



## Impact of Wheat Straw Biochar and Lignite on Plant Growth of *Astragalus podolobus* Boiss. & Hohen

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#### Authors

Ehsani S.M. <sup>\*1 PhD</sup>,  
Niknahad Gharmakher H. <sup>1 PhD</sup>,  
Motamedi J. <sup>2 PhD</sup>,  
Akbarlou M. <sup>1 PhD</sup>,  
Sheidai Karkaj E. <sup>3 PhD</sup>

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<sup>1</sup>Rangeland Management Department, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran

<sup>2</sup>Rangeland Research Division, Research Institute of Forests and Rangelands, Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran

<sup>3</sup>Rangeland and Watershed Management Department, Agriculture and Natural Resources Faculty, Urmia University, Urmia, Iran

#### \*Correspondence

Address: Gorgan University of Agricultural Sciences and Natural Resources, Basij Square, Gorgan, Iran.  
Postal Code: 4918943464

Phone: -

Fax: +98 (17) 32220640

mohadeseh\_ehsani@yahoo.com

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### ABSTRACT

**Aims** Biochar is a soil amendment used to improve soil quality and plant productivity in an agricultural application, and there were fewer researches to use it in rangeland species. This study aimed to determine if lignite and wheat straw biochar (WSB) could be used to promote *Astragalus podolobus* growth, inclusive Plant height, crown diameter, canopy cover, the volume of cover, leaf area, and leaf perimeter. In this study, it is assumed that WSB and lignite's use will increase the growth of *A. podolobus* species. *A. podolobus*, as a palatable shrub from the Leguminosae family, is a native species of Turkmen Sahra.

**Materials & Methods** A greenhouse experiment was designed with (WSB) and lignite, at 1.25%, 2.5%, and 3.75%w/w of soil in six replications. The soil texture was clay loam. Statistical analyses were performed by two-way analysis of variance using the SPSS16 statistical software.

**Findings** In lignite application, the highest height, crown diameter, canopy cover, and volume of cover were observed for a 3.75% application rate after the 4<sup>th</sup> month and were 25.03cm, 23.52cm, 528.65cm<sup>2</sup>, and 15581cm<sup>3</sup>, respectively. While the highest values of these parameters for WSB were obtained for 2.5% of the application rate after the fourth month and were 22.62cm, 20.66cm, 401.66cm<sup>2</sup>, and 11318.3cm<sup>3</sup>, respectively.

**Conclusion** Plant height, crown diameter, canopy cover, the volume of cover, leaf area, and leaf perimeter were promoted by increasing lignite dosage (3.75%) in the soil while nearly all parameters decreased at the same WSB incorporation dose.

**Keywords** Biochar; Soil Amendment; Structural Characteristics; *Astragalus podolobus*

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## Introduction

High yield and fodder quality, as well as its soil conservation value and atmospheric nitrogen fixation capacity of *Astragalus podolobus* Boiss. & Hohen. (from *Leguminosae* family) makes it proper species for rangeland rehabilitation projects in semi-arid rangelands of Iran [1]. It is estimated that about 50% of land available on earth are arid and semi-arid lands [2]. In these regions, the low soil quality, such as high salinity and low organic matter, has led to soil degradation [2] and caused serious problems in managing rangelands and natural ecosystems. Increasing evidence implies direct or indirect effects of Biochar (the product of feedstock heating under oxygen-limited or zero oxygen conditions) to improve most agricultural plant production [3]. Several studies have revealed the positive effects of different biochars applications into soils on plant growth [4, 5]. For instance, applying 4% wheat straw biochar to saline soil enhanced plant height, stem diameter, plant fresh and dry weights, and yield tomato plant [4]. An increase in nutrient availability, i.e., P, Mg, K, Ca, and S, directly influences plant growth [6], whereas improving soil chemical, physical and biological properties indirectly results in growth [5]. Also, Biochar and urban waste compost provide optimal conditions for plant growth [7]. Different types of biochars, based on their feedstock and production conditions, have different chemical and physical properties [8], so it has different effects on different soils and plants in field trials and greenhouse experiments. However, there are pieces of evidence that biochar application may decrease plant growth [9-12]. Housley *et al.* used *Eucalyptus saligna* to evaluate the growth of *Acmena smithii* and found that 2.5, 5, and 10% by weight of Biochar added to the soil did not show a significant difference in species growth [9]. Vaughn *et al.* also found that applying 15% by weight of the southern yellow pine biochar did not significantly affect *Agrostis stolonifera* species' height and wet weight [12]. Moreover, Cho *et al.* were observed that 20% by weight of Biochar derived from Crab skin along with 0.5% and 1% by weight of fertilizer had a negative effect on Zelkova's height and dry weight *serrate* stem [11]. The role of American oak and walnut biochar on *Capsicum annuum* growth also showed no significant difference in growth even

if 20% and 40% of Biochar is added to the soil [10].

The feedstock and production temperature affect the properties of the Biochar. Moreover, its incorporation dose can contribute to differing results in different plants [13].

Plant structural and functional traits are the key indicators in a plant species' competitive potential in the plant community and its co-existence mechanisms. Moreover, these traits determining the potential of a species for light-harvesting and, therefore, species position in the plant community [14].

Currently, it is not common to use biochars in rangeland improvement projects. To introduce biochars in rangeland markets, essential values of different biochars in terms of species response and soil quality advantages need to be quantified. In this study, it is assumed that the use of wheat straw biochar and lignite will increase the growth of *A. podolobus* species. Therefore, this study aimed to evaluate the effect of wheat straw biochar and lignite on structural traits of *A. podolobus*, including plant height, crown diameter, canopy cover, the volume of cover, leaf area, and leaf perimeter in greenhouse conditions. It could be applied to produce standard seedling in large pots and could be applied to the field. We use field soil in our experiments to say that it could be scaled up from greenhouse to field

## Material and Methods

### Soils and Biochars

The soil was collected from Golestan province (the natural habitat of *A. podolobus* species) in Iran. Obvious vegetation materials, roots, and stones were removed, and then the soils were air-dried and sieved <2mm. Subsamples (approx. 1kg) were taken for physical and chemical analyses (Table 1).

**Table 1)** Some physio-chemical properties of the experimental soil, lignite, and Wheat straw biochar

| Variable                          | Soil  | Lignite | WSB   |
|-----------------------------------|-------|---------|-------|
| pH                                | 6.8   | 5       | 8.1   |
| EC (dSm <sup>-1</sup> )           | 4.9   | 0.75    | 7.9   |
| Organic carbon (%)                | 0.50  | 17.34   | 51    |
| Total Nitrogen (%)                | 0.045 | 2       | 1.09  |
| Adsorbable                        | 3.43  | 14      | 38    |
| Phosphorus (mg kg <sup>-1</sup> ) |       |         |       |
| Exchangeable                      | 24.16 | 500     | 23500 |
| Potassium (mg kg <sup>-1</sup> )  |       |         |       |
| Silt (%)                          | 50    | -       | -     |
| Clay (%)                          | 29    | -       | -     |
| Sand (%)                          | 21    | -       | -     |

The wheat straw biochar was purchased from the Noavaran zistbonyan avisa Company, Ahvaz, Iran. This Biochar was generated at 400°C (6 hours) under oxygen-limited conditions. The lignite was obtained from the Kouhbanan mine in the Kerman province of Iran. Lignite and wheat straw biochar levels at 1.25%, 2.5%, and 3.75%w/w were added to the soils.

### Greenhouse experiment

The seedlings of *A. podolopus* were planted in plastic pots, of 25.5cm diameter and 24.5cm height, each containing 10kg air-dried sieved soil, in a greenhouse under controlled environmental conditions (9h light at 25-30°C and 13h dark at 10-15°C) at Research Institute of Forest and Rangeland, Tehran, Iran. *A. podolopus* seedlings, about 45 days after planting growth, were prepared from FRWO (Forests, Rangelands, and watersheds organization) and transplanted into the pots with different levels of two biochar and control treatments without Biochar too. This stage lasted for four months. All the treatments were in six reps (n=6) with Two- factor factorial design. Time and levels of Biochar and lignite are independent treatment

### Structural characteristics measurement

Seedlings height, crown diameter, canopy cover, the volume of cover, leaf area, and leaf perimeter were measured monthly as structural characteristics. It is continued for four months. Seedlings' height and crown diameter were measured by rule. Canopy cover and volume of cover were calculated using the following equations [15]:

$$\text{Canopy cover} = \frac{\pi}{4} \times (\text{crown diameter})^2$$

$$\text{The volume of cover} = \text{Canopy cover} \times \text{Seedling height}$$

Leaf area and leaf perimeter were calculated using the Auto CAD software version 2018. The dry weight of leaflets was measure using a digital Balance, too.

### Statistical analyses

The effects of different biochar addition rates on structural and functional traits of *A. podolopus* were determined by Two-way analysis of variance using the SPSS<sub>16</sub> statistical software. Insignificant differences, Duncan test ( $p < 0.05$ ) was used for mean comparisons. Tests of normality and homogeneity were done by Kolmogorov-Smirnov and Levene statistic, respectively.

## Findings

### Effects of Biochar on structural characteristics of *A. podolopus*

All measured structural traits of *A. podolopus* significantly changed after the lignite application. Except for plant height, all studied structural traits of *A. podolopus* were significantly affected by wheat straw biochar applications (Table 2). Significant effects of time were observed in all measured variables ( $p < 0.01$ ).

Because the only interactions were significant for the parameters of Crown diameter, Canopy cover, and volume of cover in the factor of wheat straw biochar and time, so the interaction slicing effects were conducted (Diagram 1). The highest canopy cover, crown diameter, and cover volume were for 2.5% and fourth month.

### Effects of lignite on structural characteristics of *A. podolopus*

The mean height of *A. podolopus* for control, 1.25%, 2.5%, and 3.75%w/w added lignite were 22.74, 20.50, 22.62, and 25.03cm, respectively. No significant difference was observed among control and lignite added treatments, while there was a significant difference between 1.25% and 3.75% levels (Table 3). The mean of *A. podolopus* crown diameter for mentioned doses was 19.43, 14.75, 19.78, and 23.52cm, respectively. A significant decrease in the level of 1.25%w/w and a significant increase in the 3.75%w/w of lignite added treatments were observed compared with control. The highest mean of canopy cover (528.65cm<sup>2</sup>) and volume (15581.71cm<sup>3</sup>) were observed in the pots with the highest dose of lignite, while the lowest ones (212.23cm<sup>2</sup> and 4670.8cm<sup>3</sup>) were observed in the first application rate of lignite, and there was a significant difference between them ( $p < 0.05$ ).

The lowest (0.27cm<sup>2</sup>) and highest (0.43cm<sup>2</sup>) leaf area was observed in the 2.5% and 3.75% lignite application rate pots, so a significant difference was observed between the 2.5% and control ( $p < 0.05$ ). Lignite addition had no significant effect on the Leaf perimeter of *A. podolopus* (Table 3).

The main effects of time were significant ( $p < 0.05$ ) on seedlings height, crown diameter, canopy cover, and volume of *A. podolopus* in the third and fourth months compared with the first month. Our results revealed that time had no significant effects on leaf area and leaf

perimeter of *A. podolopus* (Table 4).

### Effects of Wheat straw biochar on structural characteristics of *A. podolopus*

The mean height of *A. podolopus* for control, 1.25%, 2.5%, and 3.75%w/w added wheat straw biochar were 23.15, 21.63, 22.62, and 19.91cm, respectively. Application of 3.75%w/w wheat straw biochar had a significant negative effect on the height of *A. podolopus* (Table 5). The mean of *A. podolopus* crown diameter for mentioned doses was 20.61, 18.20, 20.66, and 15.42cm, respectively. A significant decrease in 1.25%w/w and 3.75%w/w wheat straw biochar added treatments was observed compared with control ( $p<0.05$ ). The highest mean of canopy cover (401.66cm<sup>2</sup>) and volume (11318.3cm<sup>3</sup>) were observed in the 2.5% added treatment, while the lowest ones (210.30cm<sup>2</sup> and 4820.4cm<sup>3</sup>) were observed in the 3.75% application rate ( $p<0.05$ ).

The lowest (0.28cm<sup>2</sup>) and the highest (0.42cm<sup>2</sup>) leaf area were observed in the 1.25% and 2.5% application rates. A significant decrease in leaf area and a perimeter was recorded in the third dose added treatment ( $p<0.05$ ; Table 5).

The main effects of time were significant ( $p<0.05$ ) on all measured traits of *A. podolopus* in the third month as compared with the first month (Table 6).

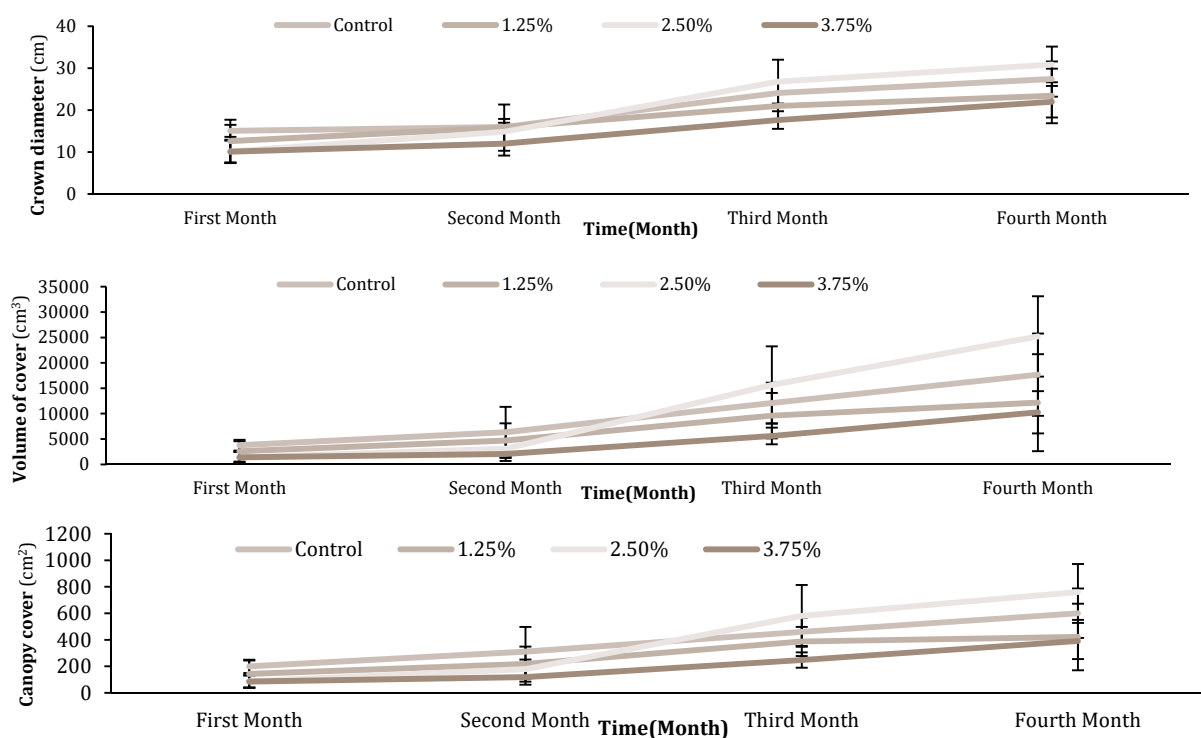
### Effects of lignite and WSB on structural characteristics of *A. podolopus*

The main effects comparison of lignite and WSB application rate showed that the highest height, crown diameter, canopy cover, and volume of cover for *A. podolopus* species have occurred on T3 and T6 treatments. The lowest height, crown diameter, and volume of cover were observed in T1 and T7 treatments. However, there was no significant difference among treatments for leaf area and perimeter (Table 7).

**Table 2)** Main effects of lignite and wheat straw biochar addition and time, as well as their interaction on structural characteristics of *A. podolopus*

| Parameters (F-value) | Lignite application rate | Time    | Lignite×Time       | WSB application rate | Time    | WSB×Time           |
|----------------------|--------------------------|---------|--------------------|----------------------|---------|--------------------|
| Plant height         | 4.82**                   | 31.98** | 1.14 <sup>ns</sup> | 2.61 <sup>ns</sup>   | 40.21** | 1.33 <sup>ns</sup> |
| Crown diameter       | 8.93**                   | 32.08** | 1.64 <sup>ns</sup> | 10.11**              | 68.66** | 2.37*              |
| Canopy cover         | 7.27**                   | 26.59** | 1.55 <sup>ns</sup> | 9.62**               | 52.14** | 2.81**             |
| Volume of cover      | 7.07**                   | 24.56** | 1.85 <sup>ns</sup> | 8.24**               | 42.01** | 2.84**             |
| Leaf area            | 6.47**                   | 35.34** | 0.62 <sup>ns</sup> | 9.52**               | 40.80** | 0.88 <sup>ns</sup> |
| Leaf perimeter       | 4.47**                   | 18.42** | 0.39 <sup>ns</sup> | 4.86**               | 21.72** | 0.33 <sup>ns</sup> |

ns: Not significant; \*\*, \*: Significant at  $p<0.01$ , 0.05



**Diagram 1)** Structural characteristics of *A. podolopus* after adding different levels of WSB during the time

**Table 3)** Comparison of main effects of lignite application rate (Average $\pm$ St.E)

| Parameters                         | Control                           | 1.25% of Lignite                 | 2.5% of Lignite                   | 3.75% of lignite                    |
|------------------------------------|-----------------------------------|----------------------------------|-----------------------------------|-------------------------------------|
| Plant height (cm)                  | 22.74 $\pm$ 1.31 <sup>ab</sup>    | 20.50 $\pm$ 0.63 <sup>a</sup>    | 22.62 $\pm$ 1.36 <sup>ab</sup>    | 25.03 $\pm$ 1.32 <sup>b</sup>       |
| Crown diameter (cm)                | 19.43 $\pm$ 1.49 <sup>b</sup>     | 14.75 $\pm$ 0.78 <sup>a</sup>    | 19.78 $\pm$ 2.01 <sup>b</sup>     | 23.52 $\pm$ 2.26 <sup>c</sup>       |
| Canopy cover (cm <sup>2</sup> )    | 336.94 $\pm$ 47.26 <sup>ab</sup>  | 212.230 $\pm$ 29.13 <sup>a</sup> | 380.72 $\pm$ 78.30 <sup>b</sup>   | 528.65 $\pm$ 92.18 <sup>c</sup>     |
| Volume of cover (cm <sup>3</sup> ) | 8820.8 $\pm$ 1600.3 <sup>ab</sup> | 4670.8 $\pm$ 79.09 <sup>a</sup>  | 10692.0 $\pm$ 2845.4 <sup>b</sup> | 15581.71 $\pm$ 3.187.2 <sup>c</sup> |
| Leaf area (cm <sup>2</sup> )       | 0.39 $\pm$ 0.04 <sup>b</sup>      | 0.36 $\pm$ 0.03 <sup>ab</sup>    | 0.27 $\pm$ 0.03 <sup>a</sup>      | 0.43 $\pm$ 0.03 <sup>b</sup>        |
| Leaf perimeter (cm)                | 2.67 $\pm$ 0.12 <sup>ab</sup>     | 2.48 $\pm$ 0.07 <sup>a</sup>     | 2.44 $\pm$ 0.13 <sup>a</sup>      | 2.93 $\pm$ 0.16 <sup>b</sup>        |

Means followed by the same letters in each row are not significantly different ( $p < 0.05$ ).

**Table 4)** Comparison of mean parameters related to the main effects of Time (Mean $\pm$ St.E)

| Parameters                         | First Month                      | Second Month                     | Third Month                     | Fourth Month                    |
|------------------------------------|----------------------------------|----------------------------------|---------------------------------|---------------------------------|
| Plant height (cm)                  | 17.86 $\pm$ 0.78 <sup>a</sup>    | 19.90 $\pm$ 0.54 <sup>a</sup>    | 24.70 $\pm$ 1.02 <sup>b</sup>   | 28.43 $\pm$ 1.12 <sup>c</sup>   |
| Crown diameter (cm)                | 12.51 $\pm$ 0.77 <sup>a</sup>    | 15.00 $\pm$ 0.90 <sup>a</sup>    | 22.71 $\pm$ 1.65 <sup>b</sup>   | 27.24 $\pm$ 1.86 <sup>c</sup>   |
| Canopy cover (cm <sup>2</sup> )    | 134.10 $\pm$ 16.17 <sup>a</sup>  | 191.89 $\pm$ 24.81 <sup>a</sup>  | 459.59 $\pm$ 64.17 <sup>b</sup> | 672.96 $\pm$ 82.49 <sup>c</sup> |
| Volume of cover (cm <sup>3</sup> ) | 2592.6 $\pm$ 392.16 <sup>a</sup> | 3952.2 $\pm$ 596.19 <sup>a</sup> | 12454 $\pm$ 2169.4 <sup>b</sup> | 20765 $\pm$ 3101.4 <sup>c</sup> |
| Leaf area (cm <sup>2</sup> )       | 0.14 $\pm$ 0.01 <sup>a</sup>     | 0.41 $\pm$ 0.03 <sup>b</sup>     | 0.45 $\pm$ 0.03 <sup>b</sup>    | 0.47 $\pm$ 0.03 <sup>b</sup>    |
| Leaf perimeter (cm)                | 1.95 $\pm$ 0.09 <sup>a</sup>     | 2.77 $\pm$ 0.11 <sup>b</sup>     | 2.88 $\pm$ 0.11 <sup>b</sup>    | 2.93 $\pm$ 0.11 <sup>b</sup>    |

Means followed by the same letters in each row are not significantly different ( $p < 0.05$ ).

**Table 5)** Comparison of mean parameters related to the main effects of WSB (Mean $\pm$ St.E)

| Parameters                         | Control                          | 1.25% of WSB                      | 2.5% of WSB                       | 3.75% of WSB                     |
|------------------------------------|----------------------------------|-----------------------------------|-----------------------------------|----------------------------------|
| Plant height (cm)                  | 23.15 $\pm$ 1.18 <sup>b</sup>    | 21.63 $\pm$ 1.24 <sup>ab</sup>    | 22.62 $\pm$ 1.72 <sup>b</sup>     | 19.91 $\pm$ 1.12 <sup>a</sup>    |
| Crown diameter (cm)                | 20.61 $\pm$ 1.20 <sup>c</sup>    | 18.20 $\pm$ 1.31 <sup>ab</sup>    | 20.66 $\pm$ 1.91 <sup>c</sup>     | 15.42 $\pm$ 1.12 <sup>a</sup>    |
| Canopy cover (cm <sup>2</sup> )    | 365.05 $\pm$ 41.71 <sup>bc</sup> | 291.63 $\pm$ 39.01 <sup>b</sup>   | 401.66 $\pm$ 65.80 <sup>c</sup>   | 210.301 $\pm$ 29.72 <sup>a</sup> |
| Volume of cover (cm <sup>3</sup> ) | 9852 $\pm$ 1515.8 <sup>bc</sup>  | 7254.2 $\pm$ 1333.9 <sup>ab</sup> | 11318.3 $\pm$ 2289.0 <sup>c</sup> | 4820.4 $\pm$ 86.54 <sup>a</sup>  |
| Leaf area (cm <sup>2</sup> )       | 0.39 $\pm$ 0.03 <sup>b</sup>     | 0.28 $\pm$ 0.03 <sup>a</sup>      | 0.42 $\pm$ 0.03 <sup>b</sup>      | 0.29 $\pm$ 0.02 <sup>a</sup>     |
| Leaf perimeter (cm)                | 2.70 $\pm$ 0.11 <sup>ab</sup>    | 2.45 $\pm$ 0.12 <sup>a</sup>      | 2.96 $\pm$ 0.15 <sup>b</sup>      | 2.45 $\pm$ 0.16 <sup>a</sup>     |

Means followed by the same letters in each row are not significantly different ( $p < 0.05$ ).

**Table 6)** Comparison of mean parameters related to the main effects of Time (Mean $\pm$ St.E)

| Parameters                         | First Month                      | Second Month                     | Third Month                       | Fourth Month                      |
|------------------------------------|----------------------------------|----------------------------------|-----------------------------------|-----------------------------------|
| Plant height (cm)                  | 16.36 $\pm$ 0.80 <sup>a</sup>    | 18.07 $\pm$ 0.80 <sup>a</sup>    | 24.52 $\pm$ 0.93 <sup>b</sup>     | 28.35 $\pm$ 1.10 <sup>c</sup>     |
| Crown diameter (cm)                | 11.97 $\pm$ 0.75 <sup>a</sup>    | 14.65 $\pm$ 0.74 <sup>b</sup>    | 22.62 $\pm$ 0.97 <sup>c</sup>     | 25.66 $\pm$ 1.19 <sup>d</sup>     |
| Canopy cover (cm <sup>2</sup> )    | 127.96 $\pm$ 15.97 <sup>a</sup>  | 178.52 $\pm$ 17.38 <sup>a</sup>  | 418.84 $\pm$ 36.94 <sup>b</sup>   | 543.32 $\pm$ 49.20 <sup>c</sup>   |
| Volume of cover (cm <sup>3</sup> ) | 2270.5 $\pm$ 333.70 <sup>a</sup> | 3910.3 $\pm$ 694.80 <sup>a</sup> | 10737.8 $\pm$ 1207.6 <sup>b</sup> | 16327.3 $\pm$ 1899.9 <sup>c</sup> |
| Leaf area (cm <sup>2</sup> )       | 0.13 $\pm$ 0.01 <sup>a</sup>     | 0.38 $\pm$ 0.02 <sup>b</sup>     | 0.42 $\pm$ 0.02 <sup>bc</sup>     | 0.45 $\pm$ 0.02 <sup>c</sup>      |
| Leaf perimeter (cm)                | 1.88 $\pm$ 0.07 <sup>a</sup>     | 2.76 $\pm$ 0.13 <sup>b</sup>     | 2.91 $\pm$ 0.11 <sup>b</sup>      | 3.01 $\pm$ 0.12 <sup>b</sup>      |

Means followed by the same letters in each row are not significantly different ( $p < 0.05$ ).

**Table 7)** Comparison of main effects of lignite and WSB application rate

| Treatment | PH                  | Cd                  | Cc                    | Vc                   | La                | Lp                |
|-----------|---------------------|---------------------|-----------------------|----------------------|-------------------|-------------------|
| T1        | 24.33 <sup>a</sup>  | 17.84 <sup>a</sup>  | 358.80 <sup>a</sup>   | 9027.7 <sup>a</sup>  | 0.46 <sup>a</sup> | 2.65 <sup>a</sup> |
| T2        | 28.58 <sup>ab</sup> | 28.50 <sup>bc</sup> | 711.89 <sup>abc</sup> | 22910 <sup>abc</sup> | 0.35 <sup>a</sup> | 2.72 <sup>a</sup> |
| T3        | 32.53 <sup>b</sup>  | 35.26 <sup>c</sup>  | 1020.8 <sup>c</sup>   | 33441 <sup>c</sup>   | 0.53 <sup>a</sup> | 3.20 <sup>a</sup> |
| T4        | 28.27 <sup>ab</sup> | 27.38 <sup>bc</sup> | 600.37 <sup>ab</sup>  | 17682 <sup>ab</sup>  | 0.53 <sup>a</sup> | 3.14 <sup>a</sup> |
| T5        | 26.38 <sup>ab</sup> | 22.38 <sup>ab</sup> | 421.39 <sup>ab</sup>  | 12154 <sup>ab</sup>  | 0.36 <sup>a</sup> | 2.66 <sup>a</sup> |
| T6        | 32.89 <sup>b</sup>  | 30.88 <sup>c</sup>  | 760.72 <sup>bc</sup>  | 25207 <sup>bc</sup>  | 0.53 <sup>a</sup> | 3.29 <sup>a</sup> |
| T7        | 25.86 <sup>a</sup>  | 22 <sup>ab</sup>    | 391.10 <sup>ab</sup>  | 10266 <sup>a</sup>   | 0.40 <sup>a</sup> | 2.95 <sup>a</sup> |

Means followed by the same letters in each row are not significantly different ( $p < 0.05$ ); T1: 1.25% Lignite, T2: 2.5%Lignite, T3: 3.75% Lignite, T4: Control, T5: 1.25% wheat straw biochar, T6:2.5% wheat straw biochar, T7:3.75% wheat straw biochar, PH: Plant height, Cd: Crown diameter, Cc: Canopy cover, Vc: Volume of cover, La: Leaf area, Lp: Leaf perimeter

## Discussion

The results showed lignite had improved the structural characteristics of *A. podolobus species*. It could be noted that lignite, as a catalyst, increase nutrient and water absorption from the soil. Biochars can have different responses to plant growth at different dosages. This was quite obvious in our work when using wheat straw biochar. It was also proven by Carter *et al.* that used rice husk

biochar for *Lactuca sativa* species [16]. Comparing the effectiveness of rice husk biochar, cotton sticks Biochar, and wheat straw biochar with farm manure, poultry manure, and press mud at the rate of 2%w/w to promote plant growth indicated that wheat straw biochar has the lowest effect on the growth and height of studied species [17] that is in accordance with our findings.

A significant difference among both treatments

(lignite and wheat straw biochar) was obtained after 90 days (third month). Thavanesan *et al.* have reported that in plant growth indicators, the difference among rice husk biochar treated treatments is significant after 60 days [18].

In the present study, no increase in the leaf area (an indication of plant yield, photosynthesis, and nutrient use) was observed in contrast with Qian *et al.*, who reported that soybean leaf area increases after rice husk biochar incorporation [19, 20].

Higher plant growth and yields for lignite treatments as compared to control demonstrate that nutrient elements were readily more available for *A. podolobus* in lignite treatments. Lignite that increased *A. podolobus* growth to a greater extent (3.75%w/w), presumably was that with a larger amount of nutrients in plant-available form, this could justify the differences found between lignite added treatments [21]. Santos Marchi *et al.* reported that *Lactuca sativa* height was affected significantly after leonardite (a secondary mineral originated from “soft coals”, commonly associated with lignite) application that is in agreement with our results [22]. Melon dry weight, numbers of fruit per plant, and average fruit weight per plant increased significantly following a Food waste-based Soil Conditioner application [23].

It can be attributed to the inhibitory effects of micronutrient deficiencies induced by high soil pH and carbonate content of wheat straw biochar [24]. Hence, the diverse and opposing effects of biochar application on soil properties may lead to the lack of response in *A. podolobus* growth because of the counteracting effects of soil properties changes. It can be suggested that the decreased accumulation of nutrients following wheat biochar addition to the soil under plantation because of increased nutrients sorption and chelation as well as nutrients fixation by soil organic matter can lead to a decrease in plant growth parameters [25].

Poormansou *et al.* stated that Wheat straw biochar incorporation at a rate of 1.25%w/w improved the yield of *Vicia faba* while its addition at a dose of 5%w/w destroyed the plant before its full growth [26]. It has been reported that Wheat straw biochar application at a rate of 3%w/w increased the productivity of rice in the Plinthudult and Psammaquent [27]. It is worth to mention that biochar application may not always improve plant growth. The effects of biochars on grown plants are different

depending on numerous factors. Different biochars and its addition rate can contribute to varying results. The feedstock used and production conditions affect the properties of the Biochar. Moreover, the impact of Biochar on plant growth varies by species since different plants have different tolerance to certain stresses different or suitable growth conditions [13].

Applying T3 and T6 treatments to soil was improved. The structural characterizes of *A. podolobus*. Thus, it could be concluded that adding Biochar to soil may have a positive effect on the physical and chemical properties of soil and enhanced nutrient and water retention. Zhang *et al.* [28] reported that green waste biochar increased plant height, root and shoot length, and root fresh and dry weight of *Calathea insignis* compared to control. Due to increased water retention, optimized total porosity, aeration porosity, water-holding porosity, nutrients, and microbial activities [28]. Overall, increased plant growth after biochar incorporation could be attributed to improved availability of nutrients and water retention, both desirable substrate properties [13].

## Conclusion

It is concluded that the application of 3.75%w/w wheat straw biochar had a significant negative effect on the height, crown diameter, and volume of the cover of *A. podolobus* species. The mean height of *A. podolobus* for control, 1.25%, 2.5%, and 3.75%w/w added lignite were 22.74, 20.50, 22.62, and 25.03cm, respectively. So, there was a significant difference between the first and third levels. Moreover, the highest height, crown diameter, canopy cover, and cover volume for *A. podolobus* species have occurred on 3.75% lignite and 2.5% WSB treatments. Thus, the application of 3.75%w/w of lignite is recommended to use in rangeland improvement projects using *A. podolobus*.

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