

Morphological Performance of Onion under Exogenous Treatments of GA₃

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Abstract

The present study was conducted to assess the morphological response of onion plants to different GA₃ levels (0, 20, 40 and 60 ppm). The factor levels of GA₃ were applied during transplanting by root soaking and foliar spray at 30 and 60 days after transplanting. The gibberellic acid had a great effect on increasing plant height (46.50 cm), shoot biomass (641.67 g m⁻²), bulb biomass (1125.00 g m⁻²) and also dry matter accumulation in onion plants under the effect of 60 ppm compared to control. Plants grown up without GA₃ application were shorter than those grown with GA₃ spray where the lowest plant height (34.67 cm) was remarked. The leaf number (11.43) was considerably increased when 60 ppm GA₃ was used as the growth promoter factor in comparison to control. The plants attain minimum fresh biomass at harvesting time in the shoot (441.67 g m⁻²) and bulb (641.67 g m⁻²) grown in control plot. Considerably (41.63%) more dry shoot biomass accumulation was recorded in 60 ppm GA₃ treated plants in comparison with the control at harvesting stages. Insignificant effect by all concentration of GA₃ was found in bulb length, fresh root biomass and dry root biomass. Thus, the use of 60 ppm GA₃ can be recommend for onion production due to the significantly increased of the fresh bulb biomass with about 42.96% over control.

Keywords: *Allium cepa*; bulb crop; growth regulators; morpho-physiology

Introduction

Globally, onion (*Allium cepa* L.) is an important crop that needs proper agricultural management in order to achieve a great flavour and to increase the production in regard with the consumer's demand (Sharma *et al.*, 2015). It is the main spice crop rather than vegetable and therapeutic in Bangladesh (BBS, 2015). This bulbous crop sparingly holds the first position in terms of production among the spice crops (BBS, 2015). Bangladesh is producing about 1,052 metric tons of onion, over 300 thousand acres of land, with the average yield about 3.33 metric tons per acre (BBS, 2015). Bangladeshi farmers grow onion during both winter and summer seasons, following traditional methods. Although the area and production of onion have been increased compared to an earlier period, still the average yield is lower as compared to much other onion producing neighbouring countries and it may be impossible to accomplish the domestic demand, due to growing population (BBS, 2015).

Plant growth regulators have a potential role in modern agriculture (Ashraf *et al.*, 2010) and have been known as key element for vegetative growth and bulbing (Rahman *et al.*, 2004; Ouzounidou *et al.*, 2011). Besides stimulating the growth processes, they also affect seed development, organ elongation, senescence and control of flowering time (Yamaguchi, 2008; Yu *et al.*, 2009; Ghoname *et al.*, 2011). GA₃ play a vital role to vigorous growth, that promoted the total plant length of onion by 35% of the control and also increased the number of leaves, fresh and dry weight significantly (Ouzounidou *et al.*, 2011). Thus GA₃ have the promoter effect on the growth and development of bulb crops, as well as the total yield (Hye *et al.*, 2002; Islam *et al.*, 2007; Amal and Hegazi, 2009).

The option of more expansion of the area under onion cultivation seems unlikely because of intense crop competition. Improving the production of onion using some modern agricultural practices need to be considered. Regarding this, the yield of onion can be increased by using plant growth regulators. Moreover, analysis of morphological features of a plant would be a feasible

technique for modelling growth and development of onion plants that is an obligate prerequisite to understanding the behavioural response.

The present study aimed to improve the onion production from the scientific and economic point of view. Therefore, an attempt was taken in the present study to evaluate the effect of GA₃ on morphological characters of onion and also to test standardized concentrations of GA₃.

Materials and Methods

Plant material and site description

The variety 'BARI Onion-1' was tested at the horticulture farm of Sher-e-Bangla Agricultural University, Bangladesh in 24.09° N latitude and 90.26°E longitude with an elevation of 8.20 m from sea level. The experimental field is under the subtropical climate characterized by scanty precipitation during the interval from October to March. 'BARI Onion-1' is a winter variety and comparatively less susceptible to pest and diseases. Plants were maintained in the open environment under natural sunlight. The soil of the experimental site is in loam textural class (Table 1).

Plant growth characters

Data was collected on plant growth features (e.g. plant height, leaf number, root length, bulb length and bulb diameter), fresh biomass assimilation (e.g. fresh root biomass, fresh shoot biomass and fresh bulb biomass) and dry biomass accumulation (e.g. dry root biomass, dry shoot biomass and dry bulb biomass).

The experimental design

The experiment was conducted by Randomized Complete Block Design with three replications. The factor levels of GA₃ studied were as follows: (i) Control: 0 ppm (G₀), (ii) 20 ppm (G₂₀), (iii) 40 ppm (G₄₀) and (vi) 60 ppm (G₆₀). These three levels of GA₃ along with control were applied three times: first one during transplanting by root soaking, while the second and third phase applications were done at 30 and 60 days after transplanting.

Growing conditions

Required seeds were sown in the seedbed on 15 October 2014 and transplanted into the experimental field on 30 November 2014 at a spacing of 15 cm × 10 cm. After transplanting, the plants were irrigated by watering cane to saturation. Fertilizers were used at the rate of usual range for commercial production at 60, 30, 80, 20, 1.5, 0.7 kg ha⁻¹ for

N, P, K, S, Zn, B, and cowdung respectively (FRG, 2012). Intercultural operations were furnished for proper growth and development of the crop. Bulbs were harvested after 90 days after transplanting.

Statistical analysis

Analysis of variance was performed in order to assess the significance of the effect of GA₃ in onion. Tukey's HSD tests were used to determine variances between each treatment where P<0.05 was considered as significant. Statistical analyses were carried out using IBM SPSS Statistics version 20.

Results and Discussion

Plant growth characters

A significant result by using GA₃ on onion was observed for plant height (Fig. 1), for the number of leaves plant⁻¹ (Fig. 2), root length and bulb diameter (Table 2). Conversely, no significant variance was found in bulb length with different doses of GA₃ (Table 2). With slightly higher the doses, plant height gradually changed.

The maximum plant height (46.50 cm) was recorded under the effect of 60 ppm GA₃. Plants grown up without GA₃ application were shorter than those grown with GA₃ spray and this increasing growth pattern was observed in the concentration of 20 to 60 ppm. The lowest plant height (34.67 cm) remarked on the control, which means without GA₃ (Fig. 1).

According to Fig. 1, the GA₃ effect regarding the plant height was small, but changed with some different doses. The increase in plant height can be attributed to the effects of gibberellic acid in comparison to the control, which is consistent with previous results when GA₃ promoted the plant height in onion (Shukla *et al.*, 2010; Ouzounidou *et al.*, 2011; Sisodia *et al.*, 2012; Nagwa *et al.*, 2013), in sweet pepper (Pérez-Jiménez *et al.* 2015), combination of GA₃ and 4-CPA regulate plant height in tomato (Choudhury *et al.*, 2013). Similar with this study, a significantly gradual increasing trend of plant height was noticed using GA₃ in gladiolus (Sarkar *et al.*, 2014) and tuberose (Sultana *et al.*, 2016) and in addition GA₃ promoted plant growth and its secondary metabolite production in purple coneflower (Jones *et al.*, 2009). Exogenously applied gibberellic acid increased plant height and, subsequently, enhanced dry weight (Sharma *et al.*, 1998). In the hereby experiment, the increased plant heights was due to the regulatory effect of

Table 1. Physical and chemical properties of the experimental soil as observed prior to experimentation

| Physical properties and mechanical fractions | | | | | |
|--|-------------------------------------|-------------------------------------|---|-------------------------------------|------------------------------------|
| Sand % (2.0-0.05 mm) | Silt % (0.05-0.002 mm) | Clay % (<0.002 mm) | Particle density (g ccG ⁻¹) | Bulk density (g ccG ⁻¹) | Porosity |
| 39.42 | 41.11 | 22.31 | 2.59 | 1.47 | 43.24 |
| Soil properties: Chemical analysis | | | | | |
| pH (1:2.5 soil-water) | Organic matter (%) | Total N (%) | Available P (μ g g ⁻¹) | Exchangeable K (meq) | Available S (μ g g ⁻¹) |
| 5.90 | 0.85 | 0.07 | 19.00 | 0.07 | 20.72 |
| Soil properties: Chemical analysis | | | | | |
| Available Fe (μ g g ⁻¹) | Available Zn (μ g g ⁻¹) | Available Mg (μ g g ⁻¹) | Available Na (μ g g ⁻¹) | Available B (μ g g ⁻¹) | |
| 227 | 4.45 | 0.83 | 0.31 | 0.92 | |

GA₃ that induce active cell division, proline accumulation, and endogenous hormones IAA, GA₃ and cytokinins in the apical meristem, resulting to the vigorous vegetative growth of onion plants. These results were also an agreement with the findings of that- GA₃ normally act by signalling the removal of proteins that repress growth, thus promoting cell proliferation and elongation (Olszewski *et al.*, 2002; Ubeda Tomas *et al.*, 2009; Taiz and Zeiger, 2010).

The number of leaves in onion plants was higher (11.43) under 60 ppm GA₃ treated plants than those grown in other concentration or in control (Fig. 2). The leaf number was considerably increased when 60 ppm GA₃ was used as the growth promoter factor in comparison to control (Fig. 2). This concentration of GA₃ might have more ability to balance the hormonal activity in plants. Subsequently, increases in cell division might have a prodigious effect in the larger number of leaves production. GA₃ leads to increased vegetative growth of plants with vigorous shoots, with increased number of leaves and it has been revealed earlier for onion (Ud-Deen *et al.*, 2005; Yamaguchi, 2008; Yu *et al.*, 2009; Ouzounidou *et al.*, 2011; Nagwa *et al.*, 2013), eddo (Ud-deen, 2009), gladiolus (Sarkar *et al.*, 2014) and tuberose (Sultana *et al.*, 2016).

Regarding the root parameter of the onion, the longest root (6.10 cm) was recorded gradually in the increased concentration up to 60 ppm GA₃, whereas the shortest roots (3.80 cm) were in control (Table 2).

At the same time, GA₃ used in onion plants with 20-60 ppm played a similar role in increasing the root length compared to control. The increased root length due to GA₃ might have resulted from the cell growth and cell elongation and thus developed an elongated root system. This result is

consistent with the previous findings for onion (Hye *et al.*, 2002).

The bulb diameter (4.30 cm) under the influence of 60 ppm GA₃ was sharply higher than that of bulbs treated with 0-40 ppm GA₃ which showed statically similar result (Table 2). It was noticed that GA₃ did not affect significantly the bulb length. A minor bulb diameter increase under GA₃ treatment was observed in the present study and might be attributed to cell growth and cell elongation (Table 2). This finding are in contrast with other studies which noted that GA₃ can affect the growth and development of bulb crops as well as promoting bulb diameter (Hye *et al.*, 2002; Islam *et al.*, 2007; Nagwa *et al.*, 2013), in tomato (Choudhury *et al.*, 2013) and in gladiolus (Sarkar *et al.*, 2014).

Fresh biomass assimilation

The effect of different concentrations of GA₃ on fresh root biomass was insignificant, whereas the significant effect was observed in both parameters of fresh shoot biomass and fresh bulb biomass of onion (Fig. 3). Different concentrations of GA₃ had a significant effect on fresh shoot and fresh bulb biomass which were sharply increased to about 641.67 gm⁻² and 1125.00 gm⁻² respectively, with the application of 60 ppm GA₃ in comparison to the other concentrations of GA₃ (Fig. 3). Plants grown in control plot obtained the minimum fresh biomass at harvesting time in the shoot (441.67 gm⁻²) and bulb (641.67 gm⁻²).

As represented in Fig. 3, the study revealed that fresh shoot and fresh bulb biomass assimilation in onion were markedly increased due to the significant effect of GA₃ while it was observed that GA₃ did not affect significantly the fresh root biomass assimilation compared to control. It

Table 2. The influence of various doses of GA₃ on root length, bulb length and bulb diameter at harvest time in onion

| Factors | Root length (cm) | Bulb length (cm) | Bulb diameter (cm) |
|-----------------|--------------------------|--------------------------|--------------------------|
| G ₀ | 3.80 ± 0.20 ^b | 3.23 ± 0.23 ^a | 3.10 ± 0.06 ^b |
| G ₂₀ | 5.63 ± 0.20 ^a | 3.53 ± 0.34 ^a | 3.43 ± 0.09 ^b |
| G ₄₀ | 6.00 ± 0.12 ^a | 3.87 ± 0.26 ^a | 3.63 ± 0.15 ^b |
| G ₆₀ | 6.10 ± 0.21 ^a | 4.03 ± 0.03 ^a | 4.30 ± 0.20 ^a |
| Df | 3 | 3 | 3 |
| F-value | 33.52 | 2.13 | 14.17 |
| P-value | 0.0001 | 0.1745 | 0.0014 |

Means with the same letter did not significantly differ from each other at $p < 0.05$. Abbreviations are as follows, G₀; 0, G₂₀; 20, G₄₀; 40 and G₆₀; 60 ppm GA₃ respectively.

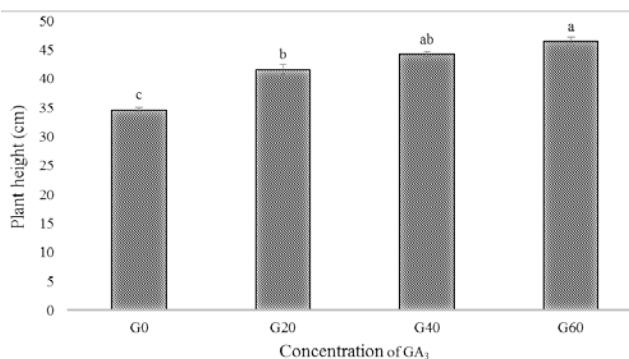


Fig. 1. Effect of various doses of GA₃ on onion plants height at harvest. Vertical bars represent means ± standard error mean. Means with the same letter did not significantly differ from each other at $p < 0.05$. Abbreviations are as follows, G₀; 0, G₂₀; 20, G₄₀; 40 and G₆₀; 60 ppm GA₃ respectively

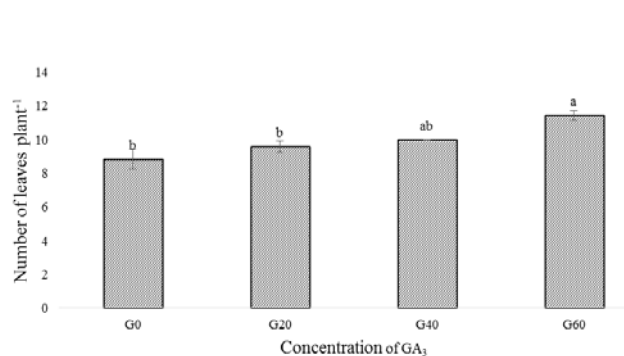


Fig. 2. Effect of various doses of GA₃ on the number of leaves at onion harvest. Vertical bar represents means ± standard error mean. Means with the same letter did not significantly differ from each other at $p < 0.05$. Abbreviations are as follows, G₀; 0, G₂₀; 20, G₄₀; 40 and G₆₀; 60 ppm GA₃ respectively

might be a suitable factor for fresh biomass assimilation in shoot and bulb resulted from the effect of cell expansion growth, increased proline accumulation, reduced ABA content and balancing hormonal activity, which led to vigorous plant growth, leaf growth, number of leaves, thickness of pseudo-stem where plant get larger surface area for photosynthesis which ultimately expands the bulb growth. The present findings are in agreement with the previous reports for onion (Hye *et al.*, 2002; Islam *et al.*, 2007; Yamaguchi, 2008; Yu *et al.*, 2009; Ouzounidou *et al.*, 2011; Nagwa *et al.*, 2013).

Dry biomass accumulation

Different concentrations of GA₃ showed the insignificant effect on dry root biomass accumulation in onion, whereas dry shoot and dry bulb biomass

accumulation was significant (Table 3). Considerably higher dry shoot biomass accumulation was observed in 60 ppm GA₃ treated plants. This accumulation was of about 41.63% compared with control.

With the increasing trend in GA₃ concentration, there was an increase in dry biomass accumulation for onion shoots and bulbs, while it was perceived that GA₃ did not affect significantly the dry root biomass accumulation (Table 3). It might be due to the effect of GA₃ on increased vigorous plant growth, as well as leaf growth and shoot growth, where the onion plant obtained greater photosynthetic potentiality resulted in maximum photosynthates accumulation, which also redistributed towards the storage organ. Similar findings were reported for onion (Sharma *et al.*, 1998; Ouzounidou *et al.*, 2011; Nagwa *et al.*, 2013).

Table 3. Influence of various doses of GA₃ on dry biomass accumulation in onion shoots, bulbs and roots

| Factors | Dry shoot biomass (g m ⁻²) | Dry bulb biomass (g m ⁻²) | Dry root biomass (g m ⁻²) |
|-----------------|---|--|--|
| G ₀ | 42.42 ± 3.18 ^b | 137.25 ± 2.83 ^b | 12.33 ± 0.79 ^a |
| G ₂₀ | 69.42 ± 4.17 ^a | 151.83 ± 6.63 ^b | 12.33 ± 0.79 ^a |
| G ₄₀ | 71.17 ± 4.99 ^a | 174.08 ± 2.59 ^{ab} | 13.25 ± 0.50 ^a |
| G ₆₀ | 72.67 ± 7.58 ^a | 197.83 ± 5.53 ^a | 14.67 ± 0.92 ^a |
| Df | 3 | 3 | 3 |
| F-value | 7.54 | 8.34 | 2.06 |
| P-value | 0.0102 | 0.0146 | 0.1835 |

Means with the same letter did not significantly differ from each other at p < 0.05. Abbreviations are as follows, G₀; 0, G₂₀; 20, G₄₀; 40 and G₆₀; 60 ppm GA₃ respectively.

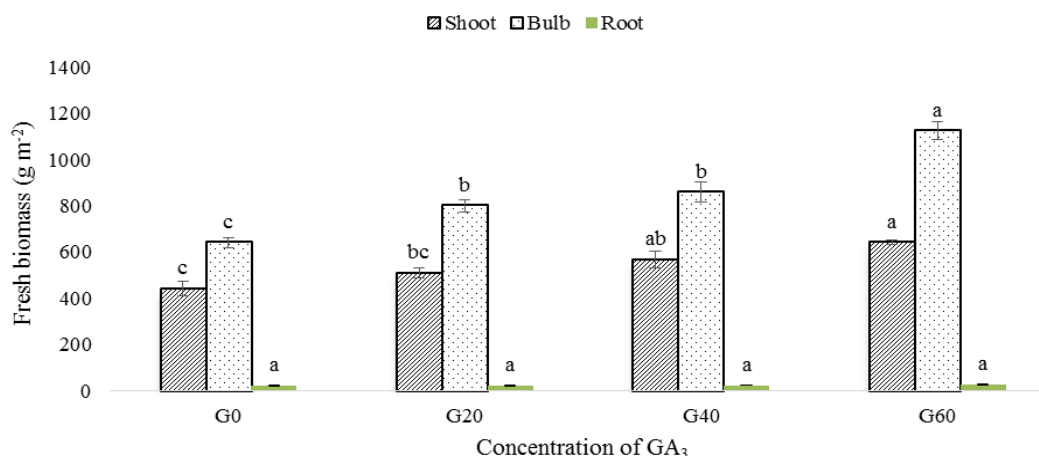


Fig. 3. Effect of GA₃ on fresh shoots, bulbs and root biomass at harvest time in onion. Vertical bar represents means ± standard error mean. Means with the same letter did not significantly differ from each other at p < 0.05. Abbreviations are as follows, G₀; 0, G₂₀; 20, G₄₀; 40 and G₆₀; 60 ppm GA₃ respectively

Conclusions

Positive significant influence of GA₃ was associated with onion plants' growth and physiological attributes. The use of GA₃ at a dose of 60 ppm provided better results than the other three concentrations tested, due to its influence on growth characters of the plants, which offer significantly higher yield potential in onion.

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