Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(5): 43-46
Received: 19-07-2019
Accepted: 21-08-2019

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A review on performance of gibberellic acid on African marigold

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Abstract
Among plant growth regulators, Gibberellins are the most widely used and proven growth substances in Horticultural crops. Generally GA_3 influences a range of developmental process in plants life like stem elongation, germination, breaking dormancy, flowering, sex expression, enzyme induction and leaf and flower senescence. Looking to the mode of action of the application of GA_3 in early stage enhances the growth of the plant. Thus, the GA_3 allow obtaining the best ratio between the vegetative growth and flower production, thereby improving the market quality of flowers. It increases in carbohydrate production, number of branches, number of flowers, flower diameter, weight of flower, yield and quality of flower.

Keywords: Performance, of gibberellic acid, African marigold

Introduction
Marigold (*Tagetes erecta* L.) belonging to family Asteraceae is one of the major important commercial flower crop of this country and widely grown all over India for loose flower production. In general, the commercially cultivated marigold is of two types i.e. African and French marigold. African marigold is popular throughout the world because of wide spectrum of attractive colours, shape and good keeping quality. Marigold has gained popularity in India on account of its easy cultivation, wide adaptability and production throughout the year. Flowers of marigold are extremely used as a loose flower in India and apart from beautification, its flower petals are also being used for xanthophyll production which is a major carotenoid fraction and accounts 80-90% lutein of total xanthophylls content (Alarm *et al.*, 1986) [1]. The carotenoids extracted from petals of marigold are the major source of pigment for poultry industry as a feed additive to intensify the yellow colour of egg yolks and broiler skin (Narsude *et al.*, 2010) [2]. Besides this, its oil and extracts from plant are used as cure for boils, ear ache, eye disease and ulcers. The oil is reported to have bronchodilator, tranquilizing and anti-inflammatory properties. Essential oil of marigold act as a repellent against flies, ant, and mosquitoes (Chaudhari, 2001) [4]. Among plant growth regulators, Gibberellins are the most widely used and proven growth substances in Horticultural crops. Generally GA_3 influences a range of developmental process in plants life like stem elongation, germination, breaking dormancy, flowering, sex expression, enzyme induction and leaf and flower senescence. The application of GA_3 in early stage enhances the growth of the plant. Thus, the GA_3 allow obtaining the best ratio between the vegetative growth and flower production, thereby improving the market quality of flowers (Marosz and Matisiak, 2005 and Bekheta *et al.*, 2008) [3, 5]. GA_3 also increase in carbohydrate production, number of branches, number of flowers, flower diameter, weight of flower, yield and quality of flower. Keeping these points in view, a review was conduct on Performance of GA_3 on African marigold.

Effect of Ga_3 on Plant Growth
Spraying of GA_3 at 200 ppm recorded maximum plant height (46.39 and 58.93, cm respectively), more number of branches (14.13 and 13.77, respectively) and more number of flowers (22.87 and 84.80, respectively) in marigold and china aster (Lal and Mishra, 1986) [23]. Application of GA_3 at 100 ppm resulted in the tallest plants and largest flower diameter and peduncle length in African marigold (Girwani *et al.*, 1987) [24]. Ravidas *et al.*, (1992) [25] GA_3 at 100 ppm resulted in maximum plant height (53.87 cm) and more number of leaves per plant (6.33), maximum number of florets (16.0) per spike, weight of corm (35.61 g) and weight of cormels (13.48 g) compared to GA_3 100 ppm in gladiolus cv. Friendship. Das *et al.*, (1992) [9] observed significant increase in plant height (69.30 cm) and number of leaves (26.00)

compared to control (45 cm and 18, respectively) with the spray of GA_3 at 200 ppm in *Hemerocallis aurantiaca* (Day lily). Dutta *et al.,* (1993) [10] while working on chrysanthemum observed that GA_3 at 50 ppm increased the duration of flowering, which was longest (212.67 and 219 days) compared with (83.67 and 87.33 days) the untreated controls. The highest flower yields (0.682 and 0.685 kg.) per plant were obtained with GA_3 at 150 ppm and this treatment also resulted in the longest cut flowers and shelf life when compared to control. Application of GA_3 at 40 ppm significantly increased the plant height (65.36 cm) and more number of leaves (25.80) per plant compared to control (45.56 cm and 21.20, respectively) in chrysanthemum (Talukdar and Paswan, 1994). Goyal and Gupta (1996) observed that GA_3 at 45 ppm increased plant height (91.63 cm) and more number of shoots (14.62) per plant increased the number of flowers (18.00) and flower yield (249.29 g) per plant compared to control in rose. Singh and Bijimol (2001) recorded an increase in plant height (35.15 cm) and more number of leaves (32.83) per plant, increased number of florets (41.66) per spike and weight of florets (55.40 g) per plant in tuberose with GA_3 at 200 ppm treatment compared to control. Spraying of GA_3 at 100 ppm recorded maximum plant spread (31.10 cm), more number of leaves (15.19), more number of flowers (18.63) per pot and diameter of flower head (7.53 cm) compared to control in gerbera (Sujatha *et al.,* 2002) [14]. Maurya and Nagda (2002) [28] noticed the maximum height (104.50 cm) in the plant treated with 100 ppm GA_3 as compared to control (95.10 cm) in gladiolus cv. Friendship. Spraying of GA_3 at 100 ppm increased the number of corms per plant (1.87), weight of corms per plant (78.70 g) and weight of corms per bed (1.60 kg) compared to control (1.20, 53.30 g and 0.95 kg/bed, respectively). Khan and Tewari (2003) [21] GA3 at 90 ppm significantly increased the plant height (69.00 cm), produced more number of branches (6.60) and flowers (15.80) per plant compared to control in dahlia. Maximum height (62.00 cm), number of branches (20.27) per plant, number of flowers (67.33) per plant, flower weight (2.86 g) and flower yield (192.59 g) with GA_3 at 200 ppm as compared to GA_3 100 ppm in China aster cv. Kamini (Kumar *et al.,* 2003). Kulkarni (2003) [20] observed induction of early flowering (88.60 days) with the application of GA_3 at 200 ppm compared to control (97.10 days) in chrysanthemum. Tripathi *et al.,* (2003) [29] observed that GA_3 at 400 ppm recorded the highest flower yield per plant (127.71 g) and number of flowers per plant (78.83) in French marigold. Verma and Parmar (2003) recorded maximum plant height (65.94 cm), maximum number of flowers per plant (7.25) and maximum stem length (58.25 cm) in GA3 at 100 ppm applied twice in carnation. GA_3 at 50 ppm produced buds of maximum size (1.83 cm) and maximum flower diameter (6.96 cm). Varma and Arha (2004) reported that GA_3 at 200 ppm registered maximum flower yield per plant (82.62 g) and yield per hectare (9617.48 kg) in African marigold as compared to control (59.46 g and 7018.37 kg, respectively).

Spraying of GA_3 at 100 ppm significantly increased plant height (119.88 cm), number of florets (14.29) per spike, number of corms (1.66) per plant and corm weight (50.80 g) compared to control in gladiolus (Rana *et al.,* 2005) [32]. Chandrappa *et al.,* (2006) recorded the maximum plant height (46.44 cm) with spraying of GA_3 at 750 ppm compared to control (45.22 cm) in anthurium cv. Royal Red. Sunitha *et al.,* (2007) found that spraying of GA_3 200 ppm recorded significantly higher plant height (101.2 cm) and number of primary branches (14.4) in marigold. Pandey and Chandra (2008) reported that GA_3 450 ppm significantly increased plant height, number of branches, diameter of main stem, number of leaves, number of flowers and total yield of flowers in French marigold as compared to other treatments. Maximum vegetative growth, flower yield and quality with treatment of GA_3 at 150 ppm in gerbera under polyhouse conditions. While, early flowering was noticed with 50 ppm GA_3 application (Dalal *et al.,* 2009) [8]. Mayoli *et al.,* (2009) [34] observed early flowering, highest quality flower, maximum stem diameter, early flower bud initiation, maximum flower head diameter and maximum tuberous root fresh weight in ranunculus cut flower when tuberous roots were soaked in 100 mg/l GA_3 before planting. Parmar *et al.,* (2009) [35] reported in spider lily that spraying of 200 ppm GA_3 twice i.e. 45 and 60 days after planting had shown superiority in all vegetative, floral and yield characters viz., plant height (79.92 cm), number of leaves per plant (60.33), leaf width (7.23 cm), leaf area (377.92 cm2), dry weight of plant (0.97 kg), flower diameter (4.26 cm), days taken for first spike emergence (53.38 days), days taken for first flower emergence (61.14 days), spike length (89.62 cm), number of flowers per spike (17.32), fresh flower weight (2.85 g), dry flower weight (0.38 g), yield (50812 flower bud bundles/hectare). Shivaprakash *et al.,* (2011) [12] recorded more plant height, maximum stem girth, more dry matter production in stem, leaf and flower with 200 ppm GA_3 in African marigold (*Tagetes erecta* L.) cv. Orange Double. The same treatment also recorded significantly more diameter of flower, number of flowers per plant, yield per plot (6.45 kg) and yield per ha (9.83 t) than control. GA_3 application at 350 ppm was found most effective as it gave highest flower yield per plant, maximum fresh weight per flower and highest number of flowers per plant and earlier flower bud initiation and flowering and also increased number of leaves as well as recorded maximum plant height in African marigold (Kumar *et al.,* 2012) [19, 22]. Sarkar *et al.,* (2018) [11] reported that the application of GA_3 at 200 ppm recorded significantly higher plant height (85.36cm), number of branches/plant (39.72 branches/plant), total leaf number (183.43), number of flowers (63.80) and flower yield per hectare (10.19t).

Effect of Ga_3 On Flowering and Yield

Badge and Panchbhai (2018) stated that foliar application of gibberellic acid 300 ppm recorded maximum flower yield, gross, net monetary returns with higher B:C ratio.

Single spray of GA_3 at 150 ppm recorded significantly higher plant height (83.30 cm), leaf area (1188.58 cm^2), number of flowers per plant (78.49), average weight of flower (4.85 g) and yield of flowers per plant (365.23 g) as well as per hectare (132.27 q/ha) in African marigold (Kanwar *et al.,* 2013) [18]. Application of GA_3 at 200 ppm registered significantly maximum flower yield per plant (639.18 gm) with longest duration of flowering (87.18 days) as compared to control in African marigold (Kumar *et al.,* 2012) [19, 22]. Application of GA_3 at higher concentration of 100 ppm as a pre-harvest spray exerted a significant influence on crop growth and recorded highest mean values for plant height (76.18 cm), stalk length (60.98 cm), stem girth (1.66 cm) and total chlorophyll content (1.826 mg g^{-1}) of rose. Similarly, the application of GA_3 at 100 ppm level drastically increased the quality traits viz., mean flower diameter (6.89 cm), anthocyanin content (0.1970 OD value) and vase life (2.6 days). Likewise the earliest flowering (40 days) was also obtained from pre-harvest spray of GA_3 at 100 ppm (Kumar *et al.,* 2012) [19, 22]. Ramdevputra *et al.* (2009) [36] observed that

all the vegetative growth characters of African marigold were highly influenced by GA_3 at 300 ppm. Maximum number of flowers per plant (86.43), weight of flowers (248.67 g) per plant and flower yield (79.56 q/ha) were obtained by spraying of GA_3 at 300 ppm. Shinde *et al*., (2010) [37] recorded significantly maximum number of branches, plant spread, number of suckers per plant, number of flowers per plant, yield of flowers per plant as well as per hectare with the spraying of GA_3 at 200 ppm in chrysanthemum (*Chrysanthemum morifolium* R.) cv. IIHR-6. However, minimum number of days for initiation of flowering and that for peak flowering, maximum duration of flowering, flower diameter, fresh flower weight, shelf and vase life of flowers were obtained with 150 ppm GA_3. Bihari and Narayan (2009) [6] revealed that spraying of 100 ppm GA_3 at 15 days after transplanting proved significantly effective for a floriferous crop of African marigold cv. African Orange. Singh (2004) reported that the greatest fresh (14.55 g) and dry weights (2.57 g) of 30 leaves per plant in French marigold were observed with GA_3 at 100 ppm and the greatest plant height (59.77 cm) was recorded with GA_3 at 200 ppm. GA_3 at 200 ppm also increased the number of seeds per flower (96.43). GA_3 at 100 ppm increased seed weight per flower (0.38 g) and 100 seed weight (0.41 g). The highest seed yield per plant (63.41 g) was also recorded with GA_3 at 200 ppm. African marigold and China aster were sprayed with GA_3 at 100 and 200 ppm after 15 days of transplanting and twice more at 10 days intervals, the best results with regard to the number of flowers per plant and seed yield were obtained with GA_3 at 200 ppm in both the species (Syamal *et al.*, 1990) [16]. Singh *et al.* (1991) [17] Induction of early flowering (85.36 days) and increased the number of flowers (56.00), flower yield (574.55 g) per plant and test weight of seed (3.31 g) were noticed with the application of GA_3 at 500 ppm compared to control (91.45 days, 27.67, 274.84 g / plant and 2.12 g, respectively) in African marigold. Nagarjuna *et al.* (1988) [38] working with the chrysanthemum reported that 50 per cent flowering was hastened by GA_3 at 100 to 200 ppm. Flower diameter was found maximum with GA_3 at 200 ppm. Beura and Maharana (1990) [7] stated that the highest shoot: root ratio (2.12) and lowest number of tubers per plant (6.25) and tuber yield (110 gm) were obtained with 200 ppm GA_3 in Dahlia variabilis. Hore and Sen (1986) [39] reported that GA_3 at 50 and 100 ppm hastened the flowering in marigold by 9 days. GA_3 at 100 ppm also showed marked increase in plant height over the control. Shedeed *et al.* (1986) conducted an experiment during two successive seasons with *Zinnia elegans* and *Tagetes erecta*. Both the species were treated with GA_3 at 100-400 ppm at 4 weeks from planting out and again a month later. In both species, GA_3 generally increased the plant height. Flowering time was not affected by GA_3 whereas, GA_3 (200 ppm) increased the seed yield in African marigold. Dahab *el al.* (1987) [40] reported that when the Chrysanthemum frutescens were treated with GA_3 at 250, 500, 1000 ppm; three times during the early stages, the treatment especially at 500 ppm and 1000 ppm increased the plant height, plant spread, diameter and the number of shoot per plant and the length of shoots. GA_3 accelerated flowering but under higher concentrations it decreased the number of inflorescence per plant.

Conclusion

Based on the results obtained from above study conclusion have been drawn: The plant height, plant spread, diameter and the number of shoot per plant, the length of shoots, number of flowers, flower yield per plant and test weight of seed increase with increases level of GA_3 foliar application.

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