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Effects of Different Media and Cultivars on the Vegetative Growth of Tomato (*Solanum lycopersicum* L.) Grown in Hydroponics

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Abstract: In the Kingdom of Eswatini tomato is a very important crop used in stews, soups, sauces and salads. However, its production is low because it is produced only in the summer season using determinate cultivars. The objective of the study was to determine the effects of different growing media on the growth, yield and quality of indeterminate tomato cultivars grown in tunnel hydroponics production system. The study was conducted in a growing tunnel located at Mphaphati area, Lubombo Region in the Lowveld of the Kingdom of Eswatini. The experiment was laid out in a Randomized Complete Block Design with split plot arrangement replicated four times. Four growing media (sawdust, vermiculite, sand and soil) were used as main plots. The sub-plots were allocated to four indeterminate tomato cultivars Esty, Heidi, Inga and Jasmine. The results showed that there were significant ($P < 0.05$) differences in the vegetative growth of tomato among the different cultivars grown in the different media. The tallest plants (172.1 cm) were obtained in cultivar Esty grown in sawdust and the highest number of leaves (20.2) were obtained in cultivar Esty grown in sawdust while the shortest plants and leaves number were obtained in cultivar Jasmine grown in soil. The highest stem diameter (1.5 cm) was obtained in cultivar Jasmine grown in sand. It is therefore recommended, that farmers could use tomato cultivar Esty grown in sawdust for highest vegetative growth of tomatoes in hydroponics tunnels in the Lowveld of Eswatini.

Key words: Hydroponics · Indeterminate · Media · Tomato · Tunnel · Vegetative Growth

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is a member of the Solanaceae family, which includes chilli peppers, bell peppers, eggplant, Irish potato and tobacco [1]. It originated from Central America but its first cultivation was in Mexico [2, 3]. They were thought to be toxic to humans and therefore used for decorative purpose [4]. They are a good source of ascorbic acid, lycopene and β carotene [5]. Tomato is a commonly grown high value vegetable crop that can add diversity to small scale and part time farming operations [6, 7]. It is one of the most consumed vegetable and it is a major source of vitamins and minerals [8]. Tomato is the most important fruit vegetable with the highest production worldwide [9, 10].

Vegetable production in Eswatini is seasonal and farmers produce maize in summer and vegetables in winter. Growing of plants in soil is unpredictable due to changing temperatures, moisture holding capacity, availability of nutrients, root aeration, diseases and pest problems [11]. In Eswatini, there is diverse climatic conditions and soil types. There is a wide range of challenges, such as variations in temperature, water holding capacity, cation exchange capacity (CEC), soils contaminated with heavy metals, available nutrient supply, proper root aeration as well as disease and insect pest control. Soilless production may alleviate some of these problems, while giving the farmer better control over plant growth and development [11]. Soilless production of vegetables, as compared with traditional field and greenhouse production in soil, allows the efficient use of water and nutrients by the crop. The growing of plants without soil is called hydroponics, it can also be defined as the science of growing plants using a solution of

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suitable nutrients instead of soil [11, 12]. However, this method requires other planting media such as gravel, sand, coconut fiber, a substance silicate, broken rock or reef, pieces of wood and foam [12]. In soilless production system, many types of growing media or substrates such as rockwool, perlite, vermiculite and peat have been used to grow many kinds of crops [13]. Vermicompost increased seed germination and growth of tomato and pepper in greenhouse condition [14]. Potting mixes or artificial substrates like peat, bark, vermiculite, rockwool and perlite, etc., have advantages such as disease and weed-free, light in weight, quicker growth and higher yields; so, tomato yields have increased three times more in the last thirty years, mainly due to mono-cropping systems and growing out of the soil [15]. Vegetable production under protected systems, greenhouses, shade houses and hydroponics allow cultivation in regions inappropriate for conventional agriculture by efficiently using natural resources particularly water and soil [7]. The main attraction of hydroponics is that, it does not demand any fertile soil for the production of crops [16].

Tomato production has increased in other countries where indeterminate tomato varieties are grown in tunnels. It is one of the most commonly grown fresh vegetable and widely grown in high tunnels [17]. High tunnels used for growing horticulture crops commercially are 6-9 metres wide and 30-60 m in length with a height of 3-5 m at the centre [18]. High tunnels are hoop house-like structures that are situated over several planting rows and allow for ease of access for growers and equipment [19]. High tunnels are an excellent method to produce high quality organic fruits and vegetables [20].

Therefore, the objective of the study was to determine the effects of different growing media on the growth of indeterminate tomato varieties grown in tunnel hydroponics production system in Eswatini.

MATERIALS AND METHODS

Experimental Site: The study was conducted in a plastic tunnel measuring; 20 m length and 10 m width with a height of 4.5 m at the center from 02 June 2017 to 09 November 2017. The site is located at Mphaphati, Lubombo Region in the Lowveld agro-ecological zone in the Kingdom of Eswatini. Mphaphati is 26° 40’ 35.51”S and 31°’32’ 46.63”E (Figure 2) at 294 m above sea level. The annual mean temperature range from 16.7°C to 25.8°C, with mean daily maximum and mean daily minimum temperature at 30°C and 11°C, respectively [21].

Experimental Design: The experiment was laid out in a Randomized Complete Block Design with split plot arrangement replicated four times. Four growing media (sawdust, vermiculite, sand and soil) were used as main plots. The sub-plots were allocated to four indeterminate tomato cultivars Esty, Heidi, Inga and Jasmine. The description of the treatments are shown in Table 1. Bags were placed as double rows at a distance of 50 cm between bags of the double row and 100 cm between double rows, with an intra-row spacing of 50 cm.

Plant Materials: Tomato seeds of four indeterminate salad tomato namely Inga, Jasmine, Heidi and Esty were obtained from Swaziland Agricultural Supplies, Manzini, Eswatini. The cultivars were supplied by Sakata’s Breeding Program/ Sakata Seed Southern Africa (Pty) Ltd. The seeds were germinated in seed trays using seedling mix and transplanted four weeks after germination into 5 kg black planting bags filled with the different growing medium. The seedlings were transplanted to the different treatments as described in Table 1.

Data Collection: There were five plants per treatment in each replication, three plants were used for data collection. The data collected included: plant height, stem diameter and number of leaves. The plant height of the sample plants was measured and recorded three weeks after transplanting and thereafter on a fortnightly basis until the plants were nine weeks after transplanting. It was measured from the plant stem crown to the growing point of the plant. A calibrated stick was used to measure the height. The stem diameter was measured 20 cm below the growing point of the main stem using a Vernier calliper (Premier Farnell, Leeds, UK). The stem diameter was measured from the third week after transplanting and thereafter on a fortnightly basis until week nine after transplanting. The number of leaves were counted from the third week after transplanting from the sample plants and thereafter on a fortnightly basis until week nine after transplanting. The average number of leaves were calculated.

Data Analysis: Data collected were subjected to analysis of variance (ANOVA) using the statistical package Genstat 3rd Ed [22]. Means where the F-test showed significant differences ($P < 0.05$) were separated using the Duncan’s New Multiple Range Test (DNMRT) at 5% level of significance [23].

Fig. 1: Tomato plants grown in a plastic tunnels at 3 weeks after transplanting

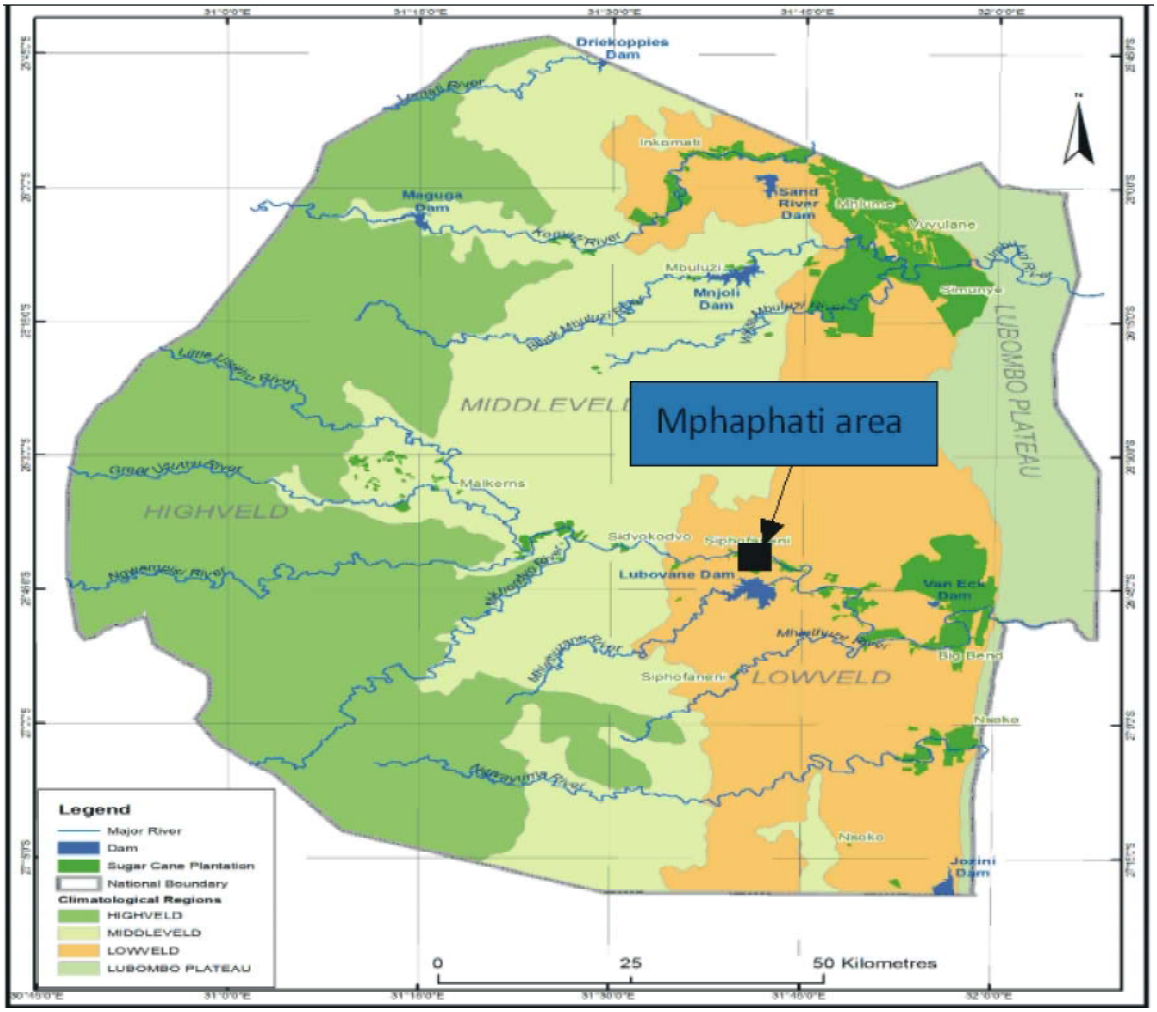

Fig. 2: Map showing location of the experimental area, Mphaphati in Eswatini

Table 1: Description of the treatments

Treatment code	Type of treatment
1	Esty in Sand
2	Esty in vermiculite
3	Esty in sawdust
4	Esty in soil
5	Inga in sand
6	Inga in vermiculite
7	Inga in sawdust
8	Inga in soil
9	Jasmine in sand
10	Jasmine in vermiculite
11	Jasmine in sawdust
12	Jasmine in soil
13	Heidi in sand
14	Heidi in vermiculite
15	Heidi in sawdust
16	Heidi in soil

RESULTS AND DISCUSSION

Plant Height: There were significant ($P < 0.05$) differences in the plant height of tomato cultivars grown in the different media. At 9 weeks after transplanting (WAT) the tallest plants (172.08 cm) was attained in Esty grown in sawdust while the shortest (145.22 cm) plants were obtained in Jasmine grown in soil (Table 2). There were no significant ($P > 0.05$) differences in the plant height of cultivars Jasmine, Inga and Heidi grown in sand. The tallest plants (167.58 cm) were obtained in cultivar Esty while the shortest plants (154.22 cm) were obtained in Jasmine (Table 2). In vermiculite, the tallest plants (170.90 cm) were obtained in cultivar Esty while the shortest plants (156.00 cm) were obtained in cultivar Jasmine. Cultivar Esty archived the tallest plants (170.08 cm) when compared to the other cultivars grown in sawdust while the shortest plant (151.07 cm) were obtained in cultivar Jasmine. The tallest plants (162.53 cm) were recorded in cultivar Esty while the shortest plants (145.22 cm) were obtained in cultivar Jasmine in plants grown in the soil (Table 2).

The higher plant heights obtained from tomato grown in sawdust and vermiculite in the experiment could be attributed probably to better physical environment in terms of nutrient holding capacity and aeration which enhanced root and shoot growth [11]. Vermiculite and cocopeat provides adequate nutrients and enhances both the physical and biological properties and the water holding capacity of soil [24]. Organic matter contents of the planting medium have a profound effect on its biological, chemical and physical properties due to the availability of chemical elements upon decomposition [25, 26]. The relatively higher plant heights observed in tomato grown in sawdust compared to sand and soil can be accredited to the same attributes. It was previously reported that tallest gladiolus plants were obtained in sawdust grown plants when compared to vermiculite, sand and soil [27]. Wild okra (*Corchorus olitorius*) grown in sand were taller when compared to plants grown in soil [28]. Similarly, the plant height of tomatoes grown in vermiculite was higher than in sand [29]. Tomato transplants grown in sand were taller than plants grown in soil [30].

Stem Diameter: The tomato stem diameter was significantly ($P < 0.05$) different among the cultivars grown in the different media. At 9 WAT cultivar Jasmine grown in sawdust gave the highest stem diameter (1.52 cm) while the lowest stem diameter (1.03 cm) was obtained in cultivar Esty grown in soil (Table 3). In sand, the highest stem diameter (1.25 cm) was obtained in cultivar Jasmine and the lowest stem diameter (1.05 cm) was obtained in Heidi. In vermiculite, the highest stem diameter (1.44 cm) was achieved in cultivar Jasmine and the lowest stem diameter (1.30 cm) was obtained in cultivar Esty (Table 3). Cultivar Jasmine gave the highest stem diameter (1.52 cm) compared to the other cultivars when grown in sawdust while cultivar Esty gave the least stem diameter (1.36 cm). In soil, the highest stem diameter (1.31 cm) was obtained in cultivar Jasmine and the lowest stem diameter (1.03 cm) was obtained in cultivar Esty (Table 3).

Plants grown in sawdust exhibited the highest stem diameter while plants grown in soil had the lowest stem diameter. Cultivar Jasmine gave the highest stem diameter. At 9 WAT cultivar Jasmine grown in sawdust gave the highest stem diameter (1.52 cm) while the lowest stem diameter (1.03 cm) was obtained in cultivar Esty grown in soil (Table 3). The highest stem diameter in the study was obtained in plants grown in sawdust followed by plants grown in vermiculite, sand and finally soil. Growing media containing organic matter like coco peat can stimulate root growth and provide high water holding capacity [11, 24]. The high stem diameter observed in tomato grown in sawdust compared to sand and soil can be attributed to the same attributes. The highest stem diameter of sweet pepper transplants were obtained in sand when compared with stem diameter of plants grown in soil [30]. In addition, the lowest stem diameter was obtained in tomato plants grown in soil [31]. Stem diameter of jute mallow was higher in plants grown in sand than plants grown in soil [28].

Table 2: Effects of different growing media and different cultivars on the plant height (cm) of tomato plants

		Weeks after transplanting			
Growing media	Cultivar	3	5	7	9
Sand	Esty	40.72 abcd	78.40 abcd	126.45 cdef	167.58 def
	Heidi	37.62 abc	77.28 abc	123.67 bcdef	160.42 bcdef
	Inga	36.77 abc	70.76 a	113.03 a	153.90 abc
	Jasmine	37.15 abc	72.67 a	115.00 ab	154.22 abc
Vermiculite	Esty	43.30 bcd	85.90 d	132.28 f	170.90 ef
	Heidi	39.60 abcd	78.45 abcd	132.12 f	166.92 cdef
	Inga	38.55 abc	77.85 abc	119.00 abcd	160.18 bcdef
	Jasmine	34.87 a	75.12 abc	117.05 abc	156.00 abcd
Sawdust	Esty	43.77 cd	83.30 cd	129.90 ef	172.08 f
	Heidi	44.75 abcd	84.83 cd	128.85 bcdef	166.4 cdef
	Inga	46.25 d	83.15 cd	123.03 bcdef	159.78 bcdef
	Jasmine	37.48 abcd	75.25 abcd	114.90 abcd	151.07 abcd
Soil	Esty	41.85 abcd	81.20 bcd	126.90 def	162.53 bcdef
	Heidi	38.07 abc	76.93 abc	121.08 abcde	158.10 bcde
	Inga	41.22 abcd	78.75 abcd	119.15 abcd	152.40 ab
	Jasmine	36.17 ab	73.07 ab	113.25 a	145.22 a

Mean values within the same column followed by the same letter are not significantly different from each other at $P \leq 0.05$. Mean separation by DNMRT.

Table 3: Effects of different media and different cultivars on the stem diameter (cm) of tomato plants.

		Weeks after transplanting			
Growing media	Cultivar	3	5	7	9
Sand	Esty	0.53 abcd	0.91 abc	0.98 a	1.06 a
	Heidi	0.50 abc	0.89 ab	0.98 a	1.05 a
	Inga	0.47 a	0.85 a	1.05 abc	1.19 bc
	Jasmine	0.60 bcde	1.00 bcd	1.10 bcd	1.25 cd
Vermiculite	Esty	0.60 bcde	1.02 cd	1.11 bcd	1.25 cd
	Heidi	0.512 abc	1.015 bcd	1.18 def	1.30 cde
	Inga	0.61 cdef	1.07 de	1.23 efg	1.43 fg
	Jasmine	0.63 def	1.19 ef	1.25 fg	1.44 fg
Sawdust	Esty	0.77 g	1.17 ef	1.26 fg	1.36 ef
	Heidi	0.69 efg	1.19 ef	1.32 gh	1.42 fg
	Inga	0.70 efg	1.26 f	1.38 h	1.38 ef
	Jasmine	0.72 fg	1.22 f	1.31 gh	1.52 g
Soil	Esty	0.51 abcd	0.89 ab	0.94 a	1.03 a
	Heidi	0.49 ab	0.93 abcd	1.01 ab	1.12 ab
	Inga	0.60 bcde	1.00 bcd	1.13 cde	1.23 cd
	Jasmine	0.67 efg	1.15 ef	1.23 efg	1.31 de

Mean values within the same column followed by the same letter are not significantly different from each other at $P \leq 0.05$. Mean separation by DNMRT

Number of Leaves: There were significant ($P < 0.05$) differences in the number of leaves of tomato cultivars grown using different media. At 9 WAT the highest number of leaves (20.22) was recorded in cultivar Esty grown in sawdust while the least number of leaves (16.18) was obtained in Jasmine grown in soil (Table 4). In sand, the highest number of leaves (18.93 was obtained in cultivar Esty while cultivar Heidi gave the lowest number of leaves (17.32) but were not significantly ($P > 0.05$) different (Table 4). The highest number of leaves (19.75) in vermiculite was attained in Esty compared to the other cultivars with Jasmine giving the least (18.60) number of leaves but they did not significantly ($P > 0.05$) differ (Table 4). Esty gave the highest number of leaves (20.22) compared to the other cultivars when grown in sawdust while Jasmine obtained the lowest number of leaves (17.68). In soil, the highest number of leaves (18.07) was obtained in cultivar Esty and the lowest number of leaves (16.18) was obtained in cultivar Jasmine (Table 4). Plants grown in vermiculite produced the highest number of leaves while the lowest number of leaves was obtained in soil. High water holding capacity and high nutrient retention capacity induced higher vegetative growth in hydroponics culture [11]. The highest number of leaves

Table 4: Effects of different media and different cultivars on the number of leaves of tomato plants

		Weeks after transplanting			
Growing media	Cultivar	3	5	7	9
Sand	Esty	7.68 ab	9.59 abcde	13.92 abcd	18.93 abcd
	Heidi	7.25 ab	8.83 cde	13.82 abcd	17.32 def
	Inga	6.83 b	8.92 cde	14.02 abc	18.33 bcde
	Jasmine	7.65 ab	9.08 cde	13.33 abcde	18.75 abcde
Vermiculite	Esty	8.35 a	10.49 a	14.82 a	19.75 ab
	Heidi	8.08 a	10.17 ab	14.00 abc	19.40 ab
	Inga	7.65 ab	10.16 ab	13.92 abcd	18.85 abcd
	Jasmine	7.25 ab	9.75 abc	12.55 cde	18.60 abcde
Sawdust	Esty	7.65 ab	9.58 abcde	14.43 ab	20.22 a
	Heidi	8.28 a	9.42 bcde	13.25 bcde	18.85 abcd
	Inga	7.78 ab	9.67 abcd	13.77 abcd	19.25 abc
	Jasmine	7.83 ab	9.08 cde	11.93 e	17.68 cdef
Soil	Esty	7.58 ab	9.00 cde	13.43 abcde	18.07 bcde
	Heidi	7.50 ab	8.58 ab	13.25 bcde	17.30 def
	Inga	7.35 ab	9.00 cde	13.35 abcde	17.15 ef
	Jasmine	7.35 ab	8.50 e	12.43 de	16.18 f

Mean values within the same column followed by the same letter are not significantly different from each other at $P \leq 0.05$. Mean separation by DNMRT

observed in tomato grown in vermiculite and sawdust in this investigation could be attributed to higher vegetative growth as a result of high water holding capacity and high nutrient retention capacity. Vermicompost improves mineral nutrition [26]

The highest number of leaves among the different cultivars was obtained in Esty and the lowest in Jasmine. At 9 WAT, the highest number of leaves was recorded in cultivar Esty grown in sawdust while the least number of leaves was obtained in Jasmine grown in soil. Number of jute mallow leaves were higher in plants grown in sand than plants grown in soil [28].

CONCLUSION

The results of this study revealed that different tomato cultivars responded differently when grown in different growing media on vegetative growth. The highest plant height, number of leaves was obtained in cultivar Esty grown in sawdust while the lowest number of leaves and plant height was obtained in cultivar Jasmine grown in soil. The highest stem diameter was obtained in cultivar Jasmine grown in sawdust. Based on these results it can be concluded that the use of tomato cultivar Esty and sawdust medium for tunnel hydroponics production of tomato can therefore increase vegetative growth of tomatoes. Research should also be carried out in the other agro-ecological zones of Eswatini to validate the results obtained in this study.

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