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Effect of Humic Acid and Nutrients on various Quantitative Attributes of African Marigold (*Tagetes erecta* L.) cv. Inca Yellow

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ABSTRACT: In marigold, the production of high quality flowers is largely influenced by various essential plant nutrients and biostimulants. These inputs effectively contribute towards the overall growth and development and facilitate the significant organic processes within the plant. With this objective, an investigation was carried out in two consecutive years, *viz.*, 2018-19 and 2019-20 at the Floriculture Research Field of the Department of Floriculture and Landscaping in the Biotechnology-cum-Tissue Culture Centre (BTCC) premises, College of Agriculture, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar, Odisha. The aim of this study was to find out the individual and combined influence of various nutrients (0.4% $MgSO_4$, 0.4% $ZnSO_4$, and 0.2% Borax) and a biostimulant (0.2% Humic Acid) on the floral, postharvest, and yield attributes of African marigold cv. Inca Yellow. The research findings revealed that foliar application of a combination of 0.2% Humic Acid and 0.4% $MgSO_4$ exhibited maximum flower diameter (8.83 cm), flower weight (15.02 g) as well as highest yield per plant (364.20 g). Furthermore, longest bloom life (24.67 days) was recorded with the foliar application of 0.2% Humic Acid, and maximum flowering duration with 0.2 % Borax. The shelf life of flowers was found to be best with the spray of a combination of 0.2% Humic Acid, 0.4% $MgSO_4$ and 0.2% Borax, although there was no significant difference among the treatments.

Keywords: *Tagetes erecta*, nutrients, humic acid, flower quality, yield.

INTRODUCTION

Marigold belongs to the family Asteraceae and is one of the most important ornamental crops in the world. Indian flower growers highly prefer this flower due to its short life cycle, excellent adaptability to diverse agro-climatic conditions, better shelf life, prolonged flowering period, ease in cultivation, and varied flower shapes and colours. Among African marigold varieties, the Inca series of hybrids is particularly preferred for its compact growth and prolific production of large, double blooms. Marigolds respond positively to supply of various essential nutrients which play important role in their growth and development. These nutrients not only contribute to overall plant health but also serve as catalysts for various organic processes within the plant.

Humic Acid (HA) plays a vital role in both plant development and soil improvement (Benedetti *et al.*, 1996). Physically, it enhances soil water retention and supports healthy soil structure maintenance. Biologically, it fosters the growth of beneficial soil organisms, while chemically, it forms complexes that adsorb and retain inorganic plant nutrients (Brannon and Sommers 1985). It is a naturally occurring polymeric organic compound and has diverse functions in various ecosystems (Schnitzer and Khan 1972; Sposito, 1989). It is produced through the microbial decomposition of organic matter and can be found in soils, oceans, rivers, peat, and lignite coals (Lawson and Stewart 1989). The ability of humic acid to form complexes facilitates the conversion of various elements into plant-accessible forms, thereby stimulating growth, enhancing nutrient availability, improving soil fertility, and increasing yield. Magnesium holds multiple essential functions in plants, as it is a component of chlorophyll, chromosomes, and polyribosomes. Additionally, it supports the synthesis of oils and fats, aids in starch movement, and facilitates numerous catalytic processes within the plants. When applied as a foliar treatment, magnesium sulphate has proven effective in improving nutrient levels in crops facing deficiencies with increased chlorophyll levels and enhanced vegetative yield (Kumar *et al.*, 2018). Zinc plays a pivotal role in various biosynthesis processes in plants, acting as a co-factor for numerous enzymes and influencing diverse biological mechanisms, including photosynthesis, nucleic acid metabolism, and carbohydrate and protein biosynthesis (Choudhary *et al.*, 2016). Furthermore, zinc contributes to the production of tryptophan, a precursor to auxin, and a deficiency in zinc has been linked to reduced auxin levels in plants (Balakrishnan *et al.*, 2007). Boron is of significant importance in various plant processes, affecting functions such as sugar translocation, membrane permeability, photosynthesis, cell elongation, division, and cell wall synthesis. It plays a vital role in nitrogen fixation, protein synthesis, amino acid metabolism, and nitrate metabolism. Boron also contributes in maintaining the structural integrity of cell walls by forming bonds with pectic polysaccharides. Additionally, it directly influences critical reproductive stages, including fertilization, pollen germination, flower and seed development, and fruit abscission (Kumar *et al.*, 2018). However, limited studies have been conducted on the impact of nutrients such as magnesium (Mg), zinc (Zn), boron (B), and biostimulants like humic acid on Inca cultivars. This study aimed to shed light on this aspect.

MATERIALS AND METHODS

The experiment was carried out at the Floriculture Research Field of the Department of Floriculture and Landscaping in the Biotechnology-cum-Tissue Culture Centre (BTCC), College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha. A total of 11 different treatments, viz., T_1 (Control), T_2 (0.2% Humic acid), T_3 (0.4% $MgSO_4$), T_4 (0.5% $ZnSO_4$), T_5 (0.2% Borax), T_6 (0.2% Humic acid + 0.4% $MgSO_4$), T_7 (0.2% Humic acid + 0.5% $ZnSO_4$), T_8 (0.2% Humic acid + 0.2% Borax), T_9 (0.2% Humic acid + 0.4% $MgSO_4$ + 0.5% $ZnSO_4$), T_{10} (0.2% Humic acid + 0.4% $MgSO_4$ + 0.2% Borax), and T_{11} (0.2% Humic acid + 0.4% $MgSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax) were taken in the experiment. The humic acid and various nutrients were applied through foliar spray. The sprayings were carried out during the early morning and late afternoon hours on windless days to maximize the absorption of the solutions by the plants.

Six floral and yield characters were observed and data was recorded. The traits under study were flower diameter (cm), flower weight (g), bloom life (days), flowering duration (days), shelf life (days), and yield per plant (g). The observations were recorded following the standard procedure. Subsequently, the collected data was subjected to statistical analyses using analysis of variance (ANOVA), and the means were compared using the Duncan Multiple Range Test (DMRT) based on the method described by Wahua (1999). The statistical analyses were carried out using the R programming software.

RESULTS AND DISCUSSION

The influence of nutrients and a biostimulant on different floral and yield parameters is presented in Table 1 & Table 2. Foliar application of 0.2% Humic Acid + 0.4% $MgSO_4$ (T_6) exhibited largest flower in 1st year (8.93 cm), 2nd year (8.91 cm), and in pooled data (8.83 cm). The data was at par with all other treatments except control in both the years as well as in pooled data showing no significant difference among the treatments for the trait under study. The results are in line with the findings of Shyala *et al*. (2019) in African marigold, Memon *et al.* (2014) in petunia, and Ahmad *et al.* (2019) in pot marigold.

The weight of the flower was found to be highest (15.23 g, 14.81 g, and 15.02 g for 1st year, 2nd year, and pooled, respectively) in the treatment with the application of 0.2% humic Acid + 0.4% $MgSO_4$(T_6). The data was at par with all other treatments except control in both the years. However, for the pooled data of both the years, the treatments T_{10} (0.2% Humic Acid + 0.4% $MgSO_4$ + 0.2% Borax), T_2 (0.2% Humic Acid), T_7 (0.2% Humic Acid + 0.5% $ZnSO_4$), T_9 (0.2% Humic Acid + 0.4% $MgSO_4$ + 0.5% $ZnSO_4$), T_8 (0.2% Humic Acid + 0.2% Borax), and T_3 (0.4% $MgSO_4$) remained at par with the best treatment. Least flower weight was found to be recorded in control. Humic acid aids in improving the soil organic matter leading to improved soil efficiency, thereby, increasing the flower production. $MgSO_4$ plays a pivotal role in plant respiration and enzyme system activation. It also ensures improved crop quality. The collective effect of humic acid and $MgSO_4$ improved the flower weight significantly. The findings are in accordance with Shyala *et al*. (2019) in African marigold, and Memon *et al.* (2014) in petunia.

Foliar application of 0.2% Humic Acid (T_2) exhibited longest bloom life with the values 24.33 days, 24.50 days, and 24.67 days for 1st year, 2nd year, and pooled data, respectively. The data stood at par with the treatments T_5 (0.2 % Borax), T_7 (0.2% Humic Acid + 0.5% $ZnSO_4$), T_4 (0.5% $ZnSO_4$), T_3 (0.4% $MgSO_4$), and T_{11} (0.2% Humic Acid + 0.4% $MgSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax) in the 1st year, and in the 2nd year, with the treatments T_5 (0.2 % Borax), T_7 (0.2% Humic Acid + 0.5% $ZnSO_4$), T_4 (0.5% $ZnSO_4$), and T_{10} (0.2% Humic Acid + 0.4% $MgSO_4$ + 0.2% Borax). However, for the pooled data of both the years, the treatments T_3 (0.4% $MgSO_4$) and control remained at par with the best treatment. The application of humic acid enhanced the bloom life as it aids in improving the soil organic matter leading to improved soil efficiency, thereby, enhancing the blooming period. The results are in accordance with Memon *et al.* (2014) in petunia, Das *et al*. (2020) in

African marigold, Ghosh *et al.* (2022) in marigold cv. Seracole, Pahare and Beura (2022) in lilium Asiatic hybrid Tresor, and Ahmad *et al.* (2019) in pot marigold. The longest flowering duration was exhibited with the foliar application of 0.2 % Borax (T_5) with the values 63.20 days (1st year), 63.20 days (2nd year) and 62.30 days (pooled) which was at par with all other treatments except T_{11} (0.2% Humic Acid + 0.4% $MgSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax) and control showing no significant difference among the treatments for the trait under study. The findings are in line with Gopichand *et al*. (2013) and Thirumalmurugan *et al*. (2021) in African marigold.

Foliar application of 0.2% Humic Acid + 0.4% $MgSO_4$ + 0.2% Borax (T_{10}) unveiled longest shelf life of 6.33 days in 1st year, 6.68 days in 2nd year, and 7.00 days for pooled data over both the years. The data remained at par with all other treatments showing no substantial difference among the treatments for the trait under study. The results are in conformity with the findings of Ghosh *et al.* (2022) in marigold cv. Seracole, and Biradar *et al.* (2017) in chrysanthemum.

Foliar application of 0.2% Humic Acid + 0.4% $MgSO_4$(T_6) revealed highest yield per plant with the values 387.95 g, 378.49 g, and 364.20 g for 1st year, 2nd year, and pooled data, respectively. The data was at par with the treatments T_7 (0.2% Humic Acid + 0.5% $ZnSO_4$), T_3 (0.4% $MgSO_4$), T_8 (0.2% Humic Acid + 0.2% Borax), T_2 (0.2% Humic Acid), and T_9 (0.2% Humic Acid + 0.4% $MgSO_4$ + 0.5% $ZnSO_4$) in the 1st year, and in the 2nd year, with all other treatments except T_4 (0.5% $ZnSO_4$), T_{11} (0.2% Humic Acid + 0.4% $MgSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax) and T_1 (control). However, for the pooled data over the years, the treatments T_8 (0.2% Humic Acid + 0.2% Borax), T_7 (0.2% Humic Acid + 0.5% $ZnSO_4$), T_3 (0.4% $MgSO_4$), T_5 (0.2 % Borax), and T_2 (0.2% Humic Acid) showed at par results with the best treatment. Humic acid stimulates nutrient absorption and has hormone like effect on growth of the plants (Nardi *et al*. 2002). $MgSO_4$ plays a pivotal role in plant respiration and enzyme system activation and also enhances the nutritional status of the crop. The cumulative effect of humic acid and $MgSO_4$ improved the yield significantly. The results confirmed with the findings of Ghosh *et al.* (2022) in marigold cv. Seracole, Biradar *et al*. (2017) in chrysanthemum, Shyala *et al*. (2019) in African marigold, Khan (2000) in dahlia, and Memon *et al.* (2014) in petunia.

Table 1: Effect of humic acid and nutrients on different floral parameters of African marigold cv. Inca Yellow.

Characters / Treatments	Flower diameter (cm)			Flower weight (g)			Bloom life (days)			Flowering duration (days)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1 (Control)	8.01^{a}	7.51^{a}	7.96^{b}	10.47^{b}	10.71^{b}	10.59^{c}	18.67^{d}	18.50^{c}	18.33^{c}	59.60^{c}	59.00^{b}	59.30^{b}
T_2 0.2% Humic Acid) (HA)	8.15^{a}	7.89^{a}	8.02^{ab}	12.76^{ab}	13.27^{ab}	13.01^{abc}	24.33^{a}	24.50^{a}	24.67^{a}	62.07^{ab}	61.27^{a}	61.67^{a}
T_3 (0.4% $MgSO_4$) (Mg)	8.72^{a}	8.72^{a}	8.11^{ab}	12.75^{ab}	12.90^{ab}	12.83^{abc}	21.65^{abcd}	18.64^{c}	18.37^{bc}	61.67^{abc}	61.93^{a}	61.80^{a}
T_4 (0.5% $ZnSO_4$) (Zn)	8.47^{a}	8.44^{a}	8.46^{ab}	12.26^{ab}	12.23^{ab}	12.25^{bc}	22.10^{abcd}	22.00^{abc}	22.20^{abc}	62.00^{ab}	62.20^{a}	62.10^{a}
T_5 (0.2% Borax) (B)	8.48^{a}	8.51^{a}	8.46^{ab}	12.02^{ab}	12.39^{ab}	12.21^{bc}	24.20^{ab}	24.27^{a}	24.43^{ab}	63.20^{a}	62.60^{a}	62.30^{a}
T_6 (0.2% HA + 0.4% Mg)	8.93^{a}	8.91^{a}	8.83^{a}	15.23^{a}	14.81^{a}	15.02^{a}	20.32^{abcd}	20.33^{bc}	20.23^{abc}	61.27^{abc}	62.33^{a}	61.80^{a}
T_7 (0.2% HA + 0.5% Zn)	8.73^{a}	8.40^{a}	8.57^{ab}	13.07^{ab}	13.10^{ab}	13.09^{abc}	23.10^{abc}	23.23^{ab}	23.57^{abc}	61.07^{abc}	62.40^{a}	61.73^{a}
T_8 (0.2% HA + 0.2% B)	8.53^{a}	8.56^{a}	8.54^{ab}	12.83^{ab}	12.90^{ab}	12.86^{abc}	19.65^{cd}	19.52^{c}	19.23^{abc}	61.67^{abc}	61.47^{a}	61.57^{a}
T_9 (0.2% HA + 0.4% Mg + 0.5% Zn)	8.47^{a}	8.71^{a}	8.59^{ab}	13.04^{ab}	12.81^{ab}	12.93^{abc}	20.10^{bcd}	19.73^{c}	19.57^{abc}	61.93^{ab}	62.27^{a}	62.10^{a}
T_{10} (0.2% HA + 0.4% Mg + 0.2% B)	8.07^{a}	7.85^{a}	8.50^{ab}	14.15^{ab}	14.50^{a}	14.32^{ab}	18.66^{d}	21.83^{abc}	22.10^{abc}	61.73^{ab}	61.93^{a}	61.83^{a}
T_{11} (0.2% HA+ 0.4% Mg + 0.5% Zn + 0.2% B)	8.59^{a}	8.31^{a}	8.45^{ab}	12.44^{ab}	12.07^{ab}	12.25^{bc}	20.23^{abcd}	19.57^{c}	19.20^{abc}	60.60^{bc}	61.40^{a}	61.60^{a}

N.B. Means with the same letters are not significantly different

Table 2: Effect of humic acid and nutrients on postharvest and yield parameters of African marigold cv. Inca Yellow.

Characters / Treatments	Shelf life (days)			Yield per plant (g)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1 (Control)	5.00 a	5.33 a	5.33 a	214.63 c	231.46 b	222.43 d
T_2 0.2% Humic Acid) (HA)	6.00 a	6.00 a	6.00 a	294.38 abc	312.34 ab	305.23 abc
T_3 (0.4% $MgSO_4$) (Mg)	5.00 a	6.33 a	6.33 a	326.53 ab	327.89 ab	327.21 ab
T_4 (0.5% $ZnSO_4$) (Zn)	5.67 a	5.33 a	5.67 a	263.91 bc	267.05 b	265.48 bcd
T_5 (0.2% Borax) (B)	5.33 a	6.00 a	6.00 a	301.43 abc	313.35 ab	306.34 abc
T_6 (0.2% HA + 0.4% Mg)	6.00 a	6.33 a	6.50 ab	387.95 a	378.49 a	364.20 a
T_7 (0.2% HA + 0.5% Zn)	6.00 a	6.00 a	5.83 ab	329.68 ab	327.82 ab	327.63 ab
T_8 (0.2% HA + 0.2% B)	5.67 a	6.33 a	6.00 ab	311.74 abc	317.05 ab	329.73 ab
T_9 (0.2% HA + 0.4% Mg + 0.5% Zn)	5.67 a	6.00 a	5.67 ab	291.58 abc	288.88 ab	290.23 bcd
T_{10} (0.2% HA + 0.4% Mg + 0.2% B)	6.33 a	6.68 a	7.00 a	279.75 bc	299.78 ab	289.71 bcd
T_{11} (0.2% HA+ 0.4% Mg + 0.5% Zn + 0.2% B)	6.14 a	6.33 a	6.33 a	216.80 c	263.85 b	239.01 cd

N.B. Means with the same letters are not significantly different

CONCLUSIONS

The best treatment for most ofthe attributes under study was found to be the combined foliar application of 0.4% magnesium sulphate and 0.2% Humic acid. Utilizing a combination of nutrients and biostimulants in plant cultivation reduces the need for chemical fertilizers, leading to improved soil health and fostering vigorous crop development. This blend of nutrients and biostimulantis advisable for flower growers involved in the loose flower production as well as the potted plant sector.

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Conflict of Interest. None.

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