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Koustav De
M.Sc. Scholar, Department of Agronomy, Naini Agricultural institute, SHUATS, Prayagraj, Uttar Pradesh, India

Prateek Kumar
Ph. D. Scholar, Department of Agronomy, Naini Agricultural institute, SHUATS, Prayagraj, Uttar Pradesh, India

Dr. Biswarup Mehera
Professor and DEAN, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Koustav De
M.Sc. Scholar, Department of Agronomy, Naini Agricultural institute, SHUATS, Prayagraj, Uttar Pradesh, India

Effect of iron, naphthalene acetic acid on growth and Economics of green gram

Koustav De, Prateek Kumar and Dr. Biswarup Mehera

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Abstract
A field experiment was conducted during *kharif* season of 2023 at Crop Research Farm Department of Agronomy on green gram. The treatments consisted of 3 levels of NAA (25, 50 and 75 ppm) and 2 level of Fe foliar Spray (0.5% and 2.5%) on 2 different growth stage (At 25 and 45 DAS). The experiment utilized a Randomized Block Design, comprising 10 treatments, each replicated three times. Application of 0.25% Fe foliar Spray (25 DAS & 45 DAS) + NAA: 50ppm (Treatment 6) recorded highest plant height (43.17 cm), maximum plant dry weight (14.82 g). The aforesaid treatment also recorded maximum gross return (INR 111465.46 /ha), net return (INR 78998.46/ha) and B:C ratio (2.43) was also recorded in the treatment 6.

Keywords: Green gram, Fe, NAA, treatment, *kharif*, growth, economics

Introduction
Green gram is commonly known as mung bean in the Indian subcontinent and is widely grown in all Asian countries. 100 g of green gram gives 30 calories and consists approximately 3 g proteins, 6 g carbohydrates and 2 g dietary fibers. It provides about 15% and 45% of the recommended dietary allowance of calcium and iron, respectively. Global pulse consumption is on the rise, driven by their high nutritional value and low glycemic index. Pulses are considered the most crucial dietary predictor of longevity among older individuals of diverse ethnic backgrounds, playing a pivotal role in extending the lifespan of populations. (Darmadi-Blackberry *et al.*, 2004) [3].

In India pulse crops are grown in an area of 139.09 (MT) with an annual production level of 86.98 (MT) and productivity of about 639 kg/ha during 2016-2017. Green gram (*Vigna radiata* L.) is one of the most important and extensively cultivated pulse crops. During the *Kharif* season, green gram production totaled 1.02 million tonnes in 2015-2016, increasing to 1.35 million tonnes in 2016-2017. Pulses contain twice the amount of protein compared to cereals.

Iron (Fe) is a vital micronutrient crucial for enhancing plant growth and reproduction. It holds the distinction of being the first nutrient element recognized as essential for plant life. In the plant system, iron plays an important role in a series of metabolic activities involving respiratory enzymes and various photosynthesis reactions. Iron also plays an important role in legumes including green gram for nodule formation and nitrogen fixation. Iron has been considered to be associated with chlorophyll formation because its deficiency in the plant system results in foliar chlorosis. Foliar application of Fe solutions is one of the most widely used methods for correcting Fe deficiency in many crops. This method of application usually circumvents the problems associated with Fe application to the soil (Guerinot and Yi, 1994) [5].

The foliar sprays of Fe significantly reduced iron deficiency chlorosis. Therefore, balanced fertilization of macro and micro nutrients particularly in combination is very important for proper growth, development and high yield production of crop plants including green gram.

Plant growth regulators (PGRs) are being used as aids to enhance yield of different crops. Naphthalene acetic acid (NAA) serves as a growth-promoting substance, exerting a notable influence on the growth characteristics and yield of green gram. Its positive impact extends to growth and dry matter production, while also playing pivotal roles in various physiological processes.

NAA contributes to cell elongation, division, vascular tissue differentiation, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, as well as fruit setting and flowering (Raoofi *et al.*, 2014) [8].

Materials and Methods

During the *Kharif* season of 2023, a field experiment was carried out at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The experimental plot featured sandy loam soil with nearly neutral soil pH (7.4) and moderate levels of organic carbon (0.75%), available nitrogen (257.46 kg/ha), phosphorus (35.20 kg/ha), and potassium (321.17 kg/ha). The experiment aimed to evaluate the effects of foliar spraying with FeSO4 and Naphthalene acetic acid (NAA) at different intervals.

The treatments were designed to include foliar spraying of FeSO4 and NAA at intervals of 25 and 45 days. Additionally, NAA was sprayed either on 25 DAS (Days After Sowing), 45 DAS, or on both days, based on treatment and density considerations. Various doses of FeSO4 were applied in conjunction with NAA spraying. The experiment was laid out in a Randomized Block Design, consisting of twelve treatments, each replicated thrice.

The treatment combinations were as follows

1. 0.5% FeSO4 foliar spray (25 DAS) + NAA- 25 ppm
2. 0.5% FeSO4 foliar spray (25 DAS) + NAA- 25 ppm
3. 0.25% FeSO4 foliar spray (25 & 45 DAS) + NAA- 25 ppm
4. 0.5% FeSO4 foliar spray (25 DAS) + NAA- 50 ppm
5. 0.5% FeSO4 foliar spray (45 DAS) + NAA- 50 ppm
6. 0.25% FeSO4 foliar spray (25 & 45 DAS) + NAA- 50 ppm
7. 0.5% FeSO4 foliar spray (25 DAS) + NAA- 75 ppm
8. 0.5% FeSO4 foliar spray (45 DAS) + NAA- 75 ppm
9. 0.25% FeSO4 foliar spray (25 & 45 DAS) + NAA- 75 ppm
10. N-P-K, 25-50-25 kg/ha (control)

Growth parameters and yield production were recorded at harvest from randomly selected plants in each plot. The collected data was analyzed using the statistical methods outlined.

This experimental setup allowed for the investigation of the effects of different combinations and concentrations of FeSO4 and NAA on crop growth and yield, providing valuable insights into their potential as foliar treatments for enhancing agricultural productivity.

Results and Discussion

Plant height

The plant height of Green gram was recorded at different intervals i.e., 15, 30, 45 and 60 DAS differed significantly influenced by application of Iron and Naphthalene acetic acid.

At 60 DAS, Significantly higher plant height (43.17 cm) was recorded in [0.25% FeSO4 foliar Spray (25 & 45 DAS) + NAA- 50 ppm] as compared to rest of the treatments. However, Treatment 9, [0.25% FeSO4 foliar Spray (25 & 45 DAS) + NAA- 75 ppm] was recorded the lowest plant height among the other treatments. Significant and higher plant height was observed with application of Naphthalene acetic acid (25 ppm). Increase in plant height might be due to the increased availability of nutrients without any harmful effect on plant through foliar application at 25 DAS and 45 DAS. Similar findings were also reported by Kuttimani and Velayutham (2015) [7] in Black gram.

Number of nodules /plant

At 30 DAS, Significantly maximum Number of nodules /plant (34.57) was recorded in treatment 7 [0.5% FeSO4 foliar Spray (25 DAS) + NAA-75 ppm] as compared to rest of the treatments. However, the treatment 5 [0.5% FeSO4 foliar Spray(45 DAS) + NAA-50 ppm], treatment 6 [0.25% FeSO4 foliar Spray(25 & 45 DAS) + NAA- 50 ppm], treatment 8 [0.5% FeSO4 foliar Spray (45 DAS) + NAA- 75 ppm], treatment 9 [0.25% FeSO4 foliar Spray(25 & 45 DAS) + NAA- 75 ppm] were found to be statistically at par with treatment 7 [0.5% FeSO4 foliar Spray(25 DAS) + NAA- 75 ppm]. The increased in effective root nodules per plant might be due to increased activity of rhizobiam in soil due to application of foliar spray of FeSO4 and NAA before flowering with proper combination and due to increase in chlorophyll content in leaves, thereby increasing photosynthetic efficiency through foliar spray of NAA.

Plant dry weight (g/plant)

At 60 DAS, Significantly higher plant dry weight (14.82 g) was recorded in treatment 6 [0.25% FeSO4 foliar Spray (25 & 45 DAS) + NAA- 50 ppm] as compared to rest of the treatments.

Significant and higher plant dry weight was with foliar Spray of FeSO4 (0.25%) might be due to increased Fe rates improves overall growth and development of plants, which enhance morphological and reproductive components along with enhancing the plant protection ability, which results in accumulation of more dry matter at the successive growth stages. Similar result was also reported by Kavya *et al.* (2021) [6].

Crop growth rate (g/m^2/day)

The growth rate of green gram crop, measured in grams per square meter per day (g/m^2/day), exhibited significant variations across different stages of development (0-15, 15-30, 30-45, and 45-60 DAS) as influenced by the application of Iron (FeSO4) and Naphthalene acetic acid (NAA). Notably, the period between 30 to 45 days after sowing (DAS) emerged as the phase with the highest growth rate.

During the crucial 30-45 DAS period, treatment 6 [0.25% FeSO4 foliar Spray (25 & 45 DAS) + NAA- 50 ppm] recorded the highest growth rate at 17.47 g/m^2/day, significantly outperforming other treatments. Conversely, treatment 8 [0.5% FeSO4 foliar Spray (45 DAS) + NAA- 75 ppm] exhibited the lowest growth rate during this phase.

The significant and maximum crop growth rate observed with the application of NAA at 50 ppm could be attributed to its auxin-like growth-promoting effects during the initial growth stages. This likely led to accelerated crop growth by enhancing light absorption and boosting photosynthetic activities, resulting in rapid biomass accumulation. These findings align with previous studies, such as those reported by Usha *et al.* (2023) [10], further corroborating the positive impact of NAA on crop growth and development.

Relative growth rate (g/g/day)

The Relative growth rate (g/g/day) of Green gram was recorded at 15-30, 30-45 and 45-60 DAS by application of Iron and NAA. The highest RGR data was recorded in between 15 to 30 DAS.

At 15-30 DAS, highest relative growth rate (0.167g/g/day) was recorded in treatment 9 [0.25% FeSO4 foliar Spray (25 & 45 DAS) + NAA- 75 ppm] as compared to rest of the treatments and there is no significance difference between the treatments.

Economics

In terms of economics, the cost of cultivation per hectare was observed to vary across different treatments, with the highest cost recorded in treatments 7, 8, and 9, where foliar spraying of FeSO4 and NAA at varying concentrations was conducted. Specifically, treatment 7 [0.5% FeSO4 foliar Spray (25 DAS) + NAA- 75 ppm], treatment 8 [0.5% FeSO4 foliar Spray (45 DAS) + NAA- 75 ppm], and treatment 9 [0.25% FeSO4 foliar Spray (25 & 45 DAS) + NAA- 75 ppm] incurred the highest cost of cultivation at 32,585 INR per hectare. Conversely, treatment 10 (control) exhibited the lowest cost of cultivation at 32,011 INR per hectare compared to other treatments.

On the other hand, gross returns per hectare varied significantly among treatments, with treatment 6 [0.25% FeSO4 foliar Spray (25 & 45 DAS) + NAA- 50 ppm] yielding the highest gross returns at 111,475.46 INR per hectare. In contrast, treatment 10 (control) generated the lowest gross returns at 66,081.85 INR per hectare.

When considering net returns, treatment 6 [0.25% FeSO4 foliar Spray (25 & 45 DAS) + NAA- 50 ppm] emerged as the most profitable, yielding the highest net returns of 78,998.46 INR per hectare.

Lastly, the benefit-cost ratio (B:C Ratio) provides an indication of the profitability of each treatment, with treatment 6 [0.25% FeSO4 foliar Spray (25 & 45 DAS) + NAA- 50 ppm] exhibiting the maximum B:C Ratio of 2.43. This suggests that for every unit of cost incurred, treatment 6 generated a benefit of 2.43 units, indicating a favorable economic outcome.

Overall, these economic metrics highlight the financial implications of different treatments on green gram cultivation, with treatment 6 demonstrating superior profitability compared to other treatments.

Table 1: Effect of Iron and NAA on growth attributes of Green gram

S. No.	Treatments	Plant Height (cm) (60 DAS)	Nodules number (30 DAS)	Dry matter (g/plant) (60 DAS)	CGR (g/m^2/day) (30-45 DAS)	RGR (g/g/day) (15-30 DAS)
1.	0.5% Fe (25 DAS) + NAA 25 PPM	34.14	32.4	11.54	12.12	0.157
2.	0.5% Fe (45 DAS) + NAA 25 ppm	37.12	32.66	12.11	10.74	0.153
3.	0.25% Fe (25 & 45 DAS) + NAA 25 ppm	36.16	32.8	12.23	12.32	0.157
4.	0.5% Fe (45 DAS) + NAA 50 ppm	37.59	33.1	12.71	12.88	0.165
5.	0.5% Fe (45 DAS) + NAA 50 ppm	36.8	33.4	12.44	11.95	0.140
6.	0.25% Fe (25 & 45 DAS) + NAA 50 ppm	43.17	33.58	*14.82*	17.47	0.151
7.	0.5% Fe (25 DAS) + NAA 75ppm	32.23	*34.57*	10.90	11.83	0.149
8.	0.5% Fe (45 DAS) + NAA 75 ppm	34.34	33.33	11.25	10.09	0.159
9.	0.25% Fe (25 & 45 DAS) + NAA 75ppm	30.64	33.46	10.36	10.90	0.167
10.	Control (RDF)	36.61	29.26	11.21	10.43	0.146
	F-Test	S	S	S	S	NS
	S.Em(+)	1.71	0.51	0.55	1.21	0.007
	CD (P=0.05)	5.09	1.52	1.64	3.60	_

Table 2: Effect of Iron and NAA on economics of Green Gram

S. No.	Treatments	Cost of Cultivation (₹/ha)	Gross Returns (₹/ha)	Net returns (₹/ha)	B:C ratio
1.	0.5% Fe (25 DAS) + NAA 25 PPM	32369	67010.31	34641.31	1.07
2.	0.5% Fe (45 DAS) + NAA 25 ppm	32369	88135.96	55766.96	1.72
3.	0.25% Fe (25 DAS & 45 DA) + NAA 25 ppm	32369	69972.71	37603.71	1.16
4.	0.5% Fe (45 DAS) + NAA 50 ppm	32477	96243.42	63766.42	1.96
5.	0.5% Fe (45 DAS) + NAA 50 ppm	32477	68691.24	36214.24	1.12
6.	0.25% Fe (25 DAS & 45 DAS) + NAA 50 ppm	32477	111475.46	78998.46	2.43
7.	0.5% Fe (25 DAS) + NAA 75ppm	32585	69332.52	36747.52	1.13
8.	0.5% Fe (45 DAS) + NAA 75 ppm	32585	83090.64	50505.64	1.55
9.	0.25% Fe (25 DAS & 45 DAS) + NAA 75ppm	32585	72659.56	40074.56	1.23
10.	Control (RDF)	32011	66081.85	34070.85	1.06

Conclusion

Application of 0.25% FeSO4 foliar Spray (25 DAS & 45 DAS) with NAA: 50ppm (Treatment 6) recorded highest seed yield and benefit cost ratio.

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