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Full Length Research Paper

Proximity effects of high voltage electric power transmission lines on ornamental plant growth

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The proximity effects of high voltage electric power transmission lines on Leyland Cypress (*xCupressocyparis leylandii* (Dallim. and A.B. Jacks.) Dallim) and Japanese Privet (*Ligustrum japonicum* Thunb.) growth were examined in a private nursery located in Sakarya, Turkey. Five transect were randomly chosen in both leylandii and privet lots in the nursery. In the summer of 2009, starting from under the power line 12 sampling point for every five meters away from the power line on each transaction was located. From these sampling points, five seedlings for each species were randomly chosen. From each sampling seedlings, five - seven leaves (for private) or spurs (for leylandii) were collected from lower-, middle- and upper-crown. For each sampling seedling diameter at breast height (dbh) were measured with a caliper. Within the laboratory, the projected surface area (SLA) of needles and leaves were determined using a leaf area meter. The relationship among measured seedling variables and the proximity to high voltage electric power transmission lines were evaluated using correlation. The effects of proximity to power-line on specific leaf area and seedling dbh were tested with an analysis of variance procedure (ANOVA). Tukey's HSD test with alpha = 0.05 was performed to compare means. The result of the data revealed that the mean of seedling dbh at 55 m away from the power line was about 25% smaller than that of the seedlings underneath the power line. The data also showed that there was a gradual decrease at dbh value of the privet with the distance from the power line. Seedling mean dbh value at the 25th m sampling point was about 10% lower than that of the seedlings underneath the power line. At the 40th m sampling point this dbh value was about 17 and 8% lower than those of the seedlings underneath the power line and of the seedling at 25th m sampling point, respectively. Specific leaf area after the 30th m away from the power line has been decreasing. The SLA value at the 30th m is about 17% lower than that of the seedling underneath the power line.

Key words: magnetic field, ornamental plant growth, power transmission line, Leyland Cypress, Japanese Privet.

INTRODUCTION

Around the middle of the twentieth century, there was a massive increase in the general public's awareness of damage being done to the environment by human activities (Yıldız et al., 2005). In the late 1960s concern about radiation focused on radioactive exposure on whole ecosystem, succession, food chain dynamics and diversity. And extensive biological, geological and oceanographic research has been conducted to determine the effects of radiation on environment. Scientists argued that exposing the American population even to permissible doses of radiation would result in thousands of cases of cancer every year. The role of ecologist was tracing the pathways which radiation could reach humans (Bocking, 1997). In 1970, The National Environmental Policy Act came into effect. One of its most significant requirements was that each federal agency proposing a major project

Abbreviations: dbh, Mean diameter at breast height; **SLA,** surface area of needles and leaves; **EMF,** electromagnetic fields; **HVEPTL,** high voltage electric power transmission lines; **LEMF,** low frequency electromagnetic field; **MF,** magnetic field; **SE,** standard error.

needs to prepare a statement assessing its environmental impacts and explaining how adverse impacts could be avoided and mitigated (Yıldırım, 2003).

Discussion over the possible biological effects of electromagnetic fields was also first initiated in the late 1960s following the introduction of new, higher voltage electric power transmission lines (HVEPTL). Then, exposure to electromagnetic fields (EMF) and related environmental issues have become an issue of concern for a great many people. Demand that we should protect nature has grown from a minority position to a major factor in the debate in 1960s. Private and government organizations (Environmental Protection Agency, the Department of Energy, the National Institute of Environmental Health Sciences, the National Cancer Institute, The National Institute of Occupational Safety and Health, the Food and Drug Administration, the Department of Defense) have conducted researches to reach conclusion to support their side on the debate since then. The Electric Power Research Institute and Cancer Institute have involved in EMF researches in 27 countries (http://www.emfservices.com/index.htm). Carbonell et al. (2008) claim that exposure to even extremely low-frequency (ELF; 50/60Hz) electromagnetic fields may have adverse effects on human health.

On the other side, considerable amount of studies have suggested that EMFs may modify plant growth and development (Smith et al., 1993; Davies, 1996; Celestino et al., 2000; Rapley et al., 1998; Stange et al., 2002). Huang and Wang (2007) argued that MF may affect motion of ions in plant cells. Frankel and Liburdy (1996) stated that both low frequency electromagnetic field (LEMF) and magnetic fields (MF) have an effect on microorganisms, plants and animals. The effects of MFs on plant growth were observed on seed germination, seedling growth, agronomic traits and seed yield (Fomicheva et al., 1992; Namba, 1995; Aladjadjıyan, 2002; Atak et al., 2003; Esitken, 2003; Rotcharoen et. al., 2003; Podlesny, 2005; Mihaela, 2007; Racuciu, 2008; Balouchi, 2009). Alikamanoglu (2007) reported that both shoot and root regeneration was increased in cultured explants exposed to magnetic fields.

Since many of the studies were conducted on ex-situ conditions, laboratory-based studies have so far failed to establish convincing biological responses to magnetic fields for *in situ* conditions. Most of these studies were criticized for inappropriate replications and for their unsystematic executions (Lacy-Hulbert et al., 1998; Galland and Pazur, 2005; Pietruszewski, 1999; Lednew 1991).

There has been an explosion in the ornamental plant nurseries in the last two decades in Turkey. Most of these nurseries were established in the vicinity of cities for closeness concern to the market. However, finding a suitable land for establishing a nursery is getting more and more difficult because of the conflict with real estate developers. Therefore, under and in the vicinity of high voltage electric power transmission lines (HVEPTL) not suitable for real estate development in and around the cities have become a popular place for nursery practices.

The aim of the current study is to investigate the proximity effects of high voltage electric power transmission lines on ornamental plant growth.

MATERIALS AND METHODS

Site description

The study sites were chosen from a private nursery located in Sakarya valley (40º 41′ N, 30º 26′ E). These experimental sites were situated about 40 - 50 km further inland from the coast of the Black Sea and were located about 30 m above sea level. The mean annual temperature is 14ºC with more than 800 mm of annual precipitation most of which occurs during the winter. In the study sites there are higher temperature fluctuations and winter snowfall comparing the coastal part of the region. The relative humidity during vegetation season is about 72% and common wind blow directions are north, north-east and north-west. The study area is one of the important alluvial valleys in the western Turkey. In land classification system the study area has been classified as I. class agricultural land. The nursery, on which the study conducted, has a deep and relatively fertile soil without any drainage and salinity problem. The textural composition ranges from clay to sandy loam. Stoniness is low, less than 5% by volume. Because of favorable climate and soil conditions, nurseries to grow ornamental plants have been promoted and partly subsidized in the region. Therefore, hundreds of nurseries with different sizes have been acting on more than 40 thousand hectares on the valley and the vicinity (Arifiye, Sapanca, Pamukova area) (Anonymous, 2009).

Data collection and analysis

To determine the proximity effects of high voltage electric power transmission lines (HVEPTL) on two commonly preferred bushes for ornamental planting, Leyland Cypress (*xCupressocyparis leylandii* (Dallim. and A.B. Jacks.) Dallim) and Japanese Privet or Wax-leaf Privet (*Ligustrum japonicum* Thunb.), 5 transect were randomly chosen in both leylandii and privet lots in the nursery (Figure 1). The seedlings in the nursery were planted from a 1+0 stocks with 1 by 1 m spacing under a high voltage transmission line in 2006. The electric field at the ground level under a high voltage transmission line is approximately uniform (50 Hz) and field lines are vertical to the ground plane according to EU standards (CEI ENV 50166-1 No).

Planting rows for both species are situated outward from HVEPTL. In three years, seedling reached about 2.5 m height. In the summer of 2009, starting from under the power line 12, sampling point for every 5 m away from the power line on each transaction was located. From these sampling points, 5 seedlings for each species were randomly chosen (5 transect*12 sampling point*5 seedlings=300 seedlings for both leylandii and private). From each sampling seedlings 5 - 7 leaves (for private) or spurs (for leylandii) were collected from lower-, middle- and upper-crown positions and samples were placed in a plastic bags and brought to the lab. For each sampling seedling diameter at breast height (dbh) were measured with a caliper graduating with 0.1 mm. Within the laboratory, the projected surface area (SLA) of needles and leaves were determined using a leaf area meter (ADC BioScientific Ltd., UK).

Statistical analysis

The relationship among measured seedling variables and the proximity to of high voltage electric power transmission lines were

Figure 1. Nurseries beneath the high voltage electric power transmission lines (HVEPTL) on Sakarya valley.

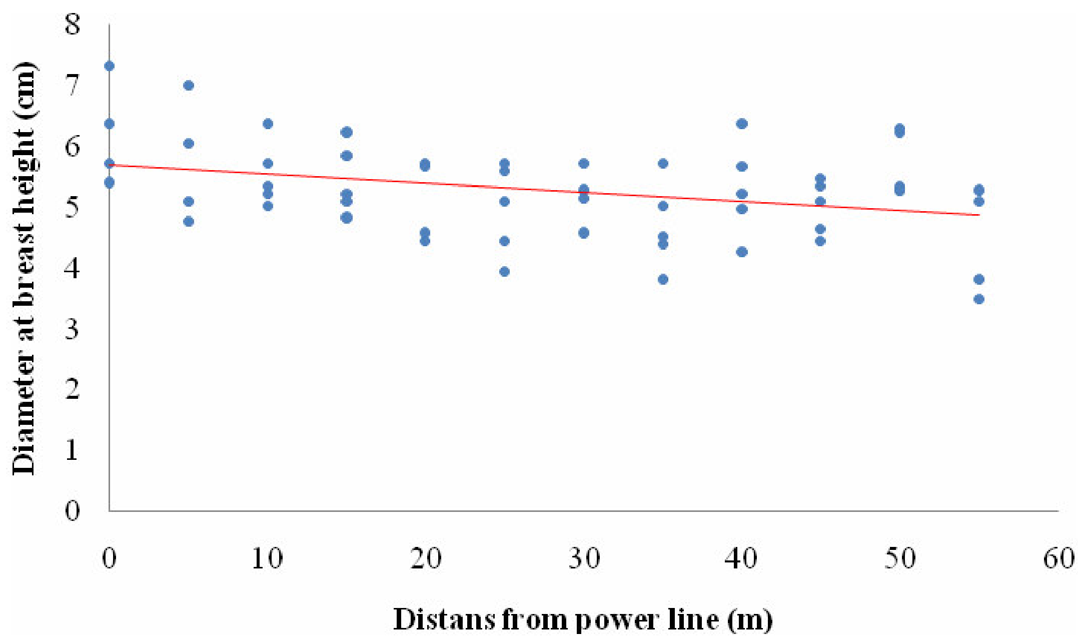

Figure 2. The relationship between diameter at breast height and distance from power line for Leyland Cypress (*xCupressocyparis leylandii* (Dallim. & A.B. Jacks.) Dallim).

evaluated using correlation. The effects of proximity to power-line on specific leaf area and seedling dbh were tested with an analysis of variance procedure (ANOVA). We used SAS for all statistical analyses (SAS Institute, Inc., 1996). Results for ANOVA were considered significant at $P < 0.05$. Tukey's HSD test with alpha = 0.05 was performed to compare means.

RESULTS AND DISCUSSION

The result of the data revealed that the proximity to power line has significant effects on diameter growth of leylandii seedlings (P-value= 0.001). There was a negative relationship between the diameter of leylandii and distance away from the power line (Person correlation coefficient = -0.354; Figure 2). There is variability on dbh at the first 50 m away from the power line. However, the mean of seedling dbh at 55 m away from the power line was about 25% smaller that of the seedlings underneath the power line (Table 1).

The data also showed that proximity to high voltage power line significantly correlated to diameter growth (P-value = 0.001) and specific leaf area (P-value = 0.001) value for Japanese privet. There was a negative relationship between the diameter of seedlings (Person correlation coefficient = -0.975; Figure 3) and specific leaf area values (Person correlation coefficient = -0.44; Figure 4)

Table 1. Mean diameter at breast height (dbh) ± SE. for Leyland Cypress (*xCupressocyparis leylandii* (Dallim. and A.B. Jacks.) Dallim) at different sampling points away from the power line.

Distance (m)	Dbh (cm)
Under	6.11 ± 0.23 a
5	5.60 ± 0.27 bac
10	5.54 ± 0.16 bdac
15	5.45 ± 0.17 bdac
20	5.24 ± 0.19 bdac
25	4.97 ± 0.22 bdc
30	5.30 ± 0.14 bdac
35	4.70 ± 0.21 dc
40	5.29 ± 0.23 bdac
45	5.00 ± 0.13 bdc
50	5.69 ± 0.16 ba
55	4.60 ± 0.26 d

Within a column, means with a common lowercase letter are not significantly different at P = 0.05.

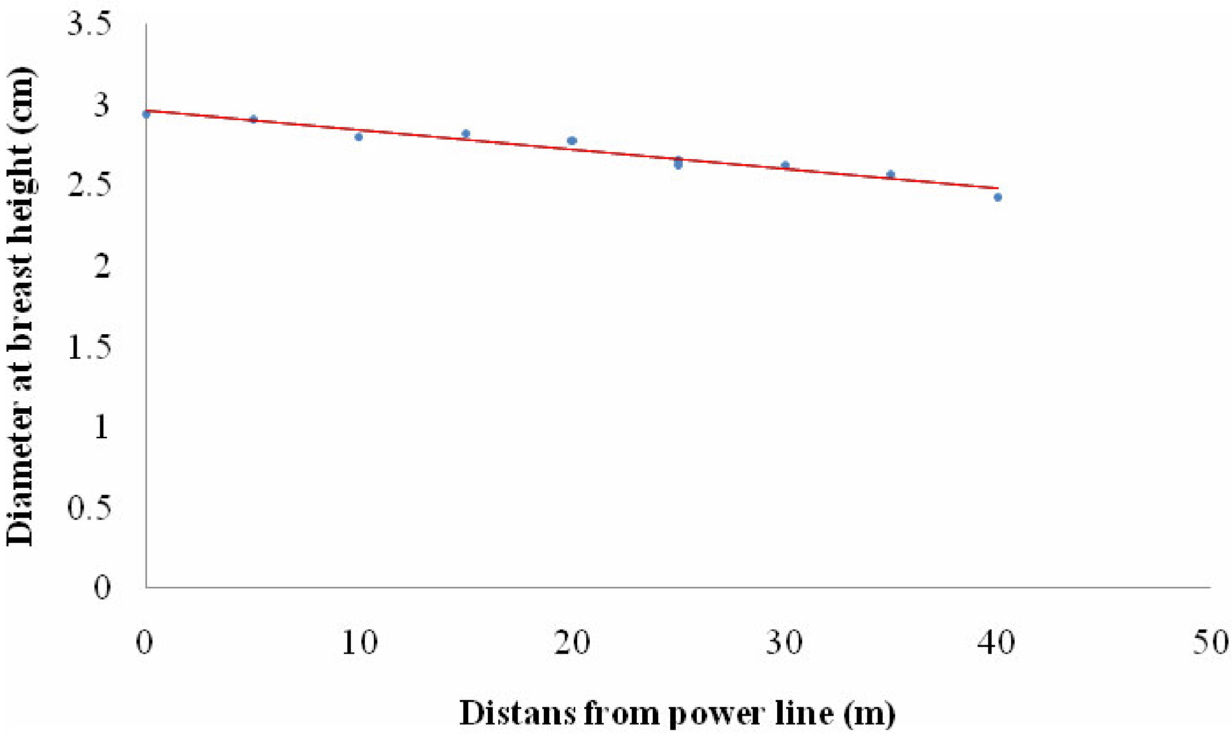

Figure 3. The relationship between diameter at breast height and distance from power line for Japanese Privet (*Ligustrum japonicum* Thunb.)

and distance away from the power line. There was a gradual decrease at dbh value of the privet with the distance from the power line. Seedling mean dbh value at the 25th m sampling point was about 10% lower than that of the seedlings underneath the power line. At the 40th m sampling point this dbh value was about 17 and 8% lower than those of the seedlings underneath the power line and of the seedling at 25th m sampling point, respectively (Table 2). Specific leaf area after the 30th m away from the power line has been decreasing. The SLA value at the 30th m is about 17% lower than that of the seedling underneath the power line (Table 2).

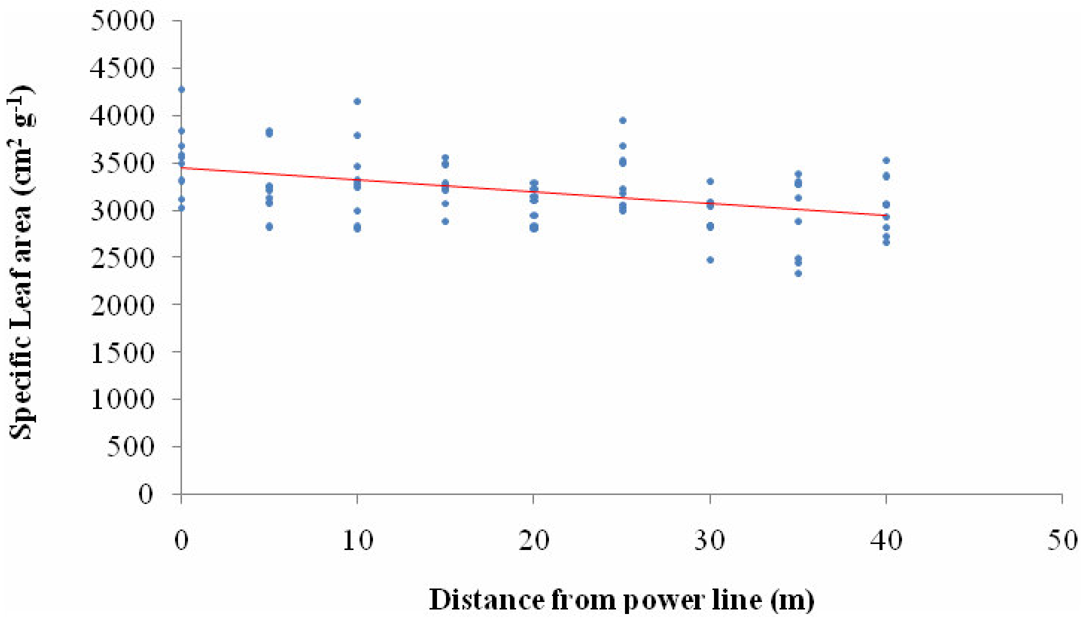

Figure 4. The relationship between specific leaf area and distance from power line for Japanese Privet or Wax-leaf Privet (Ligustrum japonicum Thunb.).

Table 2. Mean diameter at breast height (dbh) and specific leaf area ± SE. for Japanese Privet or Wax-leaf Privet (*Ligustrum japonicum* Thunb.) at different sampling points away from the power line.

Distance (m)	Dbh (cm)	SLA (mm^2 g^{-1})
Under	2.94 ± 0.01 a	3557 ± 127 a
5	2.91 ± 0.01 b	3288 ± 112 ba
10	2.80 ± 0.01 c	3328 ± 147 ba
15	2.82 ± 0.01 d	3285 ± 72 ba
20	2.78 ± 0.01 e	3009 ± 66 b
25	2.65 ± 0.01 f	3358 ± 111 ba
30	2.62 ± 0.01 g	2962 ± 79 b
35	2.57 ± 0.01 h	2956 ± 139 b
40	2.43 ± 0.01 ı	3054 ± 95 b

Within a column, means with a common lowercase letter are not significantly different at P = 0.05.

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