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# Effect of Plant Growth Regulator and Crop Geometry on Growth and Yield of Green Gram (*Vigna radiata* L.)

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

A field trial was conducted during the *Zaid* season of 2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) on the Green Gram (*Vigna radiata* L.). The experiment was executed in a Randomized Block Design with ten treatments and replicated three times. Application of brassinolide 0.25% and plant density 35 cm x 10 cm (T2) recorded highest plant height (78.70 cm), dry weight (33.25 g/plant), number of nodules/plant (28.93), number of pods/plant (42.00), number of seeds/pod (14.00), test weight (31.89 g), seed yield (1273.70 kg/ha), stover yield (3401.50 kg/ha) and harvest index (27.24 %). however, maximum crop growth rate (8.87 g/m$^2$/day) was recorded in GA3 0.50% + 25 cm x 15 cm (T7). Maximum gross returns (INR 89,159.00/ha), net returns (INR 56,539.00/ha), and B:C ratio (1.73) were also obtained highest in

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the same treatment (T2) in Green Gram crop. Therefore, application of brassinolides 0.25% and plant spacing 35 cm x 10 cm (T2) result in significant improvement in the crop production and also proven economically viable in green gram.

*Keywords: Brassinolide; economics; gibberellin; growth; naphthalene acetic acid; yield.*

## 1. INTRODUCTION

Green gram (*Vigna radiata* L.) is also known as ‘Mung bean' or 'Moong' and belongs to the family Leguminoceae. It is a crop with short growing period (0-60 days) and broad adaptability, which is grown in summer as well as in kharif season. According to Parvati *et al.* (2017), it is a significant pulse crop and a great source of premium protein. It is an excellent source of Riboflavin, Thiamine and Vitamin C (Ascorbic acid). It generates a significant biomass and recovers after grazing to produce plentiful seeds, it serves a dual purpose as both seed and fodder and is also used in broilers diets as a non-traditional feed stuff [1]. As a leguminous crop, it can fix atmospheric nitrogen and check soil erosion. It is also used as a good silage and green manure crop (Santhosh *et al*., 2021). More than 70% of the world’s green gram production was contributed by India. It is grown in about 16 lakh hectares with a total production of 2.05 million tonnes and productivity of about 500 kg/ha. The important growing states include Orissa, Maharashtra, Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan and Bihar [2].

Crop geometry plays a significant role on the growth and development of crop as wider spacing reduces the competition between the plants [3]. Number of plants per unit area influences plant size, yield components and ultimately the seed yield (Ejaz *et al.,* 2010). Suitable sowing time, variety and plant population are important non-cash inputs to achieve synchronous maturity and higher productivity [4-6]. Maintaining optimum spacing and population density per unit area provides conditions such as maximum light interception, photosynthetic activity, assimilation and accumulation of more photosynthates, which facilitates luxuriant crop growth and better plant canopy area and hence they produce more seed yield with best quality traits (Renthunglo *et al*., 2018). Too wide spacing may not utilize the natural resources efficiently whereas narrow spacing may result in severe inter and intra row spacing competition. Optimum spacing is an important factor to realize the potential yields as it directly affects plant growth and development (Rabish *et al*. 2017). It ensure proper growth of the aerial and underground parts of the plant through efficient utilization of solar radiation, nutrients, water, land as well as air spaces. Spacing for line sowing is recommended to maintain the required number of plant population and to undertake intercultural operations while harvesting for higher yields (Sulakshana *et al*., 2021).

Plant hormones are signal molecules produced within the plant and occur in extremely low concentrations. The plant growth regulators (PGRs) play an important role to improve biological productivity in pulses (Tensingh *et al*., 2018). The PGRs are also known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates, thereby increasing the productivity [7]. Brassinolide, a novel plant growth promoting steroidal lactone, was first isolated from rape (*Brassica napus* L.). Brassinosteroids occur ubiquitously in plants and present in extremely low concentrations. The pollen and immature seeds contain about 1-100 mg per gm fresh weight, while shoots and leaves possess still lower amounts in the range of 0.01-0.l gm per g fresh weight, considered as Phyto-hormones [8].

It induces plant growth with increased metabolic processes like photosynthesis, nucleic acid and protein synthesis. It also helps in regulating a wide range of processes, including source/sink relationships, seed germination, photosynthesis, senescence, photomorphogenesis, flowering and responses to different abiotic and biotic stresses [9]. Naphthalene acetic acid (NAA) is a synthetic plant hormone in the Auxin family. It would enhance the cytokinin content and in turn auxillary bud growth. It also transports sugars from source to sink to increase dry matter production [10]. The application of Naphthalene acetic acid (NAA) can increase fruit setting ratio, prevent fruit dropping, promote flower sex ratio. Foliar application of Naphthalene acetic acid has also found to increase plant height, number of leaves per plant, fruit size with consequent enhancement in seed yield in different crops [1]. It prevents flower drop by preventing the development of abscission layer in black gram and green gram. Gibberellic acid (GA3) play a major role in all growth processes like seed germination and development, stimulate fast stem and root growth, induce mitosis in the leaves, increase seed germination rate, the control of flowering time and cell elongation. It regulates mobilization of food reserves and interact with inhibitors such as abscisic acid (Tensingh *et al*., 2018).

With the aforementioned considerations in mind, the current study was conducted to determine "Effect of plant growth regulator and crop geometry on growth and yield of Green gram (*Vigna radiata* L.)"

### 1.1 Justification

In India, Green gram is grown widely throughout the year. Plant population and nutrient use efficiency are the most limiting factors affecting crop production and productivity. Spacing plays an important role for higher yield because thick plant population will not get proper light for photosynthesis and infestation of diseases whereas very low plant population will also reduce the output. Plant growth regulators are well known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates thereby helping in effective flower formation, fruit and seed development and ultimately enhance productivity of the crops. Due to this optimum plant population and growth regulators are the effective components for fetching higher returns [11-13].

## 2. MATERIALS AND METHODS

A Field experiment was conducted during *Zaid* 2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) on green gram (*Vigna radiata* L.). The soil of experimental plot was sandy loam in texture, low in organic carbon (0.72%), nearly neutral in soil pH (7.2), Nitrogen (178.48 kg/ha), Phosphorous (27.80 kg/ha), Potassium (233.24 kg/ha) were determined by Jackson's method, Subbaiah and Asija's method, Olsen's method, Flame photometer method, respectively. The experiment was laid out in randomized block design (RBD) consists of three plant growth hormones; three different crop geometry and were replicated thrice when applied in combinations as follows, $T_1$: Brassinolide 0.25% + 25 cm x 15 cm, $T_2$: Brassinolide 0.25% + 35 cm x 10 cm, $T_3$: Brassinolide 0.25% + 45 cm x 10 cm, $T_4$: NAA 0.40 % + 25 cm x 15 cm, $T_5$: NAA 0.40 % + 25 cm x 15 cm, $T_6$: NAA 0.40 % + 25 cm x 15 cm, $T_7$: GA3 0.50 % + 25 cm x 15 cm, $T_8$: GA3 0.50 % + 25 cm x 15 cm, $T_9$: GA3 0.50 % + 25 cm x 15 cm and $T_{10}$ : Control (RDF) 25:50:25 NPK kg/ha + Spacing 30 cm x 10 cm. The pure, healthy, disease, insect free vigorous and good quality green gram seeds were used for sowing. Seeds were sown at a depth of 3-4 cm in lines at a spacing of 30 cm × 10 cm. Weeding was done manually at 25 and 45 days after sowing with the help of khurpi. First light irrigation was done just after sowing then subsequent irrigations were applied as per the requirement of the crop. The observations on various growth and yield parameters were recorded from the selected plants. The data collected was computed and statistical analysis by analysis of variance method [14]. The results are presented at 5% level of significance (p=0.05) for making comparison between treatments [15,16].

## 3. RESULTS AND DISCUSSION

### 3.1 Growth Attributes

At 60 DAS, significantly highest plant height (78.70 cm), Number of nodules per plant (28.93), dry weight (33.25 g/plant) was recorded in treatment-2 with (Brassinolide 0.25% + 35 cm x 10 cm). Brassinolide, a plant growth promoting hormone induce the plant height by increasing the metabolic processes such as photosynthesis, nucleic acid and protein synthesis. It stimulate cell elongation, elongation of shoot, cell division, membrane permeability to water uptake and RNA synthesis. Similar results were found by Islam *et al.* [17] and Hari *et al.* (2020). Increase of vegetative growth in wider spacing might be due to in wider spacing less competition for space, mutual shading effect, nutrients and moisture due to reduced plant density per unit area Amruta *et al*., [18]. Application of brassinolide resulted in efficient nutrient better root development and nodulation Pradeep and Elaimathi (2007). Maintaining a proper plant distance of 30 cm x 10 cm helps the plant to grow more spaciously and allows the roots to penetrate and spread around efficiently which in turn leads to grow more nodules. Similar results were reported by Peruru *et al.* (2022). The widest row spacing of 30 cm x 10 cm produced higher number of branches per plant, functional leaves, greater spread and more aerial dry matter production per plant (Arpita *et al*., 2023).

**Table 1. Effect of plant growth regulator and crop geometry on Growth attributes of Greengram**

| S.No | Treatments | Plant height (cm) | Dry weight (g/Plant) | CGR ($g/m^2/day$) | Nodules/plant (No.) |
|---|---|---|---|---|---|
| 1 | Brassinolide 0.25% + 25 cm x 15 cm | 76.20 | 30.45 | 8.15 | 24.73 |
| 2 | Brassinolide 0.25% + 35 cm x 10 cm | 78.70 | 33.25 | 6.18 | 28.93 |
| 3 | Brassinolide 0.25% + 45 cm x 10 cm | 72.50 | 29.59 | 4.86 | 21.33 |
| 4 | NAA 0.40 % + 25 cm x 15 cm | 75.60 | 30.32 | 8.39 | 24.27 |
| 5 | NAA 0.40 % + 35 cm x 10 cm | 78.20 | 32.48 | 6.31 | 27.60 |
| 6 | NAA 0.40 % + 45 cm x 10 cm | 72.20 | 28.14 | 3.91 | 20.87 |
| 7 | GA3 0.50 % + 25 cm x 15 cm | 74.60 | 30.28 | 8.87 | 23.07 |
| 8 | GA3 0.50 % + 35 cm x 10 cm | 76.30 | 32.22 | 6.83 | 25.00 |
| 9 | GA3 0.50 % + 45 cm x 10 cm | 72.20 | 29.61 | 6.03 | 20.87 |
| 10 | Control(RDF)25:50:25 NPK kg/ha + 30 cm x 10 cm | 71.20 | 25.25 | 8.07 | 20.00 |
| | SEm (±) | 0.86 | 0.41 | 1.03 | 0.39 |
| | CD (p=0.05) | 2.56 | 1.23 | 3.05 | 1.16 |

**Table 2. Effect of plant growth regulator and crop geometry on yield attributes and yield of Greengram**

| S. No. | Treatment combinations | Pods/plant (no.) | Seeds/pod (no.) | Test weight (g) | Seed yield (Kg/ha) | Stover yield (Kg/ha) | Harvest Index (%) |
|---|---|---|---|---|---|---|---|
| 1. | Brassinolide 0.25% + 25 cm x 15 cm | 38.00 | 11.00 | 30.19 | 1174.90 | 3302.70 | 26.24 |
| 2. | Brassinolide 0.25% + 35 cm x 10 cm | 42.00 | 14.00 | 31.89 | 1273.70 | 3401.50 | 27.24 |
| 3. | Brassinolide 0.25% + 45 cm x 10 cm | 33.00 | 10.00 | 29.00 | 1110.40 | 3238.20 | 25.54 |
| 4. | NAA 0.40 % + 25 cm x 15 cm | 37.00 | 10.00 | 29.76 | 1170.00 | 3297.80 | 26.20 |
| 5. | NAA 0.40 % + 35 cm x 10 cm | 41.00 | 12.00 | 31.01 | 1251.20 | 3379.00 | 27.02 |
| 6. | NAA 0.40 % + 45 cm x 10 cm | 32.00 | 10.00 | 28.56 | 1080.10 | 3207.90 | 25.20 |
| 7. | GA3 0.50 % + 25 cm x 15 cm | 35.00 | 10.00 | 29.41 | 1141.20 | 3269.00 | 25.88 |
| 8. | GA3 0.50 % + 35 cm x 10 cm | 40.00 | 12.00 | 30.34 | 1210.90 | 3338.70 | 26.62 |
| 9. | GA3 0.50 % + 45 cm x 10 cm | 31.00 | 9.00 | 27.00 | 1064.50 | 3192.30 | 25.01 |
| 10. | Control (RDF) 25:50:25 NPK kg/ha + 30 cm x 10 cm | 31.00 | 8.00 | 28.26 | 1001.00 | 3140.20 | 24.17 |
| | SEm (±) | 0.48 | 0.16 | 0.43 | 17.62 | 47.52 | 0.39 |
| | CD (p=0.05) | 1.44 | 0.49 | 1.29 | 52.37 | 141.2 | 1.16 |

**Table 3. Effect of plant growth regulator and crop geometry on economics of Greengram**

| S. No. | Treatment combinations | Cost of cultivation (INR/ha) | Gross return (INR/ha) | Net returns (INR/ha) | B C ratio (B: C) |
|---|---|---|---|---|---|
| 1. | Brassinolide 0.25% + 25 cm x 15 cm | 32620.00 | 82243.00 | 49623.00 | 1.52 |
| 2. | Brassinolide 0.25% + 35 cm x 10 cm | 32620.00 | 89159.00 | 56539.00 | 1.73 |
| 3. | Brassinolide 0.25% + 45 cm x 10 cm | 32620.00 | 77728.00 | 45108.00 | 1.38 |
| 4. | NAA 0.40 % + 25 cm x 15 cm | 32194.00 | 81900.00 | 49706.00 | 1.54 |
| 5. | NAA 0.40 % + 35 cm x 10 cm | 32194.00 | 87584.00 | 55390.00 | 1.72 |
| 6. | NAA 0.40 % + 45 cm x 10 cm | 32194.00 | 75607.00 | 43413.00 | 1.35 |
| 7. | GA3 0.50 % + 25 cm x 15 cm | 32864.00 | 79884.00 | 47020.00 | 1.43 |
| 8. | GA3 0.50 % + 35 cm x 10 cm | 32864.00 | 84763.00 | 51899.00 | 1.58 |
| 9. | GA3 0.50 % + 45 cm x 10 cm | 32864.00 | 74515.00 | 41651.00 | 1.27 |
| 10. | Control(RDF) 25:50:25NPK kg/ha + 30 cm x 10 cm | 31950.00 | 70070.00 | 38120.00 | 1.19 |

### 3.2 Yield Attributes and Yield

According to yield attributes data that was collected and analyzed at harvest, significantly higher number of pods/plant (42.00), number of seeds/pod (14.00), test weight (31.89 g), seed yield (1273.70 kg/ha) and stover yield (3401.50 kg/ha) were recorded in treatment-2 with (Brassinolide 0.25% + 35 cm x 10 cm) [19,20]. The decreased plant height by the application of plant growth regulator is effective for 25 to 30 days which coincides with the pod formation and pod development stages. During this time, maximum photosynthates are utilized by the reproductive parts rather than the vegetative parts. The reduction of vegetative growth at critical stage like flowering and pod development stages are important for the enhancement of yield and harvest index of the crop Sivakuma *et al*., [21]. Brassinolides application as foliar spray enhances the growth parameter which ultimately results in higher yield attributes like number of pods per plants, number of seeds per plants, test weight, seed and stover yield Guggulla and Shikha [8]. Application of hormones at the flowering and pod formation stages influenced the growth parameters and resulted in higher seed yield Karuppusamy *et al*., (2022). The increase in yield attributes might be due to supplementation of nutrients at the critical stage without physiological stress Sruthi *et al.* [22] Individual crops are able to absorb moistures and nutrients due to wider spacing which results in higher yield Kabir and Sarkar (2018). The translocation and accumulation of photosynthates in the economic sinks thus increased yield attributes, chlorophyll content and nitrate reductase activity resulted in increased grain yield Santosh *et al*., (2021). Optimum to low plant population had produced significantly highest harvest index while high population stand had produced minimum harvest index. This might be due to the fact that in case of low seed rate, seed yield to biological yield ratio was higher as compared to higher seed rate where seed yield to biological yield ratio was low [23,24]. As harvest index value is positively correlated with seed yield and had negative correlation with biological yield therefore the harvest index value was higher in low seed rate and minimum in higher seed rate Ejaz *et al*., (2010). Optimum row spacing plays an important role in contributing to the high yield because thick plant population won't get sufficient light for photosynthesis and can be easily attacked by diseases. The more biomass produced at narrow plant spacing was due to more plant population contributing to the final biomass production Suraj *et al*., (2020).

### 3.3 Economics (INR/ha)

Maximum gross return (INR 89,159.00/ha), net return (INR 56,539.00/ha) and benefit cost ratio (1.73) were obtained highest in treatment-2 with (Brassinolide 0.25% + 35 cm x 10 cm). Foliar spray of brassinolides significantly improved seed yield and highest benefit cost ratio in green gram crop [25]. Spacing of 30 cm × 10 cm recorded economically feasible Suraj *et al*., (2020).

## 4. CONCLUSION

It can be concluded that plant density of 35 cm x 10 cm along with application of brassinolide 0.25% brought about significant improvement in the production and also proven economically viable in Green gram crop.

## ETHICAL APPROVAL

This article does not contain any studies with human participants or animals performed by any of the authors.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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