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RESEARCH PAPER

Influence of Bamboo Biochar and Gibberellic Acid on Vegetative and Flower Production of *Tagetes erecta* L.

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A B S T R A C T:

This research was carried out in open field Grdarasha, Agriculture College, Salahaddin University through March 18th to August 21th 2021 to study the effects of Bamboo biochar (0, 3, 6 and 9 ton.ha^{-1}) as soil application and foliar spray GA_3 (0, 200, 400 ml.l^{-1}) on (*Tagetes erecta* L.) vegetative growth and flowering. The maximum number of leaves.plant^{-1}, number of branches plant^{-1}, vegetative growth dry mass (511.24, 61.82 and 115.63g) were observed from 9 ton.ha^{-1} of Bamboo biochar, and the highest stem diameter (22.31mm) was recorded from 6 ton.ha^{-1} of Bamboo biochar. However, the maximum values of number of leaves per plant (502.20), plant height (54.00 cm) and vegetative growth dry weight (109.09 g) were recorded in a higher GA_3 concentration 400 ml.l^{-1}. The interaction treatment of 6 ton.ha^{-1} of Bamboo biochar and 400 ml.l^{-1} GA_3 gave the highest value of plant height and stem diameter (55.83 cm and 24.00 mm respectively). The best result time to reach %50 flowering (55.00 days) was obtained from 3 ton.ha^{-1} of Bamboo biochar, and the best results of time to reach 50% flowering (55.83 days), number of flowers per plant(46.02) and number of flowers per plot(184.08) were obtained from 400 ml.l^{-1} of GA_3. The interaction treatment of 400 ml.l^{-1} of GA_3 without Bamboo biochar gave the highest of number of flowers per plant (57.58), number of flowers per plot (230.33), flowers fresh weight per plant (212.17 g), flowers fresh weight per plot (848.67 g) and flowers fresh weight per hectar (7.07 ton).

KEY WORDS: African marigold, Growth, Flowering, Bamboo biochar, GA_3
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1. INTRODUCTION:

African marigold (*Tagetes erecta* L.) is annual flowering plant and member of the Asteraceae family (Sajjad *et al*., 2013). The color of the flowers changes from lemon yellow to yellow, golden yellow, orange or bronze, and flower buds are large, well-shaped, and have longitudinal grooves (Tiwari *et al*., 2018). African Marigold is a beautiful commercial flower in gardens and for cutting
(Asif, 2008 and it has medicinal value (Karuppaiah and Kumar, 2010).

Biochar is a type of organic fertilizer from woody plants and made through the process of slow pyrolysis in which biomass is combusted under oxygen restriction, biochar can improve soil fertility by enhancing the retention of nutrients and lowering the emissions of nitrous oxide and high fixed carbon content (Roberts *et al*., 2015).

Karimi *et al*. (2020 a) evaluated the effect of humic acid dissolved in irrigation water after the plant cultivation at different rates (0, 250, and 500 mg.l^{-1}) and biochar (mixed with dry soil) (0, 20, and 40 g. kg^{-1}) on the growth, physiological properties, and nutrients uptake of (*Calendula officinalis* L.), the use of biochar and humic acid separatly had no influence on the plant growth and physiological properties but significantly improve the amount of macro- and micro-elements in the shoots, these effects were stronger when both treatments were used together, 40 g. kg^{-1} biochar and 500 mg.l^{-1} humic acid, improved the availability of nutrients and plant growth parameters. Karimi *et al*.(2020 b) tested the influence of biochar (0, 2 and 4%) and mycorrhizal fungi (non-inoculation and root inoculation) on the morphophysiological properties and elements content of (*Calendula officinalis* L.), biochar and mycorrhizal fungi inoculation enhanced flower diameter, plant height, leaf area, stem diameter, plant dry mass

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and concentration of nutrient contents. Altaf *et al*. (2021) studied the effect of various agricultural residues (leaf compost, peanut shell compost, rice straw and biochar 1:1:1:1) on growth quality of (*Matthiola incana*) and Geranium (*Pelargonium* spp), optimum plant height, number of leaves per plant, root length, number of flowers, flower diameter, evapotranspiration rate, transpiration rate and complete chlorophyll contents were measured in biochar + peat moss + leaf compost media while optimum leaf area, photosynthetic rate stomatal conductance, respiration rate, internal CO_2 and required days to first flower occurrence were measured in peanut shell + soil media.

Gibberellins play a key function in variety growth processes, as hormone of growth including seed development, organ lengthening and flowering time regulation (Yamaguchi, 2008). Kumar *et al*. (2014) investigated the effects of GA_3 (100, 200 and 300 ppm), Ethrel and Maleic hydrazide (200, 300 and 400 ppm) for each on flowering traits and yield characteristics of (*Tagetes erecta* L.), between all the treatments GA_3 300 ppm followed by 200 ppm caused in early flower bud induction, opening of first flower and optimum period of flowering, flower stalk length, number of flowers per Plant, weight of flowers per plant and flower yield per hectar. Tiwari *et al*. (2018) found that the application of NPK (100 kg N, 75 kg P and 75 kg $K.ha^{-1}$) + vermi-compost (17.85 q.ha) + foliar application of GA_3 (100 ppm) together caused significant increase in plant height, plant spread, number of branches, earliest flower bud initiation, days required to opening of first flower, flowering duration, length of flower stalk, flower diameter, number of flowers per plant, flower fresh weight and flower yield of (*Tagetes erecta* L.). Khangjarakpam *et al*. (2019) investigated the effect of foliar spray of GA_3 (0, 50, 100, 150, 200, 250, 300, 350, 400, 450 and 500 ppm) on growth, development, yield and biochemical constituents of (*Tagetes erecta* L.), the rate of 250 ppm significantly increased plant height, number of branches, number of leaves, plant spread, total weight, shoot fresh weight, root fresh weight, days to flower bud initiation, flower longevity on plants, duration of flowering, number of flowers per plant, flower diameter and expected flower yield) over control treatment, the same rate was effective in improving leaf chlorophyll, protein (carotenoids, carbohydrate and reducing sugar contents and non-reducing sugar contents in petals.

This research was conducted to estimate the response of African marigold vegetative growth and flowering to Bamboo biochar, GA_3 and their combinations.

2. Materials and Methods

Open field research completed in grdarasha field, Agriculture College of, Salahaddin University (Latitude 36° 4′ North, Longitude 44° 2′ East-elevation 436m above sea level), through March 18th to August 21th 2021 to study the effects of Bamboo biochar (at four levels 0, 3, 6 and 9 $ton.ha^{-1}$) as a soil application in the circle with diameter of 25 cm, one time applied and three times foliar spray GA_3 (at the concentration 0, 200, 400 $ml.l^{-1}$) on vegetative growth and flowering of African marigold (*Tagetes erecta* L.) after two weeks from transplanting. On march 18th 2021 taishan ball cultivar seed were sown in plastic cell filled with peat moss (pH 5.2-6.0 and organic matter 85%. Under plastic house condition, at the date of April 25th 2021, the uniform seedlings were transplanted to the experimental plots in the afternoon, each plot contain 4 plants and watered immediately after transplanting. Drip irrigation was applied. Also all plants were used for the analyzes. Some of soil properties shown in table (1). Monthly average temperature and relative humidity were recorded throughout the experiment period shown in table (2). Vegetative growth and flowering parameters which were measured at the end of experiment included: number of leaves per plant, number of branches per plant, plant height (cm), vegetative growth dry weight (g), stem diameter (mm), leaf area (cm^2), time to reach %50 flowering (days), flower diameter, number of flowers per plant, number of flowers per plot, flowers fresh weight per plant (g), flowers fresh weight per plot (g), flowers fresh weight per hectar (ton) (Ali and Mjeed, 2017 and Situmeang *et al*.,2018).

- Statistical Analysis

Factorial experiment in Randomized Complete Block Design (RCBD) with 12 treatments were applied, including 4 levels of Bamboo biochar and 3 concentration of GA_3, the treatment were replicated 3 times, each replicate include 4 seedlings. Duncan's Multiple Range Test at 0.05 probability level was used for comparision

between means, SAS system was used for all statistical analysis (SAS institute,2005).

Table (1): Some physical and chemical properties of the soil used in the study*.

Properties	**Field Soil (Grdarasha)**
pH	7.65
EC	1.23 $dS.m^{-1}$
Organic mater	1.14%
Total N	2.35 mg. g^{-1}soil
P_2O_5	3.42 ug. g^{-1}soil
K_2O	0.09 $mmol^{-1}$
Sand	12.935%
Silt	52.355%
Clay	33.710%
Soil texture	Silty Clay loam

*Directorate of Agriculture Research Center. Ministry of Agriculture and water resources, Kurdistan region –Iraq

Table (2): The metrological data during the study periods*:

Month	Average air temperature °C		Average air Humidity %	Rain (mm)
	Minimum	Maximum	42.7	26.01
March	11.7	20.0		
April	17.6	28.9	24.3	0.2
May	24.3	35.3	16.6	0.2
June	26.5	38.5	13.5	0.0
July	31.0	42.0	13.4	0.0
August	30.4	41.9	13.7	0.0

*Agriculture research center Erbil, Ministry of agriculture of Kurdistan region.

3. Results and Discussion

3.1Vegetative growth parameters:

Figure (1 a and b) shows significant effect of Bamboo biochar levels on number of leaves, number of branches, vegetative growth dry weight, and stem diameter, the maximum number of leaves per plant (511.24), number of branches per plant (61.82) and vegetative growth dry weight (115.63g) were observed from (9 $ton.ha^{-1}$) of Bamboo biochar. However, the highest stem diameter (22.31mm) was recorded from (6 $ton.ha^{-1}$) of Bamboo biochar treatment.

Figure (2 a and b) shows significant effect of varying doses of GA_3 on number of leaves, plant height and vegetative growth dry weight. The maximum values of number of leaves per plant (502.20), plant height (54.00 cm) and vegetative growth dry weight (109.09 g) were recorded with a higher GA_3 concentration (400 $ml.l^{-1}$) over control. While, the number of branches, stem diameter and leaf area were not affected significantly with GA_3 treatment.

The data in the table (3) shows significant effects between Bamboo biochar and GA_3 interaction treatments on vegetative growth parameters except leaf area. The best results of number of leaves per plant (555.75), number of branches per plant (70.75) and vegetative part dry weight (133.50 g) were recorded from (9 $ton.ha^{-1}$) of Bamboo biochar and (200 $ml.l)^{-1}$ GA_3 interaction treatment. The highest plant height (55.83 cm) and stem diameter (24.00 mm) were resulted from (6

ton.ha^{-1}) of Bamboo biochar and (400 ml.l^{-1}) GA_3.

This result is agree to some extent with the findings of (Badge *et al*., 2014) on African marigold, (Sajid *et al*., 2016) on Chrysanthemum and (Ali and Majeed, 2017) on Chrysanthemum. This might be indicated that Bamboo biochar treatment may have an indirect effect on the number of leaves because number of leaves is reliant on nutrient uptake. Bamboo biochar media contain significant amount of nitrogen, which is significant for enhancing vegetative growth of plants, and the effect of GA_3 may be attributed to the fact that GA_3 spray enhanced internodal elongation and cell expansion which improves growth of plants and also raises auxin level which indirectly promote the growth and apical dominance this is one of the physiological effects of auxins (Acharya *et al*., 2021).

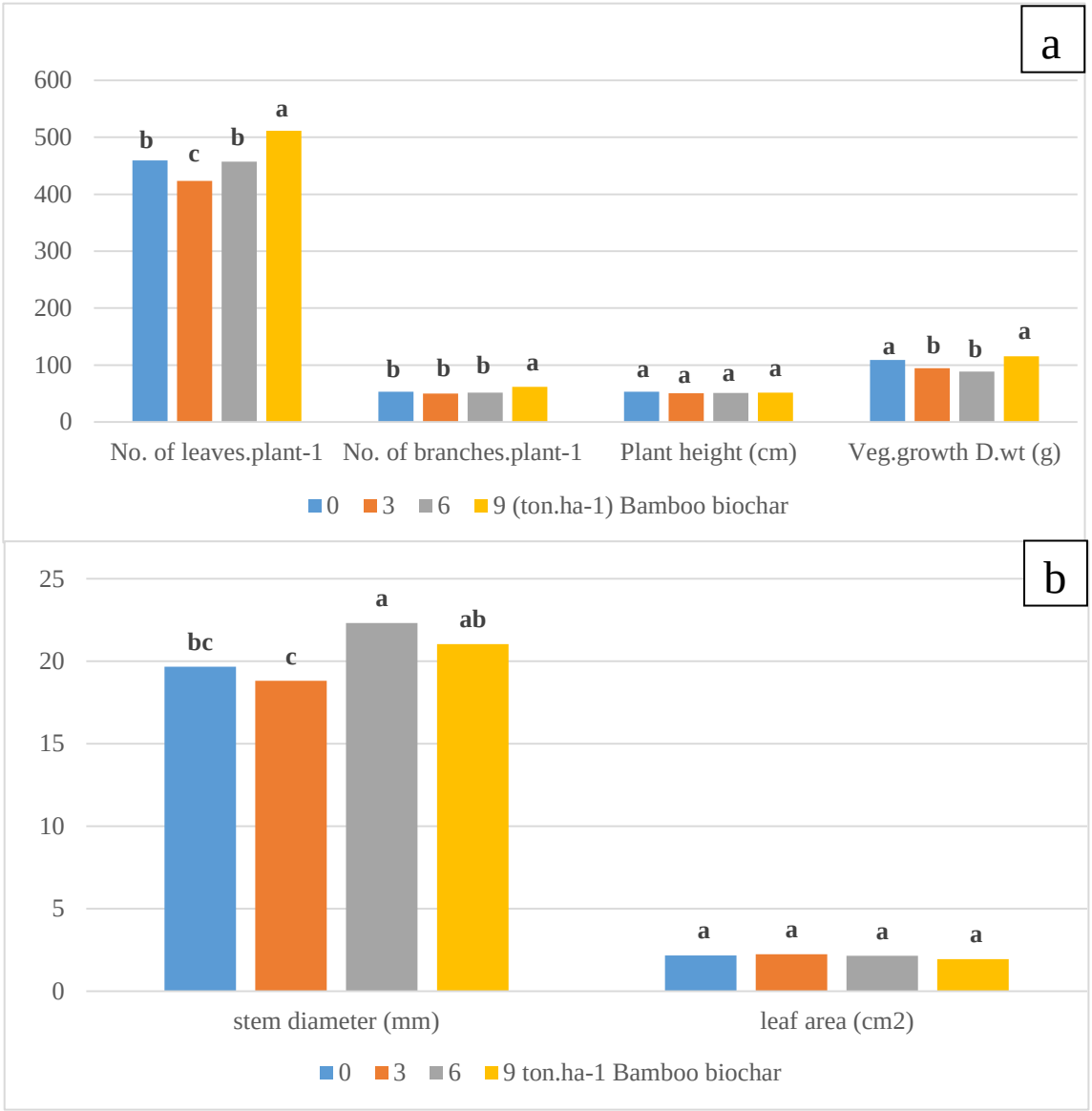

Figure (1) a and b Effect of Bamboo biochar on vegetative growth parameters of *Tagetes erecta* L. (a) number of leaves per plant, number of branches per plant, plant height (cm) and vegetative growth dry weight (g). (**b**) stem diameter (mm) and leaf area (cm^2) *

*(columns with the same letter are not significantly different from each other according to Duncan's Multiple Range test at 0.05 level).

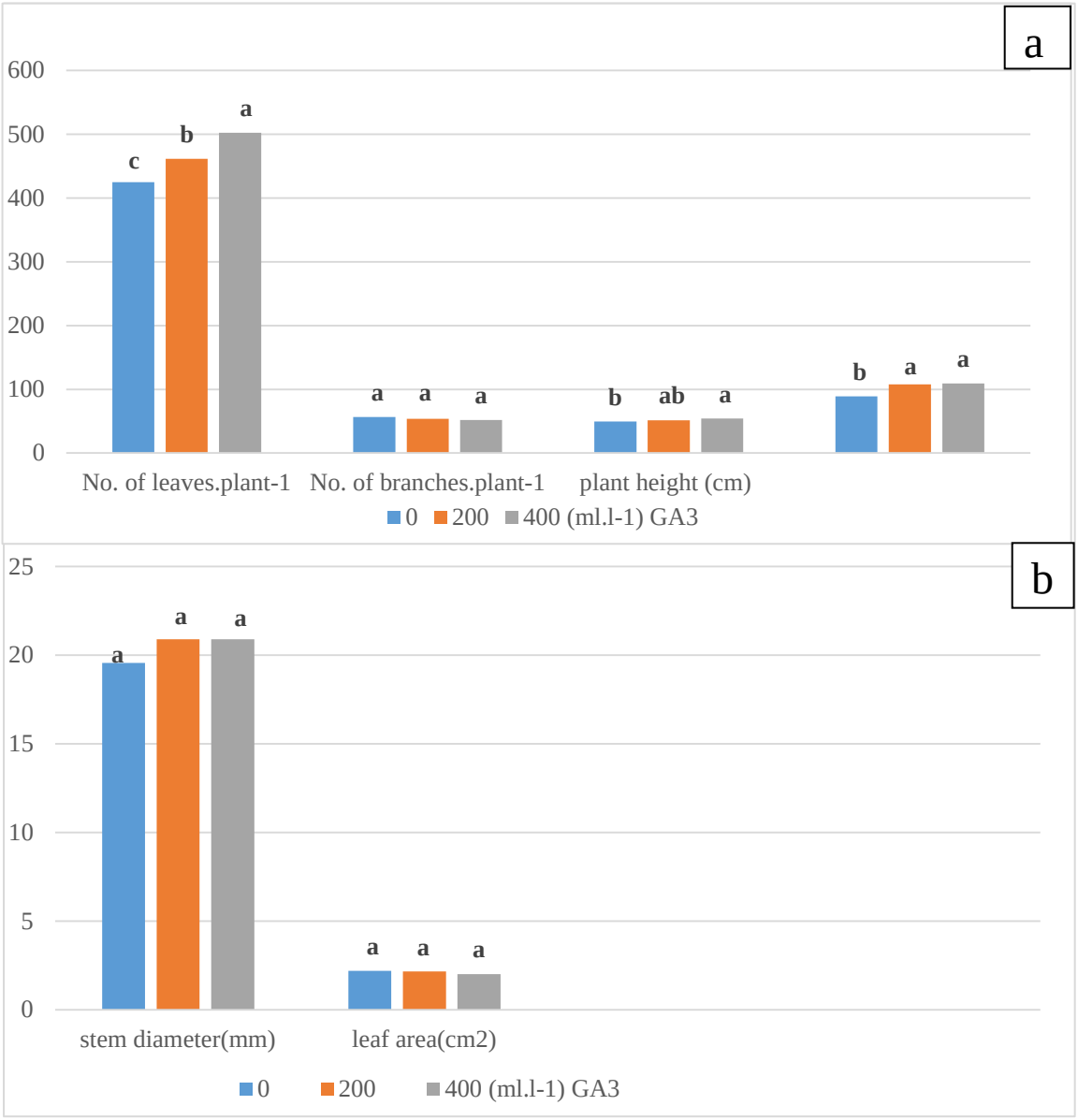

Figure (2) a and b Effect of GA_3 on vegetative growth parameters of *Tagetes erecta* L. (a) number of leaves per plant, number of branches per plant, plant height (cm) and vegetative growth dry weight (g). (**b**) stem diameter (mm) and leaf area (cm^2) *
*(columns with the same letter are not significantly different from each other according to Duncan's Multiple Range test at 0.05 level).

Table (3) Interaction effects of Bamboo biochar and GA_3 on vegetative growth parameters of *Tagetes erecta* L.*

Bamboo biochar (ton.ha^{-1})	GA_3 (ml.l$^{-1)}$)	No. of leaves. plant^{-1}	No. of branches. plant^{-1}	Plant height (cm)	Veg. growth D.Wt (g)	Stem diameter (mm)	Leaf area (cm^2)
0	**0**	389.72 d	52.19 b-e	50.79 a-d	87.59 de	17.86 e	2.11 a
	200	461.25	54.00	55.25	113.92	20.75	2.38

		b	b-e	ab	bc	bcd	a
	400	527.33 a	52.83 b-e	54.33 abc	125.33 ab	20.39 cd	2.02 a
3	**0**	408.79 cd	59.00 bc	52.08 a-d	87.93 de	20.70 bcd	2.56 a
	200	442.87 bc	42.97 e	48.06 cd	99.70 cd	17.75 e	2.19 a
	400	419.19 bcd	48.25 cde	51.33 a-d	96.17 cde	17.97 d	1.97 a
6	**0**	439.08 bc	54.83 bcd	48.42 cd	78.38 e	19.17 cd	2.19 a
	200	385.92 d	47.31 cde	48.92 bcd	83.63 de	23.75 ab	2.22 a
	400	546.17 a	52.33 b-e	55.83 a	103.22 cd	24.00 a	2.01 a
9	**0**	461.83 b	60.67 b	46.83 cd	101.75 cd	20.50 cd	1.94 a
	200	555.75 a	70.75 a	53.25 a-d	133.50 a	21.36 abc	1.85 a
	400	516.13 a	54.06 b-e	54.5 abc	111.63 bc	21.25 abc	2.01 a

*Values within each column followed with the same latters are not significantly different from each other according to Duncan's Multiple Range test at the 0.05 level.

3.2Flower parameters:

Figure (3 a and b) show negative effect of different level Bamboo biochar on flower parameters except time to reach %50 flowering, the best result (55.00 days) was obtained from (3 ton.ha^{-1}) of Bamboo biochar. The optimum results of flowers fresh weight per plant (184.99 g), flowers fresh weight per plot (739.97 g) and flowers fresh weight per hectar (6.16 ton) were recorded from control treatment. Moreover, Bamboo biochar had no significant effect on flower diameter per plant, number of flowers per plant and number of flowers per plot.

Figure (4 a and b) show significant effect of GA_3 on flower parameters of African marigold. The best results of time to reach 50% flowering (55.83 days), number of flowers per plant (46.02) and number of flowers per plot (184.08) were obtained from (400 ml.l), but had no significant effects on flower diameter per plant, flowers fresh weight per plant, flowers fresh weight per plot and flowers fresh weight per hectar.

It is obvious from table (4) that Bamboo biochar and GA_3 interaction caused significant effects on all flower parameters except flower diameter per plant. The lowest time to reach 50% flowering (47.33 days) was obtained from (3 ton.ha^{-1}) Bamboo biochar with (400 ml.l^{-1}) GA_3. The

highest number of flowers per plant (57.58), number of flowers per plot (230.33), flowers fresh weight per plant (212.17 g) flowers fresh weight per plot (848.67 g) and flowers fresh weight per hectar (7.07 ton) were recorded from (400 ml.l^{-1}) GA_3 without Bamboo biochar.

The results partially agree with finding of (Kumar *et al*., 2014) on African marigold, (Situmeang *et al*.,2018) on *Amaranthus tricolor* L. and agree with those obtained by (Suthar *et al*., 2018) on tomato plants. Application of biochar has been found to improve plant growth by feeding nutrient components to plants grown, enhance water and nutrient holding capacity and increased cation exchange capacity, avoiding cationic nutrients from being leached (Suthar *et al*., 2018). The application of GA_3 led to raises in number of flowers may be attributed to the number of leaves was increased in the same treatment, may affect to make and collect preserve carbohydrates for appropriate flower bud differentiation (Thasappan,2018).

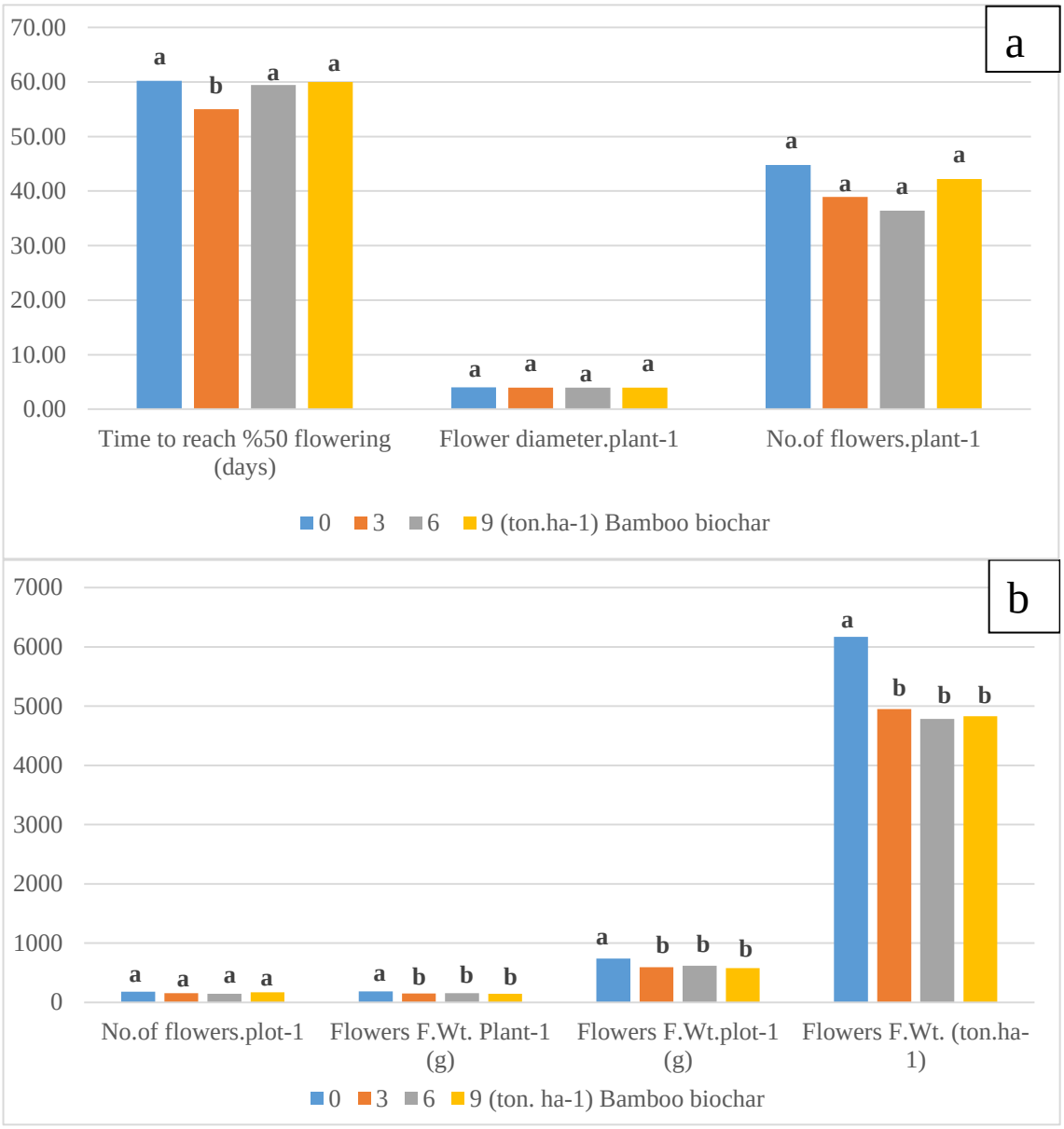

Figure (3) a and b Effect of Bamboo biochar on flower parameters of *Tagetes erecta* L. (a) time to reach %50 flowering (days), flower diameter per plant, number of flowers per plant, **(b)** number of flowers per plot, flowers fresh weight per plant (g), flowers fresh weight per plot (g), flowers fresh weight per hectar (ton)*****

*(columns with the same letter are not significantly different from each other according to Duncan's Multiple Range test at 0.05 level).

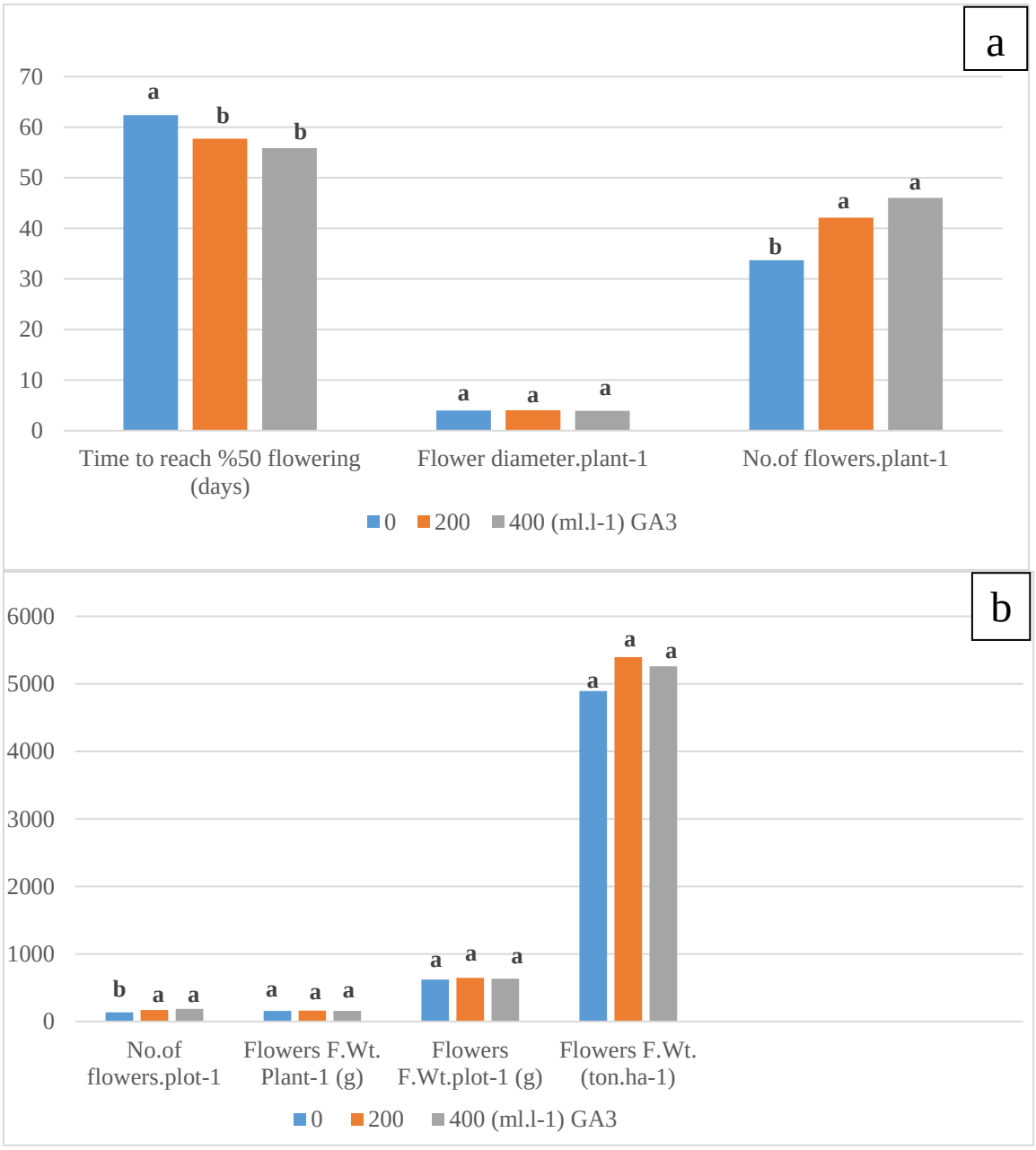

Figure (4) a and b Effect of GA_3 on flower parameters of *Tagetes erecta* L. (a) time to reach %50 flowering (days), flower diameter per plant, number of flowers per plant, **(b)** number of flowers per plot, flowers fresh weight per plant (g), flowers fresh weight per plot (g), flowers fresh weight per hectar (ton)*****

*(columns with the same letter are not significantly different from each other according to Duncan's Multiple Range test at 0.05 level).

Table (4) Interaction effects of Bamboo biochar and GA_3 on flower parameters of *Tagetes erecta* L.*

Bamboo biochar (ton.ha^{-1})	GA_3 (ml.l^{-1})	Time to reach %50 flowering (days)	flower diameter.plant^{-1}	No.of flowers.plant^{-1}	No.of flowers.plot^{-1}	Flowers F.Wt. Plant^{-1} (g)	Flowers F.Wt.plot^{-1} (g)	Flowers F.Wt. (ton.ha^{-1})

0	**0**	63.27 ab	4.17 a	29.18 c	116.75 c	178.56 ab	714.25 ab	5.96 ab
	200	60.67 abc	3.98 a	47.62 ab	190.50 ab	164.25 bcd	657.00 bcd	5.47 abc
	400	56.67 bc	3.97 a	57.58 a	230.33 a	212.17 a	848.67 a	7.07 a
3	**0**	64.67 a	4.14 a	36.00 bc	144.00 bc	151.75 b-e	607.00 b-e	5.05 bc
	200	53.00 cd	3.88 a	36.12 bc	144.50 bc	129.64 de	518.57 de	4.32 bc
	400	47.33 d	3.81 a	44.75 abc	179.00 abc	166.42 bcd	665.67 bcd	5.47 abc
6	**0**	57.67 abc	3.73 a	35.58 bc	142.33 bc	157.75 b-e	631.00 b-e	4.13 c
	200	59.33 abc	4.28 a	34.75 bc	139.00 bc	170. 76 bc	682.50 bc	5.68 abc
	400	61.33 ab	3.87 a	38.92 bc	155.67 bc	135.67 cde	542.67 cde	4.52 bc
9	**0**	64.00 ab	3.90 a	33.92 bc	135.67 bc	132.58 cde	530.33 cde	4.41 bc
	200	58.00 abc	3.99 a	49.88 ab	199.50 ab	182.87 a	731.50 ab	6.09 ab
	400	58.00 abc	4.04 a	42.83 abc	171.33 abc	119.37 e	477.50 e	3.97 c

*Values within each column followed with the same latters are not significantly different from each other according to Duncan's Multiple Range test at the 0.05 level.

4.Conclusions

Bamboo biochar positively affected vegetative growth of African marigold and had negative effects on flower characteristics except time to reach 50% flowering. Vegetative growth and flower characteristics showed significant differences as a result of the treatments that were primarily dependent on the highest levels of GA_3. Regarding the interaction between two factors had encouraging responses.

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