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Effects of *Aloe vera* Gel, Plant Charcoal and Their Interaction on the Growth and Flowering of *Senna alata* L.

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ABSTRACT

Background: Organic fertilizers are defined as materials originally produced from plant residues and animal waste. These fertilizers are rich in water and carbon compounds.

Methods: The present study was conducted under a lath house structure in Agricultural Experiment Station affiliate the Department of Horticulture and Landscape Design, College of Agriculture, University of Kirkuk-Iraq, during the 25 January 2024-25 April 2025 growing seasons. The experiment aimed to evaluate the effects of *Aloe vera* gel (0, 20, 40 and 80 g L^{-1}) and Plant Charcoal (0, 10, 20 and 40 g pot^{-1}) on the vegetative and flowering performance of three-year-old candle bush plants.

Result: Foliar application of *Aloe vera* gel at 80 g L^{-1} resulted in greater plant height (190.3 cm), number of branches (20.18 branches $plant^{-1}$), number of leaves (170.41 leaves $plant^{-1}$), stem diameter (10.1 mm), leaf area (16.2 cm^2) and chlorophyll content (54.33%). The same concentration also significantly improved the number of flowers (34.19 flowers $plant^{-1}$), flower diameter (9.40 mm), floral stalk diameter (9.12 mm), days to flowering (145 days) and flower dry weight (39.40 g). Regarding plant charcoal application, the highest rate 40 g pot^{-1} resulted in greater plant height (190.22 cm), with 12.30 branches per $plant^{-1}$, 169.40 leaves per $plant^{-1}$, a main stem diameter of 16.33 mm, leaf area of 140 cm^2 and chlorophyll content (9.90%). The same concentration also significantly improved the number of flowers 29.40 flowers per $plant^{-1}$, earlier flowering (129.8 days) and a flower dry weight (45.92 g).

Key words: *Aloe vera* gel, Candle bush, Ornamental plant, Plant charcoal (biochar), *Senna alata* L.

INTRODUCTION

Senna alata L., commonly known as Candle bush, belongs to the family fabaceae. It is an evergreen shrub reaching approximately 1.5 m in height; The leaves are pinnately compound, with multiple smooth, closely arranged leaflets and range in color from dark green to bluish-green, the plant produces distinctive yellow, candle-like inflorescences, which enhance its ornamental value in landscape design; The species is native to Mexico (Al-Batal, 2010). Candle bush is characterized by a relatively short and sturdy trunk with rough, fissured bark varying in color from gray to dark brown or black, the flowers develop in compact inflorescences and emit a strong fragrance that attracts pollinators, some species synthesize tannins in their leaves, resulting in a bitter taste when subjected to excessive grazing by animals, additionally, they may release volatile chemical signals that alert neighboring plants to initiate defensive responses (Al-Dab *et al.*, 2019). *Aloe vera* gel is considered a natural bio stimulant rich in growth-promoting substances and is classified as an organic fertilizer containing biologically active compounds (Nephali *et al.*, 2020). Its composition includes sugars, amino acids, fatty acids, vitamins and essential mineral elements such as Cu, Mg, K and P, as well as enzymes involved in oxidation-reduction processes (*e.g.*, amylase and oxidase). It also contains amino acids (*e.g.*, glycine and leucine) and vitamins B and C (Mengel and Kirkby, 1982; Yakhin *et al.*, 2017). Furthermore, *Aloe vera* gel is reported to contain plant growth regulators, including auxins and gibberellins, in addition to root growth-stimulating compounds such as Salicylic acid (Al-Fatlawi *et al.,* 2021; Surjushe *et al.*, 2008). Previous studies have demonstrated that diluted *Aloe vera* gel can significantly enhance growth and yield in *Salvia officinalis* plants (Abbas *et al.*, 2016). Similarly, an investigation evaluating different concentrations of *Aloe vera* gel (0, 1%, 30%, 60% and 100%) on the germination and growth of *Moringa oleifera* revealed that the 100% concentration significantly improved

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germination percentage (82.66%), germination index (4.99), vigor index (2230), plant height (42.11 cm) and number of branches (14.66) compared with the control treatment (Chachar *et al.*, 2025). Moreover, it has been reported that *Aloe vera* gel provides essential nutrients required for spinach growth and contains biologically active compounds necessary for seed germination and seedling development of *Moringa oleifera* (Aamur *et al.*, 2025). Plant Charcoal, a black and porous substance obtained by the combustion of wood that is understood to be a carbon-rich chemical transformation product, it has various forms such as wood charcoal, coal charcoal and bone charcoal and is defined as additional amendments to organic fertilizers from the decomposition of plant and animal residues (Abdl-Rhmaan and Hussein, 2026; René *et al.*, 2024). Wood pyrolysis (The process of heating wood in an environment with limited or no oxygen) generates biochar, a key ingredient for improving soil characteristics and plant performance, it plays a role in enhancing the availability of carbon to aquatic flora, participates in processes vital for plant respiration and provides an element supply of microelements like cobalt and iron, moreover, it has been used as a biological stimulant to enhance plant growth, inhibit fungal and bacterial pathogens and cyanobacteria and boost chlorophyll content, in rose cultivation, pine wood Charcoal has been found to have significant benefits in increasing flower quality, using four concentrations (0, 25, 50 and 75%) showed that the 25%, 50% and 75% treatments were significantly higher than that of the control in electrical conductivity, carbon % and potassium + sodium concentrations in leaves, these treatments significantly increased flowering parameters (number and flower diameter) as well as vegetative growth (higher chlorophyll content), compared to the untreated control, alongside ensuring root accumulation of magnesium (Giancarlo *et al.*, 2017). This study aims to know the role of different levels of *Aloe vera* gel and plant charcoal and their interaction in some vegetative and flowering characteristics of the *Senna alata* L. plant.

MATERIALS AND METHODS

The experiment was conducted under a lath house structure in Agricultural Experiment Station affiliate the Department of Horticulture and Landscape Design, College of Agriculture, University of Kirkuk-Iraq, during the 25 January 2024-25 April 2025 growing seasons. The study utilized pots with a diameter of 30 cm and a weight of 7 kg, filled with a mixed soil medium (AL-Qadi *et al.*, 2020), Some physical and chemical properties of the agricultural medium in which the plants were grown were measured after recycling the plastic pots (Table 1). Before planting, the soil was analyzed to determine its chemical and physical properties. Three-year-old *Senna alata* L. seedlings were then transplanted into the pots. One month after planting, two factors were applied: Foliar application of *Aloe vera* gel at four concentrations (0, 20, 40 and 80 g L^{-1}). The plants were sprayed twice with a 21-day interval between applications and soil amendment with Plant Charcoal at four levels (0, 10, 20 and 40 g pot^{-1}), so it was incorporated into the growing medium before transplanting. The experimental design included a total of 16 treatments (4×4 factorial arrangement) with three replications ($3 \times 4 \times 4$). The experiment was arranged according to a randomized complete block design (RCBD) and means were compared using the least significant difference (LSD) test at a 5% probability level (Al-Sahouki and Karima, 1990; Al-Fatlawi and Al-Bayati, 2021). The following traits were measured at flower color emergence.

- **Vegetative traits:** Plant height (cm), main stem diameter (mm), number of branches per $plant^{-1}$, number of leaves per $plant^{-1}$, leaf area (cm^2) and chlorophyll content (%).
- **Floral traits:** Number of flowers per $plant^{-1}$, flower diameter (cm), floral stalk diameter (mm), days to flowering and flower dry weight (g).

RESULTS AND DISCUSSION

Role of *Aloe vera* gel, plant charcoal and their interaction on vegetative and flowering traits of *Senna alata* L.

The result showed in Table 2(A), the application of *Aloe vera* gel significantly influenced the vegetative growth of *Senna alata* L. Plants treated with 80 g L^{-1} exhibited superior performance compared with the control treatment, attaining a plant height of 190.83 cm, 170.41 leaves $plant^{-1}$, a leaf area of 160.2 cm^2 and a chlorophyll content of 54.33%. These findings indicate a pronounced stimulatory effect of the higher *Aloe vera* concentration on vegetative development. With regard to the Plant Charcoal factor, which is shown in Table 2(B) regarding, the 40 g pot^{-1} treatment resulted in significant enhancements in branching and leaf development. Plants under this treatment recorded 12.30 branches $plant^{-1}$, 169.40 leaves $plant^{-1}$, a leaf area of 140 cm^2 and a chlorophyll percentage of 49.40%, outperforming the control. According to Table 2(C) regarding the interaction between *Aloe vera* gel and plant charcoal treatments demonstrated a marked synergistic effect, the combined application of 80 g L^{-1} *Aloe vera* gel and 40 g pot^{-1} plant charcoal yielded the highest values

Table 1: Some physical and chemical properties of the growth medium.

Soil properties	Results of analogs
Sand %	5.42
Silt %	2.36
Clay %	86.8
Plt	7.33
Ec	5.80
Arrange enteral	9.1
Calcium	2.17
N	3.2
P	6.29
K	6.32

across all evaluated vegetative traits, in comparison with the control treatment. According to Table 3(A), *Aloe vera* gel also exerted a significant effect on flowering characteristics. The 40 g L^{-1} concentration promoted earlier flowering and increased flower diameter, reaching 222 days to flowering and 9.99 mm, respectively. In contrast, the 80 g L^{-1} treatment produced the highest values for number of flowers, floral stem diameter and flower fresh weight, which reached 34.19 flowers $plant^{-1}$, 9.12 mm and 39.40 g, respectively, relative to the control. According to Table 3(B) regarding plant charcoal applications, the 10 g pot^{-1} level significantly accelerated flowering by 4.21 days compared with the control. Meanwhile, the 20 g pot^{-1} treatment resulted in the greatest flower fresh weight (43.81 g). The 40 g pot^{-1} level significantly improved the number of flowers, flower diameter and floral stem diameter, reaching 29.40 flowers $plant^{-1}$, 10.4 cm and 9.24 mm, respectively. According to Table 3(C) significant improvements in all studied flowering parameters were observed at 20 and 80 g L^{-1} *Aloe vera* gel when combined with 40 g pot^{-1} plant charcoal, in comparison with the control treatment.

The significant differences observed in most vegetative and flowering traits following the application of *Aloe vera* gel and the organic amendment plant charcoal to candle bush can be attributed primarily to improvements in soil physicochemical properties associated with organic inputs. The incorporation of organic materials enhances nutrient availability through gradual decomposition, thereby

Table 2: Effect of *Aloe vera* gel and plant charcoal on vegetative growth traits of *Senna alata* L.

A- Effect of *Aloe vera* gel on vegetative growth traits of *Senna alata* L.

Treatment (g L^{-1})	Plant height (cm)	Number of branches (Branches $plant^{-1}$)	Number of leaves (Leaves $plant^{-1}$)	Main stem diameter (mm)	Leaf area (cm^2)	Chlorophyll content (%)
0 *Aloe vera*	170.01	10.22	158.20	10.11	135.0	30.10
20 *Aloe vera*	188.15	12.30	159.40	13.22	137.0	42.20
40 *Aloe vera*	189.12	15.21	166.01	15.11	158.1	52.30
80 *Aloe vera*	190.30	18.20	170.41	18.30	160.2	54.33
LSD (5%)	12.03	10.11	148.22	9.11	11.2	13.11

B- Effect of plant charcoal on vegetative growth traits of *Senna alata* L.

Treatment (g pot^{-1})	Plant height (cm)	Number of branches (Branches $plant^{-1}$)	Number of leaves (Leaves $plant^{-1}$)	Main stem diameter (mm)	Leaf area (cm^2)	Chlorophyll content (%)
0 Plant charcoal	180.20	9.40	148.00	9.40	122.0	22.09
10 Plant charcoal	182.14	10.11	158.00	12.11	125.0	32.15
20 Plant charcoal	190.11	11.12	160.22	14.11	130.0	44.41
40 Plant charcoal	190.22	12.30	169.40	16.33	140.0	49.40
LSD (5%)	14.40	0.80	12.11	15.40	9.80	11.22

C- Interaction between *Aloe vera* gel, plant charcoal and their effect on vegetative growth traits of *Senna alata* L.

Aloe vera (g L^{-1})	Plant charcoal (g pot^{-1})	Plant height (cm)	Number of branches (Branches $plant^{-1}$)	Number of leaves (Leaves $plant^{-1}$)	Main stem diameter (mm)	Leaf area (cm^2)	Chlorophyll content (%)
0	0	175.02	11.20	140.22	9.50	120.0	31.22
0	10	184.30	14.20	160.22	9.25	126.4	34.80
0	20	186.30	14.30	164.11	10.30	130.40	36.30
0	40	188.30	18.20	175.30	13.00	140.30	38.40
20	0	176.40	18.40	141.22	11.30	138.11	32.30
20	10	189.20	20.23	170.40	14.20	136.20	35.30
20	20	192.12	25.40	178.03	15.40	138.40	38.00
20	40	196.30	28.30	180.30	17.00	130.22	40.00
40	0	179.40	22.40	177.40	12.00	140.40	32.40
40	10	181.20	22.30	153.24	16.30	144.20	38.21
40	20	185.30	26.60	177.33	18.80	150.11	40.18
40	40	190.40	30.41	185.40	20.40	153.20	42.30
80	0	180.11	22.41	182.30	18.30	147.14	32.60
80	10	186.20	25.41	199.32	16.40	150.30	40.00
80	20	195.40	30.40	200.40	11.80	155.40	45.00
80	40	200.10	35.40	205.10	25.30	160.20	47.00
LSD (5%)		8.30	10.40	12.30	3.15	2.40	13.20

increasing soil fertility. This process stimulates microbial activity and biomass in the rhizosphere, which in turn improves soil structure, particularly porosity and aeration. Enhanced soil porosity facilitates nutrient uptake and root development, ultimately increasing the proportion of tender vegetative tissues and promoting overall plant vigor. These findings are consistent with previous reports (Alwan *et al.*, 2023; Sajid, 2024; Fatmi, 2023; Al-Bayati *et al.*, 2020). This is consistent with what was found by (Chachar *et al.*, 2025; Aamur *et al.*, 2025 and Srikanth *et al.*, 2017).

The promotive effects of *Aloe vera* gel may also be linked to its role in modulating endogenous phytohormones, particularly auxins and cytokinins, which regulate cell division and differentiation. In addition, gibberellins are known to stimulate both cell division and elongation by activating genes involved in DNA synthesis and chromosomal replication, thereby enhancing enzymatic activity associated with cell proliferation and expansion (Krigas *et al.*, 2021) Such hormonal regulation contributes to structural and functional modifications at the cellular level, leading to enhanced vegetative growth, as supported by earlier findings (El-Attar and Sakr, 2022). Furthermore, *Aloe vera* should improve carbon assimilation and energy metabolism, thus providing the biochemical resources for cell formation. Moreover, the enhanced production of carbohydrates, proteins and starch in leaves may promote assimilate accumulation and its subsequent translocation to developing floral organs. Such increased assimilate partitioning is probably the reason for the observed positive effects on plant height, leaf number and area and ultimately

Table 3: Effect of *Aloe vera* gel and plant charcoal on flowering traits of *Senna alata* L.

A- Effect of *Aloe vera* gel on flowering traits of *Senna alata* L.

Treatment ($g\ L^{-1}$)	Number of flowers (Flowers $plant^{-1}$)	Flower diameter (cm)	Floral stem diameter (mm)	Days to flowering	Flower fresh weight (g)
0 *Aloe vera*	18.60	6.46	6.75	228	24.30
20 *Aloe vera*	25.51	8.32	7.82	230	33.31
40 *Aloe vera*	27.32	9.99	8.35	222	38.24
80 *Aloe vera*	34.19	9.45	9.12	245	39.40
LSD (5%)	6.11	1.89	2.23	7.3	9.08

B- Effect of plant charcoal on flowering traits of *Senna alata* L.

Treatment ($g\ pot^{-1}$)	Number of flowers (Flowers $plant^{-1}$)	Flower diameter (cm)	Floral stem diameter (mm)	Days to flowering	Flower fresh weight (g)
0 Plant charcoal	16.22	6.22	8.40	21.22	22.24
10 Plant charcoal	21.55	9.22	8.40	4.21	32.30
20 Plant charcoal	28.30	8.19	9.12	4.91	43.81
40 Plant charcoal	29.40	10.40	9.24	19.80	35.92
LSD (5%)	7.40	2.37	2.77	10.40	8.30

C- Effect of the combined application of *Aloe vera* gel, plant charcoal and their effect on flowering traits of *Senna alata* L.

Aloe vera ($g\ L^{-1}$)	Plant charcoal ($g\ pot^{-1}$)	Number of flowers (Flowers $plant^{-1}$)	Flower diameter (cm)	Floral stem diameter (mm)	Days to flowering	Flower fresh weight (g)
0	0	15.14	3.66	7.22	122	23.11
0	10	24.22	7.22	8.23	224	27.30
0	20	25.11	8.43	8.40	133	30.32
0	40	27.20	8.33	8.41	132	31.40
20	0	19.12	6.40	7.33	110	25.22
20	10	23.10	7.33	8.22	123	30.40
20	20	24.25	8.34	8.40	122	34.55
20	40	28.22	8.40	9.52	124	38.40
40	0	14.33	7.22	8.40	124	10.11
40	10	24.40	8.50	8.50	132	35.40
40	20	28.21	9.40	8.40	240	40.60
40	40	31.10	9.12	9.40	245	42.11
80	0	24.40	8.30	8.40	144	32.40
80	10	27.31	9.00	8.50	148	40.11
80	20	31.40	9.40	8.62	250	45.40
80	40	34.40	10.30	9.40	252	52.30
LSD (5%)		5.22	4.39	2.62	20.11	22.11

flowering performance (Steenkamp and Stewart, 2007). The plant charcoal improves the microbial activity and biological mass of the soil as organic fertilizer. The addition of organic matter enhances the physical and chemical properties of soil, increases water holding capacity and improves porosity. So, these improvements increase nutrient uptake efficiency and chlorophyll synthesis, with a significant number of positive influences on flower number, flower diameter and total leaf chlorophyll content (Abdl-Rhmaan and Hussein, 2026; Alkaç *et al.*, 2023; Al-Bayati *et al.*, 2023). This is consistent with what was found by (Giancarlo *et al.*, 2017; Nasar *et al.*, 2019 and Anjali *et al.*, 2019).

CONCLUSION

1- Treatment with *Aloe vera* gel at 40 g L^{-1} resulted in significant differences in all studied vegetative traits except for the number of branches. Regarding flowering traits, this treatment increased flower diameter and accelerated flowering, while the highest values for the number of flowers, floral stem diameter and flower fresh weight were observed at 80 g L^{-1} compared to the control.

2- Application of Plant Charcoal at 40 g pot^{-1} induced significant differences in all vegetative traits except plant height. For flowering traits, early flowering occurred at 10 g pot^{-1}, while 20 g pot^{-1} significantly increased flower fresh weight. Furthermore, the 40 g pot^{-1} level significantly enhanced the number of flowers, flower diameter and floral stem diameter compared to the control.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

Experiment on plants, not animals.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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