPK and spraying of Nano-urea (once-60 DAS)	45.36	10.83	34.49
T <sub>4</sub>	100% Recommended NPK and spraying of Nano-urea (twice- 60 & 90 DAS)	46.01	10.68	34.31
T <sub>5</sub>	100% Recommended NPK and spraying of Nano-urea (thrice-45, 60 & 90 DAS)	51.14	11.87	37.98
T <sub>6</sub>	75% Recommended N + Recommended PK	34.49	8.34	24.74
T <sub>7</sub>	75% Recommended N + Recommended PK and spraying of Nano-urea (once-60 DAS)	37.31	8.86	27.57
T <sub>8</sub>	75% Recommended N + Recommended PK and spraying of Nano-urea (twice- 60 & 90 DAS)	37.71	8.74	28.03
T <sub>9</sub>	75% Recommended N + Recommended PK and spraying of Nano-urea (thrice-45, 60 & 90 DAS)	38.06	8.77	27.57
SE (m) ±		2.65	0.71	2.01
CD at 5%		7.96	2.12	6.03
CV		11.32	12.6	11.51

### Potassium uptake

The data (Table 2) on effect of nano urea on total K uptake by cotton indicate that significantly higher K uptake (37.98 kg ha<sup>-1</sup>) by cotton was observed in treatment 100% RDF and spraying of Nano-urea (thrice-45, 60 & 90 DAS) (T<sub>5</sub>) and was on par with 100% RDF and spraying of Nano-urea (once-60 DAS) (T<sub>3</sub>), 100% RDF and spraying of Nano-urea (twice- 60 & 90 DAS) (T<sub>4</sub>), and 100% RDF (T<sub>2</sub>). The lowest K uptake by cotton (23.38 kg ha<sup>-1</sup>) was observed in treatment control (no fertilizer) (T<sub>1</sub>). The increase in total K uptake by cotton was 62.4% and 11.1% in treatment (T<sub>5</sub>) as compared to treatment T<sub>1</sub> and T<sub>2</sub> respectively.

The increase in K uptake in cotton after spraying of nano urea might be due to nano structured formulation that controls the release speed of nutrients to match the uptake pattern of crop. Nano sized formulation of mineral nutrient may improve solubility and dispersion of insoluble nutrients in soil, reduce nutrient losses, fixation and increase the bioavailability which leads to increased potash use efficiency. The results are in conformity with the findings of Gousia *et al.* (2023) <sup>[12]</sup> and Parve *et al.* (2023) <sup>[17]</sup>.

### Carbohydrates

The data indicated that significantly higher carbohydrates in leaf (0.95 mg g<sup>-1</sup>) was observed in treatment 100% RDF and spraying of Nano-urea (thrice-45, 60 & 90 DAS) (T<sub>5</sub>) and was on par with 100% RDF and spraying of Nano-urea (twice- 60 & 90 DAS) (T<sub>4</sub>), 100% RDF and spraying of Nano urea (once-60 DAS) (T<sub>3</sub>). The increase in carbohydrates content in cotton leaf was 21.8% and 11.7% higher in treatment (T<sub>5</sub>) as compared to treatment T<sub>1</sub> and T<sub>2</sub> respectively.

Nitrogen is an important component of chlorophyll which is responsible for photosynthesis. Higher nitrogen availability from nano urea enhances chlorophyll content, which in turn improves photosynthetic rates. This leads to increased carbohydrate production in leaf. The photosynthesis process directly produces sugars, starches, and other carbohydrates, such as glucose, fructose, and starch, in cotton leaves. This carbohydrate accumulation serves as an energy reserve that supports growth and development, particularly under stressful conditions. The results are in conformity with the findings of Attia *et al.* (2016) <sup>[4]</sup> and Guo *et al.* (2022) <sup>[13]</sup>

### Flavonoid

Application of 100% RDF and spraying of Nano-urea (thrice-45, 60 & 90 DAS) (T<sub>5</sub>) found significantly superior over other treatments resulting in lowest flavonoids content in leaf. The decrease in flavonoids under high N fertilization might be attributed to decrease in phenylalanine availability due to enhancement of protein synthesis under N availability. The results are in conformity with the findings of Stewart *et al.* (2001) <sup>[21]</sup>, Awad and Jager (2002) <sup>[7]</sup> and Ben Abdallah *et al.* (2018) <sup>[8]</sup>.

### Anthocyanin

The data indicated that the application of 100% RDF and spraying of Nano-urea (thrice-45, 60 & 90 DAS) (T<sub>5</sub>) found significantly superior over other treatments resulting in lowest anthocyanin content in leaf tissue. Anthocyanin pigment in cotton leaves were found to be increased with maturity of crops.

**Table 3:** Effect of foliar application of nano urea biochemical properties of cotton

Treatments		Carbohydrates (mg g <sup>-1</sup> )	Flavonoid (mg 100 g <sup>-1</sup> )	Anthocyanin (mg g <sup>-1</sup> )
T <sub>1</sub>	Control (no fertilizer)	0.78	2.70	3.10
T <sub>2</sub>	100% Recommended NPK	0.85	2.65	3.01
T <sub>3</sub>	100% Recommended NPK and spraying of Nano-urea (once-60 DAS)	0.90	2.61	2.93
T <sub>4</sub>	100% Recommended NPK and spraying of Nano-urea (twice- 60 & 90 DAS)	0.94	2.51	2.82
T <sub>5</sub>	100% Recommended NPK and spraying of Nano-urea (thrice-45, 60 & 90 DAS)	0.95	2.43	2.63
T <sub>6</sub>	75% Recommended N + Recommended PK	0.80	2.73	3.06
T <sub>7</sub>	75% Recommended N + Recommended PK and spraying of Nano-urea (once-60 DAS)	0.84	2.70	2.99
T <sub>8</sub>	75% Recommended N + Recommended PK and spraying of Nano-urea (twice- 60 & 90 DAS)	0.86	2.80	2.98
T <sub>9</sub>	75% Recommended N + Recommended PK and spraying of Nano-urea (thrice-45, 60 & 90 DAS)	0.88	2.80	2.95
SE (m) ±		0.02	0.02	0.03
CD at 5%		0.05	0.05	0.08

Results indicated that foliar application of nutrients found to be beneficial for minimizing the anthocyanin pigment because during boll development stage leaf nutrients translocated toward bolls and deficiency of nutrients occur which reduces the chlorophyll and enhances the anthocyanin accumulation in leaf. Reduction in anthocyanin content might be due to foliar application of macro and micronutrients at specific growth stages of cotton which increased the supply of nitrogen to leaf and reduce the formation of anthocyanin. The results are in conformity with the findings of Byale *et al.* (2014)<sup>[9]</sup> and Deshmukh *et al.* (2019)<sup>[10]</sup>.

### Conclusion

Hence, it is concluded that the application of 100% recommended NPK and spraying of Nano-urea @ 4 ml/liter resulted in higher nutrient uptake and yield of cotton and was on par with 100% RDF. However, application of 100% recommended NPK and spraying of Nano-urea @ 4 ml/liter resulted in higher improvement in biochemical properties of cotton in Vertisols under rainfed conditions.

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