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The Effect of Laser Treatment on Seedling Growth of the Invasive *Prosopis juliflora* (Sw.) DC.

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Abstract— A commercial use of lasers for weed and invasive plant control, however, require a systematic investigation of the irradiance exposure time of laser beam effect on different plant species, growth stages, *etc.* In this study, we investigated the impact of laser treatment directed towards the apical meristems of seedlings of the invasive tree *Prosopis juliflora* at the cotyledon stage. Diode laser source —a 1W, 532nm laser was tested and four different exposure times were applied: 0 (control), 1, 2 and 4h of laser under controlled glasshouse conditions. Root, shoot, seedling length, seedling basal, biomass and seedling survivorship were recorded. The length of shoots and roots were decreased with laser exposure time. Total length of seedling was decreased significantly with laser time varied between 20.0 ± 1.2 cm at control conditions and 12.8 ± 0.6cm at 4 h. Plants rooted at control treatment presented the higher biomass than other laser treatments). Laser exposure time reduced seedling basal. No seedling died at control treatment. Seedling survivorship was very high (93%) for 1 h treatment, showing a tendency to decrease with laser time exposure recording minimum survivorship value (75%) for 4 h treatment. Our results could be useful to control *P. juliflora* invasion, towards the apical meristems, because a commercial use of lasers to a 1W, 532nm would prevent its growth.

Index Terms— Apical meristems, Biomass, Invasion, Root production, Seedling length, Shoot production, Tropical region.

1 INTRODUCTION

LASER technology has been widely used in farming and forestry, horticulture, genetics, bioengineering, *etc*. Increased public concern about herbicides in relation to food safety, farm workers health, biodiversity, and the environment in general have renewed interest in alternative weed control measures. The main alternatives are physical weed control methods such as mechanical hoeing, harrowing, and brushing [1], [2], [3]. The genus *Prosopis* are some of the most abundant tree in tropical and subtropical regions worldwide and include several species that are pests outside their native ranges. It has attracted attention because of their great ability to survive in very inhospitable environments, and their capacity to provide fuel, timber, fodder and edible pods. *Prosopis juliflora* (Sw.) D.C. (Fabaceae - Mimosoideae), commonly known as Ghaf Bahri or Velvet Mesquite It is considered as an invasive alien in many tropical countries where it was introduced from its native south west United States and northwest Mexico [4], was introduced to several deserts in tropical and subtropical regions, including North of Africa the Arab Gulf, for greening of landscapes and for sand and desertification control [5], [6].

As far as the authors are aware, the exact mechanism of laser effect on invasive plants is not investigated at all. The aim of this study was to investigate the impact of four laser exposure times treatment directed towards the apical meristems on the initial growth of the invasive tree *P. juliflora* under controlled glasshouse conditions, to find alternatives to use safty physical methods represented in the commercial laser instead of herbicidesto control weeds and its invasion. Studies the effect of laser beam on plant germination and growth under controlled laser exposure time conditions could be useful in determining the optimal conditions required to control weed plants. Understanding the growth and establishment characteristics of *P. juliflora* in laser irradiation conditions may reveal its invasion mechanisms and consequently the information may be useful to help fight its invasion. We hypothesised that *P. juliflora* growth, establishment and seedling physiological status would be limited by conditions of laser exposure time with low energy.

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2 Materials and Methods

2.1 Seed Material

Seeds of *P. juliflora* were collected in September 2013 from multiple mature individuals in Wadi Merikwan, Gebel Elba National Park, southeast Egypt (22° 14´ 2˝ E – 36° 36´ 30.1˝ W; see ([7], [8], for site description). After harvesting, seeds were stored dry in a dark room until the beginning of the experiment

2.2 Laser Experiment

A glasshouse experiment was conducted from 1st December 2013 to the end of February 2014 to test the effects of laser treatments on survival and growth of seedlings of *P. juliflora*. Ten replicates of one seed were sown 1 cm deep in in peat soil in plastic pots (10 cm diam and 11 cm ht; vol of 1.37 l) in a potting mixture consisting of sandy-loam soil, sand and peat (2:1:1 w/w%). Plants were maintained at ambient light and temperature and were irrigated gently once a day with fresh water (0.5 ppt) to ensure the moisture of the soil would be about 70% of its water holding capacity; fresh water was used to avoid salinity effects on germination. The laser treatments were carried out on 15 December 2013 at the cotyledon stage of the *P. juliflora* species. Four different exposure times: Control (0 hour), 1, 2 and 4 hours with wave diode lasers were tested—a 1W, 532nm laser using a spot diameter of 0.9 mm with continuous mode. A distance of 30 mm was used applied vertically on plant's meristem (n = 6 pots per treatment) (Fig.1).

Fig.1. Targeting the apical meristem with a hand-held laser.

After 35 days, root length, shoot length, seedling length and seedling basal of three of the tallest seedlings were measured (n = 6 pots per treatment). Seedling survivorship was also recorded for every laser treatment (n = 6 pots per treatment). Plants were carefully excavated from the soil and roots were washed to remove soil particles. Seedling biomass was recorded for all plants (n = 6 plants per treatment). Biomass was determined after drying plant material at 80 ºC for 48 hours.

2.3 Statistical analysis

Analyses were carried out using SPSS release 20.0 (SPSS Inc., Chicago, IL, USA). Data were tested for homogeneity of variance and normality with the Brown– Forsythe test and the Kolmogorov–Smirnov test, respectively (P < 0.05). Mean plant traits were compared among laser treatments by one-way analysis of variance (F-test). Tukey honestly significant difference (HSD) test was used to determine significance among means for treatments with a significant F-test (P < 0.05). Deviations were calculated as standard errors.

3 Results

The length of shoots and roots were significantly greater in the control than in the laser treatments, even when re-growth occurred (shoot: F = 9.20, P < 0.01; root: F = 11.28, P < 0.01). The total length of seedling differ significantly among treatments (F = 17.42, P < 0.01). However, it showed a tendency to decrease with laser time exposure. Seedling basal was significantly different among treatments (F = 4.29, P < 0.05), varied from 2.6 ± 0.4 control to 1.0 ± 0.3 at 4 h. The lowest dry seedling biomass (0.15 ± 0.01) was recorded at 4 h and the highest at control (0.75 ± 0.01) (F = 7.19, P < 0.05) (Table 1).

Table1

Shoot length (cm), root length (cm), Seedling length (cm), seedling basal (mm) and dry seedling biomass of *Prosopis juliflora* at four different laser exposure times (the control treatment corresponded to no laser applied). Different letters indicate significantly different between treatments (ANOVA, P < 0.05).

Laser exposure times (h)	Shoot length (cm)	Root length (cm)	Seedling length (cm)	Seedling basal (mm)	Dry seedling biomass (g)
Control (0)	16.1 ± 0.9^a	4.0 ± 0.2^a	20.0 ± 1.2^a	2.6 ± 0.4^a	0.75 ± 0.01^a
1	13.7 ± 0.7^b	2.6 ± 0.1^b	16.3 ± 0.6^b	2.2 ± 0.4^b	0.64 ± 0.22^b
2	12.4 ± 0.3^c	2.0 ± 0.4^c	14.4 ± 0.6^c	1.6 ± 0.2^c	0.24 ± 0.04^c
4	11.3 ± 0.7^d	1.5 ± 0.4^d	12.8 ± 0.6^d	1.0 ± 0.3^d	0.15 ± 0.01^d

No seedling died at control treatment. Seedling survivorship was very high (93%) for 1 h treatment, showing a tendency to decrease with laser time exposure recording minimum survivorship value (75%) for 4 h treatment . (F = 530.6, P < 0.001) (Fig. 2).

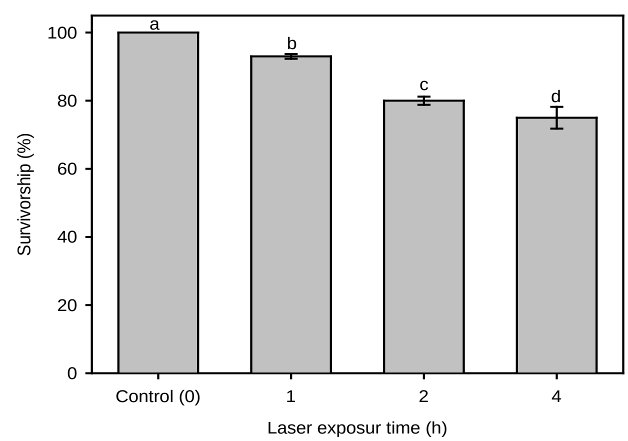

Fig.2. Magnetization Survivorship (% of emerged seedlings) of *Prosopis juliflora* at four different laser exposure times (the control treatment corresponded to no laser applied). Different letters indicate significantly different between treatments (ANOVA, P < 0.05).

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4 Discussion

This study showed the laser exposure time can limit growth and establishment for *P. juliflora* seedling. We recorded a reverse relationship between seedling growth and laser exposure times for invasive *P. juliflora* which has been reported previously for other weeds [9]. The effects of laser exposure time conditions on *P. juliflora* after germination and establishment were also reflected in its physiological status, with plants showing a low physiological plasticity. Two months after germination, shoots, roots, and total seedlings length were significantly decreased with laser exposure times. [10], observed markedly negative effect of laser light on roots and shoots length in Ligustrum vulgare L, because of a reduction in root growth and function in laser heat conditions leading to insufficient supply of food to the shoots. In contrast, laser can be used to pre-treat plant seeds in order to enhance the rate at which seeds turn into seedlings, the field rate of seedling emergence, the neatness of seedling emergence, the promotion of seedling growth, the germination rate, vigor index, etc., even under poor surroundings [11], [12]. *P. juliflora* recorded the lowest biomass value for 4 h (0.15 ± 0.01) and the highest was recorded for control (0.75 ± 0.01) These results are in agreement with the results obtained by [13], who reported that laser induced can reduced biomass and chlorophyll concentration in maize. All of these indicate that laser exposure time with low energy the apical meristem of invasive *P. juliflora* in order to decrease the root, shoot and total seedlings length with decreasing its survivorship and biomass allocations. Thus, application of this technology in plant growth can help control plant invasion.

5 Conclusion

The experiment showed that laser exposure of the apical meristem of invasive *P. juliflora* species can be used as a method of physical weed control. The efficiency of the laser weed control is related to wavelength, exposure time. The highest efficacy was obtained using the 1W, 532 nm laser and 1,8mm spot diameter for 4 h daily. The results indicate that it is possible to improve the laser application method and to obtain a better performance by increasing the laser power and exposure time.

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