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The Effects of Different Surfactants to Dry Weight Wheat

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Abstract

Surfactant is used as wetting agent, dispersant, emulsifier, foaming agent, bactericide in detergent, soap, herbicide and insecticides. The pollution from their residue in nature affects agricultural products as well. In this study was performed to determine the effects of anionic, cationic and nonionic surfactants on the dry weight of wheat (*Triticum aestivum).* This research was conducted as randomized split parcels with 3 repetetives in greenhouse. Surfactants were applied at 0, 180, 360, 540 and 720 mg kg^{-1} concentration after sowing, it was harvested on the 50th day. Anionic surfactant caused to decrease the dry weight ($p < 0.05$) of wheat plant. While cationic surfactant caused to decrease the dry weight ($p < 0.05$), the application of nonionic surfactant did not. According to study results; anionic and cationic surfactants have a negative impact on the growth of plant roots of wheat. Therefore experiencing difficulties in the acquisition of plant nutrients can be attributed to a decrease in plant dry weight.

Keywords: Anionic, cationic, nonionic surfactants, wheat (*Triticum aestivum* L.), soil.

Farklı Yüzey Aktif Maddelerin Buğday Kuru Ağırlığına Etkileri

Öz

Yüzey aktif madde (YAM) deterjan, sabun, herbisit ve insektisitlerde nem arttırıcı, seyreltici, emulsifiyer, köpürtücü, bakteri engelleyici olarak kullanılmaktadır. Bunların doğadaki birikiminlerinden oluşan çevre kirliliği tarımsal ürünleri de etkilemektedir. Çalışma, anyonik, katyonik, ve iyonik olmayan YAM'lerin, buğday (*Triticum aestivum)* bitki kuru ağırlığına etkilerini belirlemek amacıyla gerçekleştirilmiştir. Denemeler tesadüf parselleri deneme desenine göre 3 tekrarlamalı olarak, serada kurulmuştur. YAM'ler 0, 180, 360, 540 ve 720 mg kg^{-1} konsantrasyonlarda buğday ekiminden sonra uygulanmış 50. günde hasat yapılmıştır. Anyonik YAM buğday bitkisinin kuru ağırlığında ($p < 0.05$) azalma meydana getirmiştir. Katyonik YAM kuru ağırlıkta ($p <0.05$) azalma meydana getirirken, iyonik olmayan YAM'nin buğdaydaki uygulaması önemli olmamıştır. Çalışma sonuçlarına göre; buğday yetiştirme ortamında bulunan anyonik ve katyonik YAM'lerin bitki köklerinin gelişmesini olumsuz etkilediği ve böylece bitki besin maddelerinin alımında sıkıntılar yaşandığı dolayısıyla da bitkinin kuru ağırlık değerlerinde azalmalara neden olduğunu söylenebilir.

Anahtar Kelimeler: Anyonik, katyonik, iyonik olmayan yüzey aktif maddeler, buğday (*Triticum aestivum* L.), toprak

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1. Introduction

Natural resources are polluted by surfactants of human activities and industrial waste [1]. These resources are used for solubility and stability effect on biphasic systems in addition to usage as wetting agent, dispersant, emulsifier, foaming agent, bactericide and corrosion inhibitor [2, 3], reducing generally surface tension of liquids at low concentration and helping water utilization of tissues [4]. Surfactant is used to improve the utilization of leaves from liquid fertilizers in herbicide and pesticide [5], and they takes part in the production process of commercial fertilizers [6]. Cationic is used as bactericide and corrosion inhibition [1] and personal care products [7]. Intakes of surfactants to agricultural field and effects of its on products appear with water resources. High concentration surfactants prevent plants from growing [8]. Adding inappropriate or high concentration adjuvants to pesticides causes plants harm [9]. Along with posing a threat to the environment for living organism, they cause other polluting organic and inorganic factors to decompose and spread to environment [10]. It is stated that removing surfactant residues from soil is very hard [11]. Surfactants that added to soil with residues can reach to 3 mg kg^{-1} level and because of decomposition, in the environments of aerobic soil the risk of linear alkyl benzene sulphonate is low at the plants growing in this environment. However; insufficient information about decomposition of alkyl phenol ethoxylate creates question marks about the condition of this substance in the future [1]. When oil additives (methylated seed oil and petroleum) is used with herbicide for the control of weed in the nitrogen fertilization, yield of corn seed decreases with the nicosulfuron reduction of 60 g to 30 g per hectare during the application of adjuvant pure 60 g ha^{-1} nicosulfuron and adjuvant and nonadjuvant 30 g ha^{-1} nicosulfuron. When the condition that methylated seed oil is added to especially ammonium nitrate and ammonium nitrate liquid fertilizer is compared with the 60 g ha^{-1} nicosulfuron application, recommended application is determined as 60 g nicosulfuron per hectare [12].

The spread of surfactant usage area, insufficient information about decomposition after reaching soil and water, problems in abating pollution reveal clearly the necessity of toxic impacts besides necessary usage areas for plants. The aim of this study was to examine the effects of on dry weight of wheat plant to application of anionic, cationic and nonionic surfactants in greenhouse conditions.

2. Material and Methods

2.1. Properties of Surfactant

In the study, anionic (Linear Alkyl Benzene Sulfonic Acid, LABSA), cationic (Quaternary Ammonium Compounds, Dodigen 226) and nonionic (Alkyl Polyglycol Ether, Dehydol LS7F) surfactants were used. Linear Alkyl Benzene Sulfonic Acid is low cost, aliphatic, biological decomposition featured anionic surfactant including good performer hydrophilic and hydrofoil group [13]. Quaternary Ammonium Compounds are used against surfactants, bacteria, virus and fungi due to their antimicrobial properties and are cationic surfactants which have less harmful impact within plastic species such as plastic, rubber and ceramic [14]. Alkyl Polyglycol Ether is stationary in the acidic and alkaline conditions that used with anionic and cationic substances because of synergistic impacts. A broad usage area is available and in the selection of nonionic surfactant, hypophilic and lipophilic balance (HLB) is important. Moreover the power of HLB emulsifier is important on the solubility of detergent foam [15].

2.2. Greenhouse Experiments

In this research, Bezostoya variety of winter wheat (*Triticum aestivum* L.) was used as test plant. The soil samples used in the study were taken with a special brass shovel from 0–20 cm depth and transferred to greenhouse in fabric bags [16]. Dry soils were sieved to pass 4 mm screen and then, prepared for the usage in greenhouse. About 2 kg soil was used to determine physical and chemical properties of soil and passed from 2 mm sieves. Soil reaction was determined by measuring with glass electrode pH–meter on saturated soil prepared with pure water, total salt was determined by measuring of electrical conductibility of water saturated soil with conductivity meter, available potassium was determined with the usage of 1 N NH_4OAc (pH 7.0) as extract solution and potassium in extract was determined by measuring with flame photometry [17]. Field capacity held by water soil under its 1/3 atm and wilting point held by water soil under its 15 atm [18], sand, silt and clay fractions of soil were found according to hydrometer method [19], lime was determined with the usage of Scheibler Calcimeter [20], organic matter was determined according to modified Walkley–Black method [21]. Available phosphorus was determined with the method whose extract solution is 0.5 M $NaHCO_3$ (pH 8.5), which was developed by Olsen [22].

Greenhouse experiment was conducted with clay loam soil according to randomized split parcel 3 repetitive in greenhouse and designed as 2500 gram soil in each pot. Wheat seeds were planted in each pot. Each three surfactant was applied on the concentrations of 0, 180, 360, 540 and 720 mg kg^{-1} and once to the soils soon after wheat plantation. Ammonium nitrate (26 % N) originating from 180 mg N kg^{-1} was applied as nitrogen fertilizer and TSP (42–44 % P_2O_5) originating from 100 mg P kg^{-1} was applied as phosphorus fertilizer to the soil. Field capacity was calculated and soils in pots were brought to field capacity then watered daily to ensure field capacity levels. Plants were controlled continuously and they were harvested 50 days after sowing with stainless steel scissors from soil the surface, washed with pure water in laboratory, dried in oven with 65 ºC air circulation. After then dry weight of plant was determined.

2. Results and Discussion

Used soil was low salt in the clay loam structure, in the light alkaline reaction (pH 7.87), organic matter and phosphorus were low and potassium was more in this research (Table 1).

Table 1. Some physical and chemical properties of used soil

Location	Sand (%)	Silt (%)	Clay (%)	Field Capacity (%)	Wilting Point (%)	Total Salt (%)	$CaCO_3$ (%)	Org. Mat.* (%)	pH	P_2O_5 (kg da^{-1})	K_2O (kg da^{-1})
Incek	33.3	29.9	36.8	32.7	16.9	0.08	20.3	2.1	7.87	2.7	84.6

*: Organic Matter

Following development period as a result of increasing levels of anionic, cationic and nonionic surfactant applications to the soil, dry weight of wheat plant were taken. At the dose of 180 mg kg^{-1} anionic surfactant was applied as increasing levels in the clay loam soil, an increase in dry weight of wheat was determined (Table 2). However; when the surfactant application doses were increased, the values of wheat dry weight decreased. Wheat dry weight decreased to the approximately 2.67 g pot^{-1} level (Table 2). In the cationic surfactant application, while in the application of 180 mg kg^{-1} an increase appeared (4.93 g pot^{-1}) in the subsequent applications, dry weight value decreased. Especially in the 360 mg kg^{-1} cationic surfactant application, dry weight value decreased under the non-treated control wheat dry weight value decreased to 3.34 g pot^{-1} level in the highest surfactant application (720 mg kg^{-1}) (Table 2). In the nonionic surfactant applications, wheat dry weight values waved (Table 2). Dry weight values of wheat were represented with linear (y = ax + b) regression graphic used frequently. According to regression analysis; the changes occurring in the plant dry weight were showed in Figure 1 depending on the amount of applied surfactant.

Table 2. The increasing levels of some surfactants application on wheat dry weight (g pot^{-1})

Dosages (mg kg^{-1})	**Anionic**				**Cationic**				**Nonionic**			
	1	**2**	**3**	**Avrg.***	**1**	**2**	**3**	**Avrg.**	**1**	**2**	**3**	**Avrg.**
0	3.75	3.60	4.19	3.85	5.03	4.76	4.59	4.79	4.38	4.60	4.81	4.60
180	3.98	3.94	4.40	4.11	5.47	4.84	4.48	4.93	4.12	3.91	3.49	3.84
360	3.72	4.30	3.76	3.93	5.32	3.68	4.17	4.39	4.06	3.16	4.08	3.77
540	3.65	3.33	4.64	3.87	5.28	3.59	3.55	4.14	4.43	3.84	5.52	4.60
720	2.51	2.55	2.96	2.67	4.04	3.66	2.32	3.34	4.39	4.55	4.98	4.64

*: Average

The application of increasing level anionic and cationic surfactant to soil caused an important decrease in the dry weight of wheat plant. The equation of relations between applications and dry weight were found as anionic and cationic respectively y= –0.0014x + 4.2013 and y= –0.0021x + 5.058. When applied anionic and cationic surfactant increased, wheat dry weight decreased. Correlation parameters were found respectively r= –0.599, p< 0.05 and r= –0.628, p< 0.05. Nonionic surfactant applications was not effective on wheat dry weight (Figure 1). As anionic and cationic surfactants caused a decrease on wheat dry weight and they affected root development negatively, the root development was limited. Thus, plant was difficulty in taking nutrient and as a reaction it was thought that the yield of dry weight decreases. The results are supported by previous studies parallel with these results. Anionic (sodium dodecyl sulfate) and nonionic (TritonX–100) 0.1 % level surfactant applications affects nutrient substances in green parts of wheat less than roots and by following plant anatomic parameters it is seen that roots have been refined, cuticle has been thickened, parenchyma cells and cell walls have been split, endodermis has been thickened [23], [24]. 300 mg kg^{-1} level nonionic surfactant applied to barley grew with hydrophonic system affects plant development by decreasing dry weight as 70 % [25], 0.01 mM level many surfactants decrease plant transpiration and proton extrusion in barley glumes [26]. It is known that anionic surfactant (Sodium dodecyl sulfate) inhibits the development of green alga culture in mustard, corn and cucumber [27], the limitation of green alga development causes cell number and thus chlorophyll to decrease [28]. In the studies at green house and field, when wheat (*Tritiaum aestivum* L.), barley (*Hordeum sativum Jess.)*, colza (*Brassica napus* L.*)* and linum *(Linum usitatissimum* L.*)* are used as test plant, a significant difference has not occurred in the condition that nonionic surfactants (Triton XA, Wex and Renex 36) are added to herbicide tanks. It is understood from the previous study results that the yield of potato is not affected with nonionic surfactant addition but N amount of plant increases [29], singlet applied anionic, nonionic and block polymer surfactants do not develop the protection and movement of soil water in hydrophilic soils [30], in the greenhouse conditions the application of 1000 mg kg^{-1} level nonionic surfactant to oaten, trefoil and pea causes plant growing to regress [31], the application of 6.000 and 12.000 mg kg^{-1} level surfactants to the soil taken from 300 g SL structured Ap horizon affects barley growing negatively [32]. Thus, positive impacts on plant growing do not appear in these conditions.

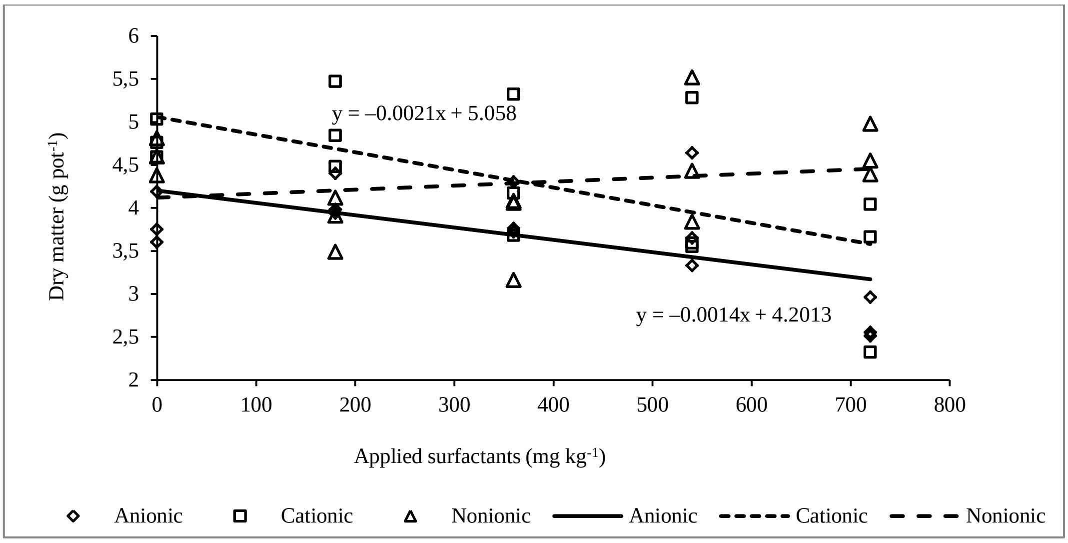

Figure 1. The relation between the dry weight of wheat and increasing levels of surfactants

3. Conclusion

While increasing level anionic surfactant added to wheat indicates decreasing effect on dry weight of wheat, the application of 180 mg kg^{-1} level surfactant indicates a little increase and then decreasing effect. The yield decreased with the application of 180 and 360 mg kg^{-1} surfactant, an increase over control issue as seen in the application of 540 and 720 mg kg^{-1} surfactant. While anionic and cationic surfactant applications were found significant statistically ($p<0.05$), the impact on wheat dry weight of nonionic surfactant applications did not significant statistically. It is thought that the decreasing effect of anionic and cationic surfactant on the dry weight is probably because plant roots did not grow enough and taking nutrient was prevented. Various domestic and industrial originated residues include surfactants, the mixing of polluting substance without purifying to underground and surface water causes water pollution, affects firstly water living beings and then other living beings. Agricultural soil will be polluted with the usage of contaminated water in the agricultural areas and agricultural production will be affected from these substances. Taking precaution without causing soil and water to pollute is easier and cheaper. For this, refining plants must be founded absolutely at polluting resource points and they must be followed. Moreover, it is necessary to be careful about the application of substances which may be reason of pollution to agricultural fields. Therefore national and international rules must be obeyed. Otherwise, regenerating balance of nature, cleaning contaminated areas will require a long time, qualified personnel and cost.

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