SEED GERMINATION CHARACTERISTICS OF BROAD BEAN, LENTIL AND COMMON BEAN IRRIGATED WITH DIFFERENT DILUTIONS OF PRE-TANNING EFFLUENTS

Şemun Tayyar and Ali Nail Yapıcı

SUMMARY

Leather manufacturing is a worldwide industry that has been carried out for centuries and has achieved great importance in Turkey. However, the leather industry is associated with the generation of large amounts of waste water and solid wastes that are a threat to the environment. A germination experiment was conducted to determine the effect of different dilutions of pre-tanning effluents on the germination characteristics of broad bean, lentil and common bean. The experiment was designed as a completely randomized block with three replications. Seeds of each species were sown and irrigated with different dilutions of pre-tanning effluents (1:10, 1:40 and 1:80 tap water:effluent), undiluted pre-tanning effluent, and tap water (control). Number of germinated seeds, germination percentage, root length, root weight, shoot length, shoot weight and root+shoot weight were measured at 15 days after planting. All germination properties varied considerably, and significant differences among them were determined (P<0.05). Undiluted pre-tanning effluent had adverse effects and no germination occurred for any of the tested plant materials. Except for the undiluted pre-tanning effluent, no significant differences were detected in the number of germinated seeds and germination percentage, whereas some differences among treatments were observed for the remaining characteristics.

Introduction

The leather industry is one of the oldest and traditional industries in Turkey. According to 2005 data, 39×10^6 pieces of skins and 116000ton of hides (DPT, 2007) are processed in ~900 operative tanneries in the country. The final leather obtained from different raw materials has many good characteristics such as superior comfort, good hygiene properties, softness, durability, flexibility, etc. (Payne and Whittaker, 1972). The industry is considered a primary polluter of the environment and has a strong potential to cause soil and water pollution owing to the discharge of untreated effluent (Sathish Kumar and Mani, 2007). Moreover, air pollution, wide-spread odors, poisoning from toxic gas and unsafe disposal of waste are other problems (Nazer *et al*., 2006). The processes carried out in leather manufacture in several developing countries remain traditional processes in terms of optimization for chemicals and water usage (Raghava Rao *et al*., 2003). Among them, especially pre-tanning stages involving "do-undo" operations such as curing (dehydration), soaking (rehydration), liming (swelling), deliming (deswelling), pickling (acidification) and depickling (basification) are significant (Bienkiewicz, 1983). These processes are performed in a wide range of pH (3-13) along with many chemicals.

The various acids, toxic salts, sulphides and heavy metals contained in the effluents released from tanneries, as well as high biological oxygen demand (BOD) and chemical oxygen demand (COD), are the major sources of environmental pollution that endanger life. In addition, the sector consumes large amounts of water in various operations (Çolak *et al*., 2005). The quantity and composition of the effluent depend on the type of raw materials used and the processing technology. These effluents are discharged into the environment without treatment and could be used by farmers for irrigation of crops without taking into consideration their negative effects on plant growth and production, soil and groundwater. The long-term use of tannery effluents for irrigation of field crops may cause changes in soil productivity, pH, electrical conductance (EC), heavy metal accumulation, etc. These adverse effects and mechanism resulting in plant stress have been studied by different researchers (Karunyal *et al*., 1994; Sinha *et al*., 2002; Tisler *et al*., 2004; Tayyar and Yapıcı, 2007; Tayyar *et al*., 2008; Calheiros *et al*., 2008; Yapıcı and Tayyar, 2009; Chandra *et al*., 2009).

The goal of the present study was to assess the effects of waste water produced in different pre-tanning processes on the germination and seedling growth of widely cultivated species such as broad bean, common bean and lentil.

Materials and Methods

This study was carried out at Biga Vocational College, Çanakkale Onsekiz Mart University, Biga-Çanakkale, Turkey, employing broad bean (*Vicia faba* L.), lentil (*Lens culinaris* L.) and common bean (*Phaseolus vulgaris* L.) as the test crops. A germination experiment was performed and evaluated to explore some germination characteristics of the plant materials, which were local populations, irrigated with different dilutions of pre-tanning effluents. They were planted in soil contained in a nursery box using a completely randomized block design with three replicates. The experimental soil was

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Şemun Tayyar. Agriculture Engineer and Ph.D. Ege University, İzmir, Turkey. Professor, Çanakkale Onsekiz Mart University, Biga Vocational College, Çanakkale, Turkey. Address: Çanakkale Onsekiz Mart University, Biga Vocational College. 17200, Biga-Çanakkale, Turkey. e-mail: sbigali@hotmail.com

Ali Nail Yapıcı. Leather Technologist and Ph.D. Ege University, İzmir, Turkey. Professor, Çanakkale Onsekiz Mart University, Biga Vocational College, Çanakkale, Turkey.

CARACTERÍSTICAS DE LA GERMINACIÓN DE SEMILLAS DE HABA, LENTEJA Y FRIJOL IRRIGADAS CON DIFERENTES DILUCIONES DE EFLUENTES DE PRETEÑIDO DE TENERÍA

Şemun Tayyar y Ali Nail Yapıcı

RESUMEN

La manufactura del cuero ha sido practicada por siglos en el mundo entero y en Turquía reviste gran importancia. No obstante, la industria del cuero se asocia con la generación de grandes cantidades de aguas residuales y residuos sólidos que constituyen una amenaza para el ambiente. Se llevó a cabo un experimento de germinación para determinar los efectos de diferentes diluciones de efluentes del preteñido de una tenería sobre las características germinativas de habas, lentejas y frijol común. El experimento fue diseñado como un bloque completamente al azar con tres réplicas. Las semillas de cada especie fueron sembradas e irrigadas con diferentes diluciones de efluentes (1:10, 1:40 y 1:80 agua corriente:efluente), efluente sin diluir y agua corriente (control). A los 15 días después de la plantación se midieron el número de semillas germinadas, porcentaje de germinación, longitud de la raíz, peso de la parte aérea y peso de la planta entera. Todas las propiedades de germinación variaron considerablemente, determinándose diferencias significativas (P<0,50) entre ellas. El efluente de preteñido sin diluir tuvo efectos adversos y no hubo germinación en ninguna de las plantas ensayadas. Exceptuando el del efluente sin diluir, no hubo diferencias significativas en el número de semillas germinadas y porcentaje de germinación, mientras que se observaron diferencias entre los tratamientos en las demás características.

CARACTERÍSTICAS DA GERMINAÇÃO DE SEMENTES DE FEIJÃO-FAVA, LENTILHA E FEIJÃO COMUM IRRIGADAS COM DIFERENTES DILUIÇÕES DE EFLUENTES DE PRE TINGIMENTO DE CURTUME

Şemun Tayyar e Ali Nail Yapıcı

RESUMO

A manufatura do couro tem sido praticada por séculos no mundo inteiro e na Turquía reveste grande importância. No entanto, a indústria do couro está associada à geração de grandes quantidades de águas residuais e resíduos sólidos que constituem uma ameaça para o ambiente. Realizou-se um experimento de germinação para determinar os efeitos de diferentes diluições de efluentes do pre tingimento de um curtume sobre as características germinativas de feijões de fava, lentilhas e feijão comum. O experimento foi desenhado como um bloco completamente aleatório com três réplicas. As sementes de cada espécie foram plantadas e irrigadas com diferentes diluições de efluentes (1:10, 1:40 e 1:80 água corrente:efluente), efluente sem diluir e água corrente (controle). Aos 15 dias após a plantação foram medidos; o número de sementes germinadas, porcentagem de germinação, longitude da raíz, peso da parte aérea e peso da planta inteira. Todas as propriedades de germinação variaram consideravelmente, determinando-se diferenças significativas (P<0,50) entre elas. O efluente de pre tingimento sem diluir teve efeitos adversos e não houve germinação em nenhuma das plantas ensaiadas. Com excesão do efluente sem diluir, não houve diferenças significativas no número de sementes germinadas e porcentagem de germinação, enquanto que se observaram diferenças entre os tratamentos nas demais características.

clay-loam with pH 7.5, EC 0.55mS·cm^{-1}, organic matter content of 2.45%, lime 0.80%, P 56kg·da^{-1} and K 80kg·da^{-1} (Anonymous, 2008). Twenty seeds were planted into the experimental soil for every replication and allowed to germinate. No fertilizers or chemicals were applied during the experiment.

Pre-tanning wastewater was obtained by processing wet-salted hides as reported earlier by Yapıcı and Tayyar (2009), following the fundamental principles of leather manufacturing (Thorstensen, 1993; Sharphouse, 1989).

Effluents were respectively collected at the end of each pre-tanning stage (soaking, liming, deliming-bating, degreasing and pickling; Figure 1). These effluents were finally mixed together and from this bulk dilutions of 1:10, 1:40 and 1:80 (w/w) were prepared with tap water. They were analyzed according to the standard methods for the examination of water and waste waters (APHA, 1998) in the Bursa Environmental Counseling Center Laboratory (Accredited by TURKAK), Bursa Chamber of Commerce and Industry, Turkey. Some physico-chemical characteristics of the effluents are shown in Table I. Undiluted pre-tanning effluent, the three dilutions and tap water (control) were used to irrigate the seeds when needed, and percolation was not allowed.

The seeds were planted into the experimental soil in plastic boxes (80×50×20cm) and irrigated with equal volumes of the undiluted effluent, the three dilutions or tap water. They were kept at room temperature.

Fifteen days planting, the seedlings were carefully uprooted and the following seed germination and growth traits were measured: germinated seeds (number), germination percentage (%), root length (cm), root weight (g), shoot length (cm), shoot weight (g), and root+shoot weight (g). Analysis of variance was performed to the data, using the SAS program. The significant differences according to the least standard deviation (LSD) test at P<0.05 were determined with the same program (SAS, 1999).

Results and Discussion

Seed germination and seedling growth of broad bean, common bean and lentil irrigated with undiluted pre-tanning effluent, different effluent dilutions (1:10, 1:40 and 1:80) and tap water (control) are reported. The physico-chemical properties of the effluents varied greatly (Table I). The high pH and EC of the dilutions used might be due to the presence of high contents of soluble salts. The statistical analyses have shown that all the characteristics of the three plant species examined in this study are significant at 5% (Table II). Since there was no germination of the seeds irrigated with the undiluted pre-tanning effluent, this group

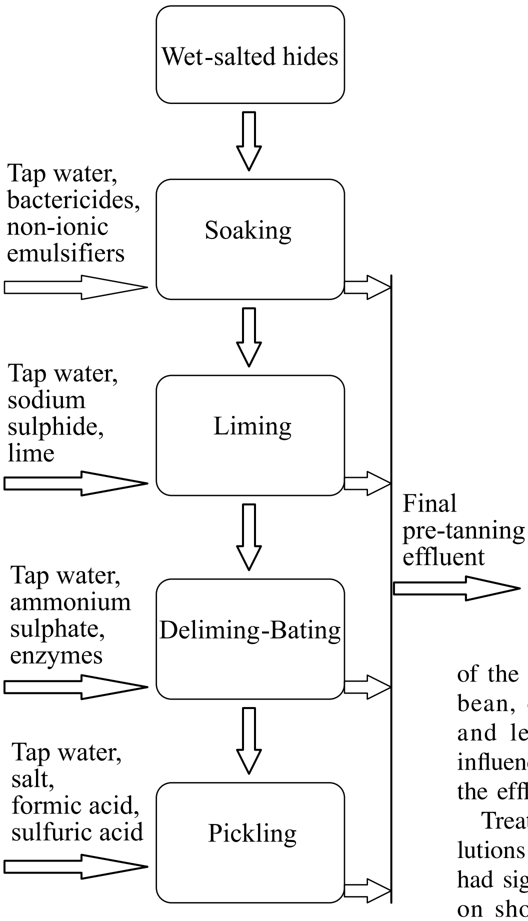

Figure 1: Flow diagram of pre-tanning processes and obtaining of final pre-tanning effluent.

TABLE I
PHYSICO-CHEMICAL CHARACTERISTICS OF THE PRE-TANNING EFFLUENT, ITS DILUTIONS AND TAP WATER*

Parameters	Tap water	Pre-tanning effluent dilution			
		1:80	1:40	1:10	Undiluted
pH	7.36	7.68	8.09	8.57	8.89
EC ($mS \cdot cm^{-1}$)	0.53	1.10	1.59	4.43	34
Total nitrogen	3.6	17.0	42.6	140.0	1426.0
Total phosphorus (PO_4-P)	<0.3	<0.3	<0.3	1.0	7.6
Total sulphur	1.3	1.9	2.2	2.9	41.6
K	2.7	4.3	6.6	17.9	211.5
Ca	71.5	76.3	78.4	98.9	404.6
Mg	11.4	11.4	11.4	15.8	37.6
Na	14.4	114.0	945.3	2017.7	14810.3
Cu	0.0074	0.0127	0.0184	0.0423	0.1289
Cl	22.9	195.3	311.0	462.2	1344.2

*All values, except pH and EC, are in $mg \cdot l^{-1}$.

was not included in Table II. The failure of the seeds to germinate when irrigated with the undiluted effluent might be due to the high salt contents, toxic compounds and high EC values of the effluent. Bailey (2003) reported that the soaking process is a major contributor to high total solids as a result of NaCl used in conservation. According to Morera *et al.* (2000) in the conventional un-hairing process sodium sulphide and lime are mainly used, making it one of the most polluting operations in the manufacturing process. Similar results were obtained by Yapıcı and Tayyar (2009) with some cereals irrigated with undiluted pre-tanning effluent. In a previous study, undiluted tannery effluent gave rise to lower germination values in bread wheat (Tayyar and Yapıcı, 2007). The number of germinated seeds and germination percentage of the seeds of broad bean, common bean and lentil were not influenced by diluting the effluent.

Treatments with dilutions of the effluent had significant effects on shoot length and shoot weight of broad bean, as well as root weight and shoot length of lentil. With common bean, however, all the measured root and shoot characteristics were affected by dilutions of the effluent, with the 1:80 dilution being the most significant.

In some dilutions, for example at 1:80 dilutions for lentil and common bean higher root weights were observed as compared to the control. The better growth of the plant materials might be due to the growth promoting effect of nitrogen and other mineral elements present in the effluent. This is possible thanks to some valuable plant nutrients such as nitrogen and sulphide in the pre-tanning effluent. Calheiros *et al.* (2008) observed that higher germination and development of root and shoot occurred when compared to the control, which could be due to the plant nutrient elements in the tannery effluent. In another study conducted with raw textile

TABLE II
SEED GERMINATION AND SEEDLING CHARACTERISTICS OF BROAD BEAN, LENTIL AND COMMON BEAN UNDER DIFFERENT TREATMENTS

Treatment	Germinated seeds (number)	Germination percentage (%)	Root length (cm)	Root weight (g)	Shoot length (cm)	Shoot weight (g)	Root + shoot weight (g)
Broad Bean							
Tap water	18.0	90.0	10.3	0.59	19.4 a	3.1 a	3.69
1:10	20.0	100.0	11.0	0.71	11.9 b	1.9 b	2.61
1:40	19.0	95.0	11.3	0.94	12.2 b	2.1 b	3.04
1:80	19.0	95.0	11.0	0.74	12.8 b	1.9 b	2.64
$LSD_{0.05}$	2.23	11.17	3.19	0.45	4.32	0.91	1.29
C.V.%	5.9	5.9	14.6	30.3	15.3	20.1	21.4
Lentil							
Tap water	17.0	85.0	6.3	0.011 a	21.7 a	0.157	0.168
1:10	17.3	86.7	6.9	0.008 b	17.7 b	0.153	0.161
1:40	16.7	83.3	6.8	0.010 ab	17.9 b	0.157	0.167
1:80	16.7	83.3	7.4	0.011 a	18.5 b	0.160	0.171
$LSD_{0.05}$	1.49	7.45	2.02	0.002	1.31	0.02	0.02
C.V.%	4.4	4.4	14.7	10.2	3.5	5.7	5.4
Common Bean							
Tap water	17.3	86.7	8.8 b	0.075 c	24.2 a	1.8 b	1.88 b
1:10	18.3	91.7	9.4 b	0.109 b	18.7 b	2.3 a	2.41 a
1:40	17.7	88.3	10.1 b	0.076 c	21.2 ab	2.3 a	2.38 a
1:80	17.3	86.7	12.6 a	0.135 a	23.1 a	2.5 a	2.64 a
$LSD_{0.05}$	1.53	7.63	2.55	0.016	3.87	0.42	0.42
C.V.%	4.3	4.3	12.5	8.1	8.9	9.5	9.1

effluent similar findings were observed (Rosa *et al*., 1999). Similar to our results, several authors have reported that tannery effluents contain plant growth nutrients that resulted in higher vegetative growth along with plant productivity (Karunyal *et al*., 1994; Bosnic *et al*., 2000; Álvarez-Bernal *et al*., 2006; Chandra *et al*., 2009). The effects and mechanisms of the waste waters generated in the leather manufacturing processes on plant production have been the subject of various studies all over the world, and results differ depending on the plant genotype and the tannery effluent being considered.

Plant genotype and environment are two main factors influencing the processes of nutrient uptake, accumulation and distribution. In future studies on this subject, the accumulation and distribution of nutrient elements in tannery effluents in different parts (roots, leaves, etc) of the plant should be studied. Because of their long-term persistence in the environment, the possible adverse effects of metals contained in the effluents on the health of humans and animals that consume these crops should also be investigated. Moreover, they may alter such soil characteristics as organic matter, pH and EC, which are important factors influencing crop productivity. In addition, field experiments must be carried out to determine their long-term negative and/ or positive effects on plant and soil.

Conclusion

The influences of pre-tanning effluent on seed germination and seedling growth of broad bean, lentil and common bean reveal differential responses of the plant materials studied to the treatments. This is mainly because the pre-tanning effluent contains a wide variety of toxic substances, as well as nitrogen and other valuable plant nutrient elements. No germination took place with the undiluted pre-tanning effluent and, generally, as the proportion of the effluents decreased, the inhibition of seed germination decreased as well. Since the effluent carries highly toxic metals it may interfere with the metabolic activities of the plants irrigated with it. There could also be some changes in soil characteristics when the pre-tanning effluent is used for irrigation. Thus, it is obvious that pre-tanning effluents should be properly treated to bring down their adverse effects within tolerable limits.

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