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The Effect of Different Water Types Techniques on the Development of the *Kalanchoe daigremontiana* Plant

Emel Atmaca

Department of Soil Science and Plant Nutrition, Selcuk University Agriculture Faculty, Konya, TURKEY

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Abstract**—***Ornamental plant cultivation requires authentic notions and design skills. Kalanchoe daigremontiana, which is a noteworthy ornamental plant in this sector, which generally operates as a family business, has recently started to take place in both pots and terrariums. This plant, which saves a lot of water due to being a CAM (Crassulaceae Acid Metabolism) plant, continues its lineage with the baby leaves it forms. In this study, the effects of water, which undertakes one of the key tasks in plant development, on certain yield and growth parameters of Kalanchoe daigremontiana through its application on pure-sterile-fountain-mineral-mix varieties was investigated. In this study, in which vermicompost, which is not used much in the ornamental plant sector, and peat, which is frequently used, are applied together (1:2.5 ratio), the highest growth parameter values were obtained from plants grown in pots irrigated with distilled water. Among these values, the difference between plant height (18.00 cm), internode distance (3.77 cm), stem dry weight (0.09 g), baby leaf number (18.33 pieces/leaf) and chlorophyll (47.30) values were found statistically significant (P<0.01 and P<0.05). Nevertheless, the highest leaf number (11.33 pieces), leaf fresh and dry weight (2.91 g-0.08 g), stem fresh weight (0.86 g), leaf projection diameter (6.20 cm) and stem diameter (2.67 mm) were obtained from plants in pots treated with distilled water, however, the difference between the values was not statistically significant (P<0.01 or P<0.05). The highest values of some macronutrient and micronutrient element values of the plant were obtained from plants irrigated with pure water, yet, no nutrient deficiency was found in any plant.*

This can be attributed to the easier decomposition and breakdown of nutrients due to the fact that pure water dissolves the nutrients in peat and vermicompost. Indeed, the fact that the lowest growth and yield parameters are obtained in pots irrigated with mineral water and that the leaves do not form offspring, confirms this.

Keywords**— *Kalanchoe daigremontiana, peat, terrarium, vermicompost, water types.***

I. INTRODUCTION

Kalanchoe is a fertile and fast-growing plant that can almost grow if it stays close to the ground. Thus, the plant was named "Kalanchoe", which means "falling and greening" in Chinese. In different regions, names such as "Mother of Thousand", "Devil's Backbone", "Mexican Hat", "Tears of Love" or "Fiery Caty" have been given [1], [2]. Kalanchoe plant is recognized as a significant indoor ornamental plant in the world floriculture sector and is a fundamental succulent with approximately 125 species. Kalanchoe is a plant species from the *Crassulaceae* family, and in the past, it was divided into three classes which are Kalanchoe, Bryophyllum and Kitchinga while contemporarily only Kalanchoe has remained in the foreground. Although these succulents are especially found in the tropics of Africa and Asia, most species are found in Madagascar. Its leaves are fleshy, bright green, elongated and oval. For plant growth, it needs normal temperature in the summer and 12-15 ^{0}C in the winter. It is resistant to short-term temperatures of 5 ^{0}C. Yet, it sheds its leaves. They like neither excessive humidity nor dry air; an average humidity is sufficient for them. Light or semi-shaded places are suitable for their development. Its flowers are brighter in full sun. Therefore, if a place with plenty of light is preferred, it becomes more flamboyant as they get older. However, it should be protected from scorching sunlight. While some species are used as medicinal plants among many distinctive Kalanchoe types, some are outstandingly preferred for pots and some for Terrariums, which is one of the most prominent occupations of recent times. While *Kalanchoe daigremontiana* is extensively used for both pots and terrariums, recent studies have revealed that the plant can also be used medicinally. The use of this plant in traditional medicine is well known, especially in North and South America [3]. Madariaga-Navarrete et al. [4] in their investigation titled "*Kalanchoe daigremontiana*: Functional Properties and Histopathological Effects on Wistar Rats under Hyperglycemia-inducing Diet" reported that the use of 2ml crude extract of *Kalanchoe daigremontiana* in diabetic patients, that is, in conditions of high sucrose, would reduce liver damage.

K. daigremontiana is a plant that dies by being efflorescent magnificently in 1 or 1.5 years, depending on its environment, soil, air and irrigation regime. However, before it dies, it takes precautions against death by cloning itself into the pot in which it grew up. As soon as the tiny, baby plant parts on the edge of the leaves fall into the pots where the mother plant grows, they instantaneously begin to grow by settling and rooting without needing any extraordinary treatment. Shaw [5] saw in cultivation a form of *K. daigremontiana* which is quite different from the average plant and could derive from a second recentintroduction, but unfortunately, he was not able to find out the source of this unusual form of *Kalanchoe daigremontiana.* Because, in conjunction with you add this plant to your living environment, it is not possible to get rid of it. *Kalanchoe daigremontiana* is a remarkable contrasting species which you will get used to seeing even in pots you have not planted.The reproduction of the plant is through tiny leaves. These tiny sprouts, which fall into the ground, grow rapidly without the need to wait for rooting as they are already rooted (Figure 1).

Fig. 1: Baby leaves propagating from the leaf of the K. daigremontiana plant.

These plants are considerably significant especially for terrariums. Because Kalanchoe is one of the rare plants that can maintain the standard of their lives without being down fallen with a little water and a little sunlight. In consideration of the significance of growing compatible plants together in terrariums, the fact that these plants can live in harmony with almost any plant causes these plants to be sought-after plants in terrariums. The materials used in terrariums, which are areas where living life can continue in a closed system such as a bell jar, are not very expensive, but the prices are quite high as it is not common, making it an attractive gift alternative. While the price of a single Kalanchoe plant is quite economical as outside the terrarium, its price may increase several times when it gets inside the terrarium. On the one hand, almost all of the floriculture sector, which requires a real knowledge of garden and soil, is in the hands of people who do not have education in this field. This is a fact that the educational attainment of the young people employed in the floristry industry is below the average and that people who are not affiliated with the Faculties of Agriculture conventionally choose this job has even been the subject of scientific articles. As a matter of fact, Torun and Bobat [6] claimed that one of the significant issues of the ornamental plant industry is the lack of qualified personnel and that most of the ornamental plant expanding sectors were established as family businesses. According to the experience gained from the family or the fact that many plants taken from these places where production is made by trial and error die in home conditions without living for practically a month, it is inferred that some applications used in this sector are built on keeping the plants alive until they are sold.

The aim of this study is to test the effect of vermicompost, which is increasingly used in the cultivation of field, garden and greenhouse plants, which has many positive features in terms of plant cultivation, on plant growth in *K. daigremontiana* with different water varieties. Vermicompost contributes to the formation of a beneficent structure by regulating the air and water content of the soil due to the high amount of suitable macro-micro nutrients in its ingredients and the presence of many soil microorganisms [7]. Nutrients covered with worm mucus in vermicompost are released gently and are readily available to the plant. In addition, vermicompost is rich in nutrients that are beneficial to the plant, since the nutrients taken by the worm in liquid form after aerobic digestion are further broken down in the digestive system [8]**.** Furthermore, the aim is to test whether the effectiveness of fertilizer changes depending on the water by using water, which is one of the key factors for the longevity of ornamental plants, in the form of different water types.

II. MATERIAL AND METHODS

2.1. Materials

1) K. daigremontiana

K. daigremontiana, used in the study, is a CAM plant belonging to *the Plantae* kingdom, *Magnoliophyta* branch, *Rosopsida* class, *Crassulaceae* family, *Kalanchoe* genus, *Kalanchoe daigremontiana* (syn. *Bryophyllum daigremontianum*) species [9]. In this study, offspring (baby leaves) emerging on the edges of the mother plant leaves were used as material. When these leaves were four-petaled, they were cut using a sterile forceps and planted in pots. Since the plants are rooted on the main leaf, there is no need to wait for rooting (Figure 2.).

Fig. 2: Collection of the parent plant leaf and the offspring (baby leaves) in the leaf from the parent leaf when they are four-petaled in K. daigremontiana.

2) Vermicompost

The vermicompost used in the experiment is a widely available and used brand in the market, and the analysis results of its content are given in Table 1. Since there are not enough studies on the effects of vermicompost on the production of ornamental plants, based on the results of some studies, in line with the recommendation of putting worm manure approximately 40% of the peat put in the pot of an ornamental plant [10], worm manure (40 g) was applied based on the peat dose (100g).

Table 1. Vermicompost analyses and results.

Analyses	Results of Analyses
Organic Matter (%)	56.19
Total N (%)	2.53
Humidity (%)	44.45
pH (1/10)	6.66
EC (1/5, mS/cm)	6.53
Total P (%)	0.47
Total K (%)	1.44
Total Ca (mg kg^{-1})	10177.90
Total Mg (mg kg^{-1})	6219.16
Total Fe (mg kg^{-1})	8517.17
Total Cu (mg kg^{-1})	60.00
Total Zn (mg kg^{-1})	181.82
Total Mn (mg kg^{-1})	351.55

3) Peat

Peat, another material used, has a pH of 6.7, an EC= 1-2 mS/cm and a purity of 95%. The peat material procured from the market is given 100 grams per pot.

4) *Steril water*

The first of the water types, sterile water, was obtained by sterilizing pure water at 121°C, 1.1 atm pressure, in an autoclave device for 30 minutes. Characteristics of sterile water are given in Table 2.

Table 2. Analyses performed in sterile water and results.

Analyses	Results of Analyses
pH (22 °C)	7.47
EC (25°C) (dS m^{-1})	0.01
Na (meq l^{-1})	0.07
K (meq l^{-1})	0.02
Ca (meq l^{-1})	-
Mg (meq l^{-1})	-
Ca + Mg (meq l^{-1})	-
CO_3^{-2} (meq l^{-1})	0.00
HCO_3^- (meq l^{-1})	0.25
Cl (meq l^{-1})	0.15
SO_4^{-2}(meq l^{-1})	-
B (mg l^{-1})	0.00

4) Pure water

Another water used is pure water, and it was obtained from a pure water device belonging to the Microbiology Laboratory at the Faculty of Agriculture, Department of Agrology and Plant Nutrition. Some chemical properties of the analyzed pure water are indicated in Table 3.

Table 3. Pure water analyses and results

Analyses	Results of Analyses
pH (22 °C)	7.47
EC (25°C) (dS m^{-1})	0.01
Na (meq l^{-1})	0.07
K (meq l^{-1})	0.02
Ca (meq l^{-1})	-
Mg (meq l^{-1})	-
Ca^{+2} + Mg^{+2} (meq l^{-1})	-
CO_3^{-2} (meq l^{-1})	0.00
HCO_3^- (meq l^{-1})	0.25
Cl (meq l^{-1})	0.15
SO_4^{-2}(meq l^{-1})	-
B (mg l^{-1})	0.00

5) Mineral water

Mineral water, another diversity of water that is commercially available and widely consumed carbonated water. The ingredients of this water are given in Table 4, that are taken from firm by confirmation.

Table 4. Mineral water analyses and results.

Analyses	Results of Analyses
Colour (pt/co)	absent
Turbidity (SiO_2)	1.0 mg l^{-1}
The amount of oxygen consumed for organic substances	1.1 mg l^{-1}
CATIONS	
Al^{+3}	0.0087 mg l^{-1}
$(NH_4)^+$	<0.05 mg l^{-1}
Ca^{+2}	235.5 mg l^{-1}
Mg^{+2}	108.4 mg l^{-1}
Na	63.01 mg l^{-1}
Fe^{+3}	0.046 mg l^{-1}
N^+	265.2 mg l^{-1}
ANIONS	
$(SO_4)^{-2}$	138.3 mg l^{-1}
F^-	0.46 mg l^{-1}
NO_3^--NO_2^-	- -
Phenolic substances and S	
(SiO_4^{4-})	62.5 mg l^{-1}
Cl^-	25.77 mg l^{-1}
$(PO_4)^{-3}$	1.87 mg l^{-1}
HCO_3^-	1865.38 mg l^{-1}
Total minerals	2767.50 mg l^{-1}

6) Mix water

Mixed water is the water in which all the waters used are mixed in equal volumes (1:1:1:1 pure water:sterile water:tap water:mineral water). Some chemical specifications of the analyzed mixed water are given in Table 5.

Table 5. Mixed water analyses and results.

Analyses	Results of Analyses
pH (22 °C)	7.14
EC (25°C) (dS m^{-1})	0.15
Na (meq l^{-1})	0.06
K (meq l^{-1})	0.02
Ca (meq l^{-1})	0.72
Mg (meq l^{-1})	0.57
Ca^{+2} + Mg^{+2} (meq l^{-1})	1.29
CO_3^{-2} (meq l^{-1})	0.00
HCO_3^- (meq l^{-11})	1.09
Cl^- (meq l^{-1})	0.24
SO_4^{-2}(meq l^{-1})	0.04
B (mg l^{-1})	0.08

7) Pots

The pots used in the experiment were plastic red pots with a depth of 10.5 cm, a ceiling of 9.5 cm, and a base diameter of 6 cm, with a capacity of approximately 500 grams. The study was carried out with a total of 15 pots established with 3 replications in which 5 different types of water were applied to pots containing 100 grams of peat and 40 grams of vermicompost. The pots were placed in the plant growth cabinet in the Plant Physiology Laboratory of the Soil Science and Plant Nutrition

Department. The cabin temperature was recorded as 26-28 °C and the humidity as 40-60% during the experiment. Since 4 plants were grown in each pot and the study included 3 replications, any measured parameter was obtained from the average of 12 plants.

The experiment was established on March 1, 2022, and 50 ml of sterile-pure-tap-mineral and mix were given to the pots once a week or twice when necessary, depending on the water requirement. The experiment was harvested on April 20, 2022, and some parameters were measured before the plant was harvested and some parameters were measured after the harvest in plants that were approximately 50 days old.

III. METHODS

Before harvesting, the number of leaves, the plant height, the distance between the nodes, leaf diameter, stem diameter, flowering rate and chlorophyll content were determined.

The number of leaves in the plant from the pre-harvest analysis: The average number of leaves for a pot was found by counting the leaves on each branch and dividing the total number accomplished by 4 plant height: The length between the soil surface and the tip of the plant in a total of 4 plants in each pot is measured with a ruler with mm division and found in cm. The distance between the nodes in the plant: It was found in cm by measuring the distance between the 1st and 2nd nodes 1 cm above the soil surface with a ruler with mm division. Leaf projection diameter of the plant: It was found as cm by measuring the distance between the rods with two sticks from two opposite leaves on the 2nd node, 1 cm above the soil surface, and measuring with a ruler with mm division. The average leaf projection diameter was resolved by dividing the sum of the numbers acquired by 4 for a pot. Plant stem diameter: The stem diameter between the 1st and 2nd nodes 1 cm above the soil surface was measured in mm with the help of a caliper. The flowering rate (number of juvenile plants-baby leaves) was calculated as the average number of juvenile leaves for a pot by counting the juvenile leaves on all the main leaves of a plant and dividing the sum by 4. These procedures were repeated for the other two pots. The chlorophyll content of the plant leaves was measured with a spadmeter (Konica Minolta-SPAD-502) on 3 leaves of 4 plants in each pot, the spad reading in 3 leaves was divided by 3 and the chlorophyll reading of 1 plant was determined. The procedure was done in the same way for the other two pots. In all procedures, the values measured from 4 plants in each pot were added and divided into 4 to find the average value for a pot. After the harvest on the 50th day of plant development, the fresh-dry weight of the leaf, fresh-dry weight of the stem, and some nutrient content were determined. The fresh weight of leaf was determined by weighing all the leaves separated from the stem one by one, and the fresh weight of stem was determined by weighing of the whole stem in 4 plants on a sensitive scale (± 0.1 g). The leaves and stems, whose fresh weights were determined, were placed in a paper bag and kept in an oven at 70 C until they reached a constant weight and then measured on a sensitive scale (± 0.1 g) and the dry weight of the average plant leaf and stem in 1 pot was determined by dividing the obtained figure by 4.

Furthermore, the leaf and stem of the experiment plant, reached a constant weight in an oven at 70 °C, were ground. Some macro (N, P, K, Ca, Mg, Na) and micro (Fe, Cu, Zn, Mn) nutrient element analyses were determined with an Atomic Absorption Spectrophotometer [11] in the filter obtained by burning the ground samples with sulfuric acid (H_2SO_4) using the wet burning method [12].

pH and EC measurements taken by electrometric, Ca, Mg, CO_3, HCO_3, Cl analysis were taken by titrimetric methods for different water styles. While Na and K measurements taken by flame photometric method, B is obtained by Carmine method. The SO_4 value calculated from cation and anion values [13].

Variance analyzes were performed using MINITAB 16 software on the data of some plant nutrients, which were established in the randomized plots trial design and obtained as a result of the experiment, and the significance controls of the applications were grouped with the DUNCAN test in the MSTAT-C program [14].

IV. RESULT AND DISCUSSION

The results of the effect of different water applications on *the K. daigremontiana* plant with vermicompost on some parameters of the plant are given in Table 6. As it is shown in the table, different types of water given to *the K. daigremontiana* plant together with the vermicompost caused different effects on the different parameters of the plant.

As seen in Table 6, the effects of the treatments on plant height, internode distance, stem dry weight, number of offspring and chlorophyll values from some measurements made on the plant before harvest were statistically significant ($P<0.05$). The effects of applications on the number of leaves, leaf fresh and dry weight, stem fresh weight, leaf projection diameter and stem diameter were not significant ($P<0.01$ and $P<0.05$). The highest values of plant height, internode distance, stem dry weight, number of offspring and chlorophyll in plants irrigated with different water types were obtained from plants irrigated with pure water (18,00 cm-3.77 cm-0.09 g, -18.33

pcs/sheet-47.30 spad reading, respectively). Kalanchoe, a CAM plant, uses water adequately and occasionally. This feature gives it an advantage for dry periods [15], [16], [17]. With its unique mechanism, the plant prevents water loss by reducing the CO_2 intake efficiency in dry periods. The main leaves of the plant send the water in its body to the young leaves when the water shortage begins. Thus, the water content in the young leaves of the plant increases and it is guaranteed to act upon the plant lineage. Giving a large number of offspring of the plant is an important feature for plant and plant breeders. As far as it goes, in all potted plants, outstandingly the offspring feature is consequential in terms of choosing the plant. Considering this feature of Kalanchoe, the highest result in baby leaf number was obtained from pots using pure water, as well as the highest results obtained in other parameters. In this study, the effect of pure water was remarkable in terms of the results collected from plants irrigated with different water. Examinations with vermicompost are extensively about finding the most sufficient compost dose or using it together with a biological fertilizer to increase the efficiency of vermicompost. Whenas, since the amount of vermicompost and peat, was applied equally in this study, the divergence was only dependent on the type of water used. Briefly, the discrepancies in yield and some measurement values in the plant can be absolutely attributed to the different water types.

Recognizing that the main leaves must reach a period of 10-11 months in order to create offspring on the *K. daigremontiana* plant, the rapid formation of baby leaves on the leaves of the two-month-old seedling plant is also an indication that worm manure accelerates the reinforcement of the plant. However, the absence of juvenile leaves in mineral water (0.00) and the presence of almost no juvenile leaves (1.33 in mixed water) again demonstrated that the outcomes of water types on the suitability of vermicompost were different. Some nutritional element values of *the Kalanchoe daigremontiana* plant, which is grown by watering with water of different properties and applied worm manure, are as given in Table 7.

According to the analysis results shown in Table 7, it is seen that the Kalanchoe plant grown in a mixture of vermicompost and peat does not suffer from a nutrient deficiency in any of the different water varieties applications. Notwithstanding, the highest macro and micronutrient values (except Calcium and Sodium) in the plant were obtained from plants treated with pure water. It has been stated that vermicompost enables greenhouse crops to grow and more products to be obtained, and ornamental plants seed and flower more quickly in vermicompost application [18].

Due to the fact that both peat and vermicompost were in equal amounts in the pots, the differences in the nutrient content of the plant gained a value depending on the differences in the water types. As the cationic charges in pure water change with H^+ in the exchanger resins of the pure water device, and the anionic charges change with OH^- in the resin, water that is separated from all its ions is obtained. Therefore, pure water may have dissolved the macro and micronutrients in both vermicompost and peat, making it more easily degradable for the plant to take. As a matter of fact, since pure water does not contain any anions, cations or minerals, it is known that it causes the body to become sluggish by absorbing the minerals and vitamins found in human and animal blood [19]. The same mechanism may have worked in the same way on these substrates, which have an organic structure such as vermicompost and peat, and by this means, pure water may have provided a more compelling conclusion. However, this situation may also cause toxicity in the plant by allowing heavy metals to pass over to the plant.

V. CONCLUSION

According to the results of the study, it can be advocated to use vermicompost and peat as a plant-growing medium, remarkably in terms of feeding pot or terrarium plants, and watering the environment with pure water. Yet, in order to make broader recommendations, the study needs to be tested with distinctive substrates, different water types, and different plants.

Table 6. Duncan's Test of results performed on the pre-harvest Kalanchoe daigremontiana plant.

Types of Water	MEASUREMENTS PERFORMED										
	Number of leaves (number	Plant height (cm)	Distance between the nodes (cm)	Fresh weight of the leaf (g)	Dry weight of the leaf (g)	Fresh weight of the stem (g)	Dry weight of the stem (g)	Leaf projection diameter (cm)	Stem diameter (mm)	Number of offspring (number/ leaf)	Chlorophyll
Pure	11.33	18.00 A	3.77A	2.91	0.08	0.86	0.09A	6.20	2.67	18.33A	47.30A
Sterilized	10.33	16.33A	3.33A B	2.64	0.08	0.66	0.05B	6.07	2.17	7.67B	30.33 B

Fountain	9.33	13.63 A	3.30AB	2.52	0.07	0.50	0.06AB	6.13	2.33	8.00B	34.53AB
Mineral Water	9.33	7.17B	2.13C	1.62	0.05	0.24	0.02B	4.53	1.96	0.00C	29.23 C
Mixture	9.33	12.43AB	2.33BC	2.86	0.06	0.43	0.04B	6.40	2.50	1.33C	30.23 B
Degree of imp.	NS	P< 0.05	P< 0.05	NS	NS	NS	P< 0.05	NS	NS	P< 0.01	P< 0.05
LSD	**-**	**5.616**	**1.047**	**-**	**-**	**-**	**0.04068**	**-**	**-**	**6.249**	**7.390**

NS: Non Significant (P<0.05 or P<0.01)

Table 7. Results of nutrient analysis of the plant Kalanchoe daigremontiana.

Types of Water	**The Analyses Performed**									
	(%)						**mg l^{-1}**			
	N	**P**	**K**	**Ca**	**Mg**	**Na**	**Fe**	**Zn**	**Cu**	**Mn**
Pure	7.58	4.36	5.76	5.48	0.35	0.24	59.44	42.54	22.38	35.48
Sterilized	5.69	1.79	4.76	12.17	0.31	0.13	39.67	37.84	11.15	19.70
Fountain	2.47	1.32	5.57	11.58	0.29	0.09	37.03	41.37	1.64	17.35
Mineral Water	4.65	3.27	4.83	5.00	0.28	0.24	56.78	42.11	10.00	17.67
Mixture	5.64	2.26	5.78	10.47	0.33	0.15	59.07	70.72	1.78	11.20

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