Plant Supporting Units (Ekobox) Application Project for Increasing Planting Success in Arid and Semi-Arid Areas

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***Abstract*—**In this study, samples of plant types including rose hip (*Rosa canina* L.), jujube (*Ziziphus jujube*), sea buckthorn (*Hippophae rhamnoides*), elderberry (*Sambucus nigra*), apricot (*Prunus armeniaca*), scots pine (*Pinus sylvestris*), and cedar of Lebanon (*Cedrus libani*) were grown using plant supporting units called Ekobox and drip irrigation systems in the Karapınar, Konya region of Turkey to reveal the efficiency of Ekobox and drip irrigation compared against a control with no irrigation. The plant diameter, height, and survival rates were determined, compared with each other, and statistically analyzed. According to the statistical analysis of the results, Ekobox applications resulted in the highest values for survival rate, diameter, and height measurements whereas the lowest values were determined in the control groups. These results indicate that the cultivation of plants with Ekobox may help protect against the loss of fertile soils as an effective mechanism for combating erosion and desertification. These advantages may also lead to a lasting economic effect on the cultivation of plants by locals of the Karapınar, Konya province who suffer from an ever-decreasing underground water level as a result of agricultural consumption.

***Keywords*—**Drip irrigation, Ekobox, plant diameter, plant height, plant survival rate.

I. INTRODUCTION

THE unconscious use of natural resources induces erosion, while industrialization reduces soil fertility and causes desertification, erosion, and ecosystem degradation. Erosion occurs as a result of drought and desertification which ultimately affects agricultural lands, pastures, and woodlands, resulting in loss of yield and ultimate poverty [1]. Every year, 24 billion tons of top layer soil is lost, and 6 billion hectares of land are deserted across the world due to various reasons. This process brings more than $42 billion in financial burden to the world and directly threatens 1.2 billion people in 110 countries. 73% of Turkey's land is subject to severe erosion which is a driving forcing for poverty, famine, thirst, and migration, which proves erosion to be one of the more catastrophic environmental problems in the world [2]. With the increase of these challenges, it is understood that plant resources such as forests have critical functions in protecting public health [3], [4].

Undoubtedly, the primary combatant to desertification and erosion is plantation. In this sense, many special plantation activities such as erosion control, arid and semi-arid area afforestation, and sand dune afforestation have accelerated since the end of the 19th century [5], [1], [6].

The Karapınar, Konya region, known as the desert of Turkey, is an area where the effects of drought, desertification, and erosion can be monitored easily. According to the geographical characteristics of the region, Karapınar is a small and old city on the Ankara-Konya-Adana road, 95 km away from Konya with a width of 2,969 square kilometers and an altitude of 1,000 meters [8]. Wind erosion is very intense in this area where dry periods are frequently experienced and loose soils dry and become a mass of dust. In its continental climate, Karapınar, Konya has an annual precipitation of 285.2 millimeter, which varies from 200-400 millimeter from year-to-year [9]. The area is affected by significant wind erosion due to the low level of moisture in the soil and the lack of water retention in the permeable structure of the soil [9]. According to observation data collected between 1971 and 1998, the desert climate had an average annual temperature of 10.1 °C with lowest and highest temperatures of -26.6 °C and 39.4 °C respectively [9].

Multiple important and successful projects have been conducted in this region but the necessity for new projects will always continue in order to maintain and protect the erosion area. Plantation activities are the most important precaution for preventing soil loss in the Karapınar, Konya region. However, wind erosion and inadequate rainfall in the area mean that effective plantation requires new technology-dependent techniques. Additionally, Karapınar, Konya has seen a 14.3 meter decrease in underground water level due to unconscious water consumption [10]. As an example, wells in the Karapınar, Konya region have seen significant drops in water level such as the Gülfet Yayla Kuyusu which decreased from -17.4 m to -41.1 m between 1969-2008 and Eğilmez Kuyusu decreased from -15.1 meters to -37.6 meters between 1974 and 2008 [11]. Agricultural and drinkable water consumption are the primary causes of the continued level decrease which already battles the effects of climate change and a lack of precipitation.

It is thought that sinkhole formation is related with not only climate, underground water chemistry or lithological character, but also decreased underground water level [10]. This idea is supported by Doğan and Yılmaz [12] who found

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that whereas there were only 6 sinkholes in Karapınar, Konya between 1977 and 2000, the number of sinkholes increased to 13 between 2006 and 2008 [13]. These sinkholes cause countless negative impacts on agricultural activities and the area's continued water necessity will only further impact the loss of life and property in the region if not reduced [13]. It is precisely for this reason that the use of plant supporting units such as Ekobox will be a beneficial option for plant growth in Karapınar, Konya, as both rain and raw water are collected through condensation and sufficient water is supplied to the plant. As seen in Fig. 1, this plant supporting unit consists of a hole for the plant, a 16-liter reservoir that collects water from the atmosphere, and a wick that transmits water from the box to the soil. This wick reduces or completely cuts off the water flow as soon as the soil reaches sufficient moisture. In the opposite direction, when the soil becomes hygroscopic by drying, water flows from the wick back to the soil.

Fig. 1 Ekobox supporting unit

In this study, rosehip, jujube, sea buckthorn, elderberry, apricot, scots pine, and cedar of Lebanon were cultivated using Ekoboxes as well as drip irrigation systems. These seven plants were selected to provide the study with an array of drought tolerances and observe if the methods assist with plant survival in nature; scots pine plants have a low tolerance to drought whereas cedar of Lebanon plants have a medium tolerance, and apricot, rosehip, sea buckthorn, and elderberry plants have a high tolerance.

In order to determine the efficiency of Ekobox and drip irrigation, these applications were compared with areas where irrigation practices were not undertaken for control purposes. With regard to the comparisons, plant diameter, height, and survival rates were measured, and statistical data were obtained. In the future, loss of fertile soils will be prevented by adopting an effective approach in combating erosion with the cultivation of these plants. The cultivation of these plants will also serve as a source of income generation for the local people.

II. Material and Method

The experiment was conducted on an area of 11,664 square meters with the coordinates 37°40'32.14"N 33°30'23.09"E within the Soil Water Desertification Research Institute in Karapınar, Konya. The total testing site for each plant was 1,296 square meters, and the distance between the plants was 4 meters.

The rose hip, jujube, sea buckthorn, elderberry, apricot, scots pine, and cedar of Lebanon plants were grown under 3 conditions which were waterless (control), drip irrigation, and Ekobox. Each plant and condition had 3 parcel replications, and each parcel had 9 plants. The plant types and growing conditions were arranged in a randomized block design with subsamples in the field.

The experimental soil was characterized by Bouyoucos method resulting in sandy silt including 74% sand, 16% silt, and 10% clay, with a pH of 8.18 (1:2.5 soil to water ratio), and 63.28% calcium carbonate [14]. Organic matter was determined by Jackson method at 0.76% [15].

Irrigation consisted of a total of 3,024 liters of water for plants grown with Ekobox applications whereas 15,750 liters was used for drip irrigation in total, and control group did not receive any water. Additionally, soil temperatures were tested for control, drip irrigation, and Ekobox with measurements of 46.2 °C, 31.6 °C, and 26.1 °C respectively. In order to determine the differing characteristics of each application, measurements of plant survival rates, diameter, and length were performed 1 year after plantation. To average the diameters and heights, only living plants were calculated using the survival rate formula (1):

$$Survival\ Rate(\%) = \frac{Number\ of\ Living\ Plants}{9\ (Number\ of\ plant\ in\ a\ parcel)} \cdot 100 \qquad (1)$$

The data collected from the measurements were analyzed using an Analysis of Variance (ANOVA) model with the means being separated using Tukey's multiple comparison tests and Factorial Analysis by Least Significant Difference (LSD) at 0.1, 0.05, and 0.01 level in JMP Pro 15 Statistical Discovery (SAS Institute Inc. 2019) [16].

III. Results and Discussion

For the survival rate, the percent of surviving of plants was calculated, and mean results were shown in Table I. The presence of water had a significant effect on plant growth (Tables I and II) including the death of all jijube plants. Other plants were also affected negatively from waterless growth resulting in low survival rates for control groups compared to drip irrigation and Ekobox groups (Table I). Considering the comparison of Ekobox and drip irrigation, in general terms, the survival rates of the plants grown in Ekobox were higher than drip irrigation (Table II), and this difference was especially observed in the sea buckthorn, elderberry and jujube plants (Table I). The results presented in Table II indicate that Ekobox was more productive than drip irrigation in terms of survival rate.

For cedar of Lebanon plants, the survival rates of control, drip irrigation, and Ekobox were 70.37%, 85.18%, and 92.59% respectively, and a statistical difference was observed at 0.1 and 0.05 levels between the control groups and other irrigation methods. However, no significant difference was observed at 0.01 level between irrigation methods for cedar of Lebanon (Table I).

For the apricot plants, survival rates in control, drip irrigation, and Ekobox were 25.9, 96.3, and 96.3%, respectively (Table I). A significant difference was observed between control and the other two applications but the survival rates for drip irrigation and Ekobox were the same. The effects of different methods on rose hip survival rates were not significantly different but the highest survival rates were obtained from drip irrigation and Ekobox applications.

TABLE I
SURVIVAL RATES OF PLANTS GROWN WITH DIFFERENT IRRIGATION METHODS (%)

Plant	Irrigation Method	Survival Rate (%)	p < 0.1	p < 0.05	p < 0.01
Cedar of Lebanon	Control	70.37	B	B	NS
Cedar of Lebanon	Drip Irrigation	85.18	A	AB	NS
Cedar of Lebanon	Ekobox	92.59	A	A	NS
Apricot	Control	25.92	B	B	B
Apricot	Drip Irrigation	96.29	A	A	A
Apricot	Ekobox	96.29	A	A	A
Rosehip	Control	75.00	NS	NS	NS
Rosehip	Drip Irrigation	92.59	NS	NS	NS
Rosehip	Ekobox	92.59	NS	NS	NS
Sea buckthorn	Control	25.92	C	B	B
Sea buckthorn	Drip Irrigation	59.25	B	B	AB
Sea buckthorn	Ekobox	96.29	A	A	A
Scots Pine	Control	37.03	B	B	B
Scots Pine	Drip Irrigation	100.00	A	A	A
Scots Pine	Ekobox	100.00	A	A	A
Elderberry	Control	0.00	B	B	B
Elderberry	Drip Irrigation	25.92	B	B	B
Elderberry	Ekobox	81.48	A	A	A
Jujube	Control	0.00	C	C	C
Jujube	Drip Irrigation	22.22	B	B	B
Jujube	Ekobox	66.67	A	A	A

NS = Non-Significant
Statistical assessments were made between each plant group, and letterings were made separately for each plant type.

TABLE II
EFFECT OF DIFFERENT IRRIGATION METHODS ON THE SURVIVAL RATE OF ALL PLANTS

Irrigation Method	Survival Rate (%)	p < 0.1	p < 0.05	p < 0.01
Control	33.46	C	C	C
Drip Irrigation	68.78	B	B	B
Ekobox	89.42	A	A	A

When comparing irrigation method effects on survival rates of rose hip plants, the results did not show any significant difference at any level. Although there was not any statistical difference, the highest percentages were determined from drip irrigation and Ekobox with 92.59% (Table I).

For sea buckthorn plants, the survival percentage resulted in significant difference between all irrigation methods (Table I). The results suggest that the highest and least percentages of survival were found from Ekobox and control respectively. These results indicate that Ekobox was more efficient than drip irrigation for sea buckthorn growth.

For the survival rates of scots pine, all plants survived under both drip irrigation and Ekobox systems. On the other hand, only 37.03% survived in the control group. Between control and other methods, a significant difference was observed at all levels (Table I).

For elderberry plants, the control group had a survival rate of 0%. On the other hand, there was a significant difference between drip irrigation (25.92%) and Ekobox (81.48%) (Table I). The results indicate that Ekobox was the most efficient method for elderberry growth.

The survival rates of jujube plants were similar to elderberry in that the control group completely died, whereas there was a significant difference between survival rates of drip irrigation (22.22%) and Ekobox (66.67%) (Table I). Again, the results indicate that Ekobox was the most effective method for growing jujube plants.

Overall, these results suggest that water irrigation is a necessity in this area for plant survival and the use of Ekobox equipment is a more effectual approach than drip irrigation for plantation and survival in Karapınar, Konya.

The effects of different irrigation methods on the plants' diameters are presented in Table III. It can be understood that the presence of water played a critical role on the plant diameter. However, as a result of excessive drying, diameter measurements were not possible for elderberry and jujube plants in the control group. Generally, significant differences were not observed between Ekobox and drip irrigation.

The results showed a statistical difference between Ekobox and other irrigation methods for cedar of Lebanon plants with lowest and highest results obtained from control of 6.73 millimeter and Ekobox of 9.35 millimeter respectively. The effectiveness of drip irrigation (7.79 millimeter) was found to be statistically the same as the control group.

For apricot plants, water had a positive effect on the diameters. The effects of Ekobox and drip irrigation on plant diameter were statistically higher than the control group. However, no difference between Ekobox and drip irrigation was observed (Table III).

Drip irrigation had a positive effect the diameter of rose hip plants when compared to Ekobox and drip irrigation (Table III). On the other hand, there was not a statistical difference between Ekobox (3.31 millimeter) and control (3.89 millimeter) groups.

For buckthorn and scots pine plants, no significant differences were observed between the methods at any level (Table III).

According to the results of this experiment, elderberry and jujube plants are highly reliant on water presence and cannot survive without watering intervention. Comparing the diameters of elderberry plants grown with drip irrigation (5.97 millimeter) and Ekobox (6.76 millimeter), no significant difference was observed at 0.05 and 0.01 levels. For jujube plants, the diameters under drip irrigation (5.98 millimeter) and Ekobox (2.75 millimeter) were found to be significantly different at all levels, with the highest result coming from drip irrigation (Table III) due to the plant's receipt of water during its vegetative state. On the other hand, plants grown with Ekobox received continuous, yet minimal, water application over time, resulting in a higher survival rate than plants grown with only drip irrigation (Table I).

TABLE III
DIAMETERS OF PLANTS GROWN WITH DIFFERENT IRRIGATION METHODS (MILLIMETER)

Plant	Irrigation Method	Diameter (millimeter)	p < 0.1	p < 0.05	p < 0.01
Cedar of Lebanon	Control	6.73	B	B	B
Cedar of Lebanon	Drip Irrigation	7.79	B	B	AB
Cedar of Lebanon	Ekobox	9.35	A	A	A
Apricot	Control	3.57	B	B	B
Apricot	Drip Irrigation	5.57	A	A	AB
Apricot	Ekobox	6.48	A	A	A
Rose Hip	Control	3.89	B	B	B
Rose Hip	Drip Irrigation	8.56	A	A	A
Rose Hip	Ekobox	3.31	B	B	B
Sea Buckthorn	Control	5.19	NS	NS	NS
Sea Buckthorn	Drip Irrigation	6.61	NS	NS	NS
Sea Buckthorn	Ekobox	6.27	NS	NS	NS
Scots Pine	Control	10.36	NS	NS	NS
Scots Pine	Drip Irrigation	9.80	NS	NS	NS
Scots Pine	Ekobox	10.69	NS	NS	NS
Elderberry	Control	0.00	C	B	B
Elderberry	Drip Irrigation	5.97	B	A	A
Elderberry	Ekobox	6.76	A	A	A
Jujube	Control	0.00	C	C	C
Jujube	Drip Irrigation	5.98	A	A	A
Jujube	Ekobox	2.75	B	B	B

NS = Non-Significant
Statistical assessments were made between each plant group, and letterings were made separately for each plant type.

TABLE IV
HEIGHT OF PLANTS GROWN WITH DIFFERENT IRRIGATION METHODS (CENTIMETER)

Plant	Irrigation Method	Height (centimeter)	p < 0.1	p < 0.05	p < 0.01
Cedar of Lebanon	Control	39.26	B	B	NS
Cedar of Lebanon	Drip Irrigation	43,47	AB	AB	NS
Cedar of Lebanon	Ekobox	48.18	A	A	NS
Apricot	Control	47.00	B	B	NS
Apricot	Drip Irrigation	65.67	A	A	NS
Apricot	Ekobox	62.21	A	AB	NS
Rose Hip	Control	19.24	B	B	B
Rose Hip	Drip Irrigation	39.82	A	A	A
Rose Hip	Ekobox	33.54	A	A	A
Sea Buckthorn	Control	58.79	NS	NS	NS
Sea Buckthorn	Drip Irrigation	67.28	NS	NS	NS
Sea Buckthorn	Ekobox	58.51	NS	NS	NS
Scots Pine	Control	72.50	AB	NS	NS
Scots Pine	Drip Irrigation	70.43	B	NS	NS
Scots Pine	Ekobox	76.93	A	NS	NS
Elderberry	Control	0.00	C	C	B
Elderberry	Drip Irrigation	41.00	B	B	A
Elderberry	Ekobox	55.18	A	A	A
Jujube	Control	0.00	C	C	C
Jujube	Drip Irrigation	16.17	B	B	B
Jujube	Ekobox	26.25	A	A	A

NS = Non-Significant
Statistical assessments were made between each plant group, and letterings were made separately for each plant type.

The results of plants height measurements are shown in Table IV. Generally, ANOVA showed significant interaction between the irrigation methods and plant heights. With the exception of sea buckthorn, there were significant differences between all methods at 0.1 level. At the 0.05 level, all plants except for scots pine showed significant differences between the irrigation methods. At the 0.01 level, the irrigation methods created meaningful height differences on rosehip, elderberry and jujube plants.

Cedar of Lebanon plants heights changed between 39.26 and 48.18 centimeters, and a significant difference was observed between control and Ekobox groups at 0.05 level. For apricot plants, the heights changed between 47.00 and 65.67 centimeters, and there are some meaningful differences between the methods at 0.05 level. It was observed that water application had a large effect on the height of rose hip plants. Statistically, it was determined that the effects of drip irrigation and Ekobox are the same on height of rosehip. However, these effects were not the same with control rosehip height (Table IV).

No statistical difference was observed between the sea buckthorn heights and irrigation methods at all levels. Similarly, it can be seen from Table IV that there was not a significant difference between control (72.50 centimeter), drip irrigation (70.43 centimeter), and Ekobox (76.93 centimeter) on scots pine plants at 0.05 level. On the other hand, it was determined that there was a difference between drip irrigation and Ekobox at 0.1 level. As stated before, elderberry and jujube could not survive as result of dryness and therefore, measurements were not possible for the heights. However, when comparing drip irrigation (41.00 centimeter) and Ekobox (55.18 centimeter) methods for elderberry plants at 0.05 level, a significant difference was determined between the methods. Similar with elderberry, jujube plant heights were affected statistically at 0.01 level with heights measuring between 16.17 centimeter and 26.25 centimeter. These results show that Ekobox had a more positive effect than drip irrigation on the height of jujube plants.

Overall, all results indicated that water presence had a vital importance on plant surviving, growth, and development. Even with drought-tolerant plant types it is apparent that plants struggled to survive due to the lack of water in the Karapınar, Konya area. This observation is supported by other research, including Brix who conducted a study related with the effects of water stress on different conifers and stated when water potential in soil is reduced, the number of dead plants increased [17]. In regard to the plant heights, the results mostly agree with a study which was related with different amounts of water applied with sprinkler irrigation on sweet cherry [17]. For the plant diameters, this study's results also agree with numerous previous studies [18]-[21].

Due to the recent availability of Ekobox mechanism, previous research is limited on their effects on plant type varieties. Therefore, more research is required to understand if plantation can be conducted under sustainable conditions in arid or semi-arid environments. Although utilizing less water than drip irrigation, Ekobox applications achieved better results. More research is needed to further evaluate the survival and development of plants, water usage, and cost of the methods.

IV. Conclusion

The results of this study suggest that a variety of plants grown in the Karapınar, Konya region of Turkey can benefit from technological advancements such as Ekobox supporting units. These advancements include the successful growth of plants in areas with soil erosion problems, decreased water consumption requirements, decreased incurrence of nearby weeds, and control of temperature variance. From these results, it can be said that the benefits provided by continued use of Ekobox supporting units may assist in the improvement of Karapınar, Konya's water depletion problems. Additionally, the lack of energy consumption and decreased maintenance costs of Ekobox application can provide sustained benefits to the Karapınar, Konya region and its people.

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