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Research Paper

ENCOURAGING EFFECT OF GIBBERELLIC ACID ON THE GROWTH AND BIOCHEMICAL CHARACTERS OF GREEN GRAM (*Vigna radiata* L.)

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Abstract

In the present investigation, the effect of Gibberellic acid (GA_3) was studied in both growth as well as biochemical features of green gram (*Vigna radiata* L.). The results indicated that the foliar application of GA_3 increased the growth characters such as shoot length, root length, fresh weight and dry weight of green gram. The growth responses were higher in all treated plants compared to control plants. But the response was varied between the concentrations of GA_3. The results indicated that the growth characters were attained maximum with 50ppm of GA_3 and gradually declined in 75 and 100ppm. The same trend was observed in the biochemical characters also. The biochemical characters as such total chlorophyll, protein, amino acids, glucose and NR activity were increased with increasing the concentration of GA_3 up to 50ppm and then gradually reduced from 75ppm.

Key words: Gibberellins, GA_3. Green gram, growth, biochemical.

INTRODUCTION

Plant hormones are signal molecules produced within the plant and occur in extremely low concentrations. Plant hormone shape the plant, affecting seed growth, time of flowering, the sex of flowers, senescence of leaves and fruits. They affect which tissues grow upward and which grow downward, leaf formation and stem growth, fruit development and ripening, plant longevity and even plant death. Hormones are vital to plant growth and lacking them, plants would be mostly a mass of undifferentiated cells. So they are also called as growth hormones. Since the growth hormones regulate the growth related activities of plants, they are popularly known as growth regulators. The plant growth regulators (PGRs) play an important role in overcoming the hurdles in manifestation of biological productivity in plants [1, 2].

Gibberellins commonly known as gibberellic acids first came to the attention of Western scientists in 1950s, they had been discovered much earlier in Japan. Rice farmers of Japan had long known of a fungal disease called foolish seedling or *bakanae* disease in Japanese that causes rice plants to grow taller and eliminated seed production. Plant pathologists found that these symptoms in rice plant were induced by a chemical secreted by a pathogenic fungus, *Gibberella fujikuroi*. Culturing this fungus in the laboratory and analyzing the culture filtrate enabled Japanese scientists in the 1930s to obtain impure crystal of two fungal "compounds" possessing plant growth promoting activity. One of these, because it was isolated from the fungus *Gibberella*, was named gibberellin A. In 1950s scientists of Tokyo University separated and characterized 3 different gibberellins from gibberellin A sample, and named them gibberellin A1, gibberellin A2 and gibberellin A3. The numbering system for gibberellins used in the past 50 y builds on this initial nomenclature of gibberellins A1 (GA1), GA2, and GA3[3, 4].

Among plant growth regulators, use of exogenous gibberellin in breaking dormancy is not well understood but it has been postulated that gibberellins regulate mobilization of food reserves [5] and interact with inhibitors such as abscissic acid [6]. Gibberellic acid (GA_3) has been used to increase the length or height of plants, increase the number of flowers and induce early flowering [7, 8]. Gibberllins 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 even organ elongation [9]. During germination process, Gibberellic acid kindles the cells of seeds to produce mRNA molecules that code for specific hydrolytic enzymes. It is well documented that these are very powerful hormones which happen to occur naturally in plants and regulates their development in response to external environment also [10].

Application of growth hormones through foliar spray enhances crop nutrition in both conventional and alternative production systems. Foliar application of hormones is being used on a wide variety of crops *i.e*. horticultural and agronomic crops. The PGR are required by the plants for normal growth and development and have an important role in the translocation of photosynthates to the reproductive sinks, besides improving quality. Agriculturists all over the world have developed certain unusual methods by which they successfully cultivate the crop plants. It is only in recent year's plant physiologists discovered how plant hormones can be effectives used in agriculture, horticultures, pomiculture and other related fields. The use of GA_3 greatly enhances the growth of plants and total area of leaf surfaces and also prevents premature falling of fruits. The application of gibberellic acid increases cell division and cell elongation in plants resulting in more number of cells and increase in cell length which ultimately affects plant growth [11]. A significant increase in the vegetative characters with increase in concentrations of GA_3 was also reported by [12] in black iris and [13] in gladiolus. In this context, the present study was taken up to find out the nursery performance of foliar application of GA_3 on growth and biochemical characteristics of green gram (*Vigna radiata* L.).

MATERIAL AND METHODS

The seeds of green gram (*Vigna radiata* L.) and growth regulator (Gibberellic acid) were purchased from Agricultural College, Virudhunagar District, Tamil Nadu, India. Healthy and uniform green gram seeds were chosen and sown in the pots contained red, black and sand soil (1:1:1). Gibberellic acid as different concentration (10ppm, 25ppm, 50ppm, 75ppm and 100ppm) sprayed as foliar at 7 days interval on green gram. The growth characters such as shoot length, root length, fresh and dry weight were analyzed in the treated and control plants. Plants were uprooted without causing any damage to the seedlings and it was thoroughly washed with tap water in order to remove soil and debris particle and then measured the shoot and root length. The fresh weight of whole plant parts (shoot, leaves and root) was also measured. The fresh undamaged whole plant system of seedlings was kept in the oven at 80°C 4-6 hours and measured their dry weight. The biochemical characters such as total chlorophyll [14], protein [15], glucose [16], free amino acid [16] and nitrate reductase activity [17] were analyzed in treated and untreated plants. Growth parameters were determined with five independent replicates. Biochemical characters were carried out at least three times. The data were reported as mean ± SE and in the figure parentheses represent the percent activity.

RESULTS

Effect of GA_3 on the growth characters of green gram

The foliar application of GA_3 increased the growth characters such as shoot length, root length, fresh weight and dry weight of green gram. The growth responses were higher in all GA_3 treated plants compared to control plants. The response was varied with the concentration of GA_3. The results indicated that the growth character was maximum with 50ppm of GA_3. It was observed that the shoot length was found to be increased in those seedlings sprayed with various concentrations of Gibberellic acid. The increments over the control were found to be 50ppm of GA_3 (30.2cm) and gradual decrease in the 75ppm (27.9cm) and 100ppm(27cm) of GA_3. Likewise, the root length was also found to be increased over the control plants and 50ppm sprayed plants produced taller root than other treatments. It was observed that the plants grown with 50ppm of GA_3 produced taller roots (23.6cm). The fresh and dry weight was also higher in plants sprayed with GA_3. The plant fresh and dry weight was increased with increasing the concentration of GA_3 up to 50ppm and there was a gradual decrease in both plant fresh and dry weight (Table 1).

Effect of GA_3 on the biochemical characters of green gram

In the nursery experiment, *Vigna radiata* L. sprayed with GA_3 increased the biochemical characters such as total chlorophyll, protein, amino acids, glucose and NR activity. The effect was varied with concentration of GA_3. The result revealed that the total chlorophyll content was higher in plants sprayed with GA_3 up to 50ppm (1.95mg) and reduced in 75 (1.82mg) and 100ppm (1.75mg). The result indicated that the glucose content was higher in plants sprayed 50ppm of GA_3 (6.23mg). The protein content was also more in the plants sprayed with 50ppm of GA_3 (3.78mg) than other concentrations and control plants. Foliar spray of GA_3 increased the free amino acid in the leaves of green gram in all treated plants but the effect was higher in 50ppm of GA_3 (2.12mg) over control plants (1.49mg). NR activity was estimated in the leaves of treated and control plants. The results indicated that NR activity was higher (5.63µm) in the plants sprayed with GA_3 @ 50ppm. In general like growth characters, the maximum response of GA_3 was achieved only at 50ppm and before and after this concentration, the response was declined (Table 2).

Table 1: Effect of Gibberellic acid on the growth characters of green gram

S. No.	Samples	Shoot Length (cm)	Root Length (cm)	Fresh Weight (g)	Dry Weight (g)
1.	Control	22.7 ±0.088 (100)	11.7 ±0.120 (100)	1.40 ±0.007 (100)	0.3 ±0.003 (100)
2.	GA_3 - 10ppm	23.0 ±0.120 (102)	15.5 ±0.115 (135)	1.50 ±0.002 (108)	0.37 ±0.003 (123)
3.	GA_3 - 25ppm	25.9 ±0.145 (113)	16.9 ±0.176 (144)	1.67 ±0.002 (122)	0.42 ±0.004 (137)
4.	GA_3 - 50ppm	30.2 ±0.088 (133)	23.6 ±0.120 (206)	1.93 ±0.002 (140)	0.67 ±0.002 (221)
5.	GA_3 - 75ppm	27.9 ±0.185 (121)	20.4 ±0.115 (178)	1.82 ±0.003 (132)	0.66 ±0.002 (214)
6.	GA_3 - 100ppm	27.0 ±0.057 (119)	19.1 ±0.088 (167)	1.72 ±0.004 (125)	0.47 ±0.001 (154)

Table 2: Effect of Gibberellic acid on the biochemical characters of green gram

S. No.	Samples	Total Chlorophyll (mg/g LFW)	Glucose (mg/g LFW)	Protein (mg/g LFW)	Amino acid (mg/g LFW)	NRA (µ moles/30 minutes)
1.	Control	1.67 ±0.006 (100)	5.29 ±0.176 (100)	2.10 ±0.005 (100)	1.49 ±0.052 (100)	4.26 ±0.072 (100)
2.	GA_3 - 10ppm	1.69 ±0.001 (102)	5.42 ±0.233 (103)	2.32 ±0.003 (111)	1.65 ±0.026 (111)	4.65 ±0.094 (109)
3.	GA_3 - 25ppm	1.73 ±0.001 (104)	5.57 ±0.264 (105)	2.66 ±0.003 (123)	1.78 ±0.040 (119)	4.87 ±0.051 (114)
4.	GA_3 - 50ppm	1.95 ±0.012 (117)	6.23 ±0.405 (118)	3.78 ±0.002 (182)	2.12 ±0.043 (143)	5.63 ±0.043 (132)
5.	GA_3 - 75ppm	1.82 ±0.009 (109)	6.09 ±0.698 (114)	3.19 ±0.006 (146)	1.96 ±0.052 (132)	5.53 ±0.644 (128)
6.	GA_3 - 100ppm	1.75 ±0.007 (106)	5.9 ±0.240 (107)	2.92 ±0.002 (138)	1.90 ±0.028 (127)	5.05 ±0.351 (120)

DISCUSSIONS

Biomass Attributes

The growth attributes like shoot length, root length, fresh weight and dry weight of *Vigna radiata* L. were significantly enhanced by foliar application of GA_3 as compared to the unsprayed plants. The GA_3 foliar spray enhanced the height and ornamental wealth of *Araucaria heterophylla* plants [18], enhanced growth attributes with foliar application of GA_3 and NAA in coriander [19] and increase in yield due to the application of GA_3 to the increase in plant height and number of branches per plant compared to

control plots [20]. The maximum plant height was recorded by the spray of GA_3 at 150 ppm. Increase in the concentration of GA_3 increased plant height as evident from the data recorded on plant height after 45 days after transplanting. This may be attributed to the capacity of GA_3 to induce mRNA synthesis pertaining to hydrolytic enzymes and to the increased cell enlargement eventually leading to increased length of internodes. The total dry matter accumulation per plant significantly differed among various treatments during both the seasons. The maximum dry matter was recorded by the spray of GA_3 at 100 ppm which was on par with GA_3 at 150 ppm. The effect of GA_3 on the growth of the aerial part may lead one to believe that consequently, roots would grow as well, causing in turn an increase in total dry matter [21].
Plant height was predominantly increased by the application of GA_3. Plant height is a very important factor for good plant growth and ultimate yield. Along with plant height pod length, number of pods, number of leaves and other vegetative and reproductive attributes were also increased [22, 23]. Gibberellic acid (GA_3) also stimulated nitrogen assimilation which affected the raw protein accumulation in okra seeds that is important for crops for seeds production. The beneficial effects of gibberellic acid on growth have been reported in different plants such as croton [24], rose [25], *Ocimum basillicum* [26], *Lavandula officinalis* [27] and *Nigella sative* [28]. The application of GA_3 increased the stem length, number of nodes and number of flowers through foliar application of gibberellic acid on lily plants [29].
Gibberellic acid is a naturally occurring growth hormone which controls the extremely important aspects of plant growth through regulation of several growth processes such as seed germination, stem elongation, uniform flowering, and increased number of flowers. Exogenous application of GA_3 hastens the vegetative and reproductive growth of plants. Therefore, the foliar application of GA_3 may be an effective strategy for maximizing the growth and yield of okra [30]. In plants, the most widely available compound is a gibberellic acid (GA_3) which induces stem and inter node elongation, seed germination, enzyme production during germination, and fruit setting and growth [31].

Biochemical Attributes

The foliar application of GA_3 increased the physiological characters of green gram such as total chlorophyll, protein, amino acids, glucose and NR activity. The physiological response was higher in all treated plants compared to control. The response was varied with the concentration of GA_3. Increase in leaf chlorophyll content might be responsible for increased phtotosynthesis, ultimately enhanced the total carbohydrate content. It is likely that increased photosynthetic CO_2 fixation might provide more carbohydrates for metabolism and for export to sink [32]. The plant regulators GA_3 were effective on production of photosynthetic pigments. Higher values of chlorophyll a and chlorophyll b were observed at different concentration of GA_3. Increasing concentrations of GA_3, determined increased values for chlorophyll a. Results for evaluations of chlorophyll of leaf showed that application of GA_3 had a significant difference compared to the control application [33, 34].
The physiological effect of PGRs on groundnut at 120 ppm increased chlorophyll content and total chlorophyll and NRA activity [35] and enhanced the chlorophyll content in cycocel treated cotton leaves [36] The chlorophyll content increased significantly due to cycocel treatment in cotton also [37]. It also exerted influence on plant growth by enlarging leaves and increasing photosynthetic activities in plants. It also activated the translocation of carbohydrates during their synthesis [38]. There

were significant increments in the biochemical contents of Chl a and b, total Chl and total carotenoids, total sugar, indoles and free amino acid of marigold leaves with GA_3 (25 mgL^{-1}) as foliar application. Total phenols were significantly enhanced by increasing GA_3 concentration (maximum at 100 mgL^{-1} GA3). In contrast, the other biochemical contents of marigold leaves were improved by GA3 at low concentration (25 mg L^{-1}). GA3 treatments (50 mg L^{-1}) similarly increased essential amino acid and total amino acid content of soybean (*Glycine max* L.) [39].

CONCLUSION

The most widely using plant growth hormone is GA_3 which increased the growth, development and biochemical characters of green gram. The effect is varied with the concentration of GA_3 with reference to growth and biochemical characters of green gram. It is clear that GA_3 has the beneficial effect and the effect was achieved even at low concentration. In general, the plant growth regulators have the beneficiary effect on the plants even at low/minute concentration and it is proved by the present investigation. The findings can be useful in the nursery as well as the field usage of GA_3 for the betterment of plant growth especially economically important crop plants like green gram.

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