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Priya K Modi
Ph.D. Scholar, Department of
Agronomy, N. M. College of
Agriculture, Navsari Agricultural
University, Navsari, Gujarat, India

Brijesh K Patel
Associate Research Scientist, Pulse
and Castor Research Station,
Navsari Agricultural University,
Navsari, Gujarat, India

Harsh N Patel
Ph.D. Scholar, Department of Soil
Science and Agricultural
Chemistry, N. M. College of
Agriculture, Navsari Agricultural
University, Navsari, Gujarat, India

JV Patel
Assistant Research Scientist,
Navsari Agricultural University,
Navsari, Gujarat, India

Corresponding Author:
Priya K Modi
Ph.D. Scholar, Department of
Agronomy, N. M. College of
Agriculture, Navsari Agricultural
University, Navsari, Gujarat, India

Optimizing nitrogen management with foliar spray for enhanced productivity and profitability of summer mungbean (*Vigna radiata* L.)

Priya K Modi, Brijesh K Patel, Harsh N Patel and JV Patel

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Abstract

A field experiment was conducted during summer 2024 at College Farm, N. M. College of Agriculture, NAU, Navsari to evaluate the response of summer mungbean (*Vigna radiata* L.) to nano urea application under south Gujarat condition. The soil was clayey in texture, low in available nitrogen, medium in P and high in K. The experiment was laid out in RBD with eight treatments and three replications. Treatments included absolute control, 100% RDF, reduced RDF with nano urea foliar sprays at different stages and conventional urea sprays. Results revealed that the application of 100% RDF (20:40:00 NPK kg ha⁻¹) significantly enhanced growth, yield attributes, seed yield (1420 kg ha⁻¹), haulm yield (2627 kg ha⁻¹) and protein yield (334.2 kg ha⁻¹). Economic analysis indicated the higher net return (₹76,123 ha⁻¹) and B:C ratio (1.72) with treatment 100% RDF. Reduced RDF (80%) with nano urea sprays showed only a marginal yield reduction indicating potential for fertilizer saving.

Keywords: Growth, mungbean, nano urea, protein, RDF, urea, yield

1. Introduction

Mungbean (*Vigna radiata* L.) is an important pulse crop in India, contributing significantly to the dietary protein of the population. In Gujarat, it is grown extensively, but productivity remains low due to nutrient stress and imbalanced fertilization. Nano urea, developed by IFFCO, is a liquid fertilizer containing 4% nitrogen in nanoscale form, which enhances nutrient use efficiency up to 80% compared to 30-50% in conventional urea. Foliar application of nano urea at critical stages may reduce dependence on soil-applied urea, improving sustainability and soil health. Mungbean (*Vigna radiata* L. Wilczek), popularly referred to as moong, mung, or green gram, is an important pulse crop belonging to the family Fabaceae. Owing to its good digestibility, it is widely regarded as a relatively light and easily digestible pulse. Besides its use as a food legume, mungbean has diverse applications in crop and livestock production. Its immature green pods are consumed as a vegetable, whereas the haulm serves as a valuable source of feed for livestock. The crop is also grown as a cover and soil-conserving crop, and its rapidly decomposing biomass makes it suitable for incorporation into the soil as green manure. Mungbean seeds possess considerable nutritional value, with reported protein and moisture contents ranging from 22.5–27.94% and 5.26–9.95%, respectively. The concentrations of fat, crude fibre, ash, and carbohydrates have been reported to vary from 0.12–2.31%, 2.90–17.04%, 2.91–4.26%, and 32.14–66.33%, respectively. Furthermore, mungbean provides a range of nutritionally important mineral elements, including calcium, magnesium, phosphorus, potassium, and sodium among the major minerals, along with manganese, iron, copper, and zinc as trace elements. (Sudhakaran and Bukan, 2021) [15]. The advancement of crop productivity and nutritional quality is closely associated with adequate nutrient management, particularly following the development of high-yielding cultivars with greater responsiveness to fertilizer application. Among the essential nutrients required by plants, nitrogen (N) has a prominent role in determining crop growth and productivity. Adequate nitrogen availability encourages vigorous vegetative development and contributes to the synthesis of several vital cellular components, including amino acids and proteins, enzymes, and chlorophyll pigments. However, significant amounts of nitrogen are lost to the atmosphere through

volatilization, denitrification, leaching and runoff. Despite these concerns, studies show that crops utilize just 45-50% of applied nitrogen in current high-input, profit-oriented agricultural systems.

2. Materials and Methods

The experiment was conducted at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (20°57'N, 72°54'E, 10 m AMSL) during summer 2024. The soil was clayey, low in nitrogen (235.72 kg ha⁻¹), medium in organic carbon (0.56%) and available P₂O₅ (45.32 kg ha⁻¹), high in available K₂O (581.92 kg ha⁻¹) with a pH of 7.32. The experiment was laid out in a Randomized Block Design with eight treatments and three replications. The treatments were:

T ₁	Absolute control (0% RDF)
T ₂	100% RDF (20:40:00 NPK kg ha ⁻¹)
T ₃	80% RDF + Spray of nano urea @ 4.0 ml/litre at 30 DAS
T ₄	80% RDF + Spray of nano urea @ 4.0 ml/litre at 45 DAS
T ₅	80% RDF + Spray of urea @ 2% at 30 DAS
T ₆	80% RDF + Spray of urea @ 2% at 45 DAS
T ₇	60% RDF + Spray of nano urea @ 4.0 ml/litre at 30 DAS + 45 DAS
T ₈	60% RDF + Spray of urea @ 2% at 30 DAS + 45 DAS

Observations were recorded on growth, yield attributes, yield, protein content and economics of summer mungbean.

Gross plot size	3.60 m x 4.00 m
Net plot size	2.70 m x 3.60 m
Spacing	45 cm x 10 cm
Recommended dose of fertilizers (kg ha ⁻¹)	20:40:00 NPK

Nitrogen (N) and phosphorus (P₂O₅) were supplied through urea and diammonium phosphate (DAP), respectively. The recommended quantities of both fertilizers were applied as a basal dose at the time of sowing of green gram. IFFCO Nano Urea was

employed as the source of nano-nitrogen. Foliar application of Nano Urea was carried out at 30 and 45 days after sowing (DAS) according to the respective treatment schedules.

3. Results and Discussion

3.1 Growth parameter

Treatment T₂ (100% RDF) recorded significantly higher growth parameters in mungbean, including plant height (48.53 cm), dry matter production plant⁻¹ (24.89 g) and number of branches plant⁻¹ (7.80) in Table 1. However, it was statistically at par with treatments T₅ (80% RDF + spray of urea @ 2% at 30 DAS) and T₆ (80% RDF + spray of urea @ 2% at 45 DAS), while treatment T₃ (80% RDF + spray of nano urea @ 4.0 ml/litre at 30 DAS), T₄ (80% RDF + spray of nano urea @ 4.0 ml/litre at 45 DAS) and T₈ (60% RDF + spray of urea @ 2% at 30 DAS + 45 DAS) also remained at par in case of number of branches plant⁻¹. The lowest values of plant height (31.53 cm), dry matter production (15.34 g) and number of branches were observed in the treatment absolute control (T₁). The variations across treatments were primarily governed by the amount and timing of nitrogen application, as nitrogen is an essential constituent of proteins, enzymes, chlorophyll and nucleic acids, thereby influencing cell division, photosynthesis, vegetative growth and biomass accumulation. The full RDF (T₂) ensured adequate and continuous nitrogen supply throughout crop growth, resulting in superior performance, whereas foliar applications at critical stages in treatments T₃ to T₆ compensated for reduced basal nitrogen, thereby achieving growth at par with T₂. These results highlight the combined effect of adequate basal fertilization and timely foliar sprays in supporting plant height, dry matter production, and branching, ultimately improving plant architecture. Similar findings were earlier reported by Rawate *et al.* (2022)^[10], Sharma *et al.* (2022)^[12], Kaushik *et al.* (2023)^[5], Subramani *et al.* (2023)^[14], Kumar *et al.* (2023)^[6], Singh *et al.* (2023)^[13], Pal *et al.* (2023)^[7] and Rani *et al.* (2024)^[9].

Table 1: Effect of Different Treatments on the Growth Parameters of Mungbean

Tr. No.	Treatment	Plant height (cm)				Dry matter production plant ⁻¹ (g)				Number of branches plant ⁻¹
		20 DAS	40 DAS	60 DAS	Harvest	20 DAS	40 DAS	60 DAS	Harvest	
T ₁	Absolute control	7.40	20.47	29.47	31.53	2.65	8.64	14.35	15.34	6.27
T ₂	100% RDF	8.73	26.00	47.87	48.53	2.96	12.35	21.98	24.89	7.80
T ₃	80% RDF + Spray of nano urea @ 4.0 ml/litre at 30 DAS	8.07	24.73	39.20	41.20	2.78	10.50	18.15	21.15	7.27
T ₄	80% RDF + Spray of nano urea @ 4.0 ml/litre at 45 DAS	8.00	24.80	38.93	40.60	2.76	10.42	17.80	20.89	7.20
T ₅	80% RDF + Spray of urea @ 2% at 30 DAS	7.87	25.93	45.47	47.33	2.94	11.34	19.42	22.34	7.60
T ₆	80% RDF + Spray of urea @ 2% at 45 DAS	7.73	25.67	41.47	43.47	2.75	10.90	18.90	21.68	7.40
T ₇	60% RDF + Spray of nano urea @ 4.0 ml/litre at 30 DAS + 45 DAS	7.53	22.67	35.20	37.80	2.58	9.97	16.10	18.44	6.67
T ₈	60% RDF + Spray of urea @ 2% at 30 DAS + 45 DAS	7.67	22.80	37.53	39.93	2.58	10.10	17.30	19.6	7.00
	S. Em. (±)	0.29	1.01	2.05	1.99	0.10	0.43	0.93	1.08	0.23
	CD at 5%	NS	3.06	6.22	6.04	NS	1.31	2.82	3.26	0.69
	C.V. (%)	6.44	7.24	9.01	8.36	6.53	7.12	8.94	9.07	5.51

3.2 Yield Attributes and Yield Performance

Significant differences were observed among treatments with respect to yield-attributing characters and yield of mungbean. The maximum number of pods plant⁻¹ (32.00) was recorded under 100% RDF (T₂), which could be attributed to the balanced and adequate supply of essential nutrients that enhanced vegetative growth, flowering and pod setting. This was statistically at par with T₆ (28.93), while the lowest number of pods plant⁻¹ (18.33) was observed in the absolute control (T₁). Similarly, significantly higher pod length (9.14 cm) was obtained with T₂ but remaining at par with treatments T₆ (8.79 cm), T₅ (8.73 cm), and T₃ (8.48 cm), whereas the lowest value (6.85 cm) was recorded under T₁.

Number of seeds pod⁻¹ was significantly higher under treatment T₂ (12.27) and remained at par with treatments T₆ and T₅. These results are in close agreement with the findings of Singh and Singh (2014)^[13], Saitheja *et al.* (2022)^[11], Chandar *et al.* (2023)^[1] and Nandhakumar *et al.* (2025)^[6]. With respect to yield, treatment T₂ (100% RDF) recorded the significantly higher seed yield (1420 kg ha⁻¹) and haulm yield (2627 kg ha⁻¹). Seed yield under treatment T₂ was at par with T₅, while haulm yield was statistically comparable with treatments T₃, T₄, T₅ and T₆. Higher haulm yield under these treatments was directly associated with improved growth attributes such as plant height, number of branches and dry matter accumulation, supported by continuous

nutrient supply through basal application and foliar sprays, which also enhanced nutrient uptake during the crop growth period. The harvest index was also significantly higher under T₂ (35.12%), which remained at par with all treatments except T₁, where the

lowest harvest index of 28.46% was recorded. These findings corroborate the results of Saitheja *et al.* (2022)^[11], Chandar *et al.* (2023)^[1], Hossain *et al.* (2023)^[3] and Chavan *et al.* (2024)^[2].

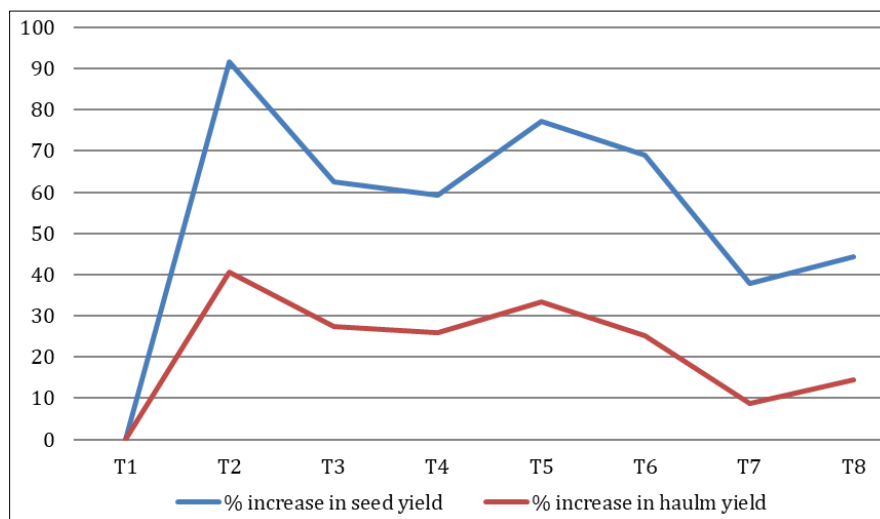


Fig 1: Percent increase in grain yield and straw yield of various treatments over control

Table 2: Effect of Different Treatments on Yield Attributes and Yield of Mungbean

Tr. No.	Treatment	No. of pods plant ⁻¹	Pod length (cm)	No. of seeds pod ⁻¹	Seed yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)	Harvest index (%)
T ₁	Absolute control	18.33	6.85	8.47	741	1869	28.46
T ₂	100% RDF	32.00	9.14	12.27	1420	2627	35.12
T ₃	80% RDF + Spray of nano urea @ 4.0 ml/litre at 30 DAS	25.67	8.48	10.67	1204	2380	33.70
T ₄	80% RDF + Spray of nano urea @ 4.0 ml/litre at 45 DAS	24.47	8.38	10.40	1180	2353	33.41
T ₅	80% RDF + Spray of urea @ 2% at 30 DAS	27.60	8.73	11.13	1313	2493	34.55
T ₆	80% RDF + Spray of urea @ 2% at 45 DAS	28.93	8.79	11.47	1252	2342	34.83
T ₇	60% RDF + Spray of nano urea @ 4.0 ml/litre at 30 DAS + 45 DAS	22.47	8.08	9.40	1022	2034	33.37
T ₈	60% RDF + Spray of urea @ 2% at 30 DAS + 45 DAS	23.33	8.31	9.67	1070	2140	33.30
	S. Em. (±)	1.10	0.24	0.51	53.92	128.91	0.74
	CD at 5%	3.33	0.74	1.55	163.54	390.99	2.25
	C.V. (%)	7.51	5.03	8.48	8.12	9.79	3.86

3.3 Quality parameter

Significant variation in protein content and protein yield of mungbean was observed due to different treatments. Significantly higher protein content (23.56%) was recorded with treatment T₂ (100% RDF) which was at par with treatments T₅ (80% RDF + spray of urea @ 2% at 30 DAS), T₆ (80% RDF + spray of urea @ 2% at 45 DAS), T₃ (80% RDF + spray of nano urea @ 4.0 ml/litre at 30 DAS), T₄ (80% RDF + spray of nano urea @ 4.0 ml/litre at 45 DAS) and T₇ (60% RDF + spray of nano urea @ 4.0 ml/litre at 30 DAS + 45 DAS). Similarly, significantly higher protein yield (334.20 kg ha⁻¹) was also recorded under treatment T₂ (100% RDF) but it remained statistically at par with T₅ (80% RDF

+ spray of urea @ 2% at 30 DAS). The increase in protein yield under T₂ was mainly due to the combined effect of higher seed yield and enhanced protein content. The improvement in protein traits can be directly attributed to higher nitrogen availability, as nitrogen is a vital constituent of amino acids, the building blocks of protein. Adequate nitrogen supply thus enhanced nitrogen accumulation in seeds, resulting in higher protein content and yield. In contrast, the lowest protein content (18.90%) and protein yield (139.95 kg ha⁻¹) were recorded under absolute control (T₁). These findings are in close agreement with the reports of Tomar *et al.* (2022)^[17] and Islam *et al.* (2023)^[4].

Table 3: Effect of different treatments on quality parameter of mungbean

Tr. No.	Treatment	Protein content (%)	Protein yield (kg ha ⁻¹)
T ₁	Absolute control	18.90	139.95
T ₂	100% RDF	23.56	334.20
T ₃	80% RDF + Spray of nano urea @ 4.0 ml/litre at 30 DAS	23.11	277.90
T ₄	80% RDF + Spray of nano urea @ 4.0 ml/litre at 45 DAS	22.93	271.03
T ₅	80% RDF + Spray of urea @ 2% at 30 DAS	23.33	306.31
T ₆	80% RDF + Spray of urea @ 2% at 45 DAS	23.14	289.13
T ₇	60% RDF + Spray of nano urea @ 4.0 ml/litre at 30 DAS + 45 DAS	22.08	225.32
T ₈	60% RDF + Spray of urea @ 2% at 30 DAS + 45 DAS	21.40	229.70
	S. Em. (±)	0.53	13.20
	CD at 5%	1.60	40.04
	C.V. (%)	4.09	8.82

3.4 Economics

Treatment T₇ (60% RDF + foliar spray of nano urea @ 4.0 ml/litre at 30 and 45 DAS) incurred the highest cost of cultivation (47,096 ₹ ha⁻¹). However, the maximum gross return (1,20,398 ₹ ha⁻¹), net return (76,123 ₹ ha⁻¹) and benefit-cost (B:C) ratio (1.72) were observed under treatment T₂ (100% RDF). In contrast, the control

treatment (T₁) recorded the lowest economic returns, with gross return of 66,804 ₹ ha⁻¹, net return of 25,967 ₹ ha⁻¹ and B:C ratio of 0.64. The higher income might be due to higher yield and lower cost of cultivation under this treatment. The results were similar to the findings of Patel *et al.* (2021)^[8] and Tejaswini *et al.* (2022)^[16].

Table 4: Effect of different treatments on economics of mungbean

Tr. No.	Treatment	Cost of cultivation (₹ ha ⁻¹)	Gross return (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	B:C ratio
T ₁	Absolute control	40837	66804	25967	0.64
T ₂	100% RDF	44275	120398	76123	1.72
T ₃	80% RDF + Spray of nano urea @ 4.0 ml/litre at 30 DAS	45688	103299	57611	1.26
T ₄	80% RDF + Spray of nano urea @ 4.0 ml/litre at 45 DAS	45688	101399	55711	1.22
T ₅	80% RDF + Spray of urea @ 2% at 30 DAS	44679	111886	67207	1.50
T ₆	80% RDF + Spray of urea @ 2% at 45 DAS	44679	106358	61679	1.38
T ₇	60% RDF + Spray of nano urea @ 4.0 ml/litre at 30 DAS + 45 DAS	47096	87805	40709	0.86
T ₈	60% RDF + Spray of urea @ 2% at 30 DAS + 45 DAS	45077	92016	46940	1.04
Selling price of mungbean		Seed 70 ₹ kg ⁻¹			
		Haulm 8 ₹ kg ⁻¹			

4. Conclusion

Application of 100% RDF (20:40:00 NPK kg ha⁻¹) proved most effective for growth, yield, nutrient uptake and profitability of summer mungbean under south Gujarat condition. However, 80% RDF with foliar spray of nano urea at flowering or pod formation stage can serve as a fertilizer-saving alternative without significant yield reduction.

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