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Short note

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Tobacco dust waste as an alternative medium to grow geranium (*Pelargonium x hortorum*) plants

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Abstract: Tobacco dust (TD) waste is the typical lignocellosic agricultural residue of cigarette processing. In the region of Peloponnese, cigarette production is carried out by the leading company of Karelias S.A. The production of TD waste of approx. 2-3 tons/month is a major problem for the company. Plant growth media containing peat (P) + 0, 5, 10, 25 or 50% TD were prepared and tested on geranium plant growth and development. The use of TD increased EC and pH of the final medium. Plants of the cvs "ML Diego" and "ML Sailing '12" grown in P+5% or in P+10% TD had similar height, number of leaves, number of flowers, photosynthetic activity and transpiration rates to the P alone (control) indicating that solid agro-industrial waste of tobacco could be used to partially substitute peat in growing medium for floricultural crop production.

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All relevant data are within the paper and its Supporting Information files.

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The authors declare no competing interests.

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1. Introduction

Pelargonium x hortorum or ''zonal geranium'' is an ornamental species that originate from South Africa, perfectly adapted to the Mediterranean region. It is propagated by cuttings and it is a hybrid between *P. inquisaus* (L.) L'Herit and *P. zonale* (L.) L'Herit (Dole and Wilkins, 2005). Zonal geraniums attract an increased commercial interest as they are extensively used in landscape designs and terrace gardens (Berninger, 1993). Flowering is strongly dependent on growth stage (i.e. juvenility), temperature (i.e. cold requirement) and sunlight (i.e. intensity and duration), but zonal geraniums are not described as long- or short-day plants (Fonteno, 1992; Dole and Wilkins, 2005).

Agricultural waste such as cotton gin trash, olive mill and green waste have been used in combination with peat for cultivation of ornamental plants (Papafotiou *et al.*, 2004; 2005; Grigatti *et al.,* 2007). The residue from tobacco processing (i.e. the tobacco dust; TD) is buried to landfields, but in high w/w concentrations can be toxic due to its high tannin and alkaloid content (Briski *et al.,* 2003). Compared to other waste material, TD contains higher N and K and has pH values ranging between 5.0 and 6.0 (Aderidan *et al.,* 2003). The application of TD waste in soil cultivated with lettuce increased yield compared to control plants (Okur *et al.,* 2008). It was suggested that incorporation of TD waste as an alternative organic amendment might improve soil chemical and biological parameters, as well as crop yield in soils containing low organic matter content.

Apparently, no previous research has been conducted on utilization of tobacco byproducts as alternatives to grow ornamental plants. In the present study, we tested growing mediums of peat + increasing concentrations of TD on growth and flowering response of zonal geraniums.

2. Materials and Methods

Plant material, media preparation and experimental lay-outs

Zonal geranium (*Pelargonium x hortorum*) rooted cuttings (3-5 leaves; up to 12 cm height) of cvs 'ML Diego' (red inflorescences) and 'ML Sailing'12' (white inflorescences) were provided by Selecta-one ltd (Kavala, Greece). Single rooted cuttings were transplanted in plastic 2.5 L pots filled with growing mediums of peat + TD. TD was provided by Karelias S.A. (Kalamata, Greece) and samples were analyzed in a continuous flow analyzer (CFA AA3; Seal-Analytical Ltd., Germany) (Table 1). Peat (Hawita, Germany) was mixed with 0, 5, 10, 25 and 50% (w/w) TD (Table 2). Six-replicate pots per treatment with geranium plants were placed on the ground of a non-heated greenhouse at the premises of the University of Peloponnese (lat. 37° 2' 20'' N, long. 22° 6' 51'' E) in a completely randomized design. Two individual experiments were carried out (one for each cultivar) from November 2017 to February 2018.

Medium properties, plant assessments and statistical analysis

Medium pH and EC (mS/cm) were measured using a pH/mV Meter (Delta OHM HD 2105.2, Padova, Italy) and a Conductivity Handheld Meter (Eutech Instruments, EcoScan CON 5, Singapore), respectively. Plant height (cm), number of leaves and number of inflorescences were recorded weekly over the entire cultivation period of nine weeks. Chlorophyll fluorescence, net CO_2 assimilation (A_s; µmol m^{-2} sec) and transpiration (E; mmol m^{-2} sec) were recorded using a handheld fluorimeter (OS-30p, Opti-Sciences, Inc. U.S.A.) and a LCpro+ portable photosynthesis system (ADC Bioscientific ltd. Great Amwell, Herts, UK), respectively, on the 5th, 6th, 7th and the 8th week from transplanting (i.e. week-1). Data means were separated using Duncan's multiple range test at P = 0.05. Statistical analysis was performed in SPSS v. 21.

3. Results

Tobacco dust contained nicotine, TSS and small amounts of nitrates and ammonia (Table 1). EC and pH values ranged between 8.92 and 9.46, and between 5.3 and 5.6, respectively. After mixing peat with 0 - 50% TD, pH and EC of the final growing medium increased linearly to reach the values of 5.42 and 6.18 mS/cm, respectively (Table 2).

Table 1 - Means and range values of tobacco dust content

Tobacco dust content	Means	Range
Nicotine (mg/L)	158.18	157.84 -160.14
TSS (mg/L)	583.12	581.36 -584.04
Nitrates (mg/L)	32.06	30.15-33.02
Ammonia (mg/L)	6.38	6.25 - 6.52
EC (mS/cm)	9.17	8.92-9.46
pH	5.5	5.3-5.6

Tobacco dust samples were analyzed in a continuous flow analyzer

Table 2 - pH and EC (mS/cm) values of growing media after mixing peat with tobacco dust at 0 (control), 5, 10, 25 and 50% (w/w)

Growing media	pH	EC (mS/cm)
Mixing peat	4.00	0.06
Mixing peat + 5% Tobacco dust	4.51	1.30
Mixing peat + 10% Tobacco dust	4.85	3.22
Mixing peat + 25% Tobacco dust	5.09	4.84
Mixing peat + 50% Tobacco dust	5.42	6.18

Peat replacement with 5 or 10% TD in the growing medium positively affected growth and flowering of cvs. "ML Diego" and "ML Sailing'12" geraniums (Table 3). Plants of cv. "ML Diego" grown in P+5% or P+10% TD maintained similar or higher height, number of leaves, number of inflorescences, net CO_2 assimilation and transpiration rates to the control plants (i.e. P+0% TD) (Table 3). However, plants grown in P+25 or P+50% TD suffered reductions in growth and flowering compared to the controls. Plants grown in P+25 or P+50% TD showed reduced number of inflorescences and transpiration rates, compared to the plants grown in P+5 or P+10% TD (Table 3). Stunting growth and reduced flowering of plants cultivated in P+25 or P+50% TD were justified by decreases in chlorophyll fluorescence (F_v/F_m) ratios (Table 3). The F_v/F_m ratios ranged between 0.571 and 0.893 for plants grown in P+25% TD and between 0.538 and 0.835 for plants grown in P+50% TD indicating damage in plants' photosystem (PS II) that induced stress responses.

Plants of cv. "ML Sailing'12" grown in P+5, P+10 or P+25% TD, showed similar or higher number of leaves, number of inflorescences, net CO_2 assimilation and transpiration rates to the control plants (Table 3). However, plants grown in P+50% TD showed reduced height, number of leaves, number of inflorescences, indicating damage in plants' photosystem (PS II) recorded as low F_v/F_m ratio ranging between 0.538 and 0.773 (Table 3). Plants in P+50% TD failed to reach minimum growth requirements and standard commercial size.

4. Discussion and Conclusions

TD successfully replaced part of peat in growth medium for zonal geranium plant production. Plants of cvs. "ML Diego" and "ML Sailing 12" responded well when grown in P+5, P+10 and in few cases in P+25% TD and, therefore, could potentially replace part of peat in the growth medium. The concept of peat replacement with agricultural waste material for the cultivation of ornamental plants has been examined the past 20 years. Papafotiou *et al.* (2004) showed that olive-mill waste composts (OWC) could partially replace peat for the production of *Euphorbia pulcherrima* (poinsettia), although, at concentration of >12.5% delayed growth compared to plants cultivated in peat/perlite medium. Tropical potted plants such as *Syngonium podophyllum*, *Ficus benjamina* and *Codiaeum variegatum* could be successfully grown in 75% OWC without showing symptoms of toxicity or other negative effects on growth and development (Papafotiou *et al.,* 2005). Cotton gin trash compost (CGTC) and rice hulls (RH) were tested as peat replacements for the production of *Nerium oleander*, *Pelargonium zonale*, *Dedranthema grandiflora* and *Lantana camara* (Papafotiou *et al.,* 2001). Replacing peat with 60% of GCTC resulted in plant height decrease of all species, except those of *P. zonale* and increase in number of flowers to all species, except those of *D. grandiflora*. The use of green waste and sewage sludge compost (WSSC) at 80% - 20% (v:v) as a 25%-replacement of white peat, had positive effects on growth and flowering of *Begonia semperflorens, Mimulus hybridus, Tagetes patula x erecta* and *Salvia splendens* (Grigatti *et al.,* 2007). All species grown in 25% WSSC showed greater height, number of flowers and plant dry weight compared to plants grown in 100% white peat. TD is a potent agricultural byproduct that could be used in concentrations of <25% without affecting growth and quality of ornamentals. Replacing peat with byproducts of the agricultural sector, merits an eco-biological prospect of environmental-friendly ornamental production. Further research is needed to test TD as peat replacement for cultivation of other ornamental species.

Table 3 - Effect of growing medium of peat amended with 0, 5, 10, 25 and 50% TD on number of leaves, plant height, number of inflorescences, chlorophyll fluorescence, net CO_2 assimilation and transpiration of *P. x hortorum* plants of cvs "ML Diego" and "ML Sailing'12"

Treatments	Plant height (cm)	Range (cm)	Number of leaves	Range	Number of inflorescences	Range	Net CO_2 assimilation (μmol m^{-2}.sec)	Range (μmol m^{-2}.sec)	Transpiration (mmol m^{-2}.sec)	Range (mmol m^{-2}.sec)	Chlorophyll fluorescence (F_v/F_m)	Range (F_v/F_m)
ML Diego'												
0	8.83±0.25 ab	4-16	11.82±0.41 c	4-24	0.85±0.07 a	0-3	2.18±0.26 a	0.34-6.11	1.00±0.087 a	0.61-1.92	0.805±0.001 a	0.778-0.834
5	8.89±0.27 ab	2-18	13.50±0.66 b	4-33	0.86±0.09 a	0-6	3.01±0.34 a	0.24-7.14	1.36±0.170 a	0.71-2.57	0.801±0.002 a	0.685-0.828
10	9.12±0.24 a	5-17	15.12±0.68 a	2-36	0.93±0.10 a	0-5	2.40±0.29 a	0.22-5.32	1.28±0.184 a	0.42-2.34	0.802±0.002 a	0.753-0.878
25	8.39±0.23 b	4-15	12.11±0.55 bc	4-28	0.60±0.08 b	0-3	2.08±0.20 a	0.28-4.00	0.65±0.060 b	0.33-1.06	0.786±0.004 b	0.571-0.893
50	7.01±0.19 c	4-18	5.79±0.32 d	2-20	0.31±0.05 c	0-2	2.23±0.68 a	0.14-4.90	0.37±0.082 c	0.13-0.61	0.731±0.006 c	0.538-0.835
ML Sailing'12'												
0	9.70±0.33 a	5-16	14.11±0.62 bc	5-24	0.83±0.10 ab	0-3	2.07±0.32 b	0.34-4.07	0.89±0.096 a	0.29-1.40	0.801±0.001 a	0.778-0.819
5	9.53±0.38 a	2-18	15.79±1.00 ab	4-33	0.76±0.11 ab	0-3	3.40±0.52 a	0.24-7.14	1.04±0.161 a	0.30-2.72	0.793±0.003 a	0.685-0.818
10	9.07±0.34 a	5-17	16.68±1.01 a	4-36	0.98±0.16 a	0-5	2.40±0.62 ab	0.22-5.32	1.17±0.232 a	0.32-2.27	0.799±0.001 a	0.777-0.824
25	7.64±0.30 b	4-14	12.94±0.83 c	4-28	0.53±0.11 b	0-3	1.77±0.40 b	0.28-3.69	0.48±0.057 b	0.26-0.71	0.779±0.005 a	0.668-0.893
50	6.25±0.14 c	4-9	5.01±0.16 d	3-7	0.20±0.06 c	0-1	-	-	-	-	0.678±0.008 b	0.538-0.773

Data are means ± SE of 9-week recordings and letters indicate the statistical differences according to Duncan's multiple range test at P = 0.05.
- not measured. Plants failed to reach minimum growth requirements.

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