Turkish Journal of Agriculture and Forestry

Volume 36 | Number 6 Article 15

1-1-2012

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Turk J Agric For
36 (2012) 757-763
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doi:10.3906/tar-1112-30

Research Article

Exploring the growth potential of *Albizia procera* and *Leucaena leucocephala* as influenced by magnetic fields

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Received: 21.12.2011 ● Accepted: 26.04.2012

Abstract: Due to the discriminate use of plant chemicals and their resultant negative impact on the environment, researchers are interested in monitoring plant behavior as modified by various nonchemical influences such as magnetic fields. A pot experiment was designed to assess the growth potential of *Albizia procera* Roxb. (Sufed Sirin) and *Leucaena leucocephala* Lam. (Ipil Ipil) seedlings, established from seeds exposed to a magnetic field (MF) of 75 millitesla for 3 different time intervals, 5 min, 10 min, and 15 min respectively. After the seeds were exposed to a MF of 75 mT for 15 min, *A. procera* plants showed 49% more germination than in the control (41%), whereas *L. leucocephala* plants gained 37% more germination in the same treatment. *A. procera* had maximum plant height (13.1 cm) when seeds were exposed to a MF of 75 mT for 15 min, while the height gained by the control was only 7.1 cm. Similarly, *L. leucocephala* gained maximum plant height (17.8 cm) when seeds were treated with MF for 15 min, i.e. 137% greater than the height gained from nontreated seeds (7.5 cm). Seed exposure to MFs also resulted in higher collar diameter in both plants. In high-MF-treated *A. procera* (18.6 cm) seedlings, root length was 3 times longer than in the control (6.5 cm); MF-treated *L. leucocephala* seedlings gained maximum (63% longer) root length (18.9 cm), as well. *A. procera* had its maximum root-to-shoot ratio (R/S) (1.9) in the seedlings treated with low MF (5 min), whereas *L. leucocephala* had its maximum R/S (1.6) in nontreated seeds. Seeds exposed to MF for 5 min resulted in minimum R/S (0.9). The results clearly suggested that by increasing the time intervals for seed exposure to the fixed MF of 75 mT, the sowed seeds of both species showed higher growth rate.

Key words: *Albizia procera*, *Leucaena leucocephala*, magnetic field, root/shoot ratio, seed germination

Introduction

Ecologists believe that all living creatures are strongly influenced by Earth's magnetic force (Esitken 2003). The extensive use of advanced chemicals such as growth hormones and salt solutions in agriculture has been a tradition until the last century. The negative impacts of these chemicals on the environment have been reported by Beltran-Garcia et al. (1997). Agricultural scientists have taken a keen interest in the study of plant behavior as influenced by various proecological factors such as electric magnetic fields (MFs), ionization, lasers, and ultraviolet radiations. Amazing changes in plant behavior were noticed with respect to quantity and quality of yields when

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plants were treated with magnetic fields of different magnitudes. For instance, higher growth rate and yield were observed in wheat plants when irrigated with magnetic water (Hozayn and Qados 2010). Therefore, researchers have recently focused their attention on the exploration of the influence of such physical factors on plants. The pronounced influence of MFs on the seed germination percentage (SGP) and the seeds' physiological behavior was reported by Esitken (2003) and Faqenabi et al. (2009).

Morphological and physiological changes occurred in plants as a result of electric field application. Researchers concluded that low-frequency MF increased SGP. Presowing seed treatment (PSST) of MF resulted in high SGP and seedling vigor of low-viability rice (Carbonell et al. 2000), wheat (Aksenov et al. 1996), lettuce (Reina et al. 2001), and barley (Lynikiene et al. 2003). Arababian et al. (2001) reported that esterase enzymes in pretreated seeds were increased by MF during germination. The MF treatment on the seeds of various crops and ornamental tree species increased the germination of nonstandard seeds and improved their qualities (Aladjadjiyan 2002; Esitken 2003) by increasing SGP (Aladjadjiyan and Ylieva 2003). Similar results in tomato were reported by De Souza et al. (2006) in seed germination enhancement.

Sustainable management of forestry is a prerequisite for balanced and sustained development and growth in various sectors including agriculture, industry, education, health, and defense. Fire wood, timber wood, pulp, paper and paper products, and innumerable industrial and railway uses are the urgent needs of Pakistan (Quraishi 2003). Pakistan is spending a large share of foreign exchange (Rs 11,000 million) to import wood and wood products in order to meet the ever-increasing demand for timber and fuel wood (FAO 2006). For developing countries like Pakistan, it is not wise to spend this much money on the import of wood and wood products. It is therefore time to achieve economic and environmental stability by introducing new techniques that may be more environmentally friendly and economically affordable.

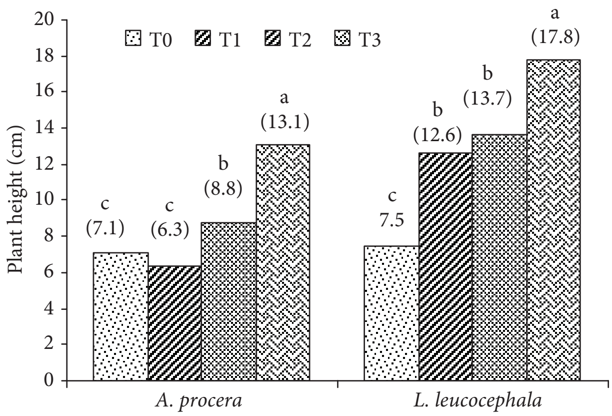
Earlier studies regarding the PSST of MFs to test the behavior of nonwoody plants have been well documented and have shown MFs to be environmentally friendly (Atak et al. 2007; Hozayn and Qados 2010). However, research work to study the behavior of woody vegetation is still ongoing. Therefore, the present study was planned to determine the effect of MF on various growth parameters in *A. procera* Roxb. (Sufed Sirin) and *L. leucocephala* Lam. (Ipil Ipil) plants.

Materials and methods

A field study was designed to assess the growth response of *A. procera* Roxb. and *L. leucocephala* Lam. tree species as affected by a MF. Well-ripened and uniform-sized seeds of *A. procera* and *L. leucocephala* were obtained from healthy trees located in the field experimental area, University of Agriculture, Faisalabad (UAF), during the first week of January 2010. They were exposed to a MF of 75 mT for 5 min (T1), 10 min (T2), or 15 min (T3) by using the Magnetic Seed Stimulator in the Biomagnetic Laboratory, Department of Physics, UAF. The MF was measured with the help of a magnetic flux meter (ELWE 8533996, Germany). No treatment was applied to the seed group of the specimens that were kept as the control (T0). The research work was initiated on 2 February 2010 at the Forest Nursery, Department of Forestry, Range Management, and Wildlife, UAF. The seeds were soaked for 24 h and were sowed in polythene bags (PBs) of dimensions 10.5 × 12 cm, which were filled with sandy loam soil. Important soil characters were: electrical conductivity (EC) = 2 dS m^{-1}, sodium adsorption ratio (SAR) = 8.37, N = 0.041%, P = 11 ppm, and K = 190 ppm. Six PBs were assigned for the growing of experimental plants of each species per treatment per replication. The experiment was laid out in a completely randomized design with 4 replications. The total number of plants for each tree species under 4 treatments with 4 replications was 96: the number of plants per treatment × T × R = 6 × 4 × 4 = 96, where T stands for the number of treatments and R for the number of replications. Seedlings were irrigated with ground water (EC = 1.4 dS m^{-1}, SAR = 17, and residual sodium carbonate (RSC) = 1.2) during the whole period of the experiment, from 2 February to 31 May 2010. Growth of the seedlings was monitored in response to different treatments of MF. Data were collected for different morphological parameters, including SGP, plant height (Ht), collar diameter (CD), and root-to-shoot ratio (R/S), to determine the growth behavior of the plants, and were statistically analyzed by analysis of variance (ANOVA) techniques (Steel and Torrie 1980) using StatistX 8.1 software. Fisher's least significance difference (LSD) tests were performed at a 5% probability level to compare the means of the tested parameters.

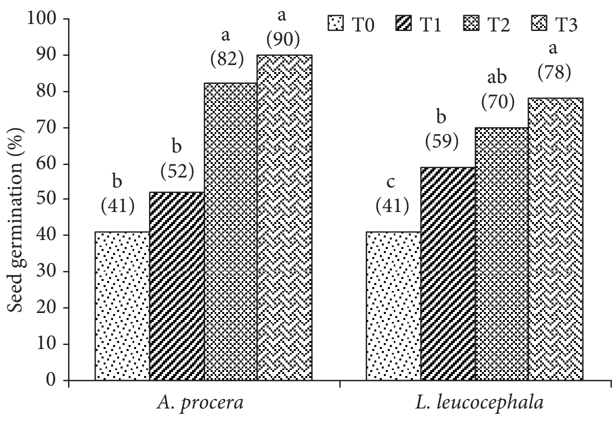
Results

The seeds of *Albizia procera* and *Leucaena leucocephala* that were treated with MF for 15 min (T3) resulted in 49% and 37% more germination than in the control, respectively (Figure 1). *A. procera* exhibited maximum height with T3, 85% greater than the height gained in the control (7.1 cm). Similarly, *L. leucocephala* gained maximum height (17.8 cm), 137% greater than the height gained in the control (7.5 cm) (Figure 2). As is clear from Figure 3, the CD of *A. procera* seedlings with T3 was maximum (2.1 mm), followed by T2 (1.9 mm). Minimum CD (1.3 mm) was noted in T0. *L. leucocephala* had almost similar CDs (3.6 and 3.7 mm) with T3 and T2, respectively. However, CD in the seedlings of nontreated seeds (T0) was significantly lower (1.3 mm). *A. procera* achieved maximum root length (RL) (18.6 cm) in T3, about 3 times longer than the control (6.5 cm). A similar trend was shown by *L. leucocephala* in T3, having 64% longer RL than the control (11.5 cm) (Figure 4). Interestingly, T1 resulted in the maximum R/S (1.9) in *A. procera*, followed by R/S values of 1.7 and 1.4 in T2 and T3, respectively. The same characteristic was minimal (0.9) in the control. In *L. leucocephala*, the maximum R/S (1.6) was noted in nontreated seeds, followed by T2 (1.3) and T3 (1.1). Seeds exposed to MF for 5 min (T1) resulted in the minimum R/S (0.9) (Figure 5). Statistical significance among means of various growth parameters in both species was determined by their respective LSD values, as shown in the Table.



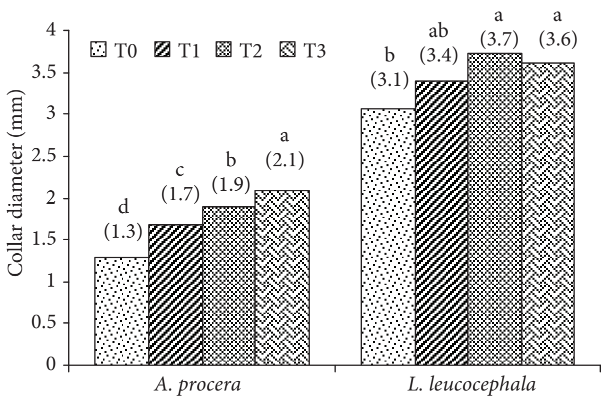
(Lettering on the bars shows statistical significance.)

Figure 2. Influence of MF (75 mT) for 5 min (T1), 10 min (T2), and 15 min (T3) on *A. procera* and *L. leucocephala* for plant height.



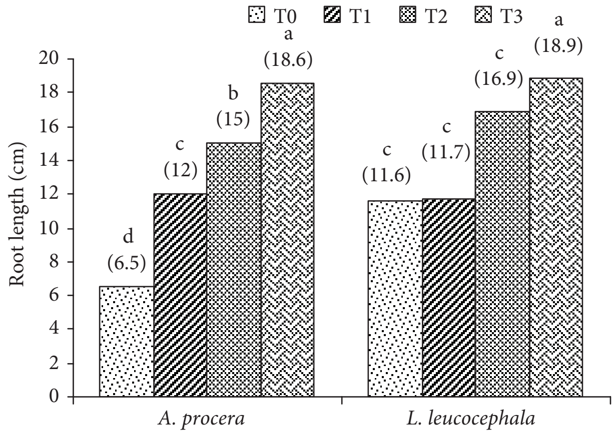
(Lettering on the bars shows statistical significance.)

Figure 1. Influence of MF (75 mT) for 5 min (T1), 10 min (T2), and 15 min (T3) on *A. procera* and *L. leucocephala* for seed germination (%).



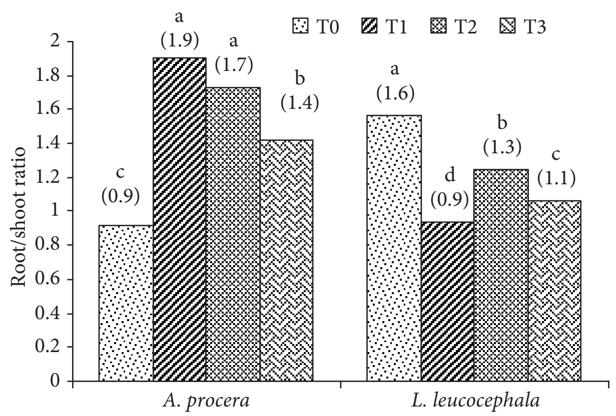
(Lettering on the bars shows statistical significance.)

Figure 3. Influence of MF (75 mT) for 5 min (T1), 10 min (T2), and 15 min (T3) on *A. procera* and *L. leucocephala* for collar diameter.



(Lettering on the bars shows statistical significance.)

Figure 4. Influence of MF (75 mT) for 5 min (T1), 10 min (T2), and 15 min (T3) on *A. procera* and *L. leucocephala* for root length.



(Lettering on the bars shows statistical significance.)

Figure 5. Influence of MF (75 mT) for 5 min (T1), 10 min (T2), and 15 min (T3) on *A. procera* and L. *leucocephala* for root-to-shoot ratio.

Table. Level of significance among means for various growth parameters in *A. procera* and *L. leucocephala*.

		Albizia procera			*Leucaena leucocephala*	
Parameters	**CV (%)**	**SE**	**LSD**	**CV (%)**	**SE**	**LSD**
Seed germination (%)	12.8	7	16	11.4	6	13
Height (cm)	5.09	0.37	0.85	4.22	0.44	1.03
CD (mm)	8.14	0.12	0.27	6.33	0.18	0.41
RL (cm)	6.28	0.67	1.54	3.74	0.45	1.04
R/S	7.5	0.09	0.21	4.44	0.04	0.1

CV: Coefficient of variation, SE: standard error, LSD: least significant difference, CD: collar diameter, RL: root length, R/S: root-to-shoot ratio.

All of the values of SGP in both species were statistically significant (Table). This showed a high effect of the magnetic treatment on SGP. These results are in conformity with the findings of previous researchers. However, previous research work was done mostly with herbaceous plants. In the present study, seeds of woody plants were treated with MF of varying intensities. Perhaps woody plants are less affected by relatively low MFs, as the SGP observed in *A. procera* under T1 and T0 was almost similar.

Discussion

Seeds of both plant species treated with MF for longer time intervals resulted in increased SGP. For instance, the highest SGP was recorded in the seeds of *A. procera* and *L. leucocephala* treated with MF for 15 min (T3) (Figure 1). Penuelas et al. (2004) reported higher SGPs in plants sown in a solution culture of different chemicals; these plants were tested for their susceptibility and different responses to MFs. PSST of MF resulted in physiological changes occurring in the plants, such as different root-growth patterns, growth rate, reproduction and growth of the meristem cells, and chlorophyll quantities (Reina et al., 2001; Atak et al. 2007; Scopa et al. 2009). Esitken (2003) applied MFs of various intensities as a PSST in lentil plants and determined the optimal range of MF intensities for increasing SGP, seedling vigor, growth, and yield. Also in agreement with our results were the findings of Celestino et al. (2000), who reported that weak electromagnetic fields increased the germination of oak seeds (acorns) and their subsequent growth. Interestingly, Reina and Pascual (2001) reported enhanced water uptake by lettuce seedlings treated with MF as a PSST. This explained the reason why higher SGP was observed in the seedlings obtained from the seeds treated with MF.

A. procera exhibited maximum plant height in T3 (13.1 cm), which was 85% greater than the height gained in the control (7.1 cm). *L. leucocephala* gained maximum height (17.8 cm) as well, which was 137% more than the height gained in the control (7.5 cm) (Figure 2). A significant increase in growth rate was reported by Scopa et al. (2009) in the shoots of *Arundo donax* (giant reed) grown on an organic substrate when treated with a DC electric field as a PSST. Atak et al. (2003) and Yaycili and Alikamanoglu (2005) concluded that MF increased the shoot growth and the fresh weight in soybean and paulownia organ cultures. Racuciu et al. (2006) noted higher growth in maize plants, and relatively more length was recorded in the seedlings established from treated seeds. In our study, all seedlings treated with MF for different time intervals had relatively greater shoot length than the seedlings of nontreated seeds.

A similar trend was observed in CD, as *A. procera* plants had maximum CD (2.1 mm) in T3, followed by 1.9 mm in T2. Minimum CD (1.3 mm) was noted in T0. *L. leucocephala* had almost similar CD values (3.6 and 3.7 mm) in T3 and T2, respectively. However, CD in the seedlings of nontreated seeds was significantly lower (1.3 mm) (Figure 3). Faqenabi et al. (2009) tested safflower with the application of MF and found that the treatment of a stationary MF resulted in a significant increase in the yield, as well as in shoot diameter. The results of the present study are strongly supported by Atak et al. (2003), Yaycili and Alikamanoglu (2005), Racuciu et al. (2006), and Scopa et al. (2009).

Figure 4 depicts that *A. procera* had 3 times higher RL (18.6 cm) in T3 than the RL noted in the control (6.5 cm). Similar behavior was shown by *L. leucocephala*, which had maximum RL (18.9 cm) in T3. Plants having healthy and long roots potentially develop their extensive root system to penetrate deeper into the soil, thus actively exploiting the moisture and nutrients from the depth of the soil (Hartmann et al. 1988). Our findings suggested that an application of MF for a longer time results in greater RL. Relatively, higher RL with a smaller plant height resulted in higher R/S values. *A. procera* had maximum R/S (1.9) in T1, followed by 1.7 and 1.4 in T2 and T3, respectively. The same measurement was minimal (0.9) in the control. A similar trend was observed in *L. leucocephala* (Figure 5). The findings of many other scientists support our results. For instance, roots were found to be more sensitive to MF than shoots (Kato 1988; Kato et al. 1989). Penuelas et al. (2004) observed strong magnetotropic effects on root development and noticed that actively growing roots could be induced to curve away from regions of high MF to regions of low MF. McLeod et al. (1992) and Pietruszewski et al. (1999) concluded that the influence of MF on seeds enhanced root growth.

Sytnik et al. (1984) and Penuelas et al. (2004) observed significant change in the RL of plants treated with weak MFs. In our study, no change could be observed in the RL (11.7 and 11.6 cm) of *L. leucocephala* seedlings in T1 or T0. However, *A. procera* was found relatively more sensitive than *L. leucocephala*. Many other scientists, including Sytnik et al. (1984) and Penuelas et al. (2004), studied nonwoody plants, which might be relatively more sensitive to MFs of low intensity, while *A. procera* and *L. leucocephala* (woody plants) seemed to be resistant to low MF applied for 5 min. Therefore, the results of Sytnik et al. (1984) and Penuelas et al. (2004) were contradictory to our findings when the plants were treated with weak MF.

The R/S in *A. procera* and *L. leucocephala* under various treatments exhibited the following response in descending order: T3 < T1 < T2 < T0. This was found to be statistically significant. The general trend was: the greater the time interval for the treatment of plant as PSST, the lower the R/S would be and vice versa. In *A. procera*, minimum R/S ocurred in T0 (0.9 cm). The noted values of R/S for other treatments were: T3 (1.4 cm), T2 (1.7 cm), and T1 (1.9 cm). *L. leucocephala* exhibited almost similar behavior in this regard. Data revealed that the MF treatment enhanced overall growth of the seedlings. Undoubtedly, the total shoot length noted in response to the MF treatment was higher as compared to RL (Figure 4); however, the percentage increase in RL was higher than the percentage increase in shoot length. For example, the percentage increase in shoot length and RL of *A. procera* in T3 was 100% and 300% of the control, respectively (Figure 2 and Figure 4). The findings of Kato (1988) and Kato et al. (1989) were similar, concluding that roots of the plant were more sensitive to MF than the shoots. Atak et al. (2003), Yaycili and Alikamanoglu (2005), and Racuciu et al. (2006) noticed that MF enhanced the growth rate and biomass of soybean and paulownia organic cultures. Scopa et al. (2009) reported significant increase in the growth rate of the plants treated with MF, which also agreed with our findings.

Albizia procera and *Leucaena leucocephala* responded equally to treatment by MF as a presowing seed treatment and were found to be quite sensitive. Both species have potential, showing enhanced seed germination percentage. The data clearly suggested that the treatment altered the growth behavior of both plants, showing different seed germination percentages, plant heights, collar diameters, root/shoot ratios, etc. Based on our findings, we suggest that such research should be repeated by using soaked and unsoaked seeds for treatment with MFs of different intensities for relatively longer time intervals.

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