INFLUENCE OF PLANT GROWTH PROMOTERS ON ASSIMILATE PARTITIONING AND SEED YIELD OF GREEN GRAM (VIGNA RADIATA L.)

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ABSTRACT

A field experiment was conducted to study the effect of plant growth promoters on assimilate partitioning and seed yield of green gram during summer 2002. The results revealed that foliar application of putrescine and spermine @ 20 ppm registered higher growth characters (plant height, number of trifoliate leaves plant⁻¹, leaf area index and dry matter production). Yield attributing characters such as number of flowers plant⁻¹, number of pods plant⁻¹, fertility coefficient, number of filled seeds pod⁻¹ and per cent filled seeds were also increased. Application of putrescine and spermine had increased per cent seed weight and reduced the seed coat dry matter accumulation. It also registered significantly increased partitioning of assimilates in economic parts from leaf, stem and root. Putrescine and spermine recorded an additional yield of 42 and 39 per cent respectively over control by maintaining better partitioning assimilates.

INTRODUCTION

Pulses are the cheapest and main source of dietary vegetable protein for majority of Indians. Per capita per day availability of pulses in India declined sharply from 69 g in 1961 to 37 g in 1995 (Anonymous, 1998), as against the requirement of 85 g as recommended by the Nutritional Advisory Committee (Singh, 1998). Green gram (Vigna radiata L.) is the third most important pulse crop grown in India next only to gram and pigeon pea. It is a favorable pulse crop since it will thrive better in all seasons as sole and intercrop or fallow crop. Productivity of green gram in India is much lower than the world’s average as the crop is mainly concentrated in rain fed conditions with poor management practices. Several steps were made to boost the productivity of green gram. One among the cheapest way is application of growth promoters for increasing and exploiting the genetic potential of the crop. Source-sink relationship in green gram is very wider (Sujatha, 2001). Physiological manipulation is needed to improve this assimilate partitioning. Earlier report (Kabir et al., 1992) proved that PAs could improve the production in tomato, apple and litchi. SA and AA are also reported to improve the production in pearl millet (Sivakumar, 2001). Reports on PAs, SA and AA on assimilate partitioning and their effects on seed yield of green gram are scanty, so the present study was made.

MATERIAL AND METHODS

A field experiment was conducted in Tamil Nadu Agricultural University, Coimbatore (11°N, 77°E, 426.7 m MSL), India to know the response of green gram to growth promoting chemicals on its assimilate partitioning and seed yield. The soil was well drained, clay loam in texture having pH of 7.6, low in available N (195.6 kg ha⁻¹), medium in available P (16.3 kg ha⁻¹) and high in available K (386.4 kg ha⁻¹). Green gram variety CO 4 with field duration of 75 days was selected for the study. The crop was sown during February 2002 and harvested in April 2002.

The experiment was laid out in
randomized complete block design with three replications. The experiment consisted of eight treatments viz., Put @ 20 ppm, Spm @ 20 ppm, Spd @ 20 ppm, Cad @ 20 ppm, AA @ 50 ppm, SA @ 400 ppm with control (water spray) and absolute control (no spray). The fungicide (Thiram @ 2 g kg⁻¹ seeds) and Rhizobium culture (200 g kg⁻¹ seeds) pre-treated seeds were sown with a spacing of 30 x 10 cm. The required quantity (25: 50: 0 NPK kg ha⁻¹) of fertilizers was applied in the form of urea and single super phosphate respectively as soil application. All the agronomic practices were carried out as per the schedule to raise the crop.

Growth promoters were sprayed twice at 35 and 55 days after sowing (DAS) during evening hours. Spray was done with high volume sprayer of 15 litres capacity. Observations were made before the first spray (35 DAS), five days after each sprays (40 and 60 DAS) and at harvest. Five randomly selected plants were tagged and observations were taken on growth parameters (Plant height, number of trifoliate leaves plant⁻¹, leaf area index and DMP) and yield attributes (Number of flowers plant⁻¹, number of pods plant⁻¹, number of seeds pod⁻¹, number of filled seeds pod⁻¹ and 100 seed weight). The height of the plant was measured from the ground level to the tip of the highest leaf petiole and expressed in cm. Fully emerged trifoliate leaves were counted from the tagged plants. The leaves collected from the sample plants were taken to laboratory and leaf area was measured by using leaf area meter (LICOR Model 3100). From the leaf area LAI was evaluated (Williams, 1946).

\[
\text{LAI} = \frac{\text{Leaf area plant}^{-1}}{\text{Ground area occupied plant}^{-1}}
\]

The plant samples were separated as root, stem, leaf and reproductive parts and then dried in the oven at 70°C till the constant weight was attained. Percentage values arrived from the dry weight.

Number of flowers plant⁻¹, number of pods plant⁻¹ was counted from the tagged plants. From randomly selected pods, number of seeds pod⁻¹, filled seeds pod⁻¹, 100 seed weight were calculated. Fertility co-efficient was calculated as follows:

\[
\text{Fertility co-efficient} = \frac{\text{Number of pods plant}^{-1}}{\text{Number of flowers plant}^{-1}} \times 100
\]

Twenty randomly selected pods were separated as seed coat and seeds, weight was measured and values converted into percentage.

Grain and haulm yields were obtained from the net plot. The data subjected to statistical analysis (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

1. Growth parameters: Growth parameters of green gram differed significantly due to various growth promoters application (Table 1). Before the spray, treatments were not varied significantly. At 40 DAS (after I spray) application of Put and Spm recorded significantly higher plant height (35.9 and 36.0 cm, respectively) over other treatments (31.5 to 31.9 cm) and control (26.7 cm). Increased number of trifoliate leaves plant⁻¹ was obtained in the treatments sprayed with Put (10.6) and Spm (10.3) as compared to other treatments (8.1 to 8.8) and control (7.3). LAI and DMP were also followed the similar trend at 40 DAS, where the higher values noticed with Put and Spm application. Almost same trend was noticed at 60 DAS (after II spray) also. LAI was increased due to Put and Spm spray (5.19
and 5.14, respectively) over other treatments (4.30 to 4.33) and control (3.78). Similarly, higher DMP (3744 and 3752 kg ha$^{-1}$) was noticed due to Put and Spm application, respectively. Increase of DMP was lower with other growth promoters spray (3332 to 3484 kg ha$^{-1}$) and control (2553 kg ha$^{-1}$).

Biomass gain in crop plants is controlled by complex interactions of photosynthetic production by source leaves and photosynthate utilization by sink tissues (Herrick, 1988). Vegetative plant growth is controlled by interaction of multiple regulatory factors (enzymes, metabolites, hormones, etc), and that the effect of interaction may change with the stage of plant development (Loomis et al., 1979).

Put and Spm increased the growth characters (plant height, number of green leaves, LAI and DMP). This increased growth in green gram due to PAs application implied that they could act as growth promoters. Put could act as source of N (Mirza and Bagni, 1991). At lower concentrations it is comparable to that of auxins (Mulkey et al., 1982) and ethylene (Estellie and Somervillie, 1987; Gifford and Evans, 1981). It can also induce the synthesis of NRase enzyme, which enhance the ‘N’ use efficiency (Bagni et al., 1981).

2. Assimilate partitioning: Assimilate partitioning before the spray was not differed significantly. Dry matter accumulation in root, stem and leaf are ranged between 28.41 to 29.90 per cent, 38.10 to 40.43 per cent and 31.94 to 33.43 per cent respectively.

Growth promoters application had significant influence on dry matter partitioning (Fig. 1). Higher dry matter accumulation in leaf was observed in the treatments with Put (40.86%) and Spm (41.14%) as compared to other treatments and control. Whereas, Put and Spm spray reduced the accumulation of dry weight in stem (32.74 and 32.82% respectively) and root (26.40 and 26.14% respectively). Absolute control and control recorded higher accumulation of dry weight in stem (41.49 and 40.51%, respectively) and lower in leaf (34.16 and 34.39%, respectively) over growth promoters spray.

Application of growth promoters at second time had a pronounced effect on dry weight of reproductive structure. Put and Spm application significantly increased DMP in reproductive parts (15.63 and 14.91 % respectively) as compared to all other treatment (12.61 to 13.11 %) and control (11.10 %). At 60 DAS, control and absolute control registered significantly higher accumulation of DMP in stem. Irrespective of the treatments, dry matter accumulation in stem, leaf and root had decreased over first spray. Maximum per cent dry weight of leaf was observed in Put (33.18%) followed by Spm (32.91%). The lowest dry matter accumulation in stem was noticed in Put and Spm sprayed treatments (31.21 and 32.01%, respectively).

At harvest maximum accumulation of dry weight was observed in reproductive parts (33.16 to 41.07%). Among the different treatments, Put and Spm recorded higher dry weight in economic parts (41.07 and 41.04% respectively) over other treatments and control. Leaf stem and root weights were decreased at this stage. Put and Spm spray recorded the lowest stem accumulation (26.31 and 25.89% respectively). At harvest per cent dry matter accumulation in leaf was not varied significantly.

Put and Spm had proved its effect by accumulating more dry weight in seed (61.55 and 62.31% respectively) over other treatments (55.96 to 57.43%) and control (52.11%). The reverse trend was noticed with seed coat.

The increased growth and allied character might be due to increased chlorophyll content. Earlier reports clearly reflects that
### Table 1. Effect of growth promoters on growth characters of green gram

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>Number of trifoliate leaves plant&lt;sup&gt;1&lt;/sup&gt;</th>
<th>LAI</th>
<th>DMP (kg ha&lt;sup&gt;-1&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before spray</td>
<td>After I spray</td>
<td>After II spray</td>
<td>Before spray</td>
</tr>
<tr>
<td>Putrescine @ 20 ppm</td>
<td>20.9</td>
<td>35.9</td>
<td>55.8</td>
<td>5.5</td>
</tr>
<tr>
<td>Spermine @ 20 ppm</td>
<td>20.6</td>
<td>36.0</td>
<td>55.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Spermidine @ 20 ppm</td>
<td>20.6</td>
<td>31.5</td>
<td>50.4</td>
<td>5.5</td>
</tr>
<tr>
<td>Cadavarine @ 20 ppm</td>
<td>20.5</td>
<td>31.8</td>
<td>50.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Salicylic acid @ 400 ppm</td>
<td>21.3</td>
<td>31.7</td>
<td>50.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Ascorbic acid @ 50 ppm</td>
<td>21.5</td>
<td>31.9</td>
<td>50.3</td>
<td>5.5</td>
</tr>
<tr>
<td>Control (water spray)</td>
<td>21.2</td>
<td>27.4</td>
<td>42.3</td>
<td>5.5</td>
</tr>
<tr>
<td>Absolute control</td>
<td>20.7</td>
<td>26.7</td>
<td>42.1</td>
<td>5.5</td>
</tr>
</tbody>
</table>

**SEd**: 0.43, 0.64, 0.93, 0.09, 0.27, 0.57, 0.02, 0.03, 0.20, 11.3, 24.8, 111.3

**CD (P=0.05)**: NS, 1.37, 2.01, NS, 0.58, 1.23, NS, 0.06, 0.44, NS, 53.4, 238.7

### Table 2. Influence of growth promoters on yield attributes of green gram

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Number of flowers plant&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Number of pods plant&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Fertility co-efficient</th>
<th>Number of seeds plant&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Number of filled seeds pod&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Per cent 100 seed weight (g)</th>
<th>100 seed yield (kg ha&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Seed yield (kg ha&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Haulm weight (kg ha&lt;sup&gt;-1&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Putrescine @ 20 ppm</td>
<td>64.8</td>
<td>47.1</td>
<td>73.9</td>
<td>11.8</td>
<td>9.2</td>
<td>78.3</td>
<td>4.11</td>
<td>11.76</td>
<td>1771</td>
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<tr>
<td>Spermine @ 20 ppm</td>
<td>64.3</td>
<td>47.6</td>
<td>74.1</td>
<td>11.9</td>
<td>9.1</td>
<td>76.7</td>
<td>4.12</td>
<td>1154</td>
<td>1784</td>
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<tr>
<td>Spermidine @ 20 ppm</td>
<td>55.8</td>
<td>38.3</td>
<td>67.9</td>
<td>11.7</td>
<td>8.3</td>
<td>71.3</td>
<td>4.12</td>
<td>986</td>
<td>1632</td>
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<tr>
<td>Cadavarine @ 20 ppm</td>
<td>56.0</td>
<td>35.1</td>
<td>61.4</td>
<td>11.7</td>
<td>8.4</td>
<td>69.3</td>
<td>4.12</td>
<td>1001</td>
<td>1623</td>
</tr>
<tr>
<td>Salicylic acid @ 400 ppm</td>
<td>56.6</td>
<td>35.9</td>
<td>63.3</td>
<td>11.7</td>
<td>8.2</td>
<td>70.1</td>
<td>4.12</td>
<td>993</td>
<td>1637</td>
</tr>
<tr>
<td>Ascorbic acid @ 50 ppm</td>
<td>55.5</td>
<td>34.9</td>
<td>62.9</td>
<td>11.7</td>
<td>8.2</td>
<td>70.0</td>
<td>4.11</td>
<td>998</td>
<td>1591</td>
</tr>
<tr>
<td>Control (water spray)</td>
<td>49.8</td>
<td>27.0</td>
<td>54.5</td>
<td>10.9</td>
<td>6.2</td>
<td>56.8</td>
<td>4.12</td>
<td>859</td>
<td>1034</td>
</tr>
<tr>
<td>Absolute control</td>
<td>49.5</td>
<td>27.0</td>
<td>54.7</td>
<td>10.8</td>
<td>5.9</td>
<td>57.7</td>
<td>4.11</td>
<td>830</td>
<td>963</td>
</tr>
</tbody>
</table>

**SEd**: 2.14, 1.30, 1.61, 0.32, 0.17, 2.26, 0.057, 47.8, 50.1

**CD (P=0.05)**: NS, 1.37, 2.01, NS, 0.58, 1.23, NS, 0.06, 0.44, NS, 53.4, 238.7
Fig. 1. Dry matter partitioning of green gram at different stages due to growth promoters spray
application of PAs would increase Rubisco activity (Pyke and Leech, 1987) as elevation of sink ‘demand’ on developing plants or increase Rubisco enzyme concentration in source leaves which resulted in increased growth and growth allied characters. The other possible mechanism of action of PA on plants may inhibit RNAase and protease activity and also increase the RNA synthesis and retardance of senescence (Cohen et al., 1982). They have been considered either as hormones (Masse et al., 1989) candidates for active regulators of plant growth (Galeton, 1983), or secondary messengers that mediate phytohormone effects (Smith, 1985). Increased growth due to these PAs was also very well documented previously (Bagni et al., 1981; Slocum et al., 1984). Advantage of Spm over Spd was also reported (Szczotka and Lewandowska, 1988; Szczotka and Lewandowska, 1989). This above discussion is in line with the present study.

3. Yield and yield attributes: Yield attributes, viz., number of flowers plant$^{-1}$, number of pods plant$^{-1}$, fertility coefficient, number of seeds pod$^{-1}$ number of filled seeds pod$^{-1}$, per cent filled seeds pod$^{-1}$ were varied significantly due to the application of growth promoters (Table 2). Spraying of Put and Spm registered higher number of flowers plant$^{-1}$ (64.8 and 64.3, respectively) over other growth promoters (55.5 to 56.6) and control (49.8). Number of filled seeds plant$^{-1}$, per cent filled seeds pod$^{-1}$ were also higher in above said treatments. Number of pods plant$^{-1}$ was also increased significantly with Put (47.1) and Spm (47.6) application. Fertility co-efficient was increased due to the application of Put and Spm (73.9 and 74.1% respectively). However, number of seeds pod$^{-1}$ was not varied due to different growth promoters except control. Similarly growth promoters had not influenced on the 100 seed weight.

Effect of growth regulators on seed and haulm yield of green gram was significant (Table 2). Seed yield was higher due to the application of Put (42 %) and Spm (39 %) over control (830 kg ha$^{-1}$). Spd, Cad, SA and AA produced 19 to 21 per cent increased yield over control. Control (Water spray) produced on par results with absolute control (No spray). The highest haulm yield of green gram was noticed with the spray of Spm (1784 kg ha$^{-1}$), which was at par with Put (1771 kg ha$^{-1}$). All other treatments performed as like seed yield.

The increase in yield and yield attributes may be due to altering the hormonal balance and improved water relation in plants. PAs namely Put and Spm are involved in stabilization of D$_1$ and D$_2$ polypeptides of photosystem II which is the source of electron for NADP$^+$ reduction at PSI (Taiz and Zeiger, 1991). It also prevented the lipid peroxidation and proteolytic attack and inhibition of ethylene
synthesis through inhibition of ACC synthase and conversion of ACC to ethylene, which is a common phenomenon occurring during senescence. The present results also in line with the report in tomato (Kabir et al., 1992) stating that PAs improved the yield and yield attributes.

Intense competition for photosynthate by developing sink tissues may increase net carbon assimilation and photosynthate production in source leaves (Gifford and Evans, 1981). In pulses, pod is a poor competitive sink against leaf and root growth. Photosynthate partitioning to pod sucrose accumulation is regulated by source diffusion path length between successive vascular rings and sucrose storage appears to function independently to photosynthate supply (Kobayashi et al., 1990). In Put and Spm treated plant, sucrose accumulation could have specifically increased compared with that of control. It clearly explains a balanced partitioning of photosynthate to leaf, root and sucrose sinks, which resulted in a significant over all improvement in crop performance. The above finding was in corroboration with the finding in sugar beet (Keithly et al., 1990). The promotive effects of Put and Spm on the harvestable yields of green gram indicate that the strengths (defined as sink size/sink activity) of reproductive parts are greatly increased, when compared with control.

REFERENCES