Water Requirement of Blueberry Cultivated in Different Growth Media

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***Abstract*—**Water scarcity is of great concern because this natural resource is critical in primary agriculture worldwide. The anticipated rise in temperature due to climate change will increase the water demand of plants, thereby reducing water availability. The main aim of this study was to investigate the effects of irrigation requirements on blueberry plants cultivated in different growing media. A pot experiment was conducted using a randomized complete block design that was replicated five times. The following growing media were used: coir, mushroom compost, peat moss, and zeolite. The growing medium significantly (P<0.05) affected the irrigation water of blueberry plants. The treatment with 100% coir required the most irrigation replenishment compared with the other treatments. The treatment with 80% coir and 20% zeolite required the least water replenishment. Generally, the vegetative parameters were improved with 60% coir and 40% peat moss. The composition of the growing media can potentially reduce the water requirements of plants.

***Keywords*—** blueberry, water conservation, growth media, production

I. INTRODUCTION

Global warming causes climate fluctuations, limited water resources, and water restrictions for agricultural activities, which compelled producers to invest in crops and different agricultural management practices that are more adapted to the potentially unfriendly future climate [1], [2]. An efficient adaptation to the fluctuating climate of farms at the sector and policy levels is a prerequisite for reducing negative impacts and obtaining possible benefits [3] from land use and land management as well as changes in inputs of water, nutrients, and pesticides [4]. In Western Cape agriculture, water demand is likely to increase in future with the expected increase in temperature and evaporation due to climate change effects [5], [6]. This will, in turn, result in increased irrigation demand for crops. Increased unstable climate change means that there may be a prolonged drought with severe consequences in the future, just as it happened in 2015-2017 [2], [6]. Irrigation volume and water use for the agricultural sector are unlikely to increase because the Department of Water and Sanitation (DWS) has capped agricultural allocations to the current level. In addition, a significant reduction in streamflow was predicted for the western region of South Africa, where several Western Cape water management areas are already water-stressed. Hence, improved water usage and productivity in agriculture is a necessity in order to provide the needed water for the projected increased water demand for human consumption and industrial production by 2030 [7]. To overcome these challenges, conservation practices should be implemented with the adaptation of water management [4], [8]. Blueberries are predominantly cultivated in the northern hemisphere and in some other countries of the Southern Hemisphere, such as Chile, Argentina, Uruguay, South Africa, New Zealand, and Australia [9]. In South Africa, the most widely cultivated cultivars are Rabbit Eye, Northern Highbush, and Southern Highbush. The domestic (South Africa) consumption of fresh blueberries increased in the 2016/2017 market year by 80% (800 tons) from 440 tons in the 2015/2016 market year. This was attributed to the increased demand from health-conscious consumers because of the inherent health benefits of blueberries, such as reduction of high cholesterol levels, protection of the heart, and prevention of cancer, among others [10]. Limitations in the availability of natural resources, such as water and soil, as well as management options, hinder the expansion of production in South Africa [11]. Therefore, it is critical that this research study investigates the agronomic and water conservation practices of blueberry production.

MATERIALS AND METHODS

A. Study Area

The experiment was conducted at the Department of Agriculture, Agricultural Hub, Cape Peninsula University of Technology, Wellington (S 33°37'55.08" E 19°00'37.4") under a tunnel during the 2022/2023 season. The Wellington region is characterized by a Mediterranean climate with cold and wet winters and dry, hot summers. The blueberry plants were

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transplanted onto 45L growing bags that were elevated with bag stands.

B. Experimental Layout and treatment application

The pot experiment was a randomized complete block design (RCBD) with five replications. Four different growth medium combinations with a total of seven treatments were used to evaluate blueberry water use per medium. Three plants per treatment were replicated five times, with a total population of 105 blueberry plants. Pot spacing was 70 cm between pots and 1m between replicates.

The two-year-old Legacy blueberry cultivar was transplanted into different growth media compositions as follows: T1-100% coir, T2- 80% coir + 20% zeolite, T3- 60% coir +40% mushroom compost, T4- 60% coir + 40% peat moss, T5- 40% coir + 20% zeolite + 20% mushroom compost, T6- 40% coir + 20% zeolite + 40% peat moss, T7- 40% coir + 30 mushroom compost + 30% peat moss. The initial media analysis results indicated that all media used were classified as sandy with pH values of 3.8, 4.2, 6.4, 3.3, 6.6, 4.7, and 6.1, respectively. The field capacity (FC) of each composition was obtained prior to transplanting and the replenishment level was set at 75% [12] for each treatment and replenishment measurements outlined in Table I.

TABLE I: TREATMENT WATER REQUIREMENT AT 75% FC

TR	Water application (L) at 75%
T1	4.25
T2	4
T3	4.5
T4	3.7
T5	4.5
T6	4.25
T7	4.5

TR- treatment, T1- 100% coir, T2- 80% coir + 20% zeolite, T3- 60% coir +40% mushroom compost, T4- 60% coir + 40% peat moss, T5- 40% coir + 20% zeolite + 20% mushroom compost, T6- 40% coir + 20% zeolite + 40% peat moss, T7- 40% coir + 30 mushroom compost + 30% peat moss; FC – field capacity, L- liters.

C. Data collection

Data collection on the different treatments water usage (L), number of leaves and number of branches, and plant height (cm) were recorded over a period of fourteen weeks after transplanting during the growing season of 2022/2023. The electrical conductivity (EC) for monitoring the salinity of the media and pH was recorded weekly after transplanting [14]. Data collection on water usage of each treatment was recorded using DFM [15] moisture probes on a daily basis and application was done as per FC replenishment requirement. The probe readings are taken from three depths 10 cm (topsoil), 20 cm (root zone), and 30 cm (buffer zone) [16]. Readings were taken from 13:00-15:00 pm, which is when plants are relatively stable in terms of water flux and water status for approximately an hour or two after solar noon [13]. Vegetative data was collected twice a month during the active growing season of 2022/2023.

Cultivation practices such as weeding were performed manually, and ammonium sulphate fertilizer was applied uniformly on all treatments.

D. Statistical analysis

Analysis of variance ANOVA at 95% confidence limit and comparison of means was carried out on parameters measured. Analysis of data of the plant data collected using IBM SPSS Statistics 22.0. Means separation was done using Fisher`s Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Influence of growth media on water requirement and vegetative growth of blueberry.

TABLE II: EFFECT OF THE DIFFERENT GROWTH MEDIA COMPOSITION ON WATER REQUIREMENT AND VEGETATIVE GROWTH OF BLUEBERRY

TR	WA (L)	NL	NB	PH (cm)
T1	2.26 (±1.57) ^{a}	121.69 (±70.67) ^{d}	3.53 (±0.83) ^{c}	56.68 (±19.79) ^{b}
T2	1.04 (±1.27) ^{c}	298.67 (±216.88) ^{ab}	4.33 (±1.73) ^{b}	48.28 (±12.34) ^{c}
T3	1.18 (±1.59) ^{bc}	304.47 (±222.82) ^{ab}	4.30 (±1.53) ^{b}	49.23 (±12.96) ^{c}
T4	1.67 (±1.47) ^{b}	318.26 (220.51) ^{a}	5.26 (±2.64) ^{a}	63.74 (±21.09) ^{a}
T5	1.19 (±1.54) ^{bc}	195.83 (140.12) ^{c}	3.53 (±1.18) ^{c}	42.79 (±10.73) ^{d}
T6	1.12 (±1.16) ^{bc}	251.93 (±184.20) ^{bc}	3.87 (±1.75) ^{bc}	44.25 (±9.34) ^{cd}
T7	1.18 (±1.65) ^{bc}	214.87 (±171.23) ^{c}	4.47 (±2.69) ^{b}	49.61 (±15.99) ^{d}
LSD	0.51	0.11	0.84	0.67

Means in the same column with the same superscript are not significantly different (P>0.05). P – probability value, LSD- lease significant difference, T1- 100% coir, T2- 80% coir + 20% zeolite, T3- 60% coir +40% mushroom compost, T4- 60% coir + 40% peat moss, T5- 40% coir + 20% zeolite + 20% mushroom compost, T6- 40% coir + 20% zeolite + 40% peat moss, T7- 40% coir + 30 mushroom compost + 30% peat moss; TR- treatment, WA- water application, L- liters, NL- number of leaves, NB- number of branches, PH- plant height, cm- centimeters.

The different media compositions influenced all measured parameters (Table II). Treatment 1, comprising 100% coir, required the highest water replenishment compared with all other treatments. This is related to the physical properties of the media in relation to the particle size distribution and water-holding capacity [17]. Further findings from the previous studies show that coir has the largest air spaces with less capability to retain water. These findings are in agreement with those of [18]. In contrast, [19] found that coir incorporated into the soil has the potential to conserve soil moisture. It was also observed that all treatments with mushroom compost required the highest water replenishment quantities (Table I), however, the frequency of application was reduced compared to the other treatments. Treatment 2, with 80% coir and 20% zeolite required less water replenishment, even though it was not significantly different from treatments 3, 5, 6, and 7. Sindesi [20], concluded that zeolite has the potential to reduce water demand on plants as it has high water-holding capacity. Zeolite has been identified as a mineral that greatly improves soil properties such as cation exchange capacity, saturated hydraulic conductivity, and water-holding capacity [21]. The composition of coir and zeolite increased water-holding capacity. The results show that 2.26 L of water per plant per day is required for treatment 1, a similar requirement was outlined by Fang [17], under a controlled environment where it ranged from 1.32 – 2.64 L per day. It is critical that blueberry plants do not experience prolonged moisture stress conditions as this results in stomatal closure and, therefore, reduces the overall productivity of the plant [22]. Hence, in this study the moisture levels of each treatment were monitored and only replenished to 100% as outlined in Table I. Blueberry plants are characterized as having shallow, fine, and fibrous root systems of approximately 30 cm, therefore the effective absorption potential is restricted [16, 23].

Treatment 4 obtained the highest number of leaves, but the difference was not significant from treatments 2 and 3. These findings are in contrast to those of [24], the study concluded that the composition of coir and peat moss gave less growth and yield compared to coir as an exclusively growing medium. According to [25], the number of leaves in plants increases their photosynthetic products, increasing biomass, and is a good indicator of healthy plants.

The composition of 80% coir and 20% peat moss significantly increased the number of branches and plant height compared with all other treatments (Table II). Similar results were obtained in a study conducted by [18], where coir improved all the vegetative parameters of the northern highbush cultivar. The highest plant height of 63.75 cm was obtained from treatment 4. However, in a study conducted by [26], 53.90 cm was the maximum plant height of the cultivar Legacy.

A pH of more than 5.5 can negatively affect the growth parameters of blueberry plants as they thrive well in acidic soils [27]. The growing media analysis results from the current study showed that treatments 3, 5, and 7 had media pH values greater than 5.5, which could have restricted all the growth parameters.

Influence of time on water application and vegetative parameters.

The water requirement for all treatments increased steadily at the beginning of the growing season and a significant decrease in water supply was observed between 105-119 and 175-189 days after transplanting (Fig. 1). A drastic increase in water application was observed between 198 and 203 days after transplanting. This could be associated with the increased temperatures during the active growing season. Reference [23], concluded that the water requirement of blueberry plants is influenced by various factors such as plant size, plant spacing, developmental stage, and climatic conditions. The water requirement of the cultivar Legacy in a study conducted by Ortiz-Delvasto [24], was 4 L/hour for 5 minutes during the active growing season and was later reduced to 2 minutes.

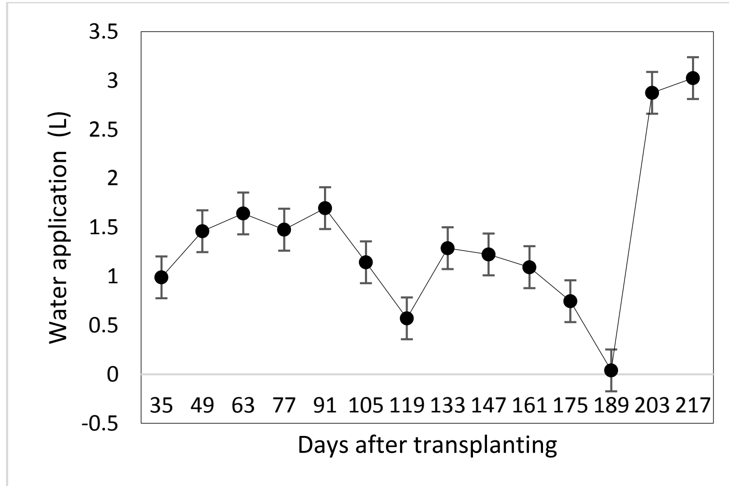

Fig. 1: Water application on all treatments over time.

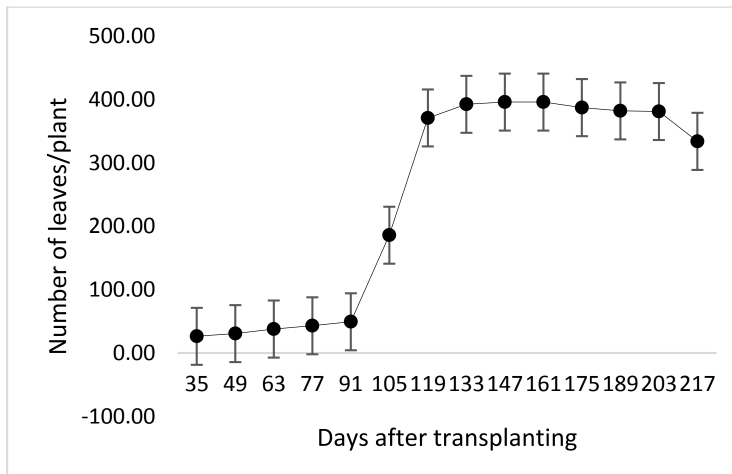

Fig. 2: Effect of time on the number of leaves of blueberry plants.

During the initial growth stages after transplanting no significant changes in the number of leaves were observed 35 – 91 days after transplanting (Fig. 2). This could have been due to the stabilization of plants after transplanting and the plants were then stabilized. There was an exponential increase in the number of leaves at 105 days after transplanting, this was the end of January. The decrease in the number of leaves towards the end of the growing season is a result of leaf drop due to seasonal changes, under the Mediterranean climate.

The number of branches and plant height increased steadily over time (Fig. 3 & 4). The highest number of branches was obtained between 119 to 147 days after transplanting. The maximum plant height across all treatments was recorded at 217 days after transplanting.

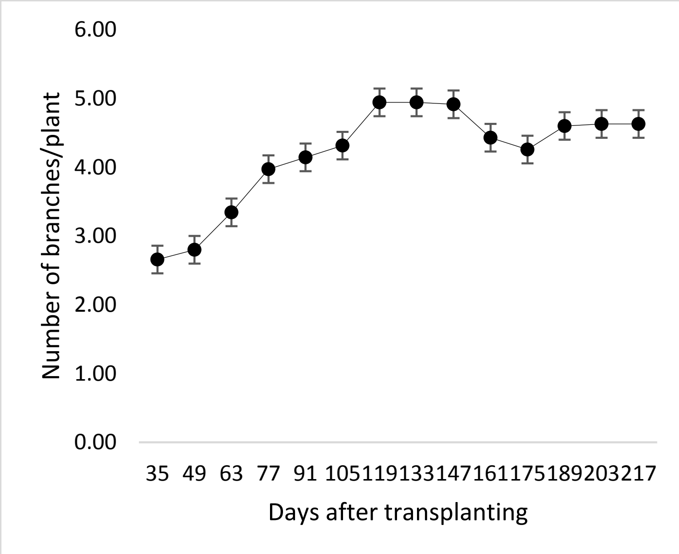

Fig. 3: Effect of time on the number of branches of blueberry plants.

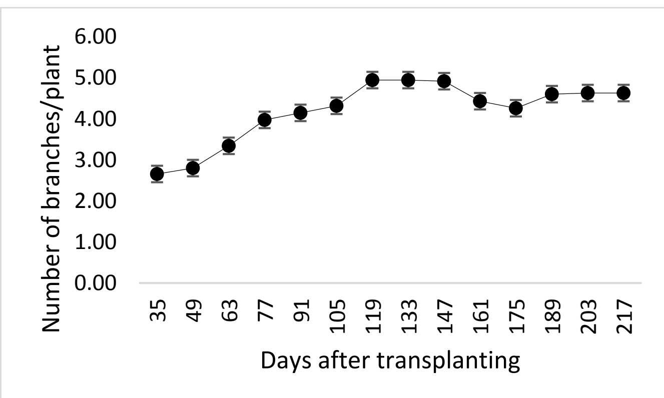

Fig. 4: Effect of time on plant height of blueberry plants.

CONCLUSION

The field capacity of any growing media is critical for water conservation. The findings from this study showed that the use of growing media in combination significantly reduced water usage and increased the water-holding capacity of the media by up to 54% when coir was exclusively used. The combination of coir and zeolite required the least water replenishment compared with the other treatments. Generally, the results showed that the media composition with 60% coir and 40% peat moss increased all vegetative parameters measured. Further research is required to determine the annual water requirements of blueberry plants under South African climatic conditions and the frequency of water application.

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DATA AVAILABILITY STATEMENT

The data presented in this research study will be made available online upon request.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

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