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EFFECTS OF DIFFERENT GROWING MEDIA ON SCOTCH PINE (*PINUS SYLVESTRIS)* PRODUCTION

M. Aklibasinda, T. Tunc* Y. Bulut and U. Sahin*

Atatürk Univ., Fac. of Agriculture, Dept. of Landscape Architecture, 25240, Erzurum, Turkey.
*Atatürk Univ., Fac. of Agriculture, Dept. of Agricultural Structures and Irrigation, 25240, Erzurum, Turkey.
Corresponding author: e-mail: ussahin@atauni.edu.tr or ussahin@yahoo.com

ABSTRACT

Scotch pine is the most extensively planted pine in the world due to it has high economic value. Scotch pine seedlings are produced from seeds. This study was carried out to determine the effects of different growing media on Scotch pine (*Pinus sylvestris)* seedling growth attributes such as collar diameter, seedling length, root length, the number of roots, fresh and dry root weight and fresh and dry seedling weight. Eighteen different media were experimented by using rice hulls, pumice and peat materials alone or mixing two of them. The water retention characteristics of each media was also determined and used to obtain pore size distribution, aeration and water retention. The results indicated that growing media had significant effects on plant production parameters. The highest seedling growth attributes were obtained from the media prepared by adding 10% rice hulls to peat material. Aeration porosity and usable water amount as volume of this media was 60.1% and 15.9%, respectively. Among the pure media, it was found that seedling could not grow in pure rice hulls media. It was observed that adding rice hulls material up to 30% to peat material almost gave same results by using peat alone as a media.

Key words: pine production, growing media, water retention, aeration.

INTRODUCTION

The advantages of seedling production in pots applied recently over field production are much more due to easy marketing, long planting and marketing period, easy transportation and rapid product rotation. Choosing the most suitable growing media for the achievement of a successful plant production is very important in potted growth. Three functions of growing media are to support plant in soil, to hold and provide water and nutrient element and to enable plant roots to get sufficient amount of oxygen (Ingram *et al.* 2003). A convenient growing media should not only supply physical, chemical and biological characteristics required by plants but also provide the conditions for practical plant production (e.g. easy to supply, suitable cost, easy processing, lightness and homogenous plant production) (Mathur and Voisin 1996; Sahin *et al.* 2002; Ingram *et al.* 2003; Sahin and Anapali 2006).

Composition of plant growing media may vary depending on the several reasons. Main materials used for the composition of media are sawdust, peat, perlite and vermiculite. As increasing cost and shortage of peat as well as its environmental harms raise doubts as to its usage, researchers have tried to find alternative growth media to peat (Knox *et al.* 1995; Abad *et al.* 2001; Alexander *et al.* 2008; Bustamante *et al.* 2008). In the studies carried out for this aim, organic materials such as rice hulls, tea waste, cotton boll, kenaf, sawdust, bark, coconut fibre and bark, sewage sludge, nut waste and inorganic materials such as pumice, styropor foam and rockwool were determined to be used as growing media (Verdonck 1988; Dueitt and Newman 1994; Sanderson 1994; Papafotiou *et al.* 2001; Kütük 2000; Ercisli *et al.* 2002, 2005a; Sahin *et al.* 2002, 2004; Ingram et al. 2003; Agbo and Omaliko 2006).

In agricultural facilities processing agricultural product, huge amount of waste materials with different characteristics are produced. These materials are collected in working sites of the facilities and they can sometimes prevent regular working (Kütük 2000). Rice hulls are one of these materials and its alternative usage is being investigated. It was reported by Marianthi (2006) that *Pinus halepensis* was able to grow better in a media with 70:30 peat and rice hulls than in 70:30 peat and perlit. Papafotiou *et al.* (2001) stated that in a mixture with equal amount of peat and rice hulls, plant height and the flower number of *Nerium olenader L.* was similar to those in control with peat and perlit.

Pumice is a porous and spongy rock type formed after volcanic activities and exhibiting no chemical reactions (Ayan 2001; Gündüz *et al.* 2001). Its physical and chemical properties do not change (Şahin *et al.* 1997; Kuşlu *et al.* 2005). Turkey has important pumice deposits. Especially Middle and East Anatolia regions of Turkey are rich in pumice (Gündüz *et al.* 2001). Pumice reserve of Turkey is nearly 1.5 billion tons (Anaç and Tamzok 2008).

As pumice is inexpensive and light having high macropores providing aeration and high water retention capacity under low matric potentials it is an important material for the composition of ideal growth media (Sahin *et al.* 2002, 2004; Kuşlu *et al.* 2005; Sahin and Anapali 2006). Maloupa *et al.* (2001) stated in their study that adding of pumice improved physical and chemical structure of substrate and increased the yield in cucumber. Sahin *et al.* (2005) indicated that pumice added to soil in different rates increased the amount of macropore and water retention under low matric potentials which caused positive effects on the growth of strawberry.

Aeration and water retention under low matric potentials of media are the most important factors for plant growth (Kuşlu *et al.* 2005). Plant roots need air for respiration therefore, air is essential for metabolic processes in living organisms. Deficient oxygen and aeration weaken roots and consequently plant itself, slowdown growth and cause plant to be more vulnerable to harms and disease caused by cold. Aeration is needed for the diffusion of carbon dioxide caused by the respiration of root cells and microorganisms to soil surface from roots. Water retained in media is necessary for plant growth and other physiological processes.

Aeration and water retention are the functions of porosity in media. Porosity is formed by pores with different sizes. Pore sizes have traditionally been divided into macropores, mesopores, micropores and ultramicropores (Sahin *et al.* 2002). The macropores (>100 µm diameter) supply drainage and aeration, the mesopores (100-30 µm diameter) supply water conductivity, and the micropores (30-3 µm diameter) supply water retention. The water retained in ultramicropores (<3 µm diameter) is unavailable for plant use.

Aeration porosity (macropores) should be 20 to 25 % at least. These values can be increased to 45 % in warm green house conditions since the oxygen need of roots and carbon dioxide production increased. Water retention decreases by increasing the macropores in a media (Kuşlu *et al.* 2005).

Pinus sylvestris can grow naturally in high altitudes in different parts of the world and it is dominantly present in East Anatolia Region of Turkey. With some characteristics, this plant species can be used in park and recreational areas as Christmas plant and in erosion control works. The aim of present study was to determine the effect of rice hulls, pumice and peat materials in Scotch pine (*Pinus sylvestris*) production and their mixtures.

MATERIALS AND METHODS

Experiments were conducted in the research area of Atatürk University, Erzurum at an altitude of 1850 m, under outdoor conditions from May 30 to November 7. Mean temperature values of May (for two days), June, July, August, September, October, and November (for seven days) are 13.7 ºC, 14.4 ºC, 18.1 ºC, 18.6 ºC, 15.2 ºC, 8.5 ºC and 3.2 ºC, respectively, while rainfall is 5.1 mm, 61.8 mm, 41.9 mm, 30.4 mm, 0.1 mm, 33.7 mm and 21.8 mm (TSMS 2009).

Mature seeds from Scotch pines (*Pinus sylvestris*) growing in Atatürk University Campus were collected and planted in growth media two seeds in 250 cm^3 pots on May 30. Growing media were prepared using peat, pumice and rice hulls materials. Eighteen growing media were prepared using certain amounts (by volume) of materials (Table 1). Pumice was obtained from Van-Erciş region of Turkey, rice hulls from Artvin-Yusufeli region of Turkey and peat was from Finland. Table 2 presents some features of materials used in the study and determined according to the standards of Klute (1986a) and Page *et al.* (1982). Peat and rice hulls for preparing of media were used in their natural forms. However, pumice was passed through a sieve with openings of 2-4 mm and < 2 mm before mixing with each other. Complete randomized experimental design was applied with three repetitions and there were 20 plants in each repetition.

After the shootings of seedlings were appeared, plants in pots were taken so as to leave only one plant in each pot. Irrigation was performed daily by spraying. All seedlings were applied composed fertiliser once a week for three months at the rate of 10 g m^{-2}. Electrical conductivity of fertiliser solution was 2.0-2.5 dS m^{-1} during growth period and 1.5-2.0 dS m^{-1} in lignification period. Composed fertilisers with the rates 13-40-13, 20-20-20 and 0-20-25 were applied to the experiment pots for the first, second and third months, respectively.

Seedlings were harvested on November 7 and plant collar diameter (0.5 cm height from ground) (Marianthi 2006), seedling length, root length, the number of roots, fresh and dry root weight, fresh and dry seedling weight were measured.

The water retention characteristics was determined using pressure plates (Klute 1986b), and was used as the basis for the calculation of the pore size distribution. Water held at suctions of 1.0, 10.1, 33.4, 101.3, and 1520 kPa were obtained when water output stopped for a given suction. Porosity was estimated by calculation (Danielson and Sutherland 1986).

Statistical analysis of collected data was conducted using SPSS 13.0 software package. For the comparison of the media, Duncan's multiple range tests was used.

RESULTS AND DISCUSSION

Collar diameter (CD), seedling length (SL), root length (RL), root number (RN), fresh root weight (FRW), dry root weight (DRW), fresh seedling weight (FSW) and dry seedling weight (DSW) of Scotch pine (*Pinus sylvestris)* grown in different media exhibited statistically significant differences depending on growing media (Table 3).

Rice hulls used alone were the most unfavourable media in respect of seedling growth attributes. Very few of the seeds planted in this media grew and they died after a short time. Fig. 1 shows the pore sizes distribution in growing media, in the rice hulls media with a total porosity rate of 94.8 %, pores were macropores in the rate of 86.1% providing drainage and aeration (> 100 µm). Since the amount of water retained in the media was very low under this condition, plants could consume this amount in a very short time. The amount of usable water retained the interval of 10.1 to 1520 kPa matric potentials in rice hulls medium was 1.92%, which was lower than in other media (Fig. 2). Allelochemicals in organic materials may also have unfavourable effects on the growth of seeds and plant depending on concentration (Leather and Einhellig 1986; Bulut *et al.* 2006; Bulut and Demir 2007). Ahn and Chung (2000) claimed that rice hulls had unfavourable effects on seed germination.

Among the pure media, the statistically best plant growth results were provided by peat (Table 3). This consequence can be explained by having better physical and chemical properties of peat for plant production than that of pumice and rice hulls (Table 2, Fig. 1 and 2).

Mixture of materials could give better results than pure ones (Table 3), which is convenient with the results in previous studies (Bulut and Güclü 1995; Şahin *et al.* 1998; Hicklenton *et al.* 2001; Papafotiou *et al.* 2004; Ercisli *et al.* 2005b; Grigatti *et al.* 2007).

Among the mixture media, the mixture of peat and rice hulls gave the best results for plant production. The media of 90% peat + 10% rice hulls (90Pe:10Rh) gave the best results, which was followed by 80% peat + 20% rice hulls (80Pe:20Rh) (Table 3). However, with the increasing rice hulls rate in the media, all seedling growth attributes decreased. Decrease in all parameters, except for collar diameter, was statistically significant. It was observed by Marianthi (2006) that in the growth of *Pinus halepensis* seedlings, increasing the proportion of rice hulls, the seedlings' height and diameter decreased. Aeration porosity (macropores) and usable water retention are among the most important physical properties of media for plant growth (Kuşlu *et al.* 2005; Sahin *et al.* 2005; Sahin and Anapali 2006). This may be the reason for that the mixtures of 90% peat + 10% rice hulls and 80% peat + 20% rice hulls gave the best results because of high aeration porosity and high usable water amount. With the increasing rate of rice hulls in peat + rice hulls mixtures, aeration porosity increased; however, usable water amount decreased (Fig. 1 and 2). Significant linear relationships were apparent among aeration porosity and usable water amount and seedling growth attributes (Table 4). In addition, cation exchange capacity (CEC) closely related to productivity and plant feeding is among the most important chemical properties (Kacar *et al.* 2009). As can be seen from Table 2, high CEC values of peat material might have contributed to better results.

Table 1. Growing media and mixture rates

Growing media	Mixture rate (by volume)	Symbol
Rice Hulls	100	Rh
Pumice	100	Pu
Peat	100	Pe
Pumice: Rice Hulls	90:10	90Pu:10Rh
Pumice: Rice Hulls	80:20	80Pu:20Rh
Pumice: Rice Hulls	70:30	70Pu:30Rh
Pumice: Rice Hulls	60:40	60Pu:40Rh
Pumice: Rice Hulls	50:50	50Pu:50Rh
Pumice: Peat	90:10	90Pu:10Pe
Pumice: Peat	80:20	80Pu:20Pe
Pumice: Peat	70:30	70Pu:30Pe
Pumice: Peat	60:40	60Pu:40Pe
Pumice: Peat	50:50	50Pu:50Pe
Peat: Rice Hulls	90:10	90Pe:10Rh
Peat: Rice Hulls	80:20	80Pe:20Rh
Peat: Rice Hulls	70:30	70Pe:30Rh
Peat: Rice Hulls	60:40	60Pe:40Rh
Peat: Rice Hulls	50:50	50Pe:50Rh

Table 2. Some chemical and physical properties of materials used in growing media

Property	Material		
	Rice Hulls	Pumice	Peat
Specific gravity (g cm^{-3})	1.531	1.614	1.532
Bulk density (g cm^{-3})	0.080	0.532	0.096
Porosity (%)	94.78	67.04	93.73
Organic matter (%)	81.9	-	88.9
CEC[#] (cmol(+) kg^{-1})	25.9	6.40	129.3
pH	6.15	7.82	5.21
$CaCO_3$ (%)	-	0.89	-
EC[$] (dS m^{-1})	0.230	0.094	0.683

[#]Cation Exchange Capacity [$]Electrical Conductivity

Plant growth was slower in pumice + peat mixtures than in peat + rice hulls mixtures (Table 3). However, pumice + peat mixture media provided a better plant growth compared to pumice alone. Increasing peat rate in the pumice + peat mixtures also increased all seedling growth attributes except root length; however root length and fresh seedling weight was found to be statistically significant. Increasing peat rate in the pumice + peat mixtures increased hairy root formation. So, root length decreased. Mixture of 50% pumice + 50% peat (50Pu:50Pe) was the media providing maximum plant

Table 3. The mean values for collar diameter (CD), seedling length (SL), root length (RL), root number (RN), fresh root weight (FRW), dry root weight (DRW), fresh seedling weight (FSW), dry seedling weight (DSW) of Scotch pine (*Pinus sylvestris)* grown in different media and standard errors of means.

Growing media	Property							
	CD (mm)	SL (cm)	RL (cm)	RN	FRW (g)	DRW (g)	FSW (g)	DSW (g)
Rh	$0^{h\&}$	0^{d}	0^{i}	0^{d}	0^{i}	0 h	0^{k}	0^{k}
Pu	1.36 ± 0.03^{cde}	7.57 ± 0.30^{c}	9.30 ± 0.15^{h}	1.07 ± 0.03^{bc}	0.316 ± 0.03^{fgh}	0.122 ± 0.01^{fg}	0.213 ± 0.01^{ij}	0.169 ± 0.01^{ghi}
Pe	2.13 ± 0.07^{a}	9.07 ± 0.03^{ab}	10.27 ± 0.38^{defg}	1.30 ± 0.00^{ab}	0.835 ± 0.10^{bc}	0.238 ± 0.01^{bcd}	0.909 ± 0.06^{bc}	0.329 ± 0.01^{cd}
90Pu:10Rh	1.22 ± 0.02^{def}	7.53 ± 0.20^{c}	10.77 ± 0.30^{defg}	1.03 ± 0.03^{bc}	0.289 ± 0.02^{fgh}	0.082 ± 0.00^{g}	0.300 ± 0.01^{hi}	0.111 ± 0.00^{hij}
80Pu:20Rh	1.12 ± 0.08^{efg}	7.40 ± 0.27^{c}	10.65 ± 0.32^{defgh}	1.03 ± 0.03^{bc}	0.169 ± 0.02^{ghi}	0.078 ± 0.01^{g}	0.196 ± 0.02^{ij}	0.108 ± 0.00^{ij}
70Pu:30Rh	1.03 ± 0.07^{fg}	7.33 ± 0.15^{c}	10.60 ± 0.42^{defgh}	1.03 ± 0.03^{bc}	0.166 ± 0.04^{ghi}	0.073 ± 0.01^{g}	0.142 ± 0.01^{ijk}	0.099 ± 0.01^{j}
60Pu:40Rh	0.95 ± 0.07^{fg}	7.27 ± 0.20^{c}	9.43 ± 0.24^{gh}	1.00 ± 0.00^{c}	0.105 ± 0.02^{hi}	0.070 ± 0.02^{g}	0.131 ± 0.01^{ijk}	0.097 ± 0.00^{j}
50Pu:50Rh	0.92 ± 0.03^{g}	7.03 ± 0.21^{c}	9.37 ± 0.65^{h}	1.00 ± 0.00^{c}	0.103 ± 0.02^{hi}	0.065 ± 0.01^{g}	0.112 ± 0.02^{jk}	0.093 ± 0.01^{j}
90Pu:10Pe	1.40 ± 0.06^{bcd}	7.40 ± 0.21^{c}	13.03 ± 0.12^{ab}	1.30 ± 0.06^{ab}	0.386 ± 0.04^{efg}	0.118 ± 0.01^{fg}	0.451 ± 0.04^{gh}	0.166 ± 0.01^{ghi}
80Pu:20Pe	1.45 ± 0.03^{bcd}	7.45 ± 0.10^{c}	11.20 ± 0.50^{de}	1.30 ± 0.10^{ab}	0.469 ± 0.03^{def}	0.118 ± 0.01^{fg}	0.496 ± 0.04^{fg}	0.174 ± 0.01^{gh}
70Pu:30Pe	1.50 ± 0.04^{bc}	7.60 ± 0.27^{c}	10.93 ± 0.26^{def}	1.33 ± 0.07^{a}	0.517 ± 0.01^{def}	0.121 ± 0.00^{fg}	0.582 ± 0.01^{efg}	0.189 ± 0.00^{g}
60Pu:40Pe	1.60 ± 0.10^{bc}	7.67 ± 0.17^{c}	10.23 ± 0.15^{defgh}	1.43 ± 0.09^{a}	0.519 ± 0.05^{def}	0.145 ± 0.02^{ef}	0.626 ± 0.06^{ef}	0.215 ± 0.01^{fg}
50Pu:50Pe	1.65 ± 0.05^{b}	7.70 ± 0.12^{c}	9.70 ± 0.15^{fgh}	1.47 ± 0.03^{a}	0.578 ± 0.06^{de}	0.149 ± 0.01^{ef}	0.659 ± 0.04^{ef}	0.224 ± 0.02^{fg}
90Pe:10Rh	2.18 ± 0.16^{a}	9.74 ± 0.10^{a}	14.20 ± 0.30^{a}	1.43 ± 0.09^{a}	1.241 ± 0.10^{a}	0.364 ± 0.05^{a}	1.258 ± 0.07^{a}	0.514 ± 0.04^{a}
80Pe:20Rh	2.17 ± 0.06^{a}	9.27 ± 0.08^{ab}	13.93 ± 0.37^{a}	1.37 ± 0.12^{a}	1.115 ± 0.09^{a}	0.295 ± 0.01^{b}	1.187 ± 0.06^{a}	0.420 ± 0.02^{b}
70Pe:30Rh	2.17 ± 0.05^{a}	8.87 ± 0.24^{b}	12.53 ± 0.04^{bc}	1.27 ± 0.12^{abc}	0.873 ± 0.08^{b}	0.268 ± 0.01^{bc}	1.005 ± 0.06^{b}	0.369 ± 0.01^{bc}
60Pe:40Rh	2.02 ± 0.04^{a}	8.86 ± 0.06^{b}	11.47 ± 0.30^{cd}	1.03 ± 0.03^{bc}	0.685 ± 0.05^{bcd}	0.226 ± 0.01^{cd}	0.830 ± 0.02^{cd}	0.306 ± 0.02^{de}
50Pe:50Rh	1.96 ± 0.04^{a}	8.83 ± 0.27^{b}	10.00 ± 0.06^{efgh}	1.03 ± 0.03^{bc}	0.643 ± 0.07^{cd}	0.203 ± 0.01^{de}	0.745 ± 0.06^{de}	0.265 ± 0.00^{ef}

$^{\&}$ There is no statistical difference between means represented by the same letter in the same column (P<0.01)

Table 4. The relationships among aeration porosity (macropores) and usable water amount retained the interval of 10.1 to 1520 kPa matric potentials and seedling growth attributes in peat + rice hulls growing media

Relationships between aeration porosity (x) and seedling growth attributes			Relationships between usable water amount (x) and seedling growth attributes		
CD	= -0.017x + 3.227	; R^2 = 0.762	CD	= 0.028x + 1.766	; R^2 = 0.524
SL	= -0.066x + 13.48	; R^2 = 0.780	SL	= 0.145x + 7.416	; R^2 = 0.920
RL	= -0.328x + 34.12	; R^2 = 0.975	RL	= 0.579x + 5.645	; R^2 = 0.746
RN	= -0.033x + 3.436	; R^2 = 0.876	RN	= 0.059x + 0.528	; R^2 = 0.684
FRW	= -0.048x + 4.126	; R^2 = 0.952	FRW	= 0.091x – 0.155	; R^2 = 0.821
DRW	= -0.011x + 1.017	; R^2 = 0.887	DRW	= 0.023x – 0.002	; R^2 = 0.937
FSW	= -0.041x + 3.742	; R^2 = 0.971	FSW	= 0.075x + 0.126	; R^2 = 0.784
DSW	= -0.017x + 1.552	; R^2 = 0.918	DSW	= 0.036x – 0.047	; R^2 = 0.926

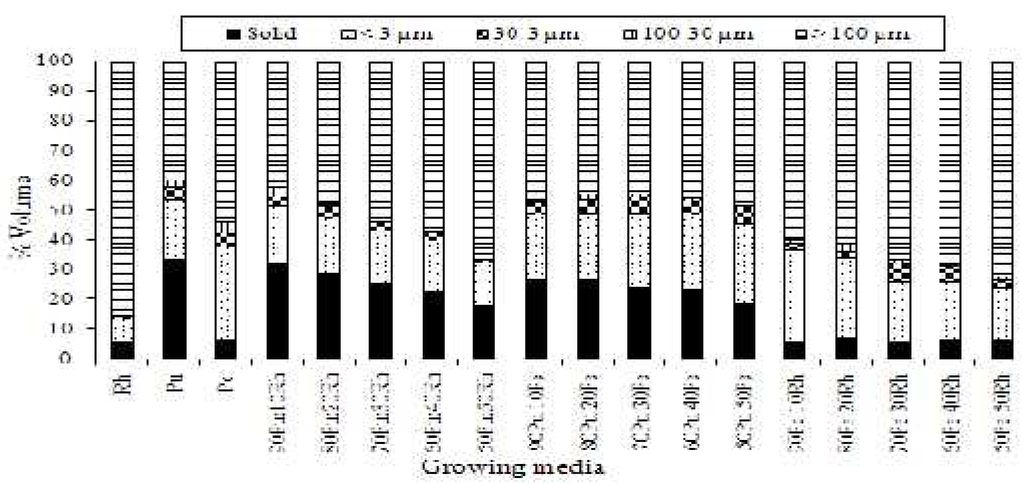

Figure 1. The solid and pore size distribution of growing media

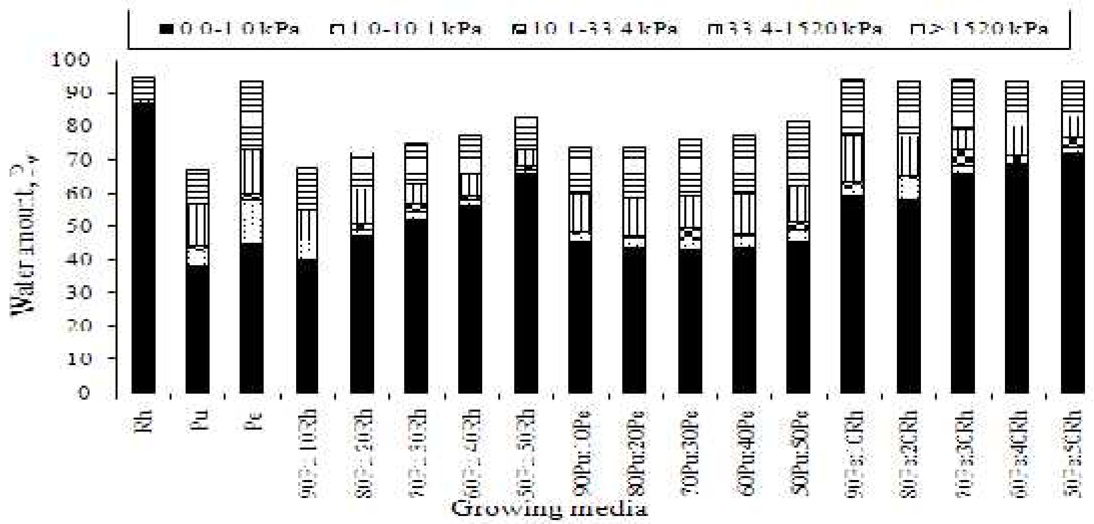

Figure 2. The water retention amounts of growing media for different matric potential intervals

growth with higher aeration porosity (macropores) and usable water amount (Fig. 1 and 2).

The lowest values for seedling growth attributes were found in the mixture of pumice and rice hulls (Table 3). Plant growth values in these media were lower than pumice alone. The best results in mixtures of pumice and rice hulls were obtained from the mixture of 90% pumice + 10% rice hulls (90Pu:10Rh). As the rice hulls increased in the media, a decrease was observed in production parameters. However, this decrease was not statistically significant for most of them. Increase in rice hulls in the mixture increased aeration porosity (macropores) while it decreased usable water amount (Fig. 1 and 2).

As a consequence, in the seedling production of Scotch pine (*Pinus sylvestris*), the best media were peat alone and mixtures of rice hulls added to peat up to 30% (Table 3). In the mixtures of peat and rice hulls, collar diameter was found to be statistically higher than other media except peat media. The biggest collar diameter was obtained as 2.18 mm in the mixture with 90% peat + 10% rice hulls (90Pe:10Rh). When the effect of media on seedling length is considered, no statistical difference was seen between peat and mixtures of peat and rice hulls. However, numerically the longest seedlings were obtained as 9.74 cm in the mixture with 90% peat + 10 rice hulls (90Pe:10Rh). The maximum values for other seedling growth attributes were also obtained in the same mixture. These values were also found to be statistically significant.

Peat is commonly used in the production of pot plants and seedling as growing media either in its pure form or mixture with other materials. Peat is imported in addition to domestically produced amount. Excessive use of peat can cause the devastation of natural resources and economic loss. Rice production is prevalent in some parts of Turkey like Blacksea, Thracia and Middle Anatolia regions and hulls are formed after harvesting. In the present study, it was found that positive results were obtained in seedling production of Scotch pine (*Pinus sylvestris*) with the addition of rice hulls in peat media to a certain level. It was suggested that healthy and quality plants can be obtained by adding rice hulls in peat media to seedling production of Scotch pine (*Pinus sylvestris*). This waste material can be evaluated by providing economical contribution to country's economy. In addition, devastation in wetlands can be prevented and reserves can be conserved.

REFERENCES

Abad, M., P. Noguera, and S. Burés (2001). National inventory of organic wastes for use as growing media for ornamental potted plant production: case study in Spain. Biores. Tech. 77:197-200.

Agbo, C. U., and C. M. Omaliko (2006). Initiation and growth of shoots of Gongronema latifolia Benth stem cuttings in different rooting media. African J. Biotechnol. 5:425-428.

Ahn, J. K., and I. M. Chung (2000). Allelopathic potential of rice hulls on germination and seedling growth of barnyardgrass. Agron. J. 92:1162-1167.

Alexander, P. D., N. C. Bragg, R. Meade, G. Padelopoulos, and O. Watts (2008). Peat in horticulture and conservation: the UK response to a changing world. Mires and Peat 3:1-10.

Anaç, S., and N. Tamzok (2008). Structural transformation in the Turkish mining industry. Proc. 21st World Mining Congress, Krakow-Poland, 367-376.

Ayan, S. (2001). Alternatives for soilless Culture media in seedling production. Gazi Univ. J. For. Fac. 1:30-42.

Bulut, Y, and K. Güclü (1995). A study on the rooting of *Rhododendron Simsii Rheinhold Ambrosius* shootings under green house in Erzurum. Atatürk Univ. J. Agric. Fac. 26:483-494.

Bulut, Y., S. Kordali, and O. Atabeyoglu (2006). The allelopathic effect of Pictacia leaf extracts and pure essential oil components on Pelargonium Ringo Deep Scarlet F1 seed germination. J. Appl. Sci. 6:2040- 2042.

Bulut, Y., and M. Demir (2007). The Allelopathic effects of Scots Pine (*Pinus sylvestris* L.) leaf extracts on turf grass seed germination and seedling growth**.** Asian J. Chem. 19:3169-3177.

Bustamante, M. A., C. Paredes, R. Moral, E. Agulló, M. D. Pérez-Murcia, and M. Abad (2008). Composts from distillery wastes as peat substitutes for transplant production. Resour. Conservat. Recycl. 52:792-799.

Danielson, R. E., and P. L. Sutherland (1986). Porosity. In: Klute, A. (ed) Methods of soil analysis: Part 1 Physical and mineralogical methods. Soil Sci. Soc. Amer. Inc., Madison, Wisconsin, pp 443-460.

Dueitt, S. and S. E. Newman (1994). Physical analysis of fresh and aged rice hulls used as a peat moss substitue in greenhouse media. Proc. SNA Research Conference 39:81-85.

Ercisli, S., O. Anapali, A. Esitken, and U. Sahin (2002). The effects of IBA, rooting media and cutting collection time on rooting of kiwifruit. Gartenbauwissenschaft 67:34-38.

Ercisli, S., A. Esitken, O. Anapali, and U. Sahin (2005a). Effects of substrate and IBA-concentration on adventitious root formation on hardwood cuttings of *rosa dumalis.* Acta Hort. 690:149-152.

Ercisli, S., U. Sahin, A. Esitken, and O. Anapali (2005b). Effects of some growing media on the growth of strawberry cvs. 'Camarosa' and 'Fern'. Acta Agrobotanica 58:185-191.

Grigatti, M., M.E. Giorgioni, and C. Ciavatta (2007) Compost-based growing media: Influence on growth and nutrient use of bedding plants. Biores. Tech. 98:3526-3534.

Gündüz, L., A. Rota and A. Hüseyin (2001). Analysis of material characteristics of pumice formation in Turkey and the world. 4th Industrial Raw Material Symposium, İzmir, 175-188.

Hicklenton, P. R., V. Rodd and P. R. Warman (2001). The effectiveness and consistency of source-separated municipal solid waste and bark composts as components of container growing media . Scientia Horticulturae 91:365-378.

Ingram, D. L., R. W. Henley, and T. H. Yeager (2003). Growth media for container grown ornamental plants. Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, BUL 241.

Kacar, B., A. V. Katkat, and Ş. Öztürk (2009). Plant physiology, 3rd ed. Nobel Publishing, Ankara.

Klute, A. (1986a) Methods of soil analysis, Part 1: Physical and mineralogical methods. Soil Sci. Soc. Amer. Inc., Madison, Wisconsin.

Klute, A. (1986b) Water retention: Laboratory methods. In: Klute, A. (ed) Methods of soil analysis, Part 1: Physical and mineralogical methods. Soil Sci Soc Amer Inc, Madison, Wisconsin, pp 635-660.

Knox, G., J. Norcini, and D. Covan (1995). Evaluation of waste products as peat substitutes in container substrates. Proc. SNA Research Conference 40: 98-100.

Kuşlu, Y., Ü. Şahin, Ö. Anapalı, and S. Şahin (2005). Use possibilities of pumice in cultural activities obtained from different parts of Turkey for aeration and water retention features. Turkey Pumice Symposium and Exhibition 2005, Isparta, 301-306.

Kütük, C. (2000). Use of the compost of tea waste and waste fungi in ornamental plant culture. Mustafa Kemal Univ. J. Agric. Fac. 5:75-86.

Leather, G. R., and F. A. Einhellig (1986). Bioassays in the study of Allelopathy. In: Putnam, A.R., Tang, C.S. (eds) The science of Allelopathy. John Wiley and Sons, New York, pp 133-145.

Maloupa, E., A. Abou Hadid, M. Prasad, and C. H. Kavafakis (2001). Response of cucumber and tomato plants to different substrates mixtures of pumice in substrate culture. Acta Hort. 559:593-600.

Marianthi, T. (2006). Kenaf (Hibiscus cannabinus L.) core and rice hulls as components of container media for growing *Pinus halepensis* M. Seedlings. Biores. Tech. 97:1631-1639.

Mathur, S. P., and B. Voisin (1996). The use of compost as greenhouse growth media. Final report, Ministry of Environment and Energy, Ontario.

Page, A. L., R. H. Miller, and D. R. Keeney (1982). Methods of soil analysis, Part 2: Chemical and microbiological properties. Soil Sci. Soc. Amer. Inc., Madison, Wisconsin.

Papafotiou, M., J. Chronopoulos, G. Kargas, M. Voreakou, N. Leodaritis, O. Lagogiani, and S. Gazi (2001). Cotton gin trash compost and rice hulls as growing medium components for ornamentals. J. Hort. Sci. Biotech. 76:431-435.

Papafotiou, M., M. Phsyhalou, G. Kargas, I. Chatzipavlidis, and J. Chronopoulos (2004). Olive-mill wastes compost as growing medium component for the production of poinsettia. Scientia Horticulturae 102:167-175.

Şahin, Ü., A. Hanay, and Ö. Anapalı (1997). A study on the use of pumice in soilless culture in greenhouses. Proc. 1st Isparta Pumice Symposium, Isparta, 133-139.

Şahin, Ü., A. Özdengiz, A. Zülkadir, and R. Alan (1998). Effects of growth media on yield, quality and plant development of *Lycopersicon esculentum* Mill. under drop irrigation conditions in green house. Turk J. Agric. For. 22:71-79.

Sahin, U., O. Anapali, and S. Ercisli (2002). Physico-chemical and physical properties of some substrates used in horticulture. Gartenbauwissenschaft 67:55-60.

Sahin, U., S. Ercisli, O. Anapali, and A. Esitken (2004). Regional distribution and some physico-chemical and physical properties of some substrates used in horticulture in Turkey. Acta Hort. 648:177-183.

Sahin, U., S. Ors, S. Ercisli, O. Anapali, and A. Esitken (2005). Effect of pumice amendment on physical soil properties and strawberry plant growth. J. Cent. Eur. Agric. 6:361-366.

Sahin, U., and O. Anapali (2006). Addition of pumice affects physical properties of soil used for container grown plants. Agric. Conspec. Sci. 71:59-64.

Sanderson, K. C. (1994). Use of cocoa bean shell mulch as a media amendment for potted chyrsanthemums. SNA Research Conference 39:86-88.

TSMS, (2009). Turkish State Meteorological Service, Ankara.

Verdonck, O. (1988). Composts from organic waste materials as substitutes for the usual horticultural substrates. Biol. Waste. 26:325-330.