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Influence of foliar application of Gibberellic acid on growth, development, yield and biochemical constituents of African marigold cv. 'Pusa Narangi Gainda'

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Abstract

An experiment was carried out on African marigold cv. 'Pusa Narangi Gainda' to study the influence of foliar application of Gibberellic acid (GA_3) on growth, development, yield and biochemical constituents at UBKV, West Bengal. The treatments consist of ten different concentrations of GA_3 with a control. GA_3 treatment at 250 ppm resulted in significantly better performance in relation to plant height (87.87cm), number of branches (13.37), number of leaves (36.01), plant spread (40.92 cm), whole biomass (447.10 g), fresh shoot weight (355.69 g), fresh root weight (92.10 g), days to flower bud initiation (52.93 days), flower longevity on plants (6.67 days), duration of flowering (24.4 days), number of flowers/ plant (53.12), diameter of flowers (6.79 cm) and expected flower yield (52.28 MT/ha). The same treatment was also effective in improving biochemical constituents like leaf chlorophyll content (54.60 SPAD), protein content (1390.5 µg/g), carotenoids (370.8 mg/Kg), carbohydrate (288.9µg/g), reducing sugar content (146.1µg/g) and non-reducing sugar content (142.8 µg/g) in petals.

Keywords: African marigold, Pusa Narangi Gainda, Gibberellic acid, foliar application

Introduction

African marigold (*Tagetes erecta*) belonging to the family Asteraceae is a flowering ornamental annual with profuse branching and flowering habit. Some of the major problems associated with cultivation of this crop are apical dominance (Sunitha *et al.*, 2007) [1], delay in flowering (Sharma *et al.*, 2006) [2] and development of long and weak stems (Gawle *et al.*, 2012) [3]. These in turn resulted in poor yield/economic returns. However, provision of ambient climatic conditions through selection of site, judicious cultural operations, balanced nutrition and physiological manipulations by pinching or application of plant growth regulators may improve the yield of the crop.

The African marigold cultivar 'Pusa Narangi Gainda' was developed by pedigree hybridization by crossing between two exotic varieties 'Cracker Jack' x 'Golden Jubilee'.The plant of this variety is of medium stature, vigorous and uniform with dark green foliage which grows to a height of 80-85 cm. It flowers in 125-136 days after sowing. It is most suitable for garland making, religious offerings and carotenoid extraction (Kanwar and Khandelwal, 2014) [4].

Now-a-days, application of plant growth regulators is gaining its popularity in various crop cultivation practices. Plant growth regulators are the organic chemical compounds which influence the plant growth, crop yield and flower quality by modification or regulating the plant physiological processes when applied in very minute quantity (Iqbal *et al.*, 2011; Fernández *et al.*, 2011) [5] [6].

Therefore, an experiment was conducted to study the effect of foliar application of gibberellic acid on growth, development, yield and biochemical constituents of African Marigold cv. 'Pusa Narangi Gainda' in order to overcome the various inherent problems in cultivation.

Materials and Methods

The experiment was conducted on African marigold cv. 'Pusa Narangi Gainda' during winter season of 2014-2015 and 2015-2016 at Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal. The treatments consisted of ten different doses of gibberellic acid (GA_3) at 50 ppm, 100 ppm, 150 ppm, 200 ppm, 250 ppm, 300ppm, 350 ppm, 400 ppm, 450 ppm and 500 ppm with a control. The experimental design followed was Randomised Block Design (RBD) with three replications per treatments. Each plot was planted with 40 plants at a spacing of 40 cm x

40 cm. Sowing was done on first fortnight of December and transplanting was carried out 30 days after sowing and standard cultural practices like hoeing, irrigation, weeding and fertilizer application were followed as per the requirement of the crop. Each treatment was applied twice at 3 weeks and 6 weeks after transplanting. Ten plants were selected randomly and tagged for different treatments to record various vegetative and reproductive parameters. Chlorophyll content of leaves was estimated using chlorophyll meter SPAD 502 at 10:00 hours. Estimation of protein content of flower petals was carried out as per Lowry *et al.*, (1951) [7]. Carotenoid content of the petals was estimated by spectrophotometric method as devised by Ranganna (2002) [8]. Estimation of total carbohydrate content (µg/g) of the flower petal was carried out as per Hodge *et al.*, (1962) [9], reducing sugar content (µg/g) and non-reducing sugar content (µg/g) of the flower petal as per Somogyi (1952) [10].

Data on various growth, flowering, yield and biochemical parameters were recorded and statistically analysed by applying the technique of analysis of variance. Data was analysed within the ANOVA of the SPSS software program, version 6.0 and level of significance for t-test was kept at 5% (P=0.05).

Results and Discussion

Vegetative growth parameters

Among different concentrations of foliar application of GA_3 on African marigold cv. 'Pusa Narangi Gainda', the treatment 250 ppm GA_3(T_5) resulted in significantly maximum plant height (87.87cm), number of branches (13.37), number of leaves per plant (36.01) andplant spread (40.92 cm) as evident from Table 1. The effect of gibberellins in increasing various vegetative parameters like plant height, number of branches, plant spread and number of leaves per plantmay be due to increased auxin level of tissues or enhance conversion of tryptophane to IAA which results inenhanced cell division, cell enlargement, promotion of protein synthesis and diversion of plant metabolites from vertical growth to horizontal growth (Nelissen *et al.*, 2012) [11]. Similar results of enhanced vegetative growth due to the effect of GA_3 have already been reported by Dhekney *et al.*, (2000) [12] in rose; Kumar *et al.*, (2003) [13] in China aster; Mohariya *et al.*, (2003) [14] in chrysanthemum; and Ramdevputra (2009) [15] in marigold. The higher concentrations of exogenously applied GA_3 were found to reduce the vegetative parameters under study as GA_3 worked with its full potential upto certain the optimum concentration and feedback inhibition occurred beyond such concentrations.

The plants treated with 250 ppm GA_3 (T_5) also resulted in significantly maximum gain in whole biomass (447.10 g), fresh shoot weight (355.69g) and fresh root weight (92.10 g) compared to other treatments as shown in Table 1. Application of GA_3 had been found to increase the photosynthetic rate in leaves of plant through changes in plastid development and chloroplast structure (Jiang *et al.*, 2012) [16] which resulted in increase in whole biomass, fresh shoot and root weight.

Table 1: Influence of different treatments of Gibberellic acid on various vegetative parameters of African marigold cv. 'Pusa Narangi Gainda' (data are mean of two season)

Treatments	Plant height (cm)	Number of main branches	Number of leaves	Plant spread (cm)	Biomass per plant (g)	Fresh weight of shoot (g)	Fresh weight of root(g)
T_0 (control)	51.73	7.40	20.07	30.42	224.43	197.04	27.39
T_1 (GA_3@ 50ppm)	80.38	9.93	30.20	33.48	310.94	264.18	46.76
T_2 (GA_3@ 100ppm)	82.32	10.00	32.07	34.12	318.71	266.04	52.68
T_3 (GA_3@ 150ppm)	83.96	11.27	32.80	34.76	363.09	299.83	63.26
T_4 (GA_3@ 200ppm)	84.43	12.43	33.00	36.30	414.68	330.69	83.99
T_5 (GA_3@ 250ppm)	87.87	13.37	36.01	40.92	447.10	355.69	92.10
T_6 (GA_3@ 300ppm)	83.73	11.33	32.87	39.43	376.48	301.42	75.05
T_7 (GA_3@ 350ppm)	82.37	10.80	31.54	35.58	347.37	287.32	60.05
T_8 (GA_3@ 400ppm)	81.37	10.33	31.26	34.33	327.86	274.82	53.04
T_9 (GA_3@ 450ppm)	80.53	10.47	29.98	33.53	329.24	278.54	50.69
T_{10} (GA_3@ 500ppm)	76.21	10.01	27.51	33.18	308.65	266.30	42.34
S. Em (±)	1.392	0.174	0.487	0.614	5.625	4.503	1.056
C. D. at 5%	4.056	0.544	1.564	1.790	17.551	14.474	3.077

Flowering parameters

Among the foliar application of different doses, treatment with 250 ppm GA_3also resulted in minimum days to flower bud initiation (52.93 days after transplanting), maximum flower longevity on plant (6.67 days) and maximum duration of flowering (24.3 days) as presented in Table 2. Earliest flower bud initiation and with maximum flowering duration observed with the application of 250 ppm GA_3 was probably due to the reduction in juvenile period through reduction of S-phase in the interphase of cell cycle inducing the shoot apical meristem instead of producing leaves and branches to start producing buds.GA_3 resulted earliness in flowering and improvement in qualitative characters of flowers like early maturity, increased duration of flowering (Dutta and Seemanthini, 1998) [17]. Increase in duration of flowering might be due to advanced bud formation and stimulating flowering in GA_3 treated plants are in conformity with the findings of Kumar *et al.*, (2010) [18]. Similar results were observed by Nair *et al.*, (2002) [19] in gerbera and Porwal *et al.*, (2002) [20] in Damask Rose. Kumar *et al.*, (2009) [21] also concluded that GA_3 at 200 ppm caused earliest appearance of initial spike and opening of first floret in tuberose.

Plants treated with GA_3 at 250 ppm (T_5) were effective to produce maximum number of flowers per plant (53.12) and maximum diameter of flowers (6.79 cm). The same treatment was also effective to produce maximum expected flower yield (52.28 MT/ha) while control produce a yield of 23.30 MT/ha. Increased loose flower yield in plants treated with GA_3 250 ppm may be probably due to the production of flowers with greater diameter and increased fresh weight. Greater diameter also might be induced through increased number of florets as a result of better nutrition during reproductive phase. All those factors in turn might be attributed to the better partitioning of photosynthates to reproductive sinks under the control of GA_3 (Morris, 1996) [22]. Singh and Kumar (2009) [23] recorded maximum flower size and flower stalk length in chrysanthemum using GA_3 at 150 ppm. GA_3 mediated yield increment were also reported by Tyagi and Singh (2006) [24], Swaroop *et al.* (2007) [25] and Maharnor *et al.*, (2012) [26] in marigold; by Kumar *et al.*, (2003) [27] in China aster; by Rakesh and Beniwal (2003) [28], Shinde *et al.*, (2010) [29] in chrysanthemum.

Table 2: Influence of different treatments of gibberellic acid on various reproductive parameters of African marigold cv. 'Pusa Narangi Gainda' (data are mean of two season)

Treatments	Days required for flower bud initiation (days)	Flower longevity on plant (days)	Flowering duration (days)	Number of flowers per plant	Flower diameter (cm)	Expected yield (MT/Ha)
T_0 (control)	60.73	4.67	20.0	34.60	4.01	23.30
T_1 (GA_3@ 50ppm)	59.47	5.67	21.4	40.21	5.25	30.22
T_2 (GA_3@ 100ppm)	58.60	5.77	22.3	42.93	5.77	31.43
T_3 (GA_3@ 150ppm)	58.13	6.13	23.4	43.87	5.94	30.92
T_4 (GA_3@ 200ppm)	55.47	6.21	23.5	46.57	6.46	35.92
T_5 (GA_3@ 250ppm)	52.93	6.67	24.4	53.12	6.79	52.28
T_6 (GA_3@ 300ppm)	53.53	6.07	23.6	50.13	6.25	39.02
T_7 (GA_3@ 350ppm)	57.93	5.67	23.4	46.27	5.81	40.78
T_8 (GA_3@ 400ppm)	58.33	6.00	22.3	43.08	5.63	32.22
T_9 (GA_3@ 450ppm)	58.67	5.67	22.1	41.23	4.89	29.37
T_{10} (GA_3@ 500ppm)	59.60	5.67	20.3	37.46	4.75	27.62
S. Em (±)	1.008	0.089	0.378	0.763	0.089	3.69
C. D. at 5%	2.937	0.287	1.101	2.223	0.285	11.86

Biochemical analysis

Treatment with GA_3 at 250 ppmresulted in maximum leaf chlorophyll content (54.60 SPAD) and protein content (1390.5 µg/g) as presented in Table 3. GA_3 had a stimulatory role to decrease the activity of particular enzyme chlorophyllase (Jacob-Wilk *et al.*, 1999) [30], which retards chlorophyll degradation leading to the enhancement of rate of photosynthesis and leaf surface area. Increase in leaf chlorophyll content through application of GA_3 was also observed by Mynett *et al.*, (2001) [31] in Freesia; Gad *et al.*, (2016) [32] in *Ixora coccinea* and Yaghoubi *et al.*, (2013) [33] in *Bellis perennis*. Gibberellic acid also checked the degradation of protein and chlorophyll as reported by Faraji *et al.*, (2011) [34] during a study in corms of gladiolus cv. White Prosperity.

Total carotenoid content in African marigold flowers was found increasing at a steady rate with exogenous application of GA_3 upto 250 ppm but thereafter started to decline sharply upto 500 ppm concentration. The maximum carotenoid concentration (370.8 mg/1000 g) was observed in GA_3 at 250 ppm (T_5) and all the concentrations of GA_3 showed significantly higher carotenoid concentration over control (148.8 mg/1000 g). Light stimulated chlorophyll biosynthesis increases the carotenoid content (Giuliano *et al.*, 1993) [35]. GA_3 mediated enhancement in carotenoid especially lutein biosynthesis in African marigold was also observed by Valadon and Mummery (1967) [36].

Exogenous treatment with GA_3 at 250 ppm also resulted in highest concentration of carbohydrate (288.9 µg/g), reducing sugar content (146.1 µg/g) and non-reducing sugar content (142.8 µg/g) in petals of African marigold as depicted in Fig 1. Increased number of leaves per plant resulted in higher photosynthesis than the rest producing greater amount of photosynthates which were channelized to different parts of the plant helping all round development during the vegetative phase reflected by higher content of carbohydrates. The GA_3 mediated enhancement in growth, biomass production and carbohydrate content in crop plants was observed by Demura and Ye (2010) [37]. The above results are in close conformity with the findings of Singh and Bijimol (2001) [38] in tuberose and Sujatha *et al.*, (2002) [39] in gerbera.

Table 3: Influence of different treatments of Gibberellic acid on chlorophyll content of leaves, protein of petals and total carotenoids of petals of African marigold cv. 'Pusa Narangi Gainda' (data are mean of two season)

Treatments	Chlorophyll (SPAD)	Protein (µg/g)	Total carotenoid (mg/1000 g)
T_0 (control)	48.8	626.2	148.8
T_1 (GA_3@ 50ppm)	50.8	790.5	197.4
T_2 (GA_3@ 100ppm)	51.3	914.3	204.1
T_3 (GA_3@ 150ppm)	51.9	983.3	219.0
T_4 (GA_3@ 200ppm)	53.3	1159.5	351.5
T_5 (GA_3@ 250ppm)	54.6	1390.5	370.8
T_6 (GA_3@ 300ppm)	53.9	1342.9	361.1
T_7 (GA_3@ 350ppm)	52.9	1052.4	241.6
T_8 (GA_3@ 400ppm)	51.5	916.7	213.0
T_9 (GA_3@ 450ppm)	50.8	809.5	198.8
T_{10} (GA_3@ 500ppm)	50.8	631.0	190.3
S. Em (±)	0.824	16.892	4.007
C. D. at 5%	2.648	49.223	12.501

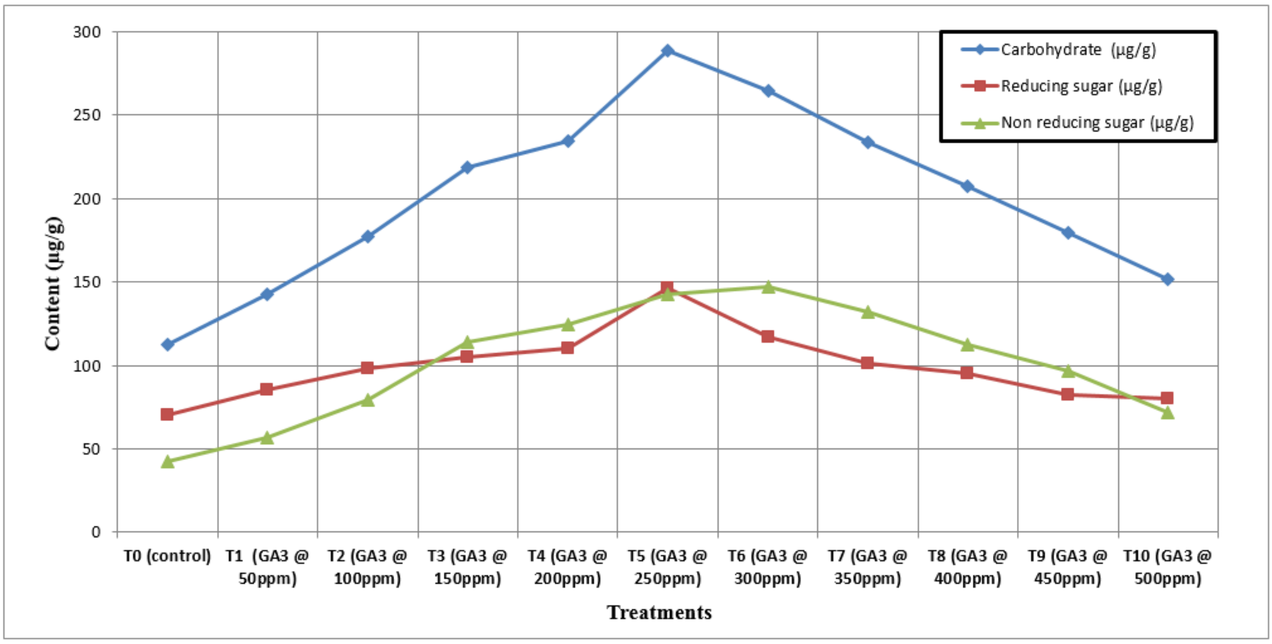

Fig 1: Influence of different treatments of Gibberellic acid on total carbohydrate content (µg/g), reducing sugar content (µg/g) and non-reducing sugar content (µg/g) of petal of African marigold cv. 'Pusa Narangi Gainda' (data are mean of two season)

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