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Samruddhi Madavi
P. G. Student, Department of Agricultural Botany and Plant Physiology, Dr. PDKV University Akola, College of Agriculture Nagpur, Maharashtra, India

PV Shende
Associate Professor, Department of Agricultural Botany, Dr. PDKV University Akola, College of Agriculture Nagpur, Maharashtra, India

Vaibhavi Madavi
P. G. Student, Department of Agricultural Botany and Plant Physiology, Dr. PDKV University Akola, College of Agriculture Nagpur, Maharashtra, India

Sapana Baviskar
Assistant Professor, Department of Agricultural Botany, Dr. PDKV University Akola, College of Agriculture Nagpur, Maharashtra, India

Corresponding Author:
Samruddhi Madavi
P. G. Student, Department of Agricultural Botany and Plant Physiology, Dr. PDKV University Akola, College of Agriculture Nagpur, Maharashtra, India

Influence of foliar application of GA_3 and NAA on biochemical, yield and yield contributing characters in mungbean (*Vigna radiata* L.)

Samruddhi Madavi, PV Shende, Vaibhavi Madavi and Sapana Baviskar

Abstract
An experiment was carried in field section of Agricultural Botany, College of Agriculture, Nagpur, during *Kharif* 2022 based on a RBD with three replications, variety PKV Green Gold with thirteen treatments were taken. The treatments composed of foliar application of two plant growth regulators *viz.*, GA_3 and NAA. The foliar application of GA_3 @ 200 PPM + NAA @ 200 PPM was found most effective for increasing the chlorophyll content, yield and yield contributing characters. However, nitrogen content in leaves and protein content in seed was measured significantly with foliar application of GA_3 @ 150 PPM + NAA @ 150 PPM over rest of the treatments. The growth regulators as foliar application increased the yield and yield components. Effect of GA_3 and NAA application was influenced by various environmental conditions and for accurate conclusion it is essential to understand the sensitivity of mungbean variety to prevailing conditions. The timing of GA_3 and NAA application is critical and sophisticated analytical techniques are required for accurate measurement of biochemical parameters. To overcome these challenges, well- controlled experiments should be designed by considering multiple factors in collaboration with experts in plant physiology and biochemistry.

Keywords: Mungbean, GA_3, NAA, biochemical

Introduction
Mungbean (*Vigna radiata* L.) is also known as green gram, it is an important pulse crop of India and grown in *Rabi* (South India), *Kharif* and *Summer* seasons. It is green with husk and yellow when dehusked. The beans are small, ovoid in shape and green in color. The mungbean is mainly cultivated in India, Pakistan, Bangladesh, Nepal, China, Korea, South Asia and Southeast Asia. It has many effective uses, green pod is cooked as peas, sprout rich in vitamins and amino acids. This crop can be used for both seed and forage since it produces a large amount of biomass and then recover after grazing to yield abundant seeds and then can be used in broilers diets as a nontraditional feed stuff (Navya *et al.* 2021) [6]. Mungbean is third most important pulse crop of India after chickpea and pigeonpea. The nutritive value of mungbean is a high with easily digestible protein (approximately 25-28%), oil 1.0-1.5%, fiber 3.5-4.5%, ash 4.5-5.5%, carbohydrate 62-65%, water 9.1%, and vitamins on dry weight basis (Prakash *et al.* 2019) [8]. Green gram is the third most important pulse crop in India. It is quite versatile crop grown for seeds, green manure and forage and it is also considered as "Golden Bean" because of its nutritive values and suitability for increasing the soil, by the way of addition of nitrogen to the soil. It has high nutritive value, and due to this, has advantage over the other pulses (Pagire and John. 2016) [7]. Mungbean is botanically recognized as (*Vigna radiata* L.) and belong to the family Fabaceae (leguminaceae). The genus Vigna has been broadened and include about 155 species but only twenty – two species are native to India. Where they are grown in large numbers and are often grouped under distinct varieties and sub species. One of most important among these species is *Vigna radiata* with dark-green foliage, spreading and green seeds (Mishra *et al.* 2021) [4].

Materials and Methods
The field experiments were carried out during *kharif* seasons of 2022 in field of section of Agricultural Botany, College of Agriculture, Nagpur.

Total number of treatments were thirteen *viz.*, T_1 (control), T_2 (GA_3 @ 50 PPM) T_3 (GA_3 @ 100 PPM) T_4 (GA_3 @ 150 PPM) T_5 (GA_3 @ 200 PPM), T_6 (NAA @ 50 PPM), T_7 (NAA @ 100 PPM), T_8 (NAA @ 150 PPM), T_9 (NAA @ 200 PPM), T_{10} (GA_3 @ 50 PPM + NAA @ 50 PPM), T_{11} (GA_3 @ 100 PPM + NAA @ 100 PPM), T_{12} (GA_3 @ 150 PPM + NAA @ 150 PPM), T_{13} (GA_3 @ 200 PPM + NAA @ 200 PPM). Solution of treatments were prepared. Foliar applications done at 25 and 35 days after sowing with the help of hand sprayer as per treatment. While in untreated control distilled water was sprayed. The experiment was planned with randomized block design in three replications biochemical parameter were taken, Total chlorophyll content of oven dried leaves was estimated by the calorimetric method as suggested by Bruinsma (1982) [1], nitrogen content of leaves was estimated by the micro-Kjeldahl method (Somichi *et al.* 1972) [10].

Results and Discussion

Biochemical parameters

The biochemical parameters like total chlorophyll content, nitrogen content in leaves and protein content in seeds have been significantly affected by foliar spray of plant growth regulators at various stages of the crop.

Total chlorophyll content

Total Leaf chlorophyll content significantly increased by all the GA_3 and NAA treatments. Among the treatments the highest value was found in treatment T_{13} (GA_3 @ 200 PPM + NAA @ 200 PPM). The higher chlorophyll content analyzed due to both GA_3 and NAA which might be due to enhanced cell division and increased chloroplast development in the plant that may contribute in improving chlorophyll content in leaves. Pagire and John (2016) [7] studied the growth and yield of mungbean and conclude that chlorophyll content was higher with higher concentration of NAA i.e., NAA @ 50 PPM. When NAA was combined with Salicylic acid it gave higher result i.e., 2.84 mg g^{-1} at 40 DAS. Chaudhary *et al.* (2023) [2] in an experiment on mungbean conducted that GA_3 @ 25 mg/l showed highest chlorophyll content as compared to other treatment of GA_3 and NAA.

Leaf nitrogen content

Observations for higher nitrogen content in leaves were estimated with foliar sprayed of T_{12} (GA_3 @ 150 PPM + NAA @ 150 PPM). GA_3 may play a key role in many metabolic pathways affecting these characteristics, such as translocation of photosynthates, chlorophyll production and degradation, translocation of assimilates, nitrogen metabolism, and nitrogen redistribution. NAA affects the total amount and distribution of nitrogenous compounds in various portions of the plants, and also in the plant as a whole. NAA also have important role in cell division. Mishra *et al.* (2021) [4] studied the growth and yield of mungbean and conclude that nitrogen content in leaf was higher in plant treated with GA_3 @ 75 PPM as compared to other treatments.

Protein content in seed

Observations were also estimate for nitrogen content in leaves and higher protein content in seeds were estimated with foliar sprayed of T_{12} (GA_3 @ 150 PPM + NAA @ 150 PPM) followed by treatments T_{13} (GA_3 @ 200 PPM + NAA @ 200 PPM), T_{11} (GA_3 @ 100 PPM + NAA @ 100 PPM), T_5 (GA_3 @ 200 PPM), T_{10} (GA_3 @ 50 PPM + NAA @ 50 PPM), when compared with treatment T_1 (control) and rest of the treatments.GA_3 increases photosynthetic activity in plant and responsible for increase in chlorophyll content in leaves. The higher protein content in seeds estimated with GA_3 which attributed with increased in structural component of RNA molecules of amino acids and also GA_3 cause marked increase DNA, RNA and protein synthesis in ribosome which is known as site of protein synthesis in plants. NAA help in the upward transport of nutrients and enhance the levels of proteins, carbohydrates, Sugar and antioxidant enzymes in plants. NAA also have important role in cell division. Mishra *et al.* (2021) [4] studied the growth and yield of mungbean and conclude that nitrogen content in leaf was higher in plant treated with GA_3 @ 75 PPM as compared to other treatments. Nandan *et al.* (2021) [5] studied the growth and yield of mungbean and conclude that nitrogen and protein content in seed was higher in plant treated with GA_3 @ 100 PPM as compared to other treatments.

Yield and yield attributing traits

Pods plant^{-1}

Among all the treatments significantly highest number of pods plant^{-1} was registered in treatment T_{13} (GA_3 @ 200 PPM + NAA @ 200 PPM), followed by treatments T_{12} (GA_3 @ 150 PPM + NAA @ 150 PPM), T_{11} (GA_3 @ 100 PPM + NAA @ 100 PPM), T_{10} (GA_3 @ 50 PPM + NAA @ 50 PPM), over control and rest of the treatments. GA_3 prevent premature falling of fruits, organ elongation. NAA contribute to increase fruit setting ratio, prevent abscission, prevent fruit dropping and also increases fruit size. Mishra *et al*. (2021) [4] conducted an experiment on mungbean with foliar application of GA_3 and NAA and concluded that the number of pod plant^{-1} was higher in plant treated with GA_3 @ 75 ppm followed by foliar application of NAA @ 150 PPM as compared to other treatments of GA_3 and NAA.

Pod length

Pod length was significantly enhanced by treatment receiving T_{13} (GA_3 @ 200 PPM + NAA @ 200 PPM) followed by treatments T_{12} (GA_3 @ 150 PPM + NAA @ 150 PPM), T_{11} (GA_3 @ 100 PPM + NAA @ 100 PPM), T_{10} (GA_3 @ 50 PPM + NAA @ 50 PPM), when compared with treatment T_1 (control) and rest of the treatments. GA_3 enhances organ elongation. NAA contribute to increases fruit size and enhances cell division. Jadhav *et al.* (2020) [3] in their experiment on mungbean conducted that pod length (cm) was longest in treatment T_4 (GA_3 @ 30 PPM) as compared to rest of the treatment. Mishra *et al.* (2021) [4] conducted an experiment on mungbean with foliar application of GA_3 and NAA and concluded that the length of pod was longest in plant treated with GA_3 @ 75 ppm followed by foliar application of NAA@ 150 PPM as compared to other treatments of GA_3 and NAA.

Table 1: Influence of foliar application of GA_3 and NAA on biochemical parameters in mungbean.

Treatments	Total chlorophyll content (mg g^{-1})			Leaf Nitrogen content (%)			Nitrogen Content in seed (%)	Protein content in Seed (%)
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS		
T1(Control)	0.84	1.05	0.74	0.44	0.60	0.41	3.165	18.21
T2 (GA_3 @ 50 PPM)	1.08	1.24	1.03	0.49	0.62	0.46	3.294	18.95
T3 (GA_3 @ 100 PPM)	1.09	1.31	1.05	0.53	0.64	0.53	3.329	19.15
T4 (GA_3 @ 150 PPM)	1.16	1.38	1.09	0.56	0.67	0.51	3.363	19.35
T5 (GA_3 @ 200 PPM)	1.21	1.39	1.11	0.59	0.65	0.52	3.384	19.47
T6 (NAA @ 50 PPM)	0.92	1.07	0.93	0.49	0.62	0.47	3.270	18.81
T7 (NAA @ 100 PPM)	0.98	1.10	0.95	0.51	0.62	0.49	3.296	18.96
T8 (NAA @150 PPM)	1.00	1.20	0.97	0.53	0.65	0.49	3.376	19.42
T9 (NAA @ 200 PPM)	1.07	1.27	1.02	0.55	0.67	0.50	3.342	19.22
T10 (GA_3 @ 50 PPM+NAA @ 50 PPM)	1.21	1.36	1.11	0.57	0.69	0.51	3.378	19.43
T11 (GA_3 @ 100 PPM+ NAA @100 PPM)	1.20	1.49	1.14	0.59	0.71	0.52	3.409	19.61
T12 (GA_3 @ 150 PPM +NAA @ 150 PPM)	1.28	1.53	1.17	0.64	0.76	0.56	3.434	19.75
T13 (GA_3 @ 200 PPM + NAA @ 200 PPM)	1.30	1.56	1.19	0.61	0.73	0.54	3.419	19.67
SE (m) ±	0.04	0.05	0.04	0.02	0.03	0.02	0.15	0.23
CD at 5%	0.12	0.13	0.11	0.07	0.08	0.06	0.45	0.67

Table 2: Influence of foliar application of GA_3 and NAA on yield and yield contributing parameters in mungbean

Treatments	Number of pods $plant^{-1}$	Pod length (cm)	Test weight	Harvest index	Seed yield $plant^{-1}$ (g $plant^{-1}$)	Seed yield $plant^{-1}$ (kg $plot^{-1}$)	Seed yield (q ha^{-1})	B:C ratio
T1(Control)	11.08	5.77	2.91	21.01	6.323	0.306	6.376	2.27
T2 (GA_3 @ 50 PPM)	13.58	6.04	3.13	21.96	6.576	0.316	6.626	2.52
T3 (GA_3 @ 100 PPM)	14.28	7.07	3.19	23.54	6.580	0.316	6.626	2.52
T4 (GA_3 @ 150 PPM)	16.77	7.08	3.25	25.62	6.603	0.320	6.643	2.54
T5 (GA_3 @ 200 PPM)	15.77	7.15	3.29	24.62	6.636	0.323	6.686	2.58
T6 (NAA @ 50 PPM)	12.37	5.83	3.03	21.38	6.703	0.326	6.746	2.64
T7 (NAA @ 100 PPM)	14.13	6.50	3.04	21.73	6.706	0.326	6.746	2.64
T8 (NAA @150 PPM)	15.56	6.72	3.07	22.38	6.763	0.330	6.873	2.77
T9 (NAA @ 200 PPM)	16.37	6.93	3.11	23.12	6.833	0.333	6.973	2.87
T10 (GA_3 @ 50 PPM+NAA @ 50 PPM)	16.86	7.35	3.32	26.95	6.956	0.336	6.990	2.88
T11 (GA_3 @ 100 PPM+ NAA @100 PPM)	16.92	7.45	3.38	27.25	7.076	0.343	7.126	2.92
T12 (GA_3 @ 150 PPM +NAA @ 150 PPM)	17.19	7.60	3.41	28.24	7.206	0.346	7.256	2.95
T13 (GA_3 @ 200 PPM + NAA @ 200 PPM)	17.88	7.78	3.52	28.29	7.270	0.353	7.333	2.98
SE (m) ±	1.09	0.29	0.23	1.54	0.31	0.02	0.16	
CD at 5%	3.17	0.83	0.68	4.50	0.90	0.07	0.47	

Test weight

Among all the treatments tested the highest 1000 seed weight was obtained in treatment T_{13} (GA_3 @ 200 PPM + NAA @ 200 PPM), over control and rest of the next to these treatments T_{12} (GA_3 @ 150 PPM + NAA @ 150 PPM), T_{11} (GA_3 @ 100 PPM + NAA @ 100 PPM), T_{10} (GA_3 @ 50 PPM + NAA @ 50 PPM), significantly more test weight was also recorded in treatmentsT_5 (GA_3 @ 200 PPM), T_4 (GA_3 @ 150 PPM) and T_3 (GA_3 @100 PPM) could not achieved their target and were found at par with treatment T_1 (control). NAA contribute to increase fruit size, cell division. GA_3 enhances organ elongation, translocation of photosynthates, metabolic activities. Mishra *et al.* (2021) [4] in their experiment in mungbean concluded that higher 100 seed weight obtained from foliar spray of GA_3 @ 50 PPM followed by NAA @ 150 PPM

Harvest index

Harvest index was significantly increased with treatment T_{13} (GA_3 @ 200 PPM + NAA @ 200 PPM), followed by treatments T_{12} (GA_3 @ 150 PPM + NAA @ 150 PPM), T_{11} (GA_3 @ 100 PPM + NAA @ 100 PPM), T_{10} (GA_3 @ 50 PPM + NAA @ 50 PPM), T_4 (GA_3 @ 150 PPM), T_5 (GA_3 @ 200 PPM) over control. NAA increases cell division, contribute to increase fruit size, fruit setting ratio. GA_3 induces mitosis, enhances organ elongation, translocation of photosynthates, increases growth in plant. Nandan *et al.* (2021) [5] in their experiment on mungbean concluded that GA_3 @ 100 PPM gave highest harvest index followed by NAA @ 100 PPM and rest of the treatments. Singh and Jambukiya (2020) [9] in their experiment on mungbean concluded that harvest index was higher in treatment NAA @ 75 PPM as compared to other treatments of NAA.

Seed yield

Seed yield $plant^{-1}$, $plot^{-1}$ and ha^{-1} were significantly increased by the application of T_{13} (GA_3 @ 200 PPM + NAA @ 200 PPM) followed by treatments T_{12} (GA_3 @ 150 PPM + NAA @ 150 PPM), T_{11} (GA_3 @ 100 PPM + NAA @ 100 PPM), T_{10} (GA_3 @ 50 PPM + NAA @ 50 PPM), T_9 (NAA @ 200 PPM), T_8 (NAA @ 150 PPM) over control and rest of the treatments. Enhancement on yield contributing factors which might due to maximum net photosynthetic rate in leaves and better translocation of photosynthetic and metabolites. Higher number of seeds per plant may be because of increased cell division, promotion of orderly development of embryos of seeds and higher level of photosynthates that led to increase in number of seeds per plant. Mishra *et al.* (2021) [4] in their experiment on mungbean concluded that maximum seed yield obtained from GA_3 @ 75 PPM followed by NAA @ 150 PPM as compared to other treatments. Also concluded that application of both GA_3 and NAA attributed maximum net photosynthetic rate in leaves and better translocation of photosynthetic and metabolism and also attribution of yield up to certain extent.

Conclusion

The significant biochemical parameter has been observed by the foliar sprayed of T_{13} (GA_3 @ 200 PPM + NAA @ 200 PPM) to increase total chlorophyll content of leaves, yield and yield contributing characters and T_{12} (GA_3 @ 150 PPM + NAA @ 150 PPM) was found most effective among all treatments to increase leaf nitrogen content at all stages i.e., 30, 45 and 60 DAS and protein content of seed in mungbean.

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