OMÜ Zir. Fak. Dergisi, 2007,22(2):149-156
J. of Fac. of Agric., OMU, 2007,22(2):149-156

THE EFFECT OF DIFFERENT MIXTURES OF ORGANIC AND INORGANIC MATERIALS AND GROWING POSITIONS ON VEGETATIVE GROWTH OF AUBERGINE (*Solanum melongena* L.) GROWN IN BAG CULTURE IN GREENHOUSE

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Received: 06.09.2005 Accepted: 20.04.2007

ABSTRACT: The aim of this study was to determine the effect of different mixtures of organic and inorganic materials and plant growing positions provided by utilising wooden benches with different heights on vegetative growth of aubergine (*Solanum melongena*, L.) grown in bag culture in unheated plastic greenhouse for late autumn growing season, at The University of Ondokuz Mayıs, Faculty of Agriculture, in the Black Sea region. The organic and inorganic materials used in the study were decomposed farmyard manure, hazelnut husk, rice hull, decomposed pine leaves, tobacco waste, sawdust, decomposed bark, sieved garden soil, sand of 2 mm, coal dust and coal ash. Cv. Megal F1 of aubergine was used in the study. Six different mixtures of organic and inorganic materials were blended and used in horizontal growing bag culture. The experiment was carried out at three different heights in the greenhouse, namely 0, 25 and 50 cm from the ground. Plant height (cm), stem diameter (mm), leaf number per plant, dry matter partitioning to leaf, stem and root of the plants (g) were investigated as well as determining plant canopy light interception (%). In general, the best results were obtained from the mixtures named A (decomposed farmyard manure, sieved garden soil, hazelnut husk, rice hull, sand of 2 mm, decomposed pine leaves, tobacco waste, coal ash and coal dust as ratios of 2:1:1:1:1/3:1:1/2:1/2:1/4, respectively), F (Decomposed farmyard manure, sieved garden soil and sand (2 mm), as ratios of 1:1:1, respectively) and D (rice hull, sieved garden soil, decomposed bark, decomposed farmyard manure, sand of 2 mm, decomposed pine leaves, tobacco waste, coal dust and coal ash as ratios of 2:1:1:2:1/2:1:1:1/2:1/2, respectively). At any given growing positions, the mixture named B (decomposed pine leaves, decomposed farmyard manure, saw dust, coal dust, decomposed bark, hazelnut husk, tobacco waste and coal ash, as ratios of 2:3:1:1/2:1/2:1:1:1, respectively) gave the lowest values in terms of selected plant growth parameters. There were also significant differences between growing positions in affecting vegetative growth of aubergine depending on media such as there appeared to be a tendency of obtaining higher values at higher growing positions.
Key Words: Aubergine, plant growth, organic and inorganic materials, growing bag culture, growing position

SERADA TORBA KÜLTÜRÜNDE PATLICAN'IN (*Solanum melongena* L.) VEJETATATİF BÜYÜMESİ ÜZERİNE YETİŞTİRME POZİSYONU VE ORGANİK VE İNORGANİK MATERYALLERDEN HAZIRLANAN FARKLI ORTAMLARIN ETKİLERİ

ÖZET: Bu araştırmada, Karadeniz Bölgesinde (Ondokuz Mayıs Üniversitesi, Ziraat Fakültesinde) ısıtılmayan plastik seralarda sonbahar yetiştirme periyodunda yatay torba kültüründe kullanılan farklı organik ve inorganik materyallerden oluşan ortamların sera içerisine 3 farklı pozisyonda (0, 25 ve 50 cm) kullanılmasının patlıcan bitkisinin (*Solanum melongena* L.) vegetatif büyümesi üzerine olan etkilerinin belirlenmesi amaçlanmıştır. Çalışmada kullanılan organik ve inorganik materyal olarak; dekompoze olmuş çiftlik gübresi, fındık zurufu, çeltik kavuzu, dekompoze olmuş çam ibreleri, tütün atıkları, hızar tozu, dekompoze olmuş ağaç kabukları, elenmiş bahçe toprağı, 2 mm çapında dere kumu, kömür tozu ve kömür külü kullanılmıştır. Çalışmada Megal F_1 patlıcan çeşidi kullanılmıştır. Çalışmada altı değişik organik ve inorganik ortam karışımı, yatay torba kültüründe kullanıldı. Çalışma sera içerisinde yerden 0, 25 ve 50 cm pozisyonlarında olmak üzere üç değişik pozisyonda yetiştirilmiştir. Çalışmada bitki boyu (cm), gövde çapı (mm) ve toplam yaprak sayısı/bitki, bitki kök, gövde ve yapraklarına kuru madde dağılımına ilave olarak bitkilerin ışık kesim oranları da (%) saptanmıştır. Genel olarak en iyi sonuçlar; sırası ile A (2 birim çiftlik gübresi, 1 birim elenmiş bahçe toprağı, 1 birim fındık zurufu, 1 birim çeltik kavuzu 1/3 birim kum, 1 birim ibre, 1/2 birim tütün artığı, 1/2 birim kömür külü ve 0.25 birim kömür tozu), F (1 birim yanmış çiftlik gübresi, 1 birim elenmiş bahçe toprağı ve 1 birim 2 mm çapında dere kumu) ve D (2 birim çeltik kavuzu, 1 birim elenmiş bahçe toprağı, 1 birim ağaç kabuğu, 2 birim çiftlik gübresi, 1/2 birim kum, 1 birim ibre, 1 birim tütün artığı, 1/2 birim kömür tozu, 1/2 birim kömür külü) ortamlarından elde edilmiştir. Yukarıda belirtilen bitki parametreleri bakımından en düşük değerler B (2 birim dekompoze olmuş çam ibresi, 3 birim dekompoze olmuş çiftlik gübresi, 1 birim hızar tozu, ½ birim kömür tozu, ½ birim dekompoze olmuş ağaç kabuğu, 1 birim fındık zurufu, 1 birim tütün atığı ve 1 birim kömür külü) ortamından elde edilmiştir. Yetiştirme pozisyonlarının da kullanılan ortamlara bağlı olarak patlıcanın vegetatif büyümesi üzerine önemli etki (istatistiksel olarak) yaptığı ortaya konmuştur. Genelde yetiştirme pozisyonu yükseldiğinde, büyüme parametreleri daha yüksek değerleri verme eğiliminde olmuştur.
Anahtar Kelimeler: Patlıcan, bitki büyümesi, organik ve inorganik materyaller, torba kültürü, yetiştirme pozisyonu

1. INTRODUCTION

Increasing soil related drawbacks of growing vegetables in soil culture in greenhouses have led to focusing on alternatives of this system in the world since 1980. Therefore, soilless culture has been popular growing system accordingly (Gül et al., 1996). Growing bag culture, which is one of the soilless growing systems, has been used in greenhouses in Europe for growing cucumber, pepper and tomato (Jensen and Collins, 1985**).** Bag culture has become the preferred method of greenhouse vegetable production in many parts of the world since it is easy to establish and manage successfully. Growing bags of 45 lt medium has been preferred for most of the vegetables (Adamson and Mass, 1981). The efficiency of growing bag culture in growing vegetables can be enhanced when used with drip irrigation. Sheldrake (1981) reported that bottom perforated bags should have been used in order to abstain from water logging in the bags. Soilless culture has been attractive to greenhouse vegetable growers in Turkey, especially in Antalya due to having serious soil problems in the current growing systems (Aydoğan and Gül, 1999). On the other hand, the inclination of vegetable growers in the Black Sea Region of Turkey to greenhouse growing systems has been increasing in recent years. In general, cucumber, tomato, pepper and different types of lettuce are widely grown vegetables on schedule in unheated plastic greenhouses in this region during early spring and late autumn. However, aubergine has not been grown widely compared to other greenhouse vegetables (Anonymous, 2002). As a research project, growing bag culture has been applied to growing different greenhouse vegetables at the University of Ondokuz Mayıs, Faculty of Agriculture since 1995 (Uzun et al., 1999).

One of the most important case to care in growing bag culture is the fact that it is necessary to choose right medium for different crops in order to get high quality yield. Previous studies showed that the effect of different growing media on plant growth, development and yield varied depending on plant species (Gül, 1990, Baş, 1991, Gül and Sevgican, 1992, Çelikel and Abak, 1995, Gül et al., 1996, Uzun et al., 1999, Aydoğan and Gül, 1999, Uzun et al., 2000, Demir et al., 2001, Özkan et al., 2002). However, there have been a few attempts for growing aubergine and determining its suitable media in growing bag (Yanmaz, 2002). Çelikel and Abak (1995) carried out an experiment on the effect of different media mixtures for growing bag culture on the yield of aubergine as a comparison to rock wool growing system and found no significant differences amongst rock wool growing system (10.8 kg/m^2) and other media, namely soil (13.6 kg/m^2), sand (13.3 kg/m^2), peat (12.9 kg/m^2) and mushroom compost waste (11.1 kg/m^2), in terms of yield (kg/m^2). Some previous studies on using growing bag culture for aubergine during both early spring and late autumn in plastic greenhouses in the Black Sea Region of Turkey were carried out in order to utilise some organic wastes such as tea waste, hazelnut husk and rice hull mixed with some other organic and inorganic materials revealed highly reasonable results in relation to growth, development and yield of aubergine (Uzun et al., 1999 and 2000). They also reported that the media used gave similar results in relation to fruit yield of aubergine and in general, yield per plant was affected by the changes in mean fruit weight rather than fruit number per plant. Demir et al., (2001) suggested two different mixtures for aubergine growing in bag culture in unheated plastic greenhouses in the Black Sea Region during late autumn season. The suggested mixtures were Medium ıı (the mixture of sand, fresh hazelnut husk, decomposed farmyard manure and rice hull as ratios of 2:1:1:1, respectively) and Medium vıı (the mixture of sand, peat, fresh hazelnut husk and decomposed farmyard manure as ratios of 2:2:1:1, respectively).

It is quite reasonable to say that a number of regional (local) organic and inorganic materials have not been used to the potential for some reasons. In order to utilise these materials, the most suitable of them ought to be determined for using in growing bag culture in greenhouses all over the world. Therefore, the present study was performed to determine different organic wastes and inorganic materials used in growing bag culture and different growing positions on early vegetative growth of aubergine in unheated plastic greenhouses in the Black Sea Region of Turkey for late autumn season.

2. MATERIALS AND METHODS

This study was carried out in an unheated plastic greenhouse having a ground area of 250 m^2, at Faculty of Agriculture, the University of Ondokuz Mayıs, during late autumn season. Cv. Megal F_1 seeds of aubergine were used in the study as seed material. The seeds were sown in modular black plastic seed tray with of 3 cm wide and 5 cm deep cells on 19 July. The cells of seed tray was filled with a mixture of sieved garden soil, decomposed and sieved farmyard manure and sand of 2 mm as ratios of 2:2:1, respectively. After emergence, seedlings were picked out at the stage of first true leaf appearance and transplanted into small brown plastic pots 10 cm high and 9 cm wide on 2 August. Growing bags filled with 30 litres of mixture were placed on the wooden benches covered with black plastic at three each 0.25 mm thick-black plastic growing bags, with a length of 100 cm and width of 40 cm, filled with six different mixtures of organic wastes and inorganic materials (named as A, B, C, D, E and F given in Table 1) on 23 August. Plants were irrigated on two occasions each day and a standard nutrient feed diluted to give a concentration of 0.2 g l^{-1} nitrogen, 0.2 g l^{-1} phosphorous and 0.4 g l^{-1} potassium, equivalent to a conductivity of 1.6 dS m^{-1} was applied fortnightly. The experiment was designed as randomised block with three replications. Starting from planting to the end of the experiment, the following measurements were performed for three labelled-plants per replication for each medium of each growing position at two weeks-intervals as well as temperature and light intensity measurements. Plant height (cm) was measured as distance from the level of upper side of growing bag to the highest point of plant stem fortnightly. Stem diameter (mm) was measured with digital callipers at the level of just below the first node on the stem.

Table 1. The type of the mixtures of organic and inorganic media used in the study.

Media	*Materials used*	*Mixing units based on volume*	*Media*	*Materials used*	*Mixing units based on volume*
A	Decomposed farmyard manure	2	**D**	Decomposed farmyard manure	2
	Sieved garden soil	1		Sieved garden soil	1
	Hazelnut husk	1		Rice hull	2
	Sand (2 mm)	1/3		Sand (2 mm)	1/2
	Rice hull	1		Decomposed pine leaves	1
	Decomposed pine leaves	1		Tobacco waste	1
	Tobacco waste	1/2		Decomposed bark	1
	Coal ash	1/2		Coal ash	1/2
	Coal dust	¼		Coal dust	1/2
B	Decomposed farmyard manure	3	**E**	Decomposed farmyard manure	2
	Hazelnut husk	1		Rice hull	2
	Decomposed bark	1/2		Hazelnut husk	3
	Decomposed pine leaves	2		Sand (2 mm)	1/2
	Tobacco waste	1		Decomposed pine leaves	1/2
	Saw dust	1		Tobacco waste	1/2
	Coal ash	1		Coal ash	1
	Coal dust	1/2		Coal dust	2
C	Decomposed farmyard manure	3	**F**	Decomposed farmyard manure	1
	Hazelnut husk	3		Sieved garden soil	1
	Decomposed pine leaves	1		Sand (2 mm)	1
	Tobacco waste	3/2			
	Coal ash	1			
	Coal dust	1/2			
	Sand (2 mm)	1/4			

Leaf number per plant was determined by counting the leaves reaching a leaf length of 5 cm. Light intensity was recorded by employing a Sun Scan Canopy Analyser (Delta-T Devices) at a two week intervals. In addition, plant light interception (%) was calculated through utilising measurements of light intensity at two different levels of the plant canopy, namely from two different horizontal points above the canopy and four different horizontal points beneath the canopy. Dry matter partitioning to different organs of the plants (leaf, stem, root and reproductive organs) was determined by means of plant destructive harvesting on 27 December and drying the plant samples in an oven at 80 ^oC. Media temperatures were recorded with a soil thermometer (HANNA Devices) at a three day-interval at 9:00 (in the morning) and 14:00 (in the afternoon) (Figure 1a and b) from 5 cm dept for each application. A thermo-hydrograph was employed for measurements of temperature (Figure 1c) and humidity (Figure 1d) inside the greenhouse. Data obtained from the present study were analysed and graphed by using computer package programmes of Excel 5.0 and Slide-Write 2.0.

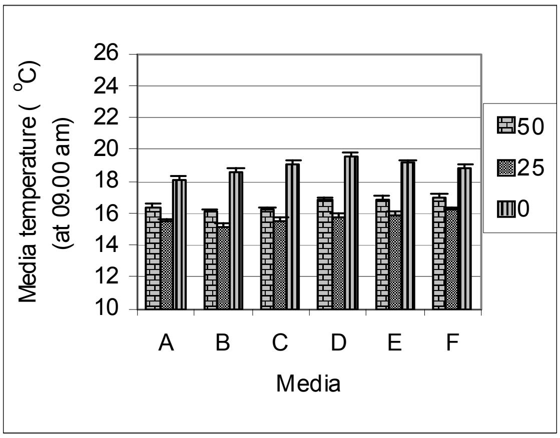
3. RESULTS AND DISCUSSION

3.1. Changes in media temperatures and air temperature and relative humidity in greenhouse

The mean temperature values measured in growing bags throughout the experiment were given in Figure 1a and b. As seen from the figure, there were significant differences between mean temperatures inside the growing bags with different mixtures. The variation in temperatures was more marked in morning measurements. Higher temperatures were measured in the growing bags placed on the ground level compared to the other positions.

Media temperatures measured in the mornings were found to be under 20 ^oC for all growing positions (Figure 1a). The highest media temperatures were obtained from the growing bags placed on the ground (0 cm) and was followed by 50 and 25 cm high growing positions, respectively. As a result of increasing natural light intensity towards midday, temperatures in the growing bags increased over 21 ^oC for afternoon measurements (Figure 1b). In general, temperatures for growing bags at 50 cm benches had the highest temperatures and was followed by 0 cm and 25 cm, respectively.

After planting, air temperatures inside the greenhouse have been in a declining trend with time (Figure 1c). There have also been some temperature fluctuations during plant growth period. However, relative humidity inside the greenhouse showed a similar tendency as temperature (Figure 1d). The decline in relative humidity with time was found to be slower than it was for temperature.



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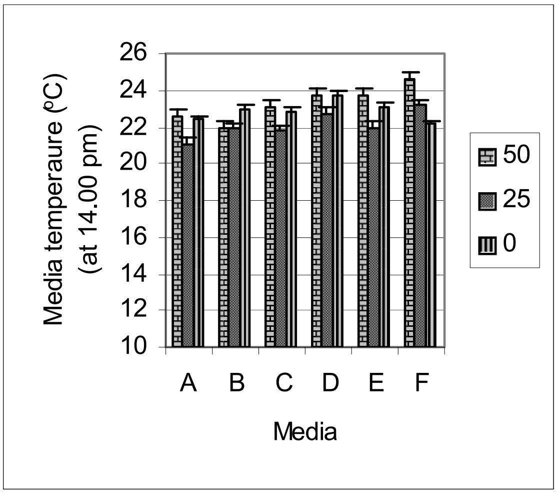

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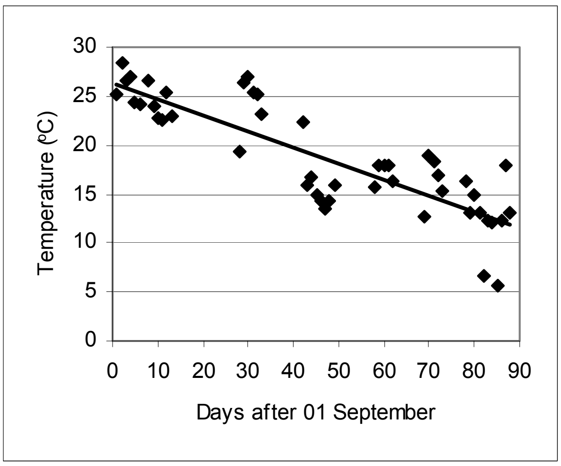

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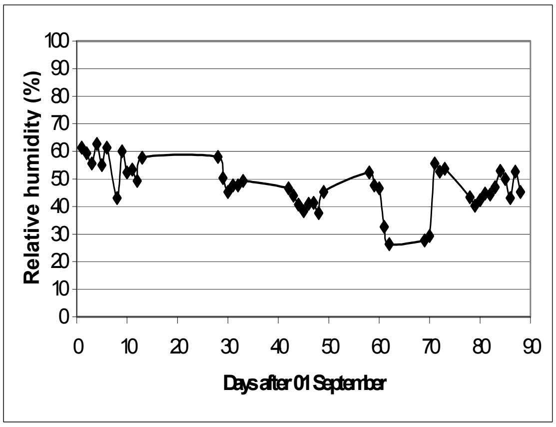


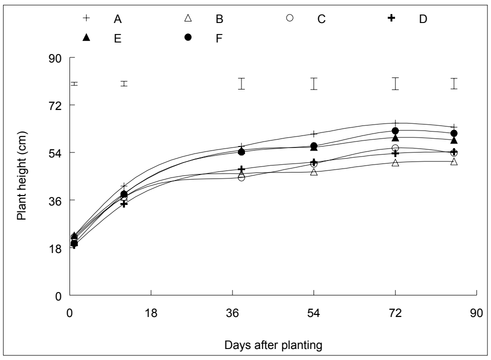
(d)

Figure 1. Changes in media temperatures (°C) measured at 9:00 (a), and 14:00 (b), air temperature inside the greenhouse (c) and relative humidity (%) inside the greenhouse (d).

3.2 Plant height, stem diameter and plant leaf number

Results for plant height as affected by growing media and growing positions are given in Figure 2a, b and c. In general, height increases of the plants grown at all the positions showed similar trend such as plant height increased until about 40 days after planting with higher rate and slowed thereafter. While the highest plant height was obtained from the plants grown in medium D at the position of 50 cm (Figure 2c), the lowest plant height was obtained from the plant grown in Medium B. Medium B also gave the smallest plants for all growing positions. It was reported that increasing temperatures resulted in higher plants of aubergine and this increase slowed down with ontogeny (Kürklü, 1994, Uzun, 1996). They also reported that the increase in plant height with temperature was more marked at lower light intensities for aubergine and tomato. It can also be said that the medium temperatures and the structure of the media had an impact on plant height (Grimstad, 1995).

The highest stem diameter was obtained from the plants grown in medium F at 0 and 25 cm and from those of the plants grown in Medium D at 50 cm (Figure 3a, b and c). Plants grown in media B and C gave the lowest stem diameter for all growing positions. As in the trend of plant height increase, stem diameter showed a rapid increase up to about 40 days after planting and a slight increase thereafter for all media and growing positions. Uzun (1996) indicated that stem diameter in aubergine increased sharply with temperature, specially, under low light intensities. It was also reported that aubergine and tomato plants with lower stem diameter and higher plant height resulted in lower fruit yield compared to those of the plants having smaller plant height and higher stem diameter (Seligmen, 1990; DeKoning, 1995: Uzun et al., 1999). Although the media having higher temperatures had generally plants with higher stem diameters, it can be said that a combined effect of media temperatures and the structure of the mixtures in the growing bags had an important role in variations of stem diameter.



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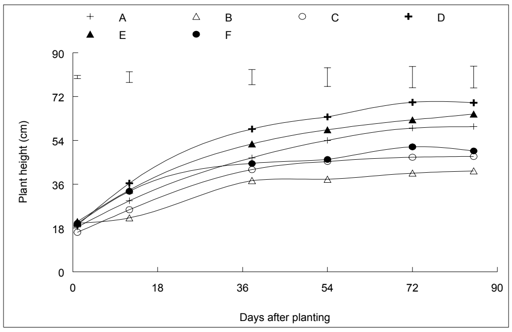

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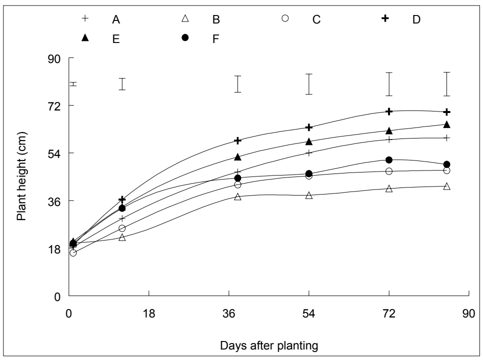
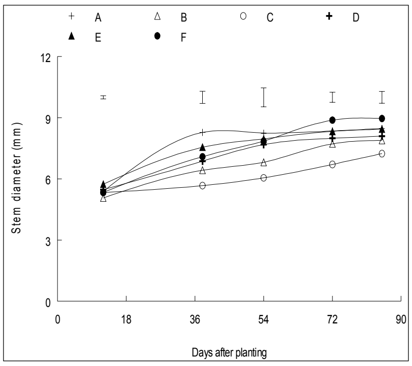


(c)

Figure 2. Changes in height (cm) of the plants grown at different growing positions (0 cm (a), 25 cm (b) and 50 cm (c)) and growing media (A, B, C, D, E, and F).



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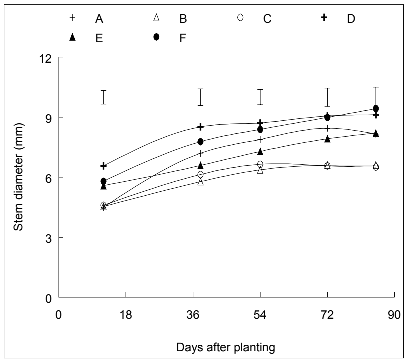

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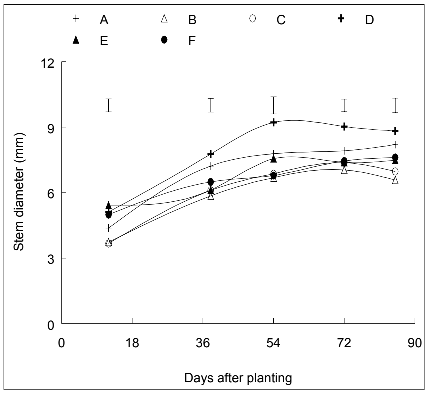
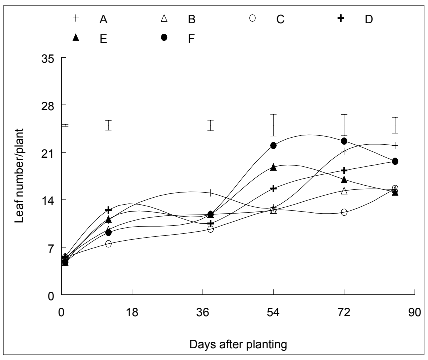


(c)

Figure 3. Changes in stem diameter (mm) of the plants grown at different growing positions (0 cm (a), 25 cm (b) and 50 cm (c)) and growing media (A, B, C, D, E, and F).

The highest leaf number per plant was obtained from the plants grown in Medium F at the position of 25 cm (Figure 4a, b and c). Moreover, leaf number per plant was found to be higher in the plants grown in Medium F for all growing positions and was followed by Medium D, A and E, respectively. The lowest leaf number per plant was obtained from the plants grown in Medium B and C, respectively. Previous studies indicated that leaf appearance rate of aubergine was affected by temperature, light intensity and growing media (Seligmen, 1990; Kürklü, 1994; Uzun, 1996, Uzun et al., 2000).



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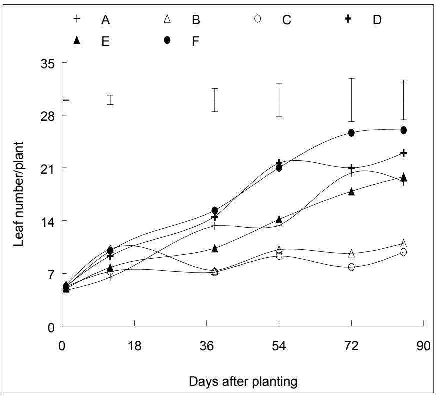

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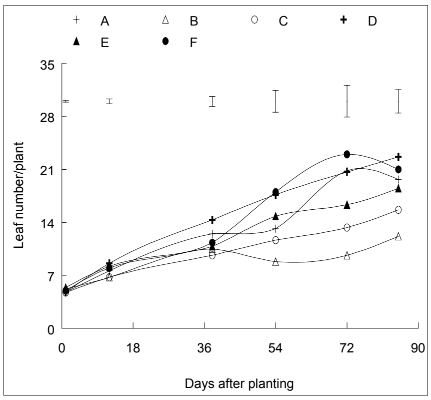


(c)

Figure 4. Changes in leaf number of the plants grown at different growing positions (0 cm (a), 25 cm (b) and 50 cm (c)) and growing media (A, B, C, D, E, and F).

3.3 Plant light interception (%)

Result of plant light interception from the present study is given in Figure 5. As seen from the Figure, the highest light intercepted by plant leaves was found in the plants from the position of 0 cm for all media mixtures (Figure 5). There was an interactive effect of the other growing positions on light interception of the plants grown in different media. Plants grown in Medium E and F intercepted more light, respectively than the other media. The lowest light interception was measured in the plants from Medium B (Figure 5). As in accordance with other plant growth parameters, plants grown in Medium B and C had the lowest light interception, respectively. Uzun (1996) revealed that light interception in aubergine increased with temperature, light intensity and time up to a peak and remained nearly constant thereafter. It was also reported that plants grown with higher temperature and light intensities reached a maximum light interception point earlier and remained three for longer time than those of the plants grown with lower light intensities (Uzun et al., 2000). They also found positive linear relationships between light interception and yield (r^2 = 0.70), stem diameter (r^2 = 0.60) and mean fruit weight (r^2 = 0.77) in aubergine. Growing aubergine in unheated plastic greenhouses for late autumn season necessitates proper planting timing for sufficient plant light interception before light intensity and temperatures declines with time towards winter months. Since it was reported that optimum temperature requirements for growth of aubergine declines slightly as plants get older (Uzun, 1996).

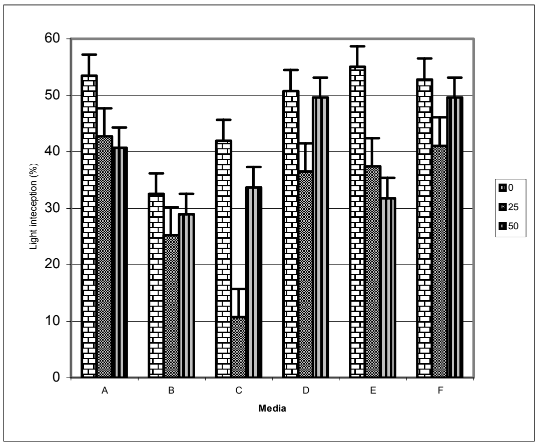


Figure 5. Changes in light interception (%) of the plants grown at different growing positions (0, 25 and 50 cm) and growing media (A, B, C, D, E, and F) 60 days after planting.

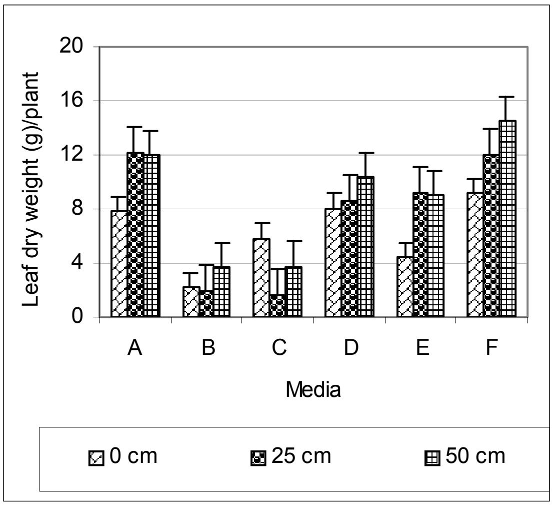
3.4 Plant dry matter partitioning

The highest leaf dry weight was obtained from the plants grown in Medium F at 50 cm (Figure 6a) and was followed by Medium A at 25 and 50 cm, Medium F at 25 cm and Medium D at 50 cm, respectively. In general, plants from Medium B and C gave the lowest leaf dry weight per plant. Although there was not a clear consistency of leaf dry weight variation on the base of growing positions, the plants grown at 50 cm tended to have higher leaf dry weight than plants at 25 and 0 cm, respectively (Figure 6a). In general the highest stem and root dry weights were obtained from Media A and F while the lowest stem and root dry weight valued were from the plants of Medium B and C, respectively (Figure 6b and c). Over all growing positions, Figure 6d shows the effect of the media used in the present study on total plant dry weight. As seen from the Figure, total plant dry weight was found to be the highest in the plants grown in Media A, F and D, respectively. As for the most of the parameters used in the study, Medium B and C gave the lowest total plant dry weight (Figure 6d and e). Generally, plants from higher growing positions gave higher total plant dry weight (Figure 6d).

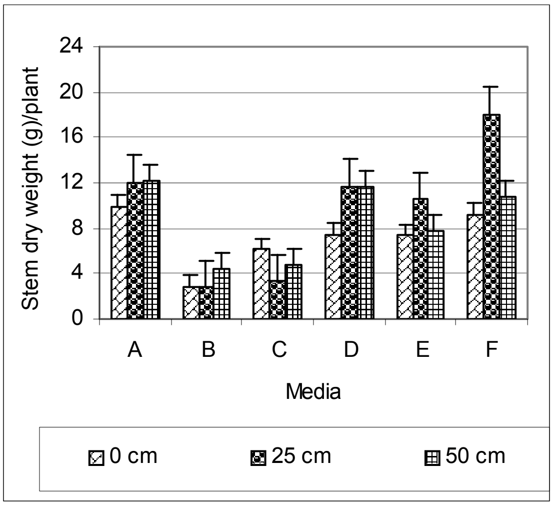
The materials used in growing bag culture should supply the plants with nutrition as much as possible. It was found in the present study that plants grown in specially Medium B and C did not get enough nutrients from the mixtures. On the basis of biomass, Medium B and C were found to be unsuitable for using in growing bag culture. The reason for this may be the fact that the units of tobacco waste used in these media are higher than the other media as well as the suitability of the other media in terms of both as soil amendments and providing the soil with better physical and chemical points of view Kürklü (1994) and Uzun (1996) also indicated that growth duration in aubergine had a significant effect on dry matter production and its distribution amongst different plant organs namely, leaf, stem, root and reproductive parts of the plants.

4. CONCLUSION

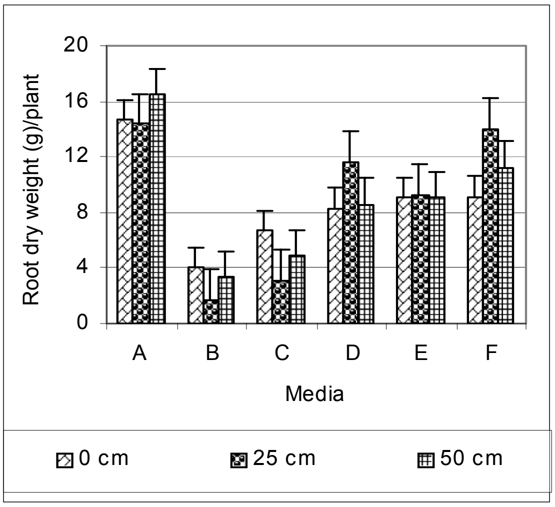
Growing bag culture (one of the soilles growing systems) has become the preferred method of greenhouse vegetable production in many parts of the world since it is easy to establish and manage successfully. Soilless culture has been attractive to greenhouse vegetable growers in some parts of Turkey, especially due to having serious soil problems in the current growing systems. It is quite reasonable to say that a number of regional (local) organic materials have not been used to the potential for some reasons. In order to utilise these materials, the most suitable of them ought to be determined for using in growing bag culture in greenhouses all over the world. The present study showed that different organic wastes found in The Black Sea Region can be used in growing bag culture for aubergine in unheated plastic greenhouses in the Black Sea Region of Turkey for late autumn season. On the other hand, considering that organic growing systems are gaining interest in recent years, using growing bag culture in organic vegetable growing in greenhouses will enable us to eliminate the effect of waste chemicals used previously, suppress weeds and related diseases. On the other hand, organic wastes found intensively in the Black Sea Region will be utilized as well as reducing the amount of water and organic fertilizers.



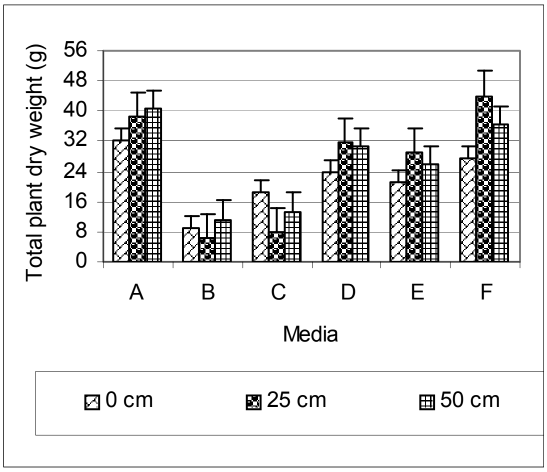
(a)



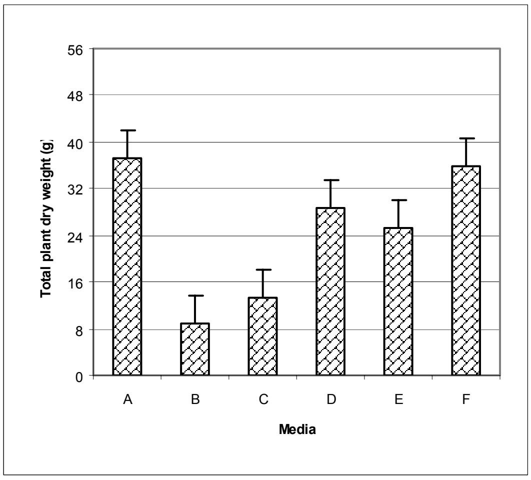
(b)



(c)



(d)



(e)

Figure 6. Plant dry matter partitioning (at the end of the experiment) amongst leaf (a), stem (b) and root (c) and total plant dry weight (g) based on growing media (A, B, C, D, E and F) and growing positions (0, 25 and 50 cm) (d) and only growing media as mean of all growing positions (e).

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