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Effect of Different Substrates on Vegetative Growth Characters of Tomato (*Solanum lycopersicum*)

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Abstract:- Pot experiment was carried out twice to evaluate vegetative growth characters of tomato grown in different substrates and to find out the most suitable substrates as a tomato growing medium during November 2018 to January 2020. Both experiments were laid out in randomized complete block (RCB) design with three replications. Substrates used were; Sand (T_1), Rice husk (T_2), Burnt rice husk (T_3), Biochar (T_4), Biochar: Sand, 1:1 (T_5), Biochar: Rice husk, 1:1 (T_6) and Biochar: Burnt rice husk, 1:1 (T_7). The tomato variety used was Sinkhayanchin - 2. In both seasons, there was no significant effect of substrates on plant height. However, number of leaf and stem diameter were influenced by the substrates. Among the substrates, sand gave the highest stem diameter which is vital for the subsequent crop growth. Maximum shoot fresh weight, shoot dry weight, root fresh weight and dry weight were also recorded from sand and the substrates containing biochar. According to the results, sand and substrates containing biochar are good component for the vegetative growth characters of tomato.

Keywords: *Soilless culture, tomato, substrates, growth*

I. INTRODUCTION

In many countries, there is a substantial use of soilless farming which is important for environmental conservation. Soilless culture is a method of modern plant cultivation that utilizes either inert organic or inorganic substrate and supplies it with nutrient solutions. Due to that, the choice of growing substrates is important for both the growth and yield of crops grown under soilless culture. A good growing medium gives the plant enough anchoring or support while also acting as a reservoir for nutrients and water, allowing oxygen to pass to the roots, and allowing gaseous exchange between the roots and the atmosphere outside the root substrate. Additionally, a suitable substrate should be sterile and chemically inert, have sufficient mechanical properties, high porosity, the ability to transmit stable levels of oxygen and water for activity, low soluble salt content, and a pH range of 5.0 to 6.5 (Yeager et al., 2007). However, different substrates have various materials and structure which could have direct and/or indirect effects on plant growth and development (Gutierrez et al. 2012).

In vegetable production, a soilless culture system can improve water use efficiency as well as water and fertilizer management. The most used growing media in soilless cultivation are rock wool, coconut fiber, perlite, volcanic tuff, sand and peat. Replacing soil with other growing media for vegetable crops especially cucumber, pepper, tomatoes etc. resulted in the better management of plant nutrition and elimination of plant diseases that are caused by soil (Olympios,1995).

Tomato is the second most widely grown vegetable crop in the world after potato (FAOSTAT, 2004). It is an economically important vegetable with an estimated global production of over 5 million ha in area with the yield of about 187 million metric tons (FAOSTAT, 2020). In Myanmar, it is one of the most profitable crops for growers. It is generally grown in winter season, planting in October/ November and harvesting from January to March (DAP 2011).The total sown area of tomato was about 98,000 ha and its average yield was about 11.69 MT/ha (MOALI, 2021).

Nowadays in Myanmar, climate change decreases the crop growth and yield, and poses crop damage due to increasing pest and disease incidence. The situation causes the increasing use of agrochemicals and pesticides which again presents chemical residues on the farm products which often cause health hazards. On the other hand, due to the limited water resource, higher fertilizer prices, and environmental pollution, the importance of closed soilless cultures systems is more and more recognized (Holmer et al., 2013).Soilless culture system is designed to solve quality issues of agricultural products and offer off-season production. There is a limited literature in tomato production by using different substrates in Myanmar. Therefore, this study was carried out to evaluate the vegetative growth characters of tomato grown in different substrates and to find out the most suitable substrates for tomato of the early growth stage.

II. MATERIALS AND METHODS

The pot experiment was carried out twice during November 2018 to January 2020 at Horticulture section, Department of Agricultural Research (DAR), Yezin, Myanmar, by using randomized complete block (RCB) design with three replications. There were seven different substrates used as treatments in both seasons which are Sand (T_1), Rice husk (T_2), Burnt rice husk (T_3), Biochar (T_4), Biochar: Sand 1:1 v/v (T_5), Biochar: Rice husk 1:1 v/v (T_6) and Biochar: Burnt rice husk 1:1 v/v (T_7). The tomato

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variety used was Sinkhayanchin -2; a semi-indeterminate tomato with bright red elliptical fruit shape.

A. Preparation of growing media and polyethylene bag

To obtain the required mixture of substrates, biochar was hand-mixed with sand, rice husk and burnt rice husk at the ratio of 1:1 v/v. Polyethylene bags (7 x 14 cm) were filled with the substrates for the growing of tomato. The volume of the substrate was 1.08 dm^3. Plastic bags were spaced at 60cm x 60cm.

B. Preparation of Tomato Seedlings

Tomato seeds were pre-germinated and the seedlings with cotyledons visible above the medium surface were sown in plastic trays (70 - cells). Seedling trays were placed under a net shade to protect from extreme sunlight, pest and diseases. They were watered two times daily and organic pesticides were applied as necessary.

C. Transplanting

Thirty - day old tomato seedlings were transplanted individually into each polyethylene bags which were earlier laid out in the net house. Each experiment unit contains ten plants.

D. Care and Management of tomato

Weeding was done manually as necessary. Drip irrigation was supplied two to five times a day with a standard nutrient solution. To maintain the temperature around 32℃ and relative humidity around 85% inside the net house, mist irrigation was applied four times daily at 10am, 11am, 2pm, and 3pm.

E. Training and Pruning

Tomatoes were trained as single stem and the plants were staked using nylon rope. Side shoots were continuously removed.

F. Data Collection

Data were collected from ten plants with one week interval starting from transplanting to first harvesting. The growth parameters recorded weekly were plant height (cm), number of leaves per main stem, stem diameter (mm) and days to flower initiation. At the time of harvest, root and shoot fresh weight, root and shoot dry weight were collected.

G. Statistical analysis

The collected data were statistically analyzed by using Statistix version 8 and the treatment means data were compared by using Least Significant Difference (LSD) test at values of 5% (0.05) level.

III. RESULTS AND DISCUSSION

A. Plant height (cm)

The vegetative growth characters of potted tomato as affected by different substrates are presented in (Figure 1A and 1B). Plant height is an important physiological measurement that indicates plant responses to stress and overall health. Mean value of plant height varied among the substrates, but there was no significant difference among the treatments in both seasons. In all substrates, plant height increased substantially from 14 days after transplanting to first harvesting. The tallest plant height (94.67 cm) was observed in the mixture of biochar and sand; however, the shortest plant height (82.78 cm) was observed from burnt rice husk at 63 DAT, in season 1. Similarly, the tallest plant height (99.42) was observed from the same treatment whereas the shortest plant height (82.03) was observed from rice husk substrate at 77 DAT in season 2. It is assumed that biochar amendments in sand substrates may have a positive impact on plant growth, enhanced nutrient and water retention, aeration and improved container physical and chemical properties.Similar results were also found with Ghehsareh et al. (2011) who observed the non-significant differences in plant height of tomato grown in different substrates such as perlite, pumice, zeolite, cocopeat, and sawdust.

B. Leaf number per plant (no.)

Leaves are the primary carbon sources for photosynthesis. Carbon partitioning and allocation are related to plant growth because carbohydrate export from leaves provides the substrate for the growth and maintenance of non-photosynthetic tissues. These resultsindicated that the number of leaves varied with the use of different substrates depending on the growing season (Figure 2A and 2B). In seasons 1, number of leaves per main stem was not significantly different among the substrates. At 63 DAT, the maximum mean value of leaves number (16.96) was found in the mixture of biochar and sand substrate whereas the minimum leaves number (12.53) was found in burnt rice husk substrate. In season 2, number of leaves per main stem was significantly different among the substrate treatments at 42 DAT and 49 DAT. The maximum leaf number per plant in the main stem (16.27) was recorded in sand substrate where the minimum leaves number per plant was recorded in biochar (12.48) at 42 DAT. At 49 DAT, the maximum leaves number per plant in the main stem (18.90) was found in sand substrate while the minimum leaves number per plant in the main stem (14.23) was found in the mixture of biochar and burnt rice husk. At 77 DAT, there were no significant difference among different substrates. However, the maximum leaf number per plant in main stem was recorded in the mixture of biochar and sand substrate (23.63) whereas the minimum leaves number per plant in main stem was recorded in the mixture of biochar and burnt rice husk (17.85). In both seasons, substrates containing sand gave the maximum leaf number per plant in the main stem. It can be assumed that better root growth and aeration promote better leaf growth.

C. Stem diameter (mm)

Stem diameter is one of the most common measurements used to evaluate the growth of woody vegetation, and the commercial and environmental benefits that it provides (e.g., wood or biomass products, carbon sequestration, landscape remediation). In season 1, there was a significant difference in stem diameter of tomato among different substrates (Figure 3A). Tomato grown in sand substrate was significant different with burnt rice husk substrate. Sand substrates gave the highest value of stem diameter (7.86 mm) among the substrates while burnt rice husk substrate gave the lowest value (6.07 mm). In season

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2, the stem diameter value of tomato was not significantly different among different substrates (Figure 3B). However, the highest value stem diameter (4.80 mm) was observed in sand substrate while the minimum value (3.26 mm) was observed in biochar substrate use alone. This could be due to sand provides the ideal environment for the growth of roots and provides root aeration. The results are in the agreement with the finding of Haddad (2007) who reported that tomato plants grown in sand substrate were taller, had thicker stems, and higher fresh weight compared to plants grown on perlite and stone pumice.

D. Days to first flowering (day)

Types of different substrates affected the date of first flowering (Table 1 and 2). In season 1, the days taken to first flowering was not significantly affected by substrates. However, the earliest flowering (23 days) was recorded from sand, rice husk, and biochar mixed with sand substrate whereas the latest flowering was found in biochar substrate (28 days). In season 2, the days taken to first flowering was not significantly affected by substrates. The earliest flowering (28 days) was observed in sand substrate whereas the latest flowering was found in biochar substrate (35 days). In these experiments, plants grown with inorganic substrate flowered earlier than that of plants grown with organic substrate. It can be assumed that poorly nutrient-dense substrates caused the maturity and blooming of tomato earlier than nutrient-dense substrates. The time required for flowers to begin to flower and the number of leaves there are before the inflorescence will vary depending on how temperature interacts with other elements, most especially light, which has an influence on development and growth. Nourizadeh (2003) has reported that the increased the number of flowers in plants due to suitable conditions in soilless substrate by ventilation and water maintenance.

E. Shoot fresh and dry weight (g)

Shoot fresh and dry weight of tomato as affected by different substrates was shown in (Table 1 and 2). In season 1, there was no significant difference in shoot fresh and dry weight among different substrates. However, shoot fresh weight of tomatoes grown in biochar substrate gave the highest value (74.01 g) whereas the lowest shoot fresh weight was observed in biochar mixed with sand substrate (47.49 g). Shoot dry weight of tomatoes grown in biochar substrate gave highest shoot dry weight (14.31 g) whereas tomato plants grown in biochar mixed with sand substrate gave the lowest value (8.77 g). This may be due to biochar stimulated microbial populations towards beneficial plant growth promoting rhizobacteria and fungi population. In season 2, shoot fresh and dry weight were significantly different among different substrates. Sand substrate was highly significant different with biochar and the mixtures of biochar with burnt rice husk substrate. The highest values of shoot fresh weight (103.93g) was observed in sand substrate while the lowest shoot freshweight (48.38 g) was observed in biochar substrate used alone. Shoot dry weight of the tomato plants that grow on sand substrate was significantly higher than biochar mixed with burnt rice husk substrate. The highest shoot dry weight per plant (17.72 g) was obtained from the plants grown in sand substrate although the lowest shoot dry weight per plant (9.56 g) was obtained from biochar and mixtures of biochar with burnt rice husk substrate. Fresh weight reduction at higher rate biochar might be due to negative effects of biochar, such as influences on pH or nutrient leaching. Kadota and Niimi (2004) observed ed that adding 10% or 30% (by vol.) biochar to peat, vermiculite, soil and sand substrates caused enhanced shoot growth for zinnia but no positive effects in marigold or scarlet sage.

F. Root fresh and dry weight

Root fresh and dry weight of tomato were also affected by different substrates. Significantly differences in root fresh and dry weight were observed in season 1(Table 1 and 2). There were highly significant differences among different substrate treatments. The mixtures of biochar and rice husk substrate was significantly higher than other substrates. The highest root fresh weight (16.52 g) was obtained in biochar mixed with rice husk substrate whereas the lowest root fresh weight (3.87 g) was obtained in burnt rice husk substrate. Root dry weight of tomato grown in biochar mixed with rice husk substrate was significantly higher than other substrates. The highest root dry weight (3.67 g) was recorded from biochar mixed with rice husk substrate while the lowest root dry weight (0.86) was recorded from biochar mixed with sand substrates. In season 2, root fresh weight was significantly difference among different substrates was observed in (Table 1). Sand substrate was significantly higher than biochar, biochar mixed with rice husk and biochar mixed with burnt rice husk. However, the highest root fresh weight (8.56 g) was observed in sand substrate while the lowest root fresh weight (3.80 g) was observed from biochar mixed with burnt rice husk substrate.Root dry weight of tomato was not significantly different among the different substrates (Table 2). However, the highest root dry weight (2.27 g) was observed in burnt rice husk substrate whereas the lowest root dry weight value (1.13 g) was observed in biochar mixed with burnt rice husk substrate. It can be assumed that the different root growths of tomato plants depend on the difference in bulk density and aeration of the growing substrate.If the bulk density becomes too high, it can limit plant root growth due to a reduction inporosity, and a high bulk density also increases the transport cost of the growing media. Altland et al. (2013) and Chan et al. (2008) observed that plant roots grow well on substrates containing biochar; as the physicochemical conditions of the rhizosphere improve, a decrease in soil resistance to root growth is observed.

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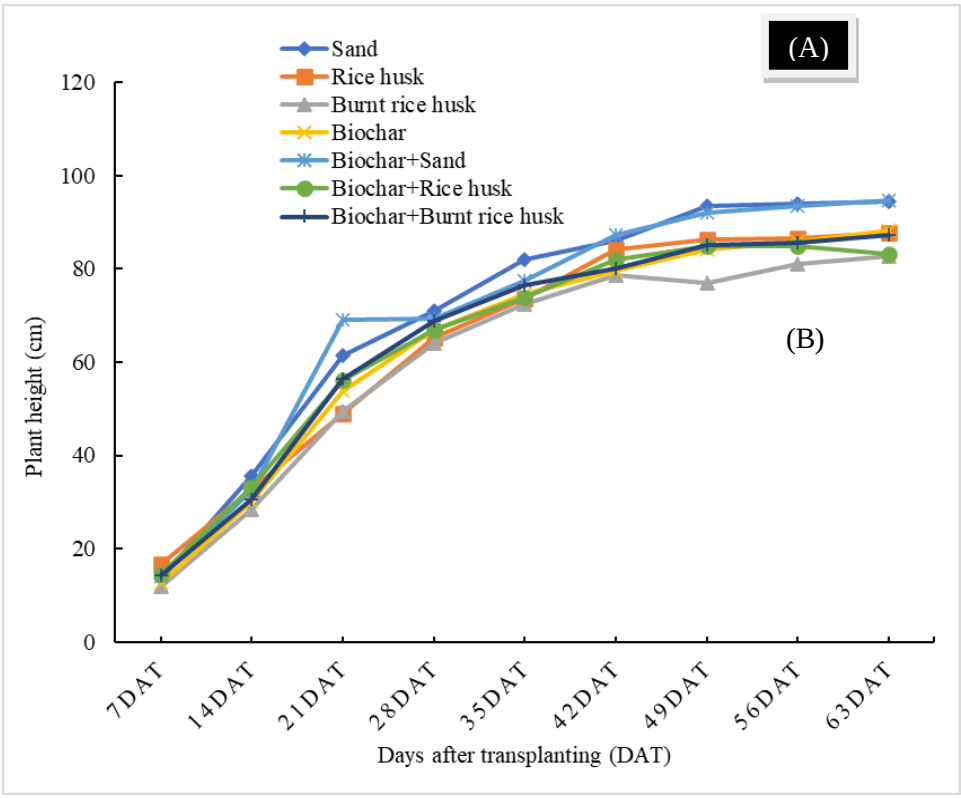

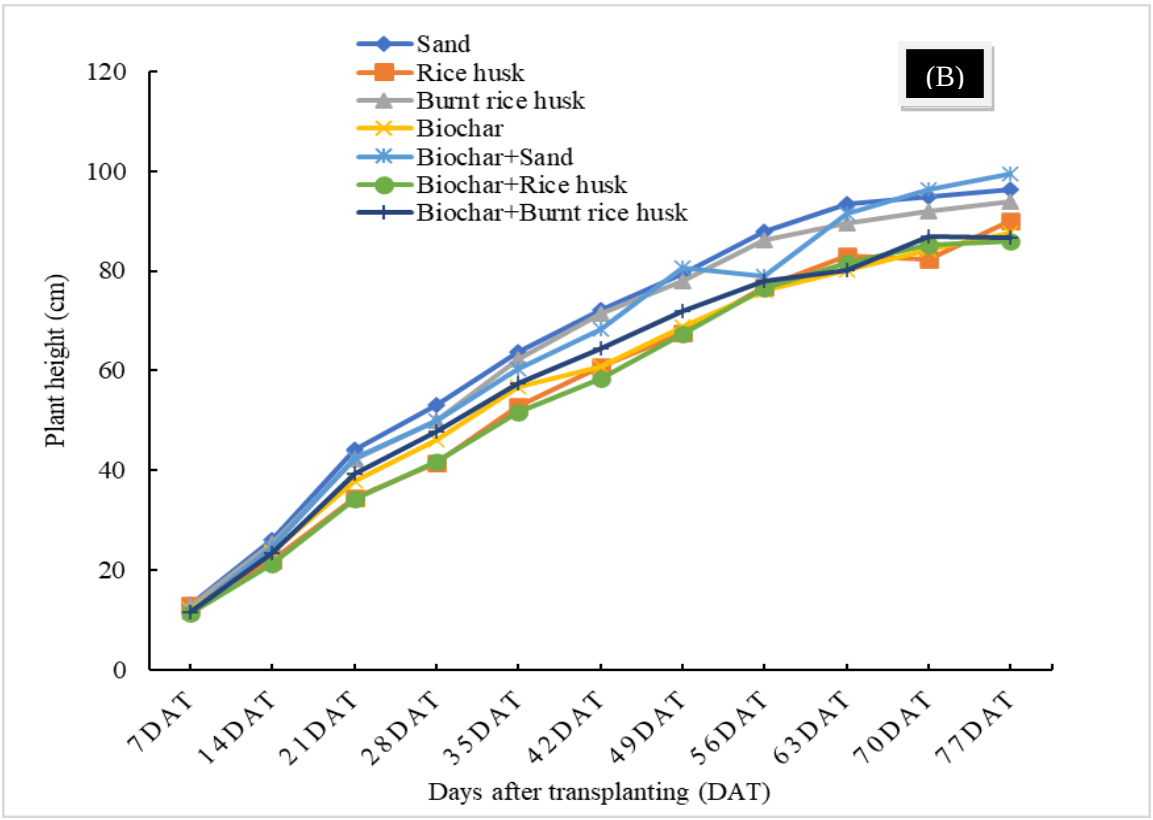

Fig. 1: Plant height (cm) as affected by different substrates in (A) season 1 (B) season 2.

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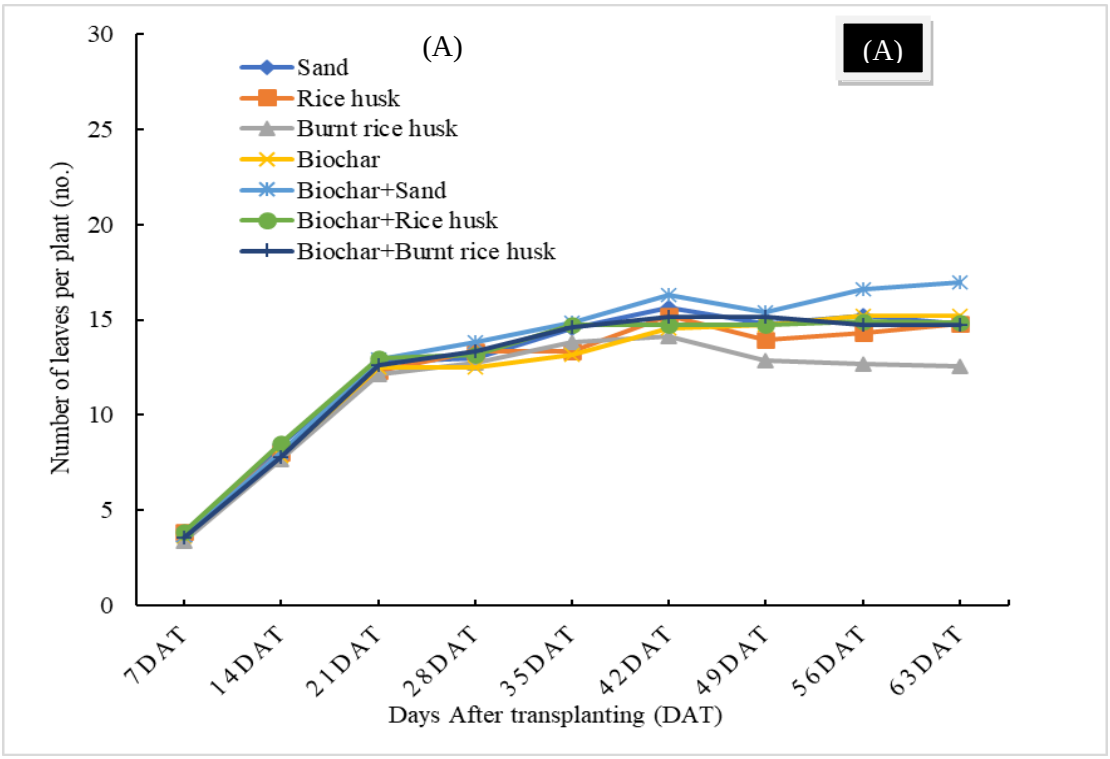

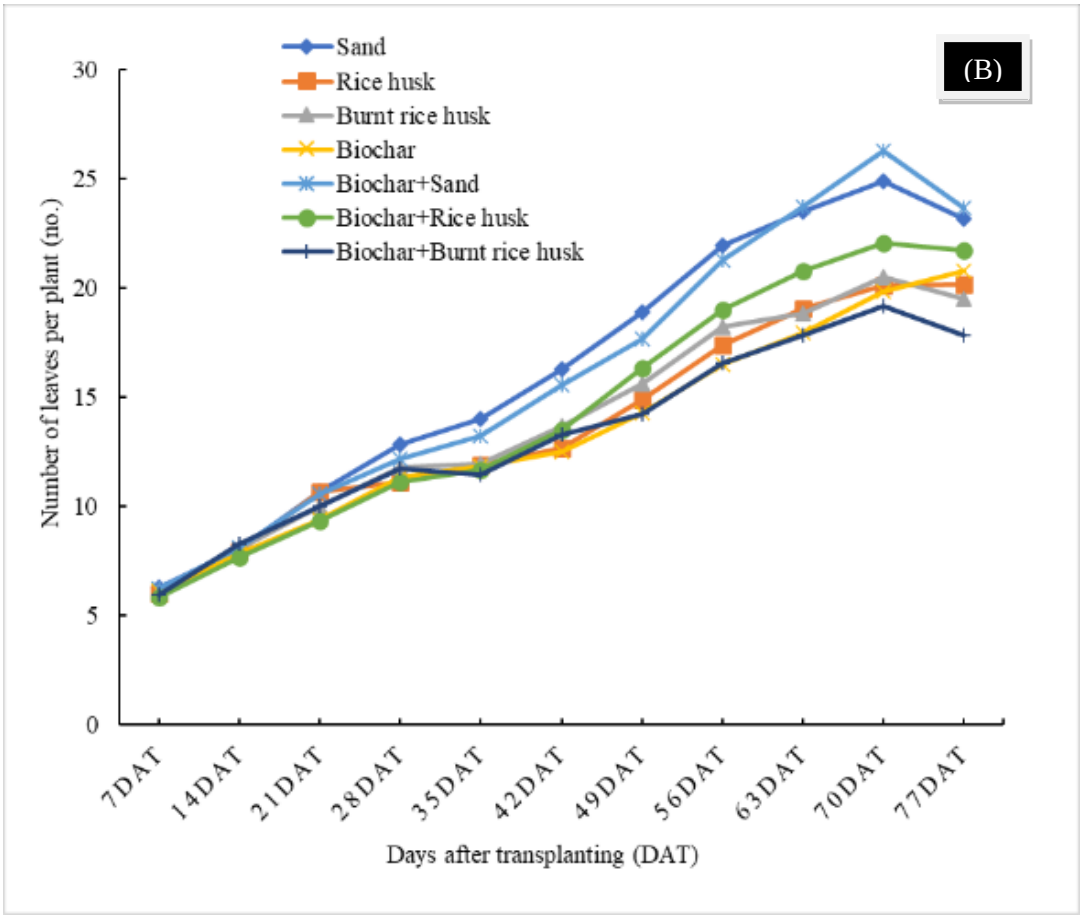

Fig. 1: Number of leaves per plant of tomato as affected by different substrates in (A) season 1(B) season 2.

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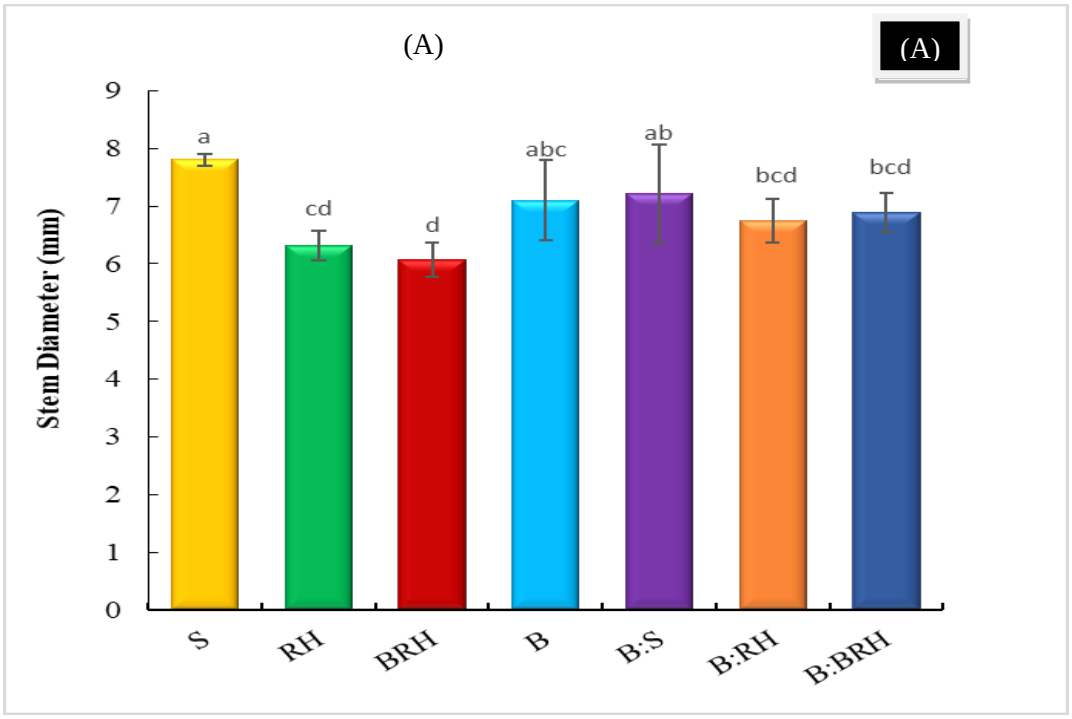

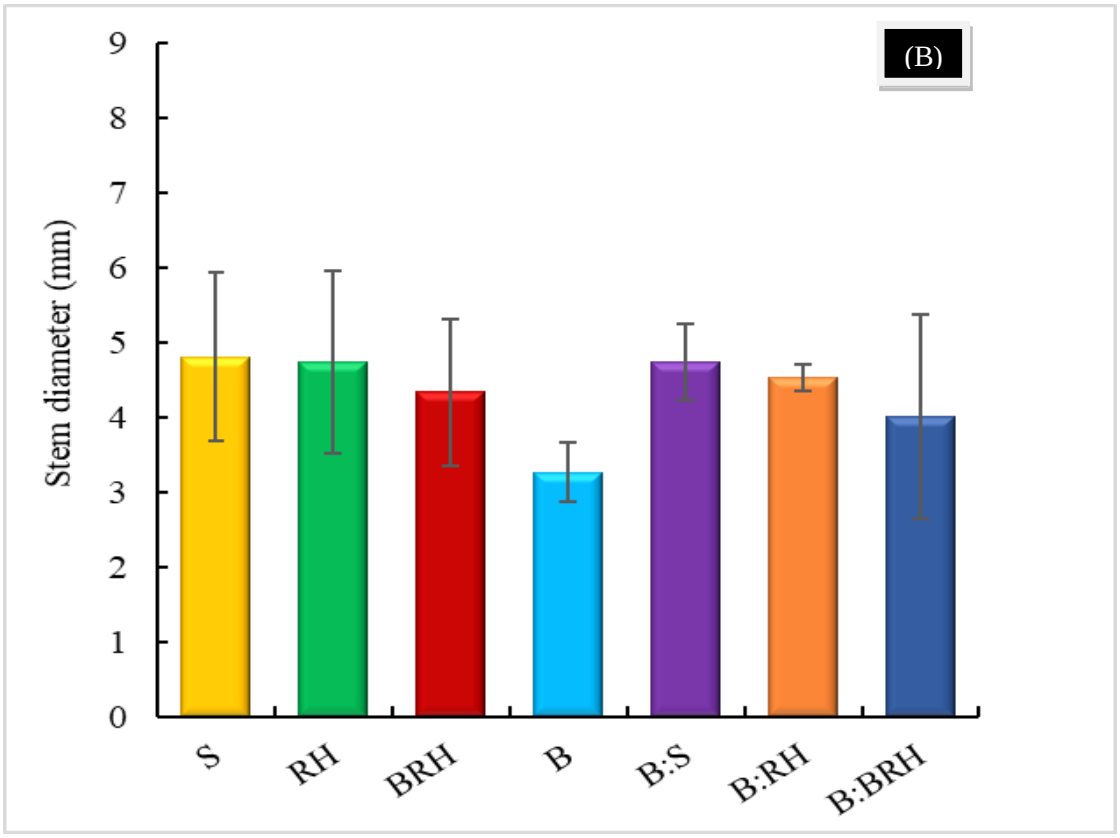

Fig. 2: Stem diameter (mm) of tomato as affected by different substrates in (A) season 1(B) season 2.

S = Sand, RH = Rice husk, BRH = Burnt rice husk, B = Biochar, B:S = Biochar: Sand (1:1 v/v), B: RH = Biochar: Rice Husk (1:1 v/v), B: BRH = Biochar: Burnt rice husk (1:1 v/v)

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Treatments	Days to first flowering	Shoot		Root	
		Shoot fresh weight/ plant (g)	Shoot dry weight/ plant (g)	Root fresh weight/ plant (g)	Root dry weight/ plant(g)
S	23.00	67.83	11.42	10.97 b	1.68 b
RH	23.00	68.18	11.43	9.73 bc	1.57 b
BRH	25.33	55.73	8.80	3.87 d	1.79 b
B	27.67	74.01	14.31	11.64 b	1.84 b
B: S	23.00	47.49	8.77	5.29 d	0.86 b
B: RH	27.33	72.85	12.86	16.52 a	3.67 a
B: BRH	27.33	65.47	13.24	6.85 cd	1.17 b
LSD $_{(0.05)}$	6.5	35.39	7.12	3.48	1.07
Pr ≥ F	ns	ns	ns	**	**
CV (%)	14.48	30.84	34.67	21.14	33.6

Table 1: Effect of substrates on plant growth characters of tomato (Season I, November 2018 to March 2019)

In a column, means followed by a common letter are not significantly different at 5% LSD.
ns = Not significant; * = Significant; ** = Highly significant
S = Sand, RH = Rice Husk, BRH = Burnt Rice Husk, B = Biochar, B: S = Biochar: Sand (1:1 v/v),
B: RH = Biochar: Rice Husk (1:1 v/v), B: BRH = Biochar: Burnt Rice Husk (1:1 v/v)

Treatments	Days to first flowering	Shoot		Root	
		Shoot fresh weight/ plant (g)	Shoot dry weight/ plant (g)	Root fresh weight/ plant (g)	Root dry weight/ plant (g)
S	28.33	103.93 a	17.72 a	8.56 a	2.11
RH	33.00	75.91 ab	14.28 ab	6.38 ab	1.79
BRH	32.67	90.99 a	15.85 a	6.39 ab	2.27
B	35.33	48.38 b	9.82 b	5.21 bc	2.03
B: S	31.67	97.50 a	16.64 a	6.59 ab	1.48
B: RH	34.67	90.79 a	14.55 ab	5.24 bc	1.29
B: BRH	31.00	55.21 b	9.56 b	3.80 c	1.13
LSD $_{(0.05)}$	4.57	31.49	5.21	2.57	1.22
Pr ≥ F	ns	**	*	*	ns
CV (%)	7.94	22.02	20.82	23.94	39.51

Table 2. Effect of substrates on plant growth characters of tomato (Season II, August 2019 to January 2020)

In a column, means followed by a common letter are not significantly different at 5% LSD.
ns = Not significant; * = Significant; ** = Highly significant
S = Sand, RH = Rice Husk, BRH = Burnt Rice Husk, B = Biochar, B: S = Biochar: Sand (1:1 v/v),
B: RH = Biochar: Rice Husk (1:1 v/v), B: BRH = Biochar: Burnt Rice Husk (1:1 v/v)

IV. CONCLUSION

The present study was performed to assess the effect of substrates on vegetative growth characters of tomato (*Solanum lycopersicum*). The result of this study revealed that the use of different substrates influences stem diameter, shoot fresh and dry weight, root fresh and dry weight. In both seasons, different substrates did not significantly influence on plant height, however biochar mixed with sand substrate gave higher plant height than other substrates. The maximum number of leaves per main stem was observed from the mixture of biochar with sand. Tomato plants grown on sand substrates alone exhibited the higher values of stem diameter and the earlier flowering than the remaining substrates. Among the treatments, the maximum shoot fresh weight, shoot dry weight, root fresh weight and root dry were recorded from biochar substrate alone and the mixtures of biochar with rice husk substrate in season 1. In season 2, the maximum shoot fresh weight, shoot dry weight, root fresh weight and dry weight were recorded from sand substrate used alone. According to the results of the experiments, sand and, substrates containing biochar can be considered as good substrates for tomato vegetative growth characters in substrate culture.

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