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Growth and Yield of Mungbean (*Vigna radiata* L.) in Response to Gibberellic Acid and Uniconizole Foliar Application

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Abstract: This study was carried out during summer seasons of 2014 and 2015 in the greenhouse of the National Research Center, Dokki, Giza, Egypt in order to investigate the response of growth and yield of mungbean (*Vigna radiata* L.) to Gibberellic acid (GA_3) (0,100 and 200 ppm) and Uniconazole (0,100 and 200 ppm). The results indicated that application of 100 ppm GA_3 significantly increased plant height of mungbean plants in comparison to untreated plants or the treatment received 200 ppm GA_3. On contrary, the plant height was significantly gradually decreased by increasing the Uniconazole concentration from zero to 100 and /or 200 ppm. The untreated plant produced the highest plant height (53.17 cm), while the lowest (44.17 cm) was produced with the treatment received 200 ppm Uniconazole. Number of pods/plant was gradually increased by increasing GA_3 from 0 to 200 ppm. The highest number of pods/plant (46.17) was observed with 200 ppm GA_3, while the lowest (22.83) was observed with control plants. On the other hand, the number of pods per plant was decreased by applying 100 and 200 ppm Uniconazole compared to control plants. The results indicated that the 1000-seed weight was gradually decreased with increasing GA_3 up to 200 ppm, while applied of 100 ppm Uniconazole produced the highest 1000-seed weight (59.30 g). Seed yield per plant was increased gradually with increasing GA_3 up to 200 ppm, while it was increased only by using 100 ppm Uniconazole resulted in the highest seed yield (16.65g). The highest content of calcium (17.25%) was recorded with the treatment received 200 ppm Uniconazole, while the lowest with untreated plants. The same trend was noticed with some micronutrients Fe, Zn and Mn. The application of 100 or 200 ppm GA_3 decreased the contents of Fe, Zn and Mn in the seeds, while applied the same concentrations of Uniconazole lead to an increase in these micronutrients.
Keywords: Mungbean (*Vigna radiata* L.), Growth, Yield, Gibberellic acid, Uniconazole.

Introduction

Mungbean (*Vigna radiata* L.) is the important pulse crop belonging to the family Fabaceae. It has worldwide productivity and commonly cultivated in Asia. The seeds contain 22-28% carbohydrates, protein 60-65%, 1-1.5% fat, 3.5-4.5% fibers and 4.5-5.5% ash. This crop can be used for both seeds and forage since it can produce a large amount of biomass and then recover after grazing to yield abundant seeds[1]. In Egypt, mungbean is untraditional field crop mainly was introduced from India and Pakistan since 1986 and it can be grown successfully in summer season under Egyptian conditions[2]. Plant growth regulators are 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. Growth regulators can improve the physiological efficiency including photosynthetic ability and can enhance the effective partitioning of accumulates from source and sink in the field crops[3]. In this respect, growth regulators application may be one of such treatments which affect plant behavior by stimulating the induction, initiation and development of mungbean flowers branches under different conditions. Gibberellins (GAs) are generally involved in growth and development. These plant growth regulators (PGRs) in general, help to increase the number of flowers on the plant when applied at the time of flowering. The plant growth regulators play an important role in overcoming the hurdles in manifestation of biological productivity in pulses. The use of plant growth regulators are known to improve the physiological efficiency including photosynthetic ability of plants and offer a significant role in realizing higher crop yields[4]. Gibberellic acid (GA) is known to be importantly concerned in the regulation of plant responses to the external environment[5]. Furthermore, results indicated that application of 100 mgL^{-1} pre-soaking + 100 mgL^{-1} foliar application of Gibberellic acid improved the growth parameters[6]. Das Gupta *et al*.[7], who recorded that foliar application of plant growth regulators like GA_3, helped the plant to restore retardation in water content in mungbean plants subjected to water stress. 1000-seeds weight, number of seeds per pod, number of pods per plant, seed yield and biological yield were significantly affected by GA application[6]. Who, also reported that seed yield was significantly affected by application of 100 mgL^{-1} as seed pre-soaking +100 mgL^{-1} as foliar application of Gibberellic acid. These means that application of GA_3 affected seed yield by increasing the 1000-seed weight, number of seeds per pod and number of pods per plant. Biological yield (total dry matter) was significantly affected by application of GA_3. It is reported that Uniconazole shows a much higher inhibitory effects on plant growth and development and it degrades more easily in soil and there are fewer residues in plant compared with paclobutrazol[8]. Wang-Xi *et al.*[9] on rice found that Uniconazole increased grain yield, yield components and rate of photosynthesis of rice plants. In this concern, Imam *et al.*[10] on wheat reported that number of tillers, leaves, yield of wheat plants increased as affected by Uniconazole under water stress conditions. Moreover, Uniconazole, as a potent and active member of the triazole family, was developed for use as plant growth retardant and is increasingly used to manipulate plant growth and yield[11] on soybean.

The application of plant growth regulators regulate the excess growth and enhance the flowering and pod setting by way of transporting the photosynthesis into sink. Keeping these aspects in view, the present study was undertaken to assess the influence of Gibberellic acid (GA_3) as growth regulator and Uniconazole as growth inhibitor on growth and yield of mungbean (*Vigna radiata* L.) under the greenhouse conditions.

Materials and Methods

A pot experiments were carried out during two summer seasons of 2014 and 2015 in the greenhouse of the National Research Centre, Dokki, Giza, Egypt in order to investigate the effect of different concentrations of Gibberellic acid (GA_3) (0, 100 and 200 ppm) and Uniconazole (0,100 and 200 ppm) on growth and yield of mungbean (*Vigna radiata* L.) cv. Kawmi-1. Seeds of mungbean (Kawmi-1) were sown in 1^{st} June in 2014 and 2015 growing seasons in plastic pots (40 cm diameter and 40 cm depth) filled by clay soil and arranged in factorial experiments in complete randomized design with five replicates for each treatment. The analysis of soil used was carried out following the methods described by Jackson[12], coarse sand 6.30%, fine sand 35.20%, silt 38.00%, clay 20.50%, soil texture silt-clay, pH 7.95, EC dSm^{-1} 0.96, OM 2.89%, $CaCO_3$ 0.72%, available N 155.00, P 5.50 and K 265 ppm. Phosphorus and potassium fertilizers were added before sowing at a rate of 6.0 and 3.0 g/ pot of calcium super phosphate (15.5% P_2O_5) and potassium sulphate (48-50% K_2O), respectively. Thinning was done twice at 21 and 35 days after planting (DAP) to leave one plant per pot till harvest. Nitrogen fertilizer was applied as two equal portions at a rate of 0.60 g/pot for each in the form of ammonium nitrate (33.5% N) at 30 and 60 days after planting. At 60 days after planting (DAP) different concentration of Gibberellic acid (GA_3) (0,100 and 200 ppm) and Uniconizole (0,100 and 200 ppm) were applied as foliar application. At 90 DAP a representative sample was taken from each treatment for determining some growth characters: plant heights (cm), number of branches/plant and dry weight/plant (g). At the same time a representative leaves sample were taken for determining the proline content (μmol/g fresh weight) in fresh leaves according to Bates *et al.*[13]. At harvest time, the following criteria were recorded, number of pods/ plant, number of seeds/pod, 1000-seed weight (g) and seed yield (g/plant). Calcium was determined in the seeds by using Flame photometer (Jenway), whereas the Fe, Zn and Mn were estimated in the seeds by using atomic absorption apparatus.

Statistical Analysis:

The obtained data were statistically analyzed in complete randomize design according to Snedecor and Cochran[14] and the combined analysis was done according to Steel and Torrie[15], Duncan's multiple range test[16] was used and also LSD test for comparing the treatments means at the 5% level of probability.

Results and Discussion

Effect of Gibberellic acid and Uniconazole on some growth characters and proline content of mungbean

Data presented in Table 1 indicated that application of 100 ppm GA_3 significantly increased plant height of mungbean plants in comparison to untreated plants or the treatment received 200 ppm GA_3. Such increases in plant height estimated by 16.57% over the control treatment and 8.40 % over the treatment received 200 ppm GA_3. Gibberellic acid (GA_3) can manipulate of growth and development phenomena of various crops. It was reported that to stimulate the stem elongation[17, 18, 19]. On contrary, the plant height was significantly gradually decreased by increasing the Uniconazole concentration from zero to 100 and /or 200 ppm. The untreated plant produced the highest plant height (53.17 cm), while the lowest (44.17 cm) was produced with the treatment received 200 ppm Uniconazole. The reduction in plant height due to applied of 100 or 200 ppm Uniconazole was 9.10 and 16.93 %, respectively. The depression effect of Uniconzole may be attributed to the inhibition of cell division or cell elongation through functioning as antiauxins and anti-gibberellins, where Uniconazole is classified as growth retardant, such as a retarding effect was due to reduction of internodes length[20, 21]. The retardation of plant height may be also attributed to inhibition of ent-kaurene oxidase, which catalyzes the sequential oxidations from ent-kaurene to kaurenoic acid in the early GA biosynthesis[22, 23]. Data presented in Table 1 indicated the application of 100 ppm GA_3 increased significantly the number of branches per plant compared with the untreated plants or with the treatment received 200 ppm. On the other hand, application of Uniconazole resulted in a decrease in number of branches/plant in comparison to applied of Gibberellic acid, in general applied of 100 or 200 ppm Uniconazole produced lower number of branches/plant than untreated plants. In this context, the dry weight/plant was also significantly affected by applying Gibberellic and Uniconazole. Mekki and Orabi[24] on oil lettuce found that dry matter accumulation was significantly decreased by increasing Uniconazole up to 300 ppm. The reduction in biomass production may be attributed to the retardation of growth due to the direct effect of Uniconazole. The effect of Uniconazole may prevent excessive growth and improve translocation on photosynthates from the source to sink. Similar findings were reported by Imam *et al.*[10], Mekki and El-Kholy[25] and Bekheta *et al.*[26]. The present data in Table 1 indicated the there is a slight increase in dry weight by applying 100 or 200 ppm GA_3 compared to the control treatment, also the differences between 100 and 200 ppm was not significant. The distribution of dry matter formed among various plant organs is a major determinant for both total dry matter production and economic yield and amount of total dry matter produced as an indication of overall efficiency of utilization of resources and better light interception[27]. In this concern, in view to apply of 100 Uniconazole, a slight increase was observed compared to untreated plants or 200 ppm Uniconazole. These results are in agreement with those obtained by Gabal *et al.*[28] on French bean, Deotal *et al.*[18] on soybean and Houqe and Houqe[29] on mungbean found that application of 100 ppm GA_3 increased the total dry matter accumulation.

Data in Table 1 indicated that the proline accumulation in fresh leaves of mungbean plants with applying GA_3 or Uniconazole was not significantly affected. However, application of 100 GA_3 and 200 ppm Uniconazole resulted in a few increase in proline content in comparison to other treatments. Mekki and Orabi[24] on prickly oil lettuce found that increasing the Uniconazole concentration up to 300 ppm increased the proline accumulation in fresh leaves in comparison to untreated plants. These results are in accordance with the findings of Abo El-Kheir *et al.*[30] on sunflower.

Table 1: Effect of Gibberellic acid and Uniconazole on some growth characters and proline content in mungbean.

Growth hormones	Concentration (ppm)	Plant height (cm)	Number of branches /plant	Dry weight/ plant (g)	Proline (µmol/g fw)
Gibberellic acid (GA_3)	0	55.33bc	11.00c	10.50a	2.76
	100	64.50a	16.00a	11.25a	2.87
	200	59.50ab	14.00b	11.25a	2.60
Uniconazole	0	53.17cd	11.00c	7.50b	2.36
	100	48.33de	8.17d	8.25b	2.27
	200	44.17e	8.17d	7.50b	2.61
	LSD 0.05	5.06	1.43	1.13	NS

Effect of Gibberellic acid and Uniconazole on yield and yield components of mungbean

Plant growth regulators are also known to play a positive role in enhancing qualitative and quantitative characters in plants. Application of Gibberellic acid and Uniconazole as foliar sprays on mungbean plants significantly affected on number of pods/plant, number of seeds/pod. 1000-seed weight and seed yield/plant (Table 2). The use of plant growth regulators are known to improve the physiological efficiency including photosynthetic ability of plants and offer a significant role in realizing higher crop yields[4]. Number of pods/plant was gradually increased by increasing GA_3 from 0 to 200 ppm. The highest number of pods/ plant (46.17) was observed with 200 ppm GA_3, while the lowest (22.83) was observed with control plants. The increase in number of pods/plant was 87.60 and 102.23% compared to control plant. However, when the GA_3 was increased from 100 ppm to 200 ppm the number of pods was increased by 7.80%. On the other hand, the number of pods per plant was decreased by applying 100 and 200 ppm Uniconazole compared to control plants. These reductions in number of pods estimated by 29.06% and 13.13% with the treatments received 100 or 200 ppm Uniconazole, respectively. Number of seeds/pod was also increased gradually by increasing GA_3 up to 200 ppm, while it was increased only with application of 100 ppm Uniconazole. The highest number of seeds/pod (8.99) was produced with applying of 200 ppm GA_3 and the lowest (5.85) with 200 ppm Uniconazole (Table 2). The results indicated the 1000-seed weight was gradually decreased with increasing GA_3 up to 200 ppm, while applied of 100 ppm Uniconazole produced the highest 1000-seed weight (59.30 g). Mekki and Orabi[24] reported that the seed index of oil lettuce no trend was observed in seed index due to spraying with Uniconazole compared untreated plants. The decrease in 1000-seed weight estimated by 4.43 and 8.8 g by applying 100 or 200 ppm GA_3 compared with untreated plants, respectively. Data presented in Table 2 illustrated that the seed yield per plant was significantly affected by applying of GA_3 or Uniconazole. Seed yield per plant was increased gradually with increasing GA_3 up to 200 ppm, while it was increased only by using 100 ppm Uniconazole resulted in the highest seed yield (16.65 g). The increase in seed yield due to application Uniconazole was reported by El-Greedly and Mekki[21] and Mekki and Orabi[24]. This might be attributed to the fact that the growth retardant Uniconazole improved photosynthetic activities with the crop canopy by improving the chlorophyll content in the leaves and retaining a higher LAI during the sink development phase and in turn trapped more photosynthetically active radiation. In this context, Hoque and Hoque[29] reported that the physiological parameters of mungbean can be favorably influenced by applying GA_3 with consequent increased seed yield. The increase in seed yield per plant estimated by 27.05 and 69.78% when GA_3 was increased from 0 to 100 or 200 ppm in comparison, respectively. In this concern, Rajesh *et al.*[27] found that the highest seed yield with 20 ppm NAA application can be attributed to more value for the number of pods per plant (25.1), seeds per pod (7.0) and test weight (37.1 g) as compared to other. Similar results were reported that significantly influenced by the application of NAA in mungbean[31].

Table 2: Effect of Gibberellic acid and Uniconazole on yield and yield components in mungbean.

Growth hormones	Concentration (ppm)	No. of pods/ plant	No. of seeds / pod	1000-seed weight (g)	Seed yield/plant (g)
Gibberellic acid (GA_3)	0	22.83c	6.99b	53.70ab	9.76c
	100	42.83ab	8.13a	49.27bc	12.40bc
	200	46.17ab	8.99a	44.90c	16.59a
Uniconazole	0	53.33a	6.23bc	45.57bc	14.11ab
	100	37.83b	6.67bc	59.30a	16.65a
	200	46.33ab	5.85c	50.80abc	13.72ab
	LSD 0.05	14.48	1.07	8.79	3.21

Effect of Gibberellic acid and Uniconazole on calcium, Fe, Zn and Mn in the mungbean seeds

Data presented in Table 3 indicated that application of 100 or 200 ppm GA_3 decreased the calcium content in the seeds of mungbean. The highest calcium content (15.31%) was observed with untreated plants, while the lowest (11.62 %) was observed with the treatment received 200 ppm GA_3. The chemical structure of applied GA_3 may play an important role in increasing the absorption of cations (or anions) by plant tissues. Akbari *et al.*[6] found that application of Gibberellic acid significantly affected content of Ca^{2+} (root and shoot). The highest content of Ca^{2+} of root and shoot (6.50 and 7.35 mg mineral ion/g dry weight, respectively) associated with the control.

The influence of GA_3 on the mechanism of ions uptake may be related to its effect on membrane permeability and rate of ion entry through the membrane, or enhances their translocation to the shoot[32]. Abdallah *et al.*[33] reported that increased micronutrients in cotton plants by application of 100 ppm GA_3. On contrary, applied of 100 or 200 ppm Uniconazole increased the content of calcium in the seeds. The highest content of calcium (17.25 %) was recorded with the treatment received 200 ppm Uniconazole, while the lowest with untreated plants. The same trend was noticed with some micronutrients Fe, Zn and Mn. The application of 100 or 200 ppm GA_3 decreased the contents of Fe, Zn and Mn in the seeds, while applied the same concentrations lead to an increase in these micronutrients. The highest content of Fe, Zn and Mn (0.89, 0.56 and 0.17%, respectively), while the lowest (0.35, 0.39 and 0.11%, respectively) with the treatment received 200 ppm GA_3. Rashad and Hussein[34] found that the foliar application of GA_3 was the most effective in resisting the severe increase levels of Fe. Also, Akman[35] found that reported that application of GA_3 increased the Fe, Zn and Mn in barley and corn. On the other hand, with applying Uniconazole, the highest content of Fe, Zn and Mn (1.47, 0.71 and 0.19%, respectively), with the treatment received 200 ppm Uniconazole, while the lowest (0.48, 0.28 and 0.13%, respectively) with untreated plants.

Table 3: Effect of Gibberellic acid and Uniconazole Calcium, Fe, Zn and Mn contents in mungbean seeds.

Growth hormones	Concentration (ppm)	Ca (ppm)	Fe (mg/g dw)	Zn (mg/g dw)	Mn (mg/g dw)
Gibberellic acid (GA_3)	0	15.31	0.89	0.56	0.17
	100	12.15	0.68	0.50	0.14
	200	11.62	0.35	0.29	0.11
Uniconazole	0	12.40	0.48	0.28	0.13
	100	16.21	1.17	0.45	0.18
	200	17.25	1.47	0.71	0.19

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