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Original Research

Effect of PGRs on Vegetative and Reproductive Traits of Bitter Gourd (*Momordica charantia* L.): A Field Assessment

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ABSTRACT

Bitter gourd (*Momordica charantia* L.) is a popular crop grown as field and backyard vegetable in Asian countries. A field experiment was performed using Randomized Complete Block Design (RCBD) to assess the effect of plant growth regulators (PGRs) on the productivity of bitter gourd cv. Faisalabad Long. There were four treatments viz. control (no PGR), GA_3 100 mg L^{-1}, IAA 200 mg L^{-1} and GA_3 50 + IAA 100 mg L^{-1}, and each treatment was replicated thrice. Results revealed that untreated (control) plants took maximum days to flower (45.66), while both GA_3 100 mg L^{-1} and GA_3 50 + IAA 100 mg L^{-1} treated plants behaved statistically alike with 41.00 and 42.33 days, respectively. Application of GA_3 100 mg L^{-1} depicted significant superiority for fruit length, average fruit weight, fruit yield per plant and seed yield per plant. However, statistically similar response was recorded for all the PGR treatments for male and female flowers per plant, time to first harvest, number of fruits per plant and fruit diameter; while maximum vine length at final harvest was recorded when GA_3 and IAA were applied in combination. Overall results indicated that application of GA_3 100 mg L^{-1} resulted in early crop maturity and significantly higher fruit yield per plant when compared with other treatments.

Keywords: *Fruit size, fruit yield, GA_3, IAA, plant growth regulator.*

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INTRODUCTION

Bitter gourd (*Momordica charantia* L.) belongs to the Cucurbitaceous family. It is domesticated more likely in eastern Asia or more precisely in Indo-Pak or southern Chinese regions (Miniraj et al., 1993). Bitter gourd has various medicinal and nutritional benefits for human beings. Its extract, obtained from leaves and fruits, is useful for the control of higher blood sugar (Raman and Lau, 1996), the treatment of infections, wounds and fevers (Behera et al., 2008). Its fruits are good source of antioxidants, minerals, vitamins and dietary fiber (Kale et al., 1991; Yuwai et al., 1991).

Plant growth regulators (PGRs) are new generation of agrochemicals after pesticides and fertilizers. They enhance source-sink relationship and accelerate translocation of photo-assimilates thereby resulting into better fruiting. General mode of action of PGRs is to modify growth and development of plants by affecting their normal homeostasis; particularly the hormonal regulation (Rafeekher et al., 2002). Flower bud initiation and its development until fruiting is controlled by physiological process in plants. These processes can be regulated by application of PGRs, chemical activators or some external stimuli. Technically, the exogenous application of PGRs is used to enhance sex expression in flowering plants towards the femaleness. The yield and other biological traits of bitter gourd can be improved by regulating fruit setting percentage. The effects of PGRs have been well documented in literature, as they can modify flowering and yield (Gedam et al., 1998), reduce male/female flower ratio (Patel et al., 2017; Ghani et al., 2013), induce early flowering and fruit maturity, increase fruit length and diameter (Ghani et al., 2013), total number of fruits and single fruit weight (Gopalkrishman and Choudhury, 1978; Hossain et al., 2006), and seed yield (Nagamani et al., 2015).

Gibberellic acid (GA) is an important PGR used to modify growth and yield of plants (Rafeekher et al., 2002). Exogenous application of GA has increased gynoecy in bitter gourd (Wang and Zeng, 1996) and was found very effective at a concentration of 50 mg L^{-1} in sex expression modification, enhancement in vegetative growth, fruit and seed yields (Nagamani et al., 2015). GA delays staminate flower setup and promotes pistillate flowers at lower concentrations (Wang and Zeng, 1997). Indole acetic acid (IAA) is also an important PGR that is in practice since decades. Its foliar spray in bitter gourd @ 35 mg L^{-1} has been reported to enhance flowering, most probably due to ethylene evolution (Damodhar et al., 2004). Although PGR's have great potential to boost growth and yield of different vegetables, but the research information is limited to optimize dose and time of application for a specific vegetable. Therefore, present study was

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Table 1: Soil characteristics of the site before the start of the experiment.

Soil characteristics	
Soil type	Sandy loam
pH	7.60
EC (dSm^{-1})	0.90
OM (%)	0.48
N (%)	0.03
P ($mg\ kg^{-1}$)	9.96
K ($mg\ kg^{-1}$)	210

designed to assess the effect of PGRs on vegetative and reproductive response of bitter gourd cv. Faisalabad Long to generate precise information for local farming community. The specific objective of the study was to induce femaleness as well as increase yield in bitter gourd by using different PGRs.

MATERIALS AND METHODS

This research was conducted at the Qureshi Farms in district Dera Ghazi Khan (30.06 °N latitude, 70.63 °E longitude and 129 m above sea level). After soil nutrient analysis (Table 1), fertilizers were applied @ 150, 125 and 125 kg ha^{-1} of nitrogen, phosphorus and potash, respectively. One third of nitrogen and full doses of phosphorus and potash fertilizer were applied at sowing time, while remaining nitrogen was applied throughout the season as needed by the crop. Standard plant protection measures were followed as and when required. Seeds were sown on both sides of raised bed 2 m wide and 6.66 m long. Plant to plant distance was maintained as 30 cm. When plants reached at 2nd true leaf stage then foliar application of PGRs (GA_3, IAA) solutions and distilled water (dH_2O) as control was made. There were four treatments i.e. control (distilled water), GA_3 100 mg L^1, IAA 200 mg L^{-1} and GA_3 50 + IAA 100 mg L^{-1}.

The experiment was laid out following Randomized Complete Block Design (RCBD). There were four treatments and each treatment were replicated thrice. Data were collected on number of nodes per plant at flowering, number of nodes per plant at final harvest, vine length at flowering (cm), vine length at final harvest (cm), time to first flower (days), time to first harvest (days), number of male and female flowers, male/female flower ratio, number of fruits per plant, average fruit weight (g), fruit length (cm), fruit diameter (cm), fruit yield per plant (kg) and seed yield per plant (kg). Analysis of variance of the data from each attribute was computed using the statistical software Statistix 8.1. The least significant difference (LSD) test at 5% level of probability was used for comparison of differences among the treatment means (Steel et al., 1997).

RESULTS

Vegetative traits

Means comparison demonstrated that average number of nodes at flowering was maximum in plants sprayed with GA_3 100 mg L^{-1} (25.33), followed by those sprayed with GA_3 50 + IAA 100 mg L^{-1} (24.66); while it was minimum (23.66) in untreated control plants (Table 2). Similarly, average number of nodes at final harvest was maximum in plants sprayed with GA_3 100 mg L^{-1} (127.00) as compared to control plants (115.67) where no PGR was applied. However, two treatments IAA 200 mg L^{-1} and GA_3 50 + IAA 100 mg L^{-1} were statistically similar for this parameter (Table 2). Significant differences were observed between PGRs treatments for vine length at flowering. Two PGRs treatments GA_3 50 + IAA 100 mg L^{-1} and GA_3 100 mg L^{-1} were statistically alike for this trait with 162.67 cm and 157.67 cm, respectively; while it was minimum (140.00 cm) in untreated control plants (Table 2). However, vine length at final harvest was maximum in GA_3 50 + IAA 100 mg L^{-1} treated plants (505.00 cm), followed by those with GA_3 100 mg L^{-1} (491.00 cm) and IAA 200 mg L^{-1} (486.33 cm) treated ones. However, latter two PGRs treatments were statistically alike. The minimum vine length at final harvest (450.00 cm) was recorded in untreated control plants (Table 2).

Reproductive traits

Data regarding time to first flower depicted significant differences among the PGRs treatments ($p < 0.05$) and it was observed that the maximum time to first flower was taken by control untreated plants (45.66 days), followed by IAA 200 mg

Table 2: Effect of PGRs treatments on growth and yield characteristics of bitter gourd.

Parameters	GA_3 (100 mg L^{-1})	IAA (200 mg L^{-1})	GA_3 + IAA (50 + 100 mg L^{-1})	Control (no PGR)
No. of nodes at flowering	25.33±1.89 a	23.83±2.00 bc	24.66±0.91 ab	23.66±2.13 c
No. of nodes at final harvest	127.00±4.90 a	122.33±3.49 b	122.67±1.77 b	115.67±4.59 c
Vine length at flowering (cm)	157.67±7.34 a	150.67±4.32 b	162.67±7.68 a	140.00±2.33 c
Vine length at final harvest (cm)	491.00±17.43 b	486.33±18.34 b	505.00±16.72 a	450.00±19.00 c
Time to first flower (days)	41.00±1.79 b	43.66±1.51 ab	42.33±1.01 b	45.66±2.01 a
Male flowers per plant	69.00±2.30 a	72.66±3.49 a	71.33±2.93 a	57.66±2.31 b
Female flowers per plant	23.00±1.06 a	22.33±1.32 a	24.66±1.86 a	16.00±1.28 b
Male/female flower ratio	3.04± 0.45 c	3.32±0.32 b	3.08±0.39 c	4.02±0.40 a
Time to 1st harvest (days)	52.00±3.00 b	54.00±2.39 b	55.00±1.71 b	60.33±1.54 a
No. of fruits per plant	15.00±0.91 a	14.00±1.11 a	14.33±1.01 a	11.00±0.81 b
Fruit length (cm)	18.33±0.89 a	17.66±1.29 ab	16.00±0.90 b	11.00±0.33 c
Fruit diameter (cm)	13.00±0.61 a	13.33±0.82 a	13.00±0.1.58 a	5.00±0.32 b
Average fruit weight (g)	113.00±7.69 a	108.00±6.01 b	104.33±5.39 b	44.00±2.11 c
Fruit yield per plant (kg)	1.18±0.11 a	1.07±0.06 b	0.96±0.02 c	0.20±0.03 d
Seed yield per plant (kg)	0.273±0.08 a	0.250±0.10 ab	0.236±0.10 b	0.094±0.00 c

*Means having different letter(s) differ significantly at 5% probability (LSD test).

L^{-1} treated ones (43.66 days); while the minimum time to first flower was recorded in the plants sprayed with GA_3 100 mg L^{-1} (41.00 days) and GA_3 50 + IAA 100 mg L^{-1} (42.33 days). These two treatments were statistically at par (Table 2). It is also evident from the Table that all the three PGRs treatments showed statistically similar response for number of male and female flowers, time to first harvest, number of fruits per plant and fruit diameter. However, higher number of male (72.66) and female flowers (24.66) were recorded in the plants treated with IAA 200 mg L^{-1} and GA_3 50 + IAA 100 mg L^{-1}, respectively (Table 2). Similarly, all PGRs treatments showed statistically similar results for number of fruits per plant with the maximum number of fruits per plant (15) in the plants sprayed with GA_3 100 mg L^{-1}. Results revealed that male/female flower ratio was significantly higher in untreated control plants (4.02), followed by those sprayed with IAA 200 mg L^{-1} (3.32); while it was the lowest in those sprayed with GA_3 100 mg L^{-1} (3.04) and GA_3 50 + IAA 100 mg L^{-1} (3.08). Latter two PGRs treatments were statistically alike for this reproductive trait (Table 2).

The maximum fruit length (18.33cm) was recorded in the plants sprayed with GA_3 100 mg L^{-1}, while it was the minimum (11cm) in untreated control plants. However, IAA 200 mg L^{-1} was statistically at par with GA_3 100 mg L^{-1} for this trait (Table 2). All the PGRs treatments significantly improved the fruit diameter as compared with control (Table 2). Data regarding average fruit weight showed significant differences among the treatments ($p < 0.05$) and it was maximum in GA_3 100 mg L^{-1} treated plants (113 g) and the minimum (44 g) in untreated control plants. However, two treatments IAA 200 mg L^{-1} and GA_3 50 + IAA 100 mg L^{-1}showed statistically similar results for average fruit weight (Table 2). Results revealed that fruit yield per plant was significantly higher (1.18 kg) in GA_3 100 mg L^{-1} treated plants, followed by 1.07 kg in IAA 200 mg L^{-1} treated ones; while it was the lowest (0.20 kg) in untreated control plants (Table 2).

Data regarding seed yield per plant also exhibited significant differences among the PGRs treatments and the results indicated that the maximum seed yield per plant was recorded in the plants sprayed with GA_3 100 mg L^{-1} (0.273 kg), followed by those treated with IAA 200 mg L^{-1} (0.250 kg). These two PGRs treatments were statistically at par for this reproductive trait. Similarly, GA_3 50 + IAA 100 mg L^{-1} was statistically at par with IAA 200 mg L^{-1}. The seed yield per plant was minimum (0.094 kg) in untreated control plants (Table 2).

DISCUSSION

Results of different vegetative traits i.e. number of nodes at flowering and final harvest disclosed that application of GA_3 showed its supremacy over all other treatments. However, vine lengths at flowering and at final harvest were maximum in plants sprayed with GA_3 + IAA. Mangave et al. (2017) revealed that foliar spray of NAA 75 mg L^{-1} was the most effective in producing longer vines and the maximum number of branches per vine in bitter gourd.

The results of present study revealed that application of PGRs (GA_3 and IAA) as single entity had positive effect on different vegetative and reproductive traits of bitter gourd as compared to their application in combination form. In the present study, application of GA_3 decreased number of days to first flower in bitter gourd plants when applied alone or in combination with IAA. These results support the findings of Hossain et al. (2006) that application of GA_3 25 mg L^{-1} can induce early flowering in bitter gourd. Similarly, Dixit et al. (2001) reported induction of early flowering in watermelon when sprayed with GA_3 25 mg L^{-1} and 50 mg L^{-1}. All PGRs treatments showed similar results for number of male and female flowers, days to first harvest, number of fruits per plant and fruit diameter but significantly differed from untreated control. Present results are in conformity with the findings of Gedam et al. (1998), Akter and Rehman (2010), Hossain et al. (2006) and Hidayatullah et al. (2012). Significant decrease was recorded in male to female flower ratio by the application of GA_3 alone or in combination with IAA. Similar results were reported by Akter and Rehman (2010), Ghani et al. (2013) and Patel et al. (2017) in bitter gourd. Similarly, Kore et al. (2003) concluded that both GA_3 and NAA were effective for the promotion of femaleness in bottle gourd. According to our results, application of PGRs had significant effect on number of days to first harvest in bitter gourd as compared to control. Gedam et al. (1998) observed early fruit maturity in bitter gourd when plants were sprayed with NAA 50 mg L^{-1}. Marbhal et al. (2005) reported similar results by the application of ethephon in bitter gourd and recorded significant reduction in days to first harvest (33.8 days) as compared to control (39.2 days). Application of GA_3 and IAA alone or in combined form showed similar results for fruit diameter. However, fruit length was reduced when these were applied in combination. These results are contradictory to the findings of Prabhu and Natarajan (2006) who reported that the maximum fruit length in Ivy gourd was recorded by the application of GA_3 and NAA @ 100 and 400 mg L^{-1}, respectively. They further revealed that increase in fruit length might be due to activation of cell division and cell elongation along with increase in metabolic activity. Similarly, increased fruit diameter has been documented by different researchers in bitter gourd by exogenous applications of GA_3 and NAA (Gedam et al., 1998; Ghani et al., 2013; Dostogir et al., 2006). The ultimate economic product of any crop is yield that is determined mainly by fruit weight and number of fruits per plant (Ghani et al., 2013). Present results showed that fruit and seed yields were significantly higher in plants sprayed with GA_3 as compared to other treatments. These results are in line with the findings Nagamani et al. (2015) that exogenous application of GA_3 50 mg L^{-1} is very effective for maximizing fruit and seed yields in bitter gourd. Akter and Rehman (2010) concluded that PGRs have significant effect on yield and fruit related traits in cucurbits. Increased seed yield in cucurbits due to foliar application of PGRs had also been reported by Shantappa (2004).

CONCLUSION

Present results suggest that application of GA_3 and IAA have significant impact on growth, and fruit and seed yields of bitter gourd. The application of these growth regulators was also found very effective to reduce male to female flower ratio. However, different reproductive traits viz. fruit length, average fruit weight and fruit yield per plant increased significantly with the foliar application of GA_3 (200 mg L^{-1}) compared to control.

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