

# Biochar and Nitrogen Fertilizers Effects on Growth and Flowering of Garland Chrysanthemum (*Chrysanthemum Coronarium L.*) Plant

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**Abstract:** *This experiment was conducted to study the effect two types of biochar and nitrogen fertilizers amendment, with different rates on morphological attributed of garland chrysanthemum plant. Two different types of biochar (BT) Eucalyptus biochar (EB), and Salix biochar (SB), four biochar rates- BR (at 0, 1, 2 and 3%), and three rates of nitrogen fertilizer- NR (0, 140 and 280 mg kg<sup>-1</sup>) with three replications on plant growth were used in this research. The (*Chrysanthemum coronarium L.*) was used as a test plant to study some morphological characters including: Plant Height (PH) cm, Fresh Weight Per Plant (FWP) g, Number of Leaves Per Plant (NLP), Stem Diameter (SD) cm, Flower Diameter (FD), Number of Flower Per Plant (NFP) and Number of Flower Bud Per Plant (NFBP) cm. The Double Barrel Design was used for making biochar by pyrolysis system. The experiment was conducted in the plastic house condition. The results showed that biochar applications at a rate of 3%, significantly increase PH, FWP, NLP, SD, FD, and NFBP, while NFP increased only at 2% biochar application and decrease at the 3% rate. The application of 280 mg kg<sup>-1</sup> of nitrogen significantly increased all of the parameters. The plant grown in the soils amended with the EB were higher than grown in the soils of the SB. In addition, the best value in the study was observed were biochar combined with nitrogen fertilizers.*

**Keywords:** Biochar, Pyrolysis System, Garland Chrysanthemum, Nitrogen Fertilizer, Infertile Soil.

## 1. INTRODUCTION

Soilless media is used for the growth of most of the potted ornamental plants and peat is one of the soilless media component that traditionally used with a higher range [1]. Due to economic and environmental issue, recently farmers try to find an alternative to peat, vermiculite, perlite, and sand and among those products peat was largely applied in the production of ornamental potted plants [2, 3]. Most of the media blends that are available in the markets have inaccurate properties such as acidity (pH), the content of soluble salt, less nutrient amount and low cation exchange capacity (CEC) and these properties reduce the performance of the plant [4, 5]. Due to the above mentioned problems and in order to increase the production of ornamental plants an organic enhancement is required for biochar.

Biochar is basically charcoal used for agricultural purposes, which produced from thermo-chemical decomposition of organic matter changed to solid which is carbon-rich solid with little or without O<sub>2</sub> conditions at temperatures between 300 and 1000°C by pyrolysis system, and contains some macro and micro-nutrients [6]. Carbon from biochar can be stabilized in the soil for extensive times, probably hundreds of years [7, 8].

Particle size distribution of biochar are differences based on the methodology and temperature of the production. When the temperature is high a quick pyrolysis occur and leads the production of fine-textured biochar with a short burn time while, slow pyrolysis with extended burn period cause the production of a coarse-textured biochar [9].

Therefore, biochar applications to soil have been shown to sequester C [7, 10, 11], increase plant growth in a variety of soils by improving soil chemical characteristics (e.g., nutrient retention, nutrient availability); physical characteristics (e.g, bulk density, porosity, cation exchange capacity CEC, and water holding capacity), and biological properties [12, 13].

Several studies reported that the total carbon [14], total nitrogen, available phosphorus, and exchangeable cations (Ca, Mg, Na, and K) increases with the addition of biochar to soil [15], and the soil pH value and some macro-and micronutrient increasing in the soil after the application of biochar with compost [16].

However, biochar has been reported to both rises [13] and decreases [17] plant growth and yield but there have been few studies recording the effect of biochar on ornamental growth.

The origin of annual herbaceous weed *Chrysanthemum coronarium L.* returns back to, Japan, China and Philippines [18, 19, 20, 21]. This plant have a big white and yellow crown, and the ability of the plant to adapt to local growing conditions make it easy to produce and spread and it is the most common flower growing in gardens and parks. 'Coronarium', is a variety of ornamental plant chrysanthemum which commonly known as garland chrysanthemum or crown daisy chrysanthemum. It is reported that the *C. coronarium* ornamental plant and its other species are used as an edible food in Asian countries like China and Japan, in addition it has biological characteristic such as antioxidant activity, antibacterial, and antifungal characteristic [22].

The aim of this research was to illustrate the influence of two types of biochar and nitrogen fertilizers amendment, with different rates on morphological attributed of garland chrysanthemum plant.

## 2. MATERIALS AND METHODS

The present research was carried out during growing season 2015-2016 under plastic house condition in the Ornamental plant department, Technical Institute of Bakrajo, Sulaimani Polytechnic University, Sulaimani, Kurdistan region/Iraq. The effects of two types of biochar and nitrogen applications on chrysanthemum plant growth were tested by using four different biochar rate (0, 1, 2, and 3 % biochar (w/w)), three different nitrogen rates (0, 140 and 280 mg kg<sup>-1</sup> N- Urea) with

three replications. Nitrogen fertilizers was added as Urea in two split application to each pots, which were 20 days after planting. The feedstock material used for the biochar production was (*Eucalyptus Camaldulensis* and *Salix Babylonia*) by pyrolysis system. While it was not statistically tested, there were differences for the measured chemical and physical properties among the different biochars.

The two types of biochar were alkaline, this is due to the formation of ash during the pyrolysis process, which typically consists of Ca, Mg, K and Na carbonates [23]. The amount of total carbon and P was very high in the EB than SB, and the EB contained high amounts of, K, Mn, Cu, and Zn compared with the SB (Table1).

**Table 1:** The concentration of macro-micronutrient and pH of (Eucalyptus (EB), and Salix (SB)) biochar.

Biochar Type	P	C	K	Ca	Mg	Na	Zn	Mn	Cu	pH
	mg/kg <sup>-1</sup>	%	mg kg <sup>-1</sup>			mg kg <sup>-1</sup>				
EB	138.34	56	1299.53	6345.09	567.23	179.76	8.34	18.23	0.78	9.12
SB	111.23	42	1385.15	4217.89	344.78	90.48	5.66	17.62	0.41	9.21

### 2.1. Double Barrel Design for Making Biochar

The double barrel design consists of a barrel in which biomass is placed, then as lightly larger barrel is placed over an inner barrel, and a cover (or lid) is placed on top, and it's a small scale. The lid has a chimney that helps control fair flow and gives heat more time to break down volatiles, resulting in a cleaner burn. The bottom section where the smaller barrel and the larger external barrel contact each other creates a seal to prevent oxygen entering but also acts as a pressure valve to allow gases to escape. Flammable gases and aerosols combust near the base of the inside barrel that further fuels the fire. This breaks down environmentally harmful gases such as methane (CH) and carbon monoxide (CO).

### 2.2. Soil and Biochar Analysis

The soil used in the study represent the dominant soil type of the region with low organic matter content, low alkaline pH, low available Zn and P content, plant available K was also not at an adequate level and high available Ca and Mg content ( Table 2). Therefore, biochar applications had potentials to improve soil fertility by improving the availability of especially Nitrogen, Phosphorous, and Zinc, and the other micronutrients. The acidity (pH) and (EC) of soil and biochar were measured in H<sub>2</sub>O suspension by using a glass electrode - calomel electrode system [24]. The Walkley-Black method was used for determining Organic Matter (O.M) in soil samples [25]. The total organic carbon content of biochar was determined by dry ash method with 600°C with 3 hours muffle furnace ignition [25].UV-VIS spectrophotometer was used to determine the concentration of phosphorus in soil by using a solution of 0.5 N sodium bicarbonate NaHCO<sub>3</sub> at pH 8.5 [26].

**Table 2:** The properties of the soil that used in this research:

Parameters	value
pH	7.65
EC (mmhos/cm)	2.0
CaCO <sub>3</sub> (%)	24.5
O.M. (%)	2.30
Ca (mgkg <sup>-1</sup> )	4521
Mg (mgkg <sup>-1</sup> )	223.2
Na (mgkg <sup>-1</sup> )	48.1
K (mgkg <sup>-1</sup> )	203
P (mgkg <sup>-1</sup> )	4.07
Fe (mgkg <sup>-1</sup> )	9.22
Zn (mgkg <sup>-1</sup> )	1.43
Cu (mgkg <sup>-1</sup> )	2.60
Mn (mgkg <sup>-1</sup> )	27.2

The DTPA-TEA extraction method that was developed by [27] for extracting metal micronutrients in neutral and calcareous soils were used for measuring plant available (Mn, Cu, Fe, and Zn) and for macronutrient another solution was prepared after extracting the soil samples by ammonium acetate (1N NH<sub>4</sub>OAc) at pH 7.0 [28] for assayed (Ca, Mg, K and Na) by using Perkin Elmer 3110 Atomic Absorption Spectrophotometer (AAS). The Total lime (CaCO<sub>3</sub> %) in soil was evaluated by using Scheibler Calcimeter method [29].

### 2.3. Plant Characteristics

All of the green part of the plants was harvested three months after planting to determine the morphological characteristic such as, Plant Height (PH) cm, Fresh Weight Per Plant (FWP) g, Number of Leaves Per Plant (NLP), Stem Diameter (SD) cm, Flower Diameter (FD), Number of Flower Per Plant (NFP) and Number of Flower Bud Per Plant (NFBP) cm. Finally, the plants were removed from the soil with attention then washed with normal water.

## 2.4. Statistical Analysis

Experiment was performed by randomized complete block design (RCBD) with three replications was used in this study to test main and interaction effects. The data sets were analyzed with (IBM SPSS Advanced Statistics version 20.0.0). For direct comparison of treatments, Duncan's' Multiple Comparison tests were used. Analysis of variance (ANOVA) was used for testing the main effect, the interaction of all variables; Biochar type, Biochar rates and Nitrogen rates for all treatments at statistical significance level ( $p \leq 0.05$ ). The figures were designed using Graph pad prism version 6.0 software.

## 3. RESULTS AND DISCUSSION

The results of analysis of variance (ANOVA) for the different biochar types, biochar rates, nitrogen rates, and their interactions with some measured morphological characters of garland chrysanthemum plant are given in (Table 3). The main effects of all treatments were significant for the all morphological attributed measured for garland chrysanthemum plant except for NLP, and it was non-significantly affected by biochar types. The effects of the interaction of biochar type and the rate for the PH, FD, and the interaction effect of biochar type and nitrogen rate for the FD, and the interaction effect of biochar rates and nitrogen rate for the PH, NFBP, and the interaction effect among the biochar type and the rate, and the nitrogen rate for the PH, NLP, and NFP of the garland were not significant.

Increasing the nitrogen rate increased all the morphological attributes of the garland chrysanthemum plant (Table 4). Application of N together with the biochar positively affected plant growth [13, 30]. The results further confirm that biochar as soil improvement can sufficiently use the nutrient amounts

by carrying ammonium ions in the soils and preventing the nitrification of nitrogen [31]. The results of the previous study are in agreement with [32], observed morphological attributes such as the height of the plant, the leaves number, the flower number for each plant and the yield of the flower for each hectare when applied with the organic material at the rate of  $10 \text{ t ha}^{-1}$  and suggesting an amount of NPK in China aster. This result in the study agreed with [33], which reported that application of nitrogen  $200 \text{ kg ha}$  was significantly raised the height of the plant and the branches number of each plant in marigold.

Increasing the biochar rate also increased the all morphological attributes in the garland chrysanthemum plant (Table 5). The biochar applications increased NFBP significantly compared to the control (0% biochar). The NFP was highest at the 2% application but decreased at the highest biochar application rate (3%).

Based on estimated marginal mean value, the effect of biochar types for morphological attributes of garland Chrysanthemum plant were compared together are given in (Table 6). In our experiments, all morphological attributed of the garland chrysanthemum plant grown in the soils amended with the EB were higher than grown in the soils of the SB. Similarly, the maximum diameter of the flower with the application of bio fertilizers along with recommended dose of NPK was reported by [34] in annual chrysanthemum. The amount of nutrients and C % of EB higher than SB due to high lignin content in biomass of EB (Table 1.) The biomass characteristic of the feedstock was essential due to its effect on the outcome pyrolysis products [35].

**Table 3:** The ANOVA results of the treatments and their interactions for the measured morphological attributes of garland chrysanthemum plant.

Parameters	Source	Df	Plant Height (cm)		Fresh Weight Per Plant (g)		No. of Leaves Per Plant		Stem Diameter (cm)		Flower Diameter (cm)		No. of Flowers Per Plant		No. of Flower Buds Per Plant	
			F-Value	Sig.	F-Value	Sig.	F-Value	Sig.	F-Value	Sig.	F-Value	Sig.	F-Value	Sig.	F-Value	Sig.
Biochar Type (BT)	1	8.064	0.007	9.486	0.003	2.195	0.145	9.286	0.004	71.262	0.000	50.043	0.000	6.933	0.011	
Biochar Rates (BR)	3	119.896	0.000	48.817	0.000	34.143	0.000	65.455	0.000	62.336	0.000	21.903	0.000	9.657	0.000	
Nitrogen Rates (NR)	2	90.330	0.000	80.993	0.000	54.172	0.000	93.830	0.000	21.128	0.000	48.868	0.000	24.664	0.000	
BT * BR	3	1.701	0.179	2.960	0.041	9.714	0.000	6.654	0.001	1.254	0.301	4.240	0.010	5.509	0.002	
BT * NR	2	3.184	0.050	6.078	0.004	5.608	0.006	12.254	0.000	2.416	0.100	11.843	0.000	4.660	0.014	
BR*NR	6	1.875	0.090	13.862	0.000	3.695	0.004	11.387	0.000	3.519	0.006	3.271	0.009	1.939	0.093	
BT * BR * NR	6	1.223	0.149	10.792	0.000	1.329	0.263	6.110	0.000	2.232	0.056	1.771	0.125	2.392	0.042	

The raised amount of ash which is an inorganic element of the feedstock outcomes caused reduction the content of C in the out coming biochar [36]. The raised amount of holocellulose: the ratio of the lignin that contented in the biomass caused increasing the product of volatiles and caused reduction in the char product [35]. In addition

high lignin content in the feedstock biomass increases the yield of biochar [37]. In a few studies, biochar used for ornamental plant growth. Many overviews have presented verification to improve soil productivity by biochar [12].

**Table 4:** The effect of the nitrogen rates on some measured morphological attributes of garland chrysanthemum plant.

Nitrogen Rate (mg/kg <sup>-1</sup> )	Plant Height (cm)	Fresh weight Per Plant (g)	No. of Leaves Per Plant	Stem Diameter (cm)	Flower Diameter (cm)	No. of Flowers Per Plant	No. of Flower Buds Per Plant
0	83.916c	59.458c	146.292b	1.330c	4.736c	4.464c	14.132c
140	100.458b	78.042b	230.458a	2.216b	5.363b	7.124b	18.492b
280	108.00a	84.333a	226.750a	2.666a	5.670a	9.000a	24.681a

\*Means in the same column followed by the same symbol are not significantly different at  $p \leq 0.05$  level based on Duncan test.

**Table 5:** The effect of the biochar rates on some measured morphological attributes of garland chrysanthemum plant.

Biochar Rate (%)	Plant Height (cm)	Fresh Weight Per Plant (g)	No. of Leaves Per Plant	Stem Diameter (cm)	Flower Diameter (cm)	No. of Flowers Per Plant	No. of Flower Buds Per Plant
0	75.278d	57.444c	137.500c	1.316d	3.893c	4.720c	13.560b
1	95.277c	74.277b	209.111b	1.811c	5.425b	7.173b	20.280a
2	107.166b	82.390a	224.944ab	2.311b	5.682ab	9.000a	22.397a
3	112.111a	81.667a	233.111a	2.844a	6.020a	6.563b	20.171a

\*Means in the same column followed by the same symbol are not significantly different at  $p \leq 0.05$  level based on Duncan test.

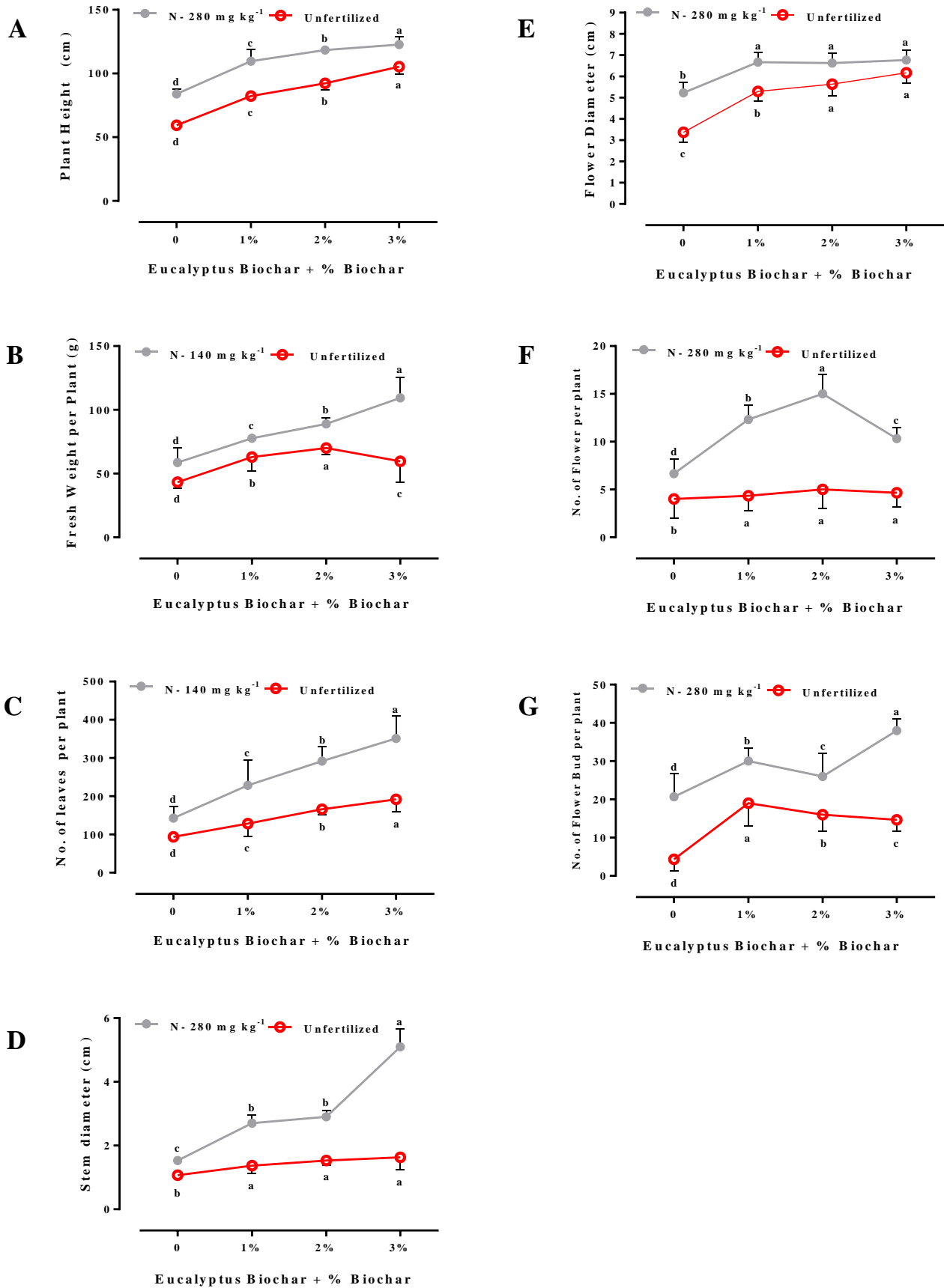
**Table 6:** The effect of the biochar types on some measured morphologic attributes of garland chrysanthemum plant.

Biochar Types	Plant Height (cm)	Fresh Weight Per Plant (g)	No. of Leaves Per Plant	Stem Diameter (cm)	Flower Diameter (cm)	No. of Flowers Per Plant	No. of Flower Buds Per Plant
Eucalyptus (EB)	99.583a	76.500a	206.694a	2.194a	5.757a	8.194a	20.722a
Salix (SB)	95.333b	71.389b	195.639b	1.947b	4.753b	5.528b	17.474b

\*Values represent based on estimated marginal mean.

Duncan's multiple comparison tests indicated that the all morphological attributed of the garland chrysanthemum plants grown in the soils amended with EB with the different application of nitrogen better than SB. In the unfertilized treatment, the PH had statistically increased by increasing the biochar rate and gets the high value at 3% (105.333) cm followed at 2% (92.333) cm and 1% (82.333)cm over 0 % of biochar rate, although maximum increases (122.667)cm on PH was obtained in the fertilized treatment with N-280 mg kg<sup>-1</sup> at 3% of biochar followed at 2% ( 118.333)cm and 1%(109.667) over the 0% (84.000) cm (Fig1 A). The FWP in the unfertilized treatments was increased at 2% (70.000) gm and decline (59.667) gm was observed at 3% rate then increases (63.000) gm at 1% and decreases (43.333) gm at 0% of biochar, while in the fertilized treatment with N-140 mg kg<sup>-1</sup> the FWP statistically was increased at 3% (109.333) gm followed at 2% (89.000) gm and at 1% (77.667) gm over the 0% of biochar (58.667) gm (Fig1 B). In the fertilized treatment N-140 mg kg<sup>-1</sup> statistically the NLP increased by increasing the biochar rate ( 351.000, 292.000, and 228.333) respectively over the control (142.667), in addition the NLP statistically increases by increasing the biochar rate in the unfertilized treatment (192.000, 166.000, and 128.667) over the control (93.667) (Fig1 C). When the soil fertilized with N-280 mg kg<sup>-1</sup> the SD significantly increases at 3% rate (5.100) cm over the 0% rate (1.533)

cm, and statistically there were no differences between 1, and 2% rates (2.900) cm, however in the unfertilized treatment the SD rising by increases of biochar rate, but statically there was similar effect between 1, 2, and 3% rate was sawed (1.633) cm over the control (1.066) cm (Fig1 D). The FD statistically there was no differences occur by increasing biochar rate (6.770) cm at 1%, 2%, and 3% in the fertilized treatment with N-280 mg kg<sup>-1</sup> but higher than control or 0% biochar (5.233)cm, in the unfertilized treatment the FD statically increased by increasing biochar rate but there were no differences observed between 2%, and 3% rate (6.170)cm followed at 1% (5.300)cm over the 0% biochar (3.370)cm (Fig1 E).the NFP increased by increasing biochar rate in unfertilized treatment but statically there was similar effect between 1%, 2, and 3% rate was sawed (5.000) but higher than control (4.000), also in the fertilized treatment with N-280 mg kg<sup>-1</sup> the NFP there was no liner relationship observed by utilized biochar rates, at 2% rate the NFP was (15.000) and decline (10.333) was observed at 3% then increases (12.333) at 1% and decreases (6.667) at 0% rate (Fig1 F). Finally the NFBP was higher (38.000) at 3% of biochar in fertilized treatment N-280 mg kg<sup>-1</sup> and followed (30.000) at 1% rate then decreases (26.000) at 2% rate over the control (20.667), also the maximum NFBP was showed (16.000) at 1% rate in unfertilized treatment over the control (4.333) (Fig1 G).



**Figure 1.** Plant growth measurements (Mean ± SE) of garland chrysanthemum. Measurements contain Plant Height (PH) cm, Fresh Weight Per Plant (FWP) g, Number of Leaves Per Plant (NLP), Stem Diameter (SD) cm, Flower Diameter (FD), Number of Flower Per Plant (NFP) and Number of Flower Bud Per Plant (NFBP) cm. That figure illustrated the best interaction between biochar rates (0, 1, 2, and 3%), two types of biochar (EB, and SB), and three Nitrogen rates (0, 140, and 280 mg kg<sup>-1</sup>), compare with non-fertilized treatment (Unfertilized). The abbreviation (a) means the greatest effect on plant morphological attributed.

#### 4. CONCLUSION

This study has highlighted the importance of balanced application different rate of nitrogen fertilizers with four rates of two types of biochar in garland chrysanthemum plant. During the experiment, we observed that Eucalyptus biochar had the greatest effect on vegetative plant growth, and generally 3% of biochar significantly was increased the morphological attributed of the plant over the control. Based on these results, it was observed that nitrogen rate 280 mg kg<sup>-1</sup> had major effects and increases (PH, FWP, NLP, SD, FD, NFP, and NFBP). Finally, based on the FWP, significantly was the greatest interaction when soil amended with the combination of (Eucalyptus biochar, 3% biochar rate, and 280 mg kg<sup>-1</sup> N application).

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## ACKNOWLEDGMENT

The authors wish to express their deep thanks to to Prof. Dr. Hüseyin Dikici and Research Assist. Ömer Faruk Demir for all of their assistance with the analysis in soil laboratory, University of Kahramanmaras Sutcu Imam. I would like to thank my dear friends, especially Assist. Lec. Yaseen N Hassan Assist. Lec. Rebin A Qadir and for his kindness, help, and he supported me during my experiments.

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