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SEED GERMINATION BEHAVIOR OF SOME SAFFLOWER (*CARTHAMUS TINCTORIUS*) VARIETIES ACCORDING TO HABITAT CONDITIONS CONTAINING DIFFERENT CONCENTRATIONS OF BORIC ACID

GULCIN ISIK[1*] AND SEMA LEBLEBICI[2]

[1]*Anadolu University, Faculty of Science, Biology Department, Eskisehir, Turkey*
[2]*Bilecik Seyh Edebali University, Agriculture Sciences and Technology Faculty, Horticulture Department, Bilecik, Turkey*
[*]*Corresponding author e-mail: glcnylmz@gmail.com; Tel.: +90-544-8605658; Fax: +90-222-3204910*

Abstract

In this study, seeds belonging to two varieties of safflower (*Carthamus tinctorius* L.) grown for biodiesel production, RemziBey and Dinçer, were used. The seeds were germinated in Petri dishes containing double layer filter papers and exposed to 16 hours light/8 hours dark photoperiod, 25±1˚C, with three repetitions (100 seeds per dish x 3). Different boric acid concentrations (10, 30, 50, 100, 200, 300, 500 ppm) were applied on seeds. Observed data was analyzed by using JMP-SAS .As a result, it was observed that there is not an important statistically relationships between seed germination of Dinçer variety of *Carthamus tinctorius* and boric acid concentrations (r^2= 0,120, t= 30, 04, p<0,05). It was observed that there is a reverse proportion between seed germination of RemziBey variety of *Carthamus tinctorius* and boric acid concentrations. According to these results, seed germination rate was decreased with increasing concentration of boric acid as statistically significantly (r^2= 0,623, t= 8, 77, p<0,05).

Key words: Ecophysiology, Boric acid, Safflower, Germination, JMP-SAS.

Introduction

Presently, there is an intensive concern and application about evaluation of new-renewable energy sources for energy technology, besides primary energy resources originated from fossils, like coal, petroleum, naturel gas (Öğüt & Oğuz, 2006). In recent years, world is searching environment friendly energy sources. .In this context, “Biomass” has the most technical potential among new-renewable energy sources (Öğüt & Oğuz, 2006; Shahbaz *et al*., 2016; Nakomcic-Smaragdakis *et al*., 2016; Dzikuć & Piwowar, 2016; Chinnici *et al*., 2015). All matters which are originated from plants or animals and also have carbohydrate compounds as main ones are called as “Biomass Energy Sources”; and the energy which is produced from any of these matters is called as “Biomass Energy” (Demirbaş, 2005).

Biodiesel is describing as originated from chemically renewable oil source and mono alcohol esters of long chained lipid acids (Öğüt & Oğuz, 2006). Biodiesel refers to fuels, which are used for diesel motors and was reproduced from renewable biological materials, animal fats and some vegetable oils (soy bean, corn, sunflower) are used to produce for biodiesel fuel (Öğüt & Oğuz, 2006). Safflower (*Carthamus tinctorius*) is the most concerned one among these plant derived products.

Because of the oil produced from safflower seeds contains unsaturated fatty acids (%78 linoleic acid) and vitamin E, it’s importance on human diet is arising day by day (Arslan *et al*., 2003). The earth is filled with an overwhelming plant biodiversity and efforts have been made to categorizing them based on their size, forms, habitat, structure, anatomy, and biochemical and molecular features to interpret the relationships among the plants (Bajpai *et al*., 2014; Feng *et al*., 2014; Nemli *et al*., 2015; Wojnicka-Poltorak *et al*., 2015).

In India and Pakistan, herbalists sell all parts of the crop for the treatment of various diseases, and the flowers of the crop are used in the food, cosmetics, paint and pharmaceutical industries (Dajue & Mundel, 1996). Seeds of safflower are used for oil production; petals are used as food, textile and chromogenous material for local food (Özel *et al*., 2004). Cartamin (% 0, 3-0, 6) is produced from petals of safflower, known as false saffron, which have yellow-red colored pigments (Özel *et al*., 2004).

Safflower (*Carthamus tinctorius* L.) belongs to family Asteraceae and is a minor crop which originated in the Middle East and part of Africa, but Mediterranean has the major area of production (Shinwari *et al*., 2014). Safflower is about 80-10 cm height, and has different forms, which are prickly or spineless (Davis, 1988). Safflower (*Carthamus tinctorius* L.) (2n =24), belonging to *Compositeae* family, is an ancient crop plant which is being cultivated 3000 years ago at Middle East (Knowles, 1982). This taxon is naturally distributed in Anatolia, and also cultivated in Eskişehir, Burdur and Isparta (Davis, 1988). Prickly forms contain much more oil than spineless ones, they also have yellow, white, creamish, red and orange colored flowers (Davis, 1988). *Carthamus tinctorius*is a drought tolerant, summer type, annual, long-day plant which can grow in 110-140 days (Uysal *et al*., 2006).

Especially high tolerance against cold and hot temperature makes safflower an alternative plant for dry agricultural areas and sulfurous soils; in addition, its tolerance against weeds makes this species useful for wetlands (Uysal *et al*., 2006; Francois & Bernstein, 1964; Yazdi-Samadi & Zali, 1979; Beg, 1993; Kaya *et al*., 2003).

Besides of these characteristics of safflower, its adaptation ability for arid zones in comparison with other oil seeds shows that the importance of safflower will arise in a near future and cultural activities on this species will develop significantly (Baydar & Gökmen, 2003).

Seed germination is the first growth stage and a basic phase of the plant to limit its development under stress (Jabeen & Ahmad, 2013). The aim of this study was to observe germination behavior of some safflower varieties, RemziBey and Dinçer, against different concentrations of boric acid (10, 30, 50, 100, 200, 300, 500 ppm) solutions.

Materials and Methods

In this study, seeds of two varieties of safflower, Dinçer and Remzi Bey, were used as experimental materials. The seeds of each varieties were germinated in seed beds which contains 100 seeds, in 9 cm Ø Petri dishes within double layer filter papers. Distilled water used as control group and 10, 30, 50, 100, 200, 300, 500 ppm boric acid (H_3BO_3) solutions were applied. The condition was 16 hours light/8 hours dark photoperiod and 25±1˚C. The germination experiments were carried out triplicate.

When a radicle has touched the seed bed, it was accepted as a germinated seed. The germination experiments were observed every day (during 3 weeks) and germinated seeds were removed from seed bed. The experiments took 3 weeks and germinated seed number was recorded at the germination table every day. Results of the seed germination experiments were analyzed by using JMP-SAS.

Results

It was observed that germination percentages of Dinçer variety were differentiated between % 62 and 76 for all treatments of boric acid (Table 1). The highest germination percentage for Dinçer variety (% 76) was observed at control and 300 ppm boric acid applications, but the lowest germination percentage (% 62) was observed at 50 ppm boric acid application.

Table 1. The seed germination percentages of Dinçer and RemziBey varieties under different boric acid (H_3BO_3) concentrations.

Boric acid application	Germination percentage (%)	
	Dinçer	RemziBey
Control group (distilled water)	76	82
10 ppm	72	80
30 ppm	66	70
50 ppm	62	40
100 ppm	70	34
200 ppm	74	38
300 ppm	76	36
500 ppm	72	18

According to the results, obtained from JMP analysis, there is no statistically important relation between seed germination percentage of Dinçer variety and increasing boric acid concentrations (r^2= 0, 120, t= 30, 04, p<0,05) (Table 1, Figs. 1-2).

However there is a negative relationship between seed germination percentage of RemziBey variety and increasing boric acid concentrations. While boric acid concentrations were increasing, seed germination percentages were decreased (r^2= 0,623, t= 8,77, p<0,05) (Table 1, Figs. 1-3). The highest germination percentage for RemziBey variety (% 82) was observed at control application, but the lowest germination percentage (% 18) was observed at 500 ppm boric acid application. Seed germination percentage of this variety dramatically decreased between 10-50 ppm applications, although results of 100-300 ppm boric acid applications were not significantly different. In addition to these results, after 500 ppm application, seed germination was reduced % 75 approximately.

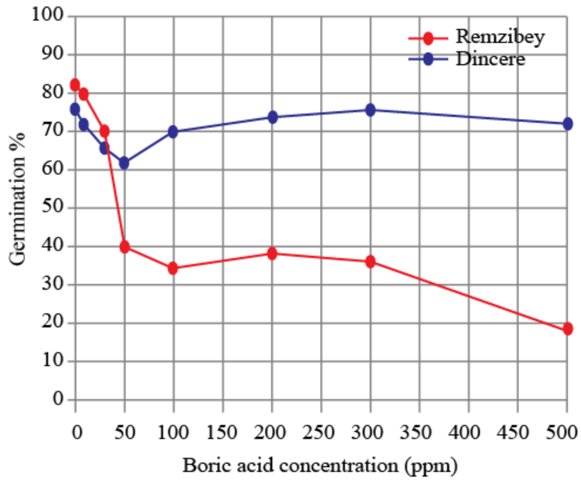

Fig. 1. The seed germination percentages of Dinçer and RemziBey under different boric acid (H_3BO_3) concentrations as graphically.

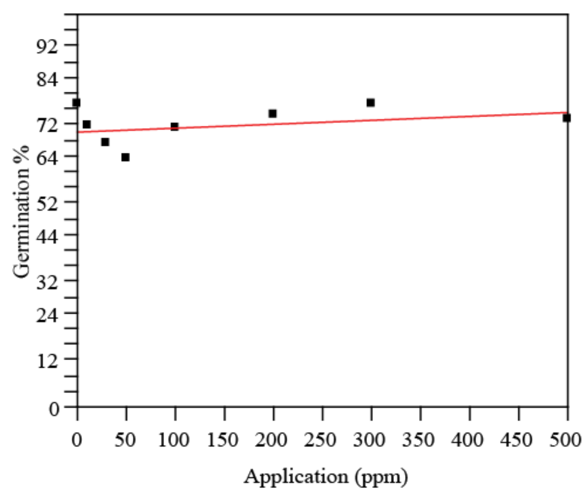

Fig. 2. Statistical graphic of seed germination percentages of Dinçer variety under increasing boric acid conditions.

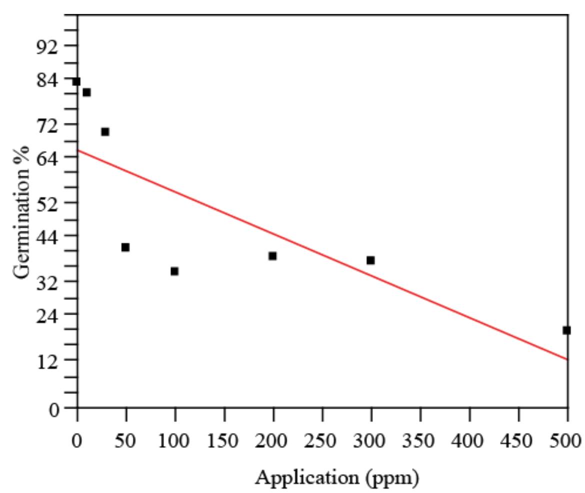

Fig. 3.Statistical graphic of seed germination percentages of RemziBeyvariety under increasing boric acid conditions.

Discussion

The seed germination of *Carthamus tinctorius* is significantly impacted under different temperatures, besides the optimum temperature range of *C. tinctorius* seeding is 10-15°C (Li *et al*., 2013). Induced osmotic potential (by chitosan application) significantly decreased germination percentage, germination index and rate, length and weight of root and shoot of safflower (Mahdavi *et al*., 2011). Application of 40 and 80 kg N/ha did not significantly affect most of the investigated traits of safflower, although nitrogen rates provided significant increases in seed yield at high seed density compared to low seed density, and seed density did not reveal any significant variation in seed yield, oil content, and oil yield. (Elfadl *et al*., 2009). Safflower was grown in previously salinized plots that varied in average electrical conductivity from 1, 8 to 7, 2 dS m^{-1} and irrigated with either high quality (EC_i< 1 dS m^{-1}) or saline (EC_i= 6,7 dS m^{-1}) water (Bassil & Kaffka, 2002).

Yau (2007) determined that Lebanese farmers in the Bekaa Valley should shift the sowing time for safflower from the spring to the winter, because December and January sowings gave higher oil percentages than the other months. The char obtained in safflower seed pyrolysis is mainly macroporous materials with a low surface area but it could be used for the production of activated carbon and also as a solid fuel in boilers; besides it can be used further for the gasification process to obtain hydrogen rich gas by thermal cracking (Onay, 2007).

In this study, safflower was used as experimental material. The boron mineral, % 70 of world reserve found in Turkey, can be used for glass industry, textile, ceramic industry, clarifying and bleaching, energy output, building and cement industry, machine and metallurgy fields, health sector (Öğüt & Oğuz, 2006). The boron mineral is essential for plant development in minor amounts, contrary to this, when it occurs in soil at high levels; plant life cycle is affected in a negative way (Kaçar & İnal, 2008).

Between 0-10 ppm boric acid applications, seed germination percentages of RemziBey variety remain stable (Table 1). However, between 100-300 ppm concentrations of boric acid applications inhibit the seed germination in comparison with 30-50 ppm applications, the results of this experimental group are close to each other statistically. As for 500 ppm application, seed germination percentage is % 75 lower than control group. These data mean that if a producer is using RemziBey variety of safflower to get biodiesel on an agricultural area which contains high level of boric acid, the biomass output or in other words agricultural income will be less than expected.

In this research, a statistical relationship between any boric acid concentrations and seed germination percentage of Dinçer variety couldn't be found. In other words, the seeds of this variety were not affected by increasing boric acid applications neither positively nor negatively (Fig. 1). In consideration of obtained data, we can say that Dinçer variety can be bred up healthfully in high level of boron containing soils.

Eventually, it was presented that RemziBey variety of safflower can be grown in soils which contain boric acid between 0-30 ppm, but higher levels of boric acid concentration in soil will have inhibitory effect on seed germination of this variety and agricultural loss will be inevitable. Besides of this, we can say that for growing of Dinçer variety boric acid concentration is not a limiting factor, in other saying, Dinçer variety is tolerant to damages which are occurred by boric acid on plant metabolism.

According to our results, Dinçer variety can be a possible boron tolerant or accumulated plant. In this situation, the individuals grown in highly boron including habitats or irrigated with boron polluted mine water can be used as plant fertilizers (boron sources) or much profitable raw materials for production of bio-oil.

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