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EFFECTS OF NANO SULFUR (S) APPLICATIONS ON YIELD AND SOME YIELD PROPERTIES OF BREAD WHEAT

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Abstract

Research was carried out to determine the effects of different nano-sulfur applications on yield and some plant properties of bread wheat during 2016-2017 winter growing season in Isparta/Turkey. Bread wheat cultivar of 'Koç 2015' was used as a plant material. The nano-sulfur (particle size 20 nm) was supplied by New Systems Petrol Products Import and Export Manufacturing Company. Five different applications control (CA), application to soil (SA), seed coating (SC), seed coating+application of booting stage (SC+BA) and seed coating+application of heading stage (SC+HA) were examined. The experiment was conducted to completely randomized block design with three replications.

Results showed that the effect of nano-S applications were significant in all of examined traits (emergence rate, mean emergence time, plant height, spike length, kernel number per spike, grain yield, protein rate and sedimentation value). Nano-sulfur applications in bread wheat have had positive effects on all the examined traits. Mean values of examined traits varied for emergence ratio 75.0-100.0%, mean emergence times 2.35-2.83 days, plant height 68.7-73.7 cm, spike length 8.37-9.92 cm, kernel number per spike 35.55-39.50, grain yield 3431-3911 kg ha^{-1}, protein ratio 13.29-14.57% and sedimentation values 38.20-48.70 ml, respectively. In particular, nano-sulfur application in seed coating+booting period resulted in 14% grain yield increase compared to control.

***Key words**: Bread wheat (Triticum aestivum), nano-sulfur (S), yield.*

INTRODUCTION

Wheat is in first place in terms of field crops cultivation area and production units in Turkey. The amount of consumption in a year of wheat, which is the main food source of our country, is over 200 kg per person. In addition, our country is one of the leading countries of the world in terms of exporting semi-processed or processed product wheat products. However, in recent years there have been significant reductions in wheat cultivation areas. The wheat cultivation areas, which were about 9.4 million hectares in 2000s, decreased by 7.7 million in 2014. Despite of the number of cultivars of wheat in Turkey (over 200) increases, significant increases in yield and production cannot be achieved. As the phrase goes, wheat production make no headway for 30 years. In addition to the increase in domestic demand for wheat, the increase in foreign demand for wheat also increases the need for high quality wheat. In some years due to adverse climatic conditions, demand cannot be met due to problems in production and quality, and imports were being made. Turkey in terms of self-sufficiency in 2005-2006 had a rate of 120% but in 2014-2015, this rate has dropped to 89%. As a matter of fact, our external procurement amount, which was 2 million tons in 2007, has exceeded 4 million tons in 2016. Finally, in 2017, 230,000 tons of wheat were purchased from the EU to meet the demand for high quality wheat and to balance the price. Efficiency and quality priorities should be included in breeding and production policies of wheat so that Turkey, which has an important geographical point in terms of agricultural potential, can preserve the position of self-sufficient countries in the wheat. After 2011, Turkish Grain Board (TMO in Turkish) has made an innovation in its wheat buying strategies and switched production-based purchasing to quality-based (protein) purchasing wage scale. For example, during the 2016-2017 purchasing period, the purchase price for wheat with 12.5-13% protein rate was 910 tl/ton; protein ratio of wheat over 13% to

949 tl/ton (Current exchange rate of 1 tl is about 0.4 Euro). In order to maintain its position in terms of wheat production and evaluation, Turkey needs to increase the production of wheat.

If we think that wheat sowing areas have declined or reached marginal borders in recent years, for the purpose of sustainable production, it is necessary to increase the yields and to obtain high quality products.

Agricultural land in regions where most of our wheat production is provided requires new technologies as well as variety improvement due to the arid or semi-arid climatic conditions and high pH characteristics.

The vast majority of our wheat production is made in dry soils in regions with arid or semi-arid climatic conditions and high pH. For this reason, new technologies are needed in addition to variety improvement.

Wrong and unconscious use of agricultural inputs (especially chemical fertilizers and pesticide) will cause physical, chemical and biological properties of agricultural soils to be adversely affected. In the long run, the soils may become completely unusable.

For this purpose, especially chemical fertilizer application should be treated very carefully.

Alternative new technologies are needed to reduce the risk of desertification and salinization of agricultural soils. Nano-technological fertilizers in this aspect will gain importance in the future in order to make sustainable plant production. Nanomaterials are defined as one billionth of a physical size, and these products exhibit much higher activity than their normal size.

Due to the fact that the soil of our country is generally calcified and the pH is very high, there are deficiencies in the plants taking of some nutrients.

There are difficulties in absorbing the nutrients from the soil and leaves in the fertilizer which was consisting of macro and micro sized fractions. Especially in the soil with high pH characteristics, in the application of many sulfuric fertilizers, it takes a long time to reduction of sulfur to sulfate and transform useful form for plants, and the plant cannot make effective use of other elements. Nano S can be highly homogeneous in the distribution to the ground with an average particle size of 20 nm. Depending on the surface size, sulfur bacteria work very quickly.

So it can be converted into forms that can be taken by plants within 1-2 days. Also, depending on the nano size, the absorption from the leaf is fast. Nano-S allows the plants to efficiently utilize many nutrients by rapidly reducing the soil reaction (pH) and cause increase in yield and quality.

The use of Nano-S prevents the use of excess fertilizer and negatively affects the environment and human health of fertilizers. As a result, nearly 100% efficiency is obtained.

This study was conducted to determine the effects of different Nano-S applications on yield and some yield characteristics of wheat.

MATERIALS AND METHODS

The experiment was conducted in the Research-Application Farm of Agriculture Faculty, University of Süleyman Demirel, Isparta in 2016-2017 growing season. Bread wheat cultivar (‘Koç 2015’ cv.) was used as a plant material. The material of nano-sulfur (particle size 20 nm) was supplied by New Systems Petrol Products Import and Export Manufacturing Company.

The soil of experiment area is texturally tinny, alkaline (pH value 8.1), cation exchange capacity 36% and total salt content 0.025%, rich in regard to lime (255 g/kg), suitable phosphor (199 mg/kg P_2O_5), rich in terms of potassium (75.4 kg/da K_20), inadequate in terms of nitrogen (0.14% N) and organic material (13.4 g/kg).

Vegetation season was semi-arid, slightly moisture, cool winter and hot climate.

The experiment was conducted to completely randomized block design with three replications. In research, 5 different Nano-S (particle size 20 nm) applications and control were examined and details of these were given at Table 1.

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Table 1. Application subjects, time and doses

Treatments	Dose and time of application
1. CA	Only water applied
2. SA	Soil application with 1% **Nano-S** before sowing
3. SC	Seed application of 10% **Nano-S** before sowing
4. SC+BA	Seed application of 1% **Nano-S** before sowing+ leaf application at booting stage
5. SC+HA	Seed application of 1% **Nano-S** before sowing + leaf application at heading stage

The fields were prepared with standard wheat production practices, such as land preparation, fertilizer application, herbicide application, and seed rate of 450 grain/m^2 was used and it was planted in plots that had four 6 m length rows with 20 cm between rows. Fertilizer (80 kg ha^{-1} P_2O_5 and 70 kg ha^{-1} N) were applied as recommended rates.

There was no irrigation during the growth period. The five applications used in the study were prepared as described fallow. Only water was sprayed to control parcels **(CA).**

The seeds were thoroughly soaked with 10% Nano S solution prepared the day before sowing for seed coating **(SC)** and seeds left to dry again. The dried seeds were kept in the refrigerator until the next sowing day.

In the case of soil application **(SA),** the solution of 1% Nano-S prepared and it was applied to the parcels by using a mini atomizer (SEKAK VETA 16 A) 16 liters, low pressure 1 mm plaque diameter rechargeable motorized back sprayer), at the rate of 200 liter water/ha before seeding. Leaf applications were performed according to the label of the Nano-S solution.

Prepared 1% Nano-S solution were sprayed at booting stage **(SC+BA)** of wheat at the dose of 200 L/ha and some dose of Nano-S sprayed at heading stage of wheat **(SC+HA)**. In leaf applications most care has been taken to homogenized spraying the whole green component of the wheat plants. Prior to the application, the device was calibrated so that each plot can be supplied with liquid at a rate of 200 liters water/ha.

The control plots are only sprayed with water. The pH of the water used in was 7.6, the total dissolved solids content was 292.6 mg/L, a salinity grade of C2S1 which has no salinity hazard.

Emergence ratio (%), mean emergence time (day), plant length (cm), spike length (cm), kernel number per spike (grain), grain yield (kg/ha), protein ratio (%) and sedimentation value (ml) were examined in the experiment. Protein ratio was found according to Kjeldahl method (Kacar, 2010) and sedimentation value was found according to Zeleny method (Willams et al., 1986).

All data were statistically analyzed by using TOTEMSTAT package program and differences between the applications were compared with LSD test.

RESULTS AND DISCUSSIONS

Analysis of variance showed that the effects of Nano S applications on emergence ratio, mean emergence time, spike length, kernel number per spike, grain yield, protein ratio and sedimentation value were significant in 0.01 levels and plant length was significant in 0.05 levels. The mean values and difference groupings for the characteristics studied are summarized in Table 2.

Application of Nano-S to soil **(SA)** resulted in the highest field emergence ratio (100%) and this application was followed by control application **(CA)** with 78.3% (Table 2).

Keşli (2009) and Bejandi et al. (2009) were reported that increasing doses of sulfur was increased in emergence ratio as compared to control. Other applications caused decrease field emergence ratio but these reductions were not significant as compared to control treatments.

Application of Nano-S in bread wheat caused decreased mean emergence time.

In other words, field emergence was faster than control application. While the fast emergence time was determined in application of SA with 2.35 days, the slowest emergence time was in CA with 2.83 days. This application was followed by SC, SC+BA and SC+HA with the value of 2.53 days, 2.55 days and 2.57 days, respectively (Table 2).

Table 2. Means of yield and some plant characteristics in applied different Nano-S bread wheat

	Means		
Treatments	Total Emergence Ratio (%)	Mean Emergence Time (day)	Plant Height (cm)
CA	78.3 b	2.83 a	68.7 b
SA	100.0 a	2.35 c	73.4 a
SC	75.0 b	2.53 b	71.6 ab
SC+BA	75.0 b	2.55 b	73.7 a
SC+HA	76.3 b	2.57 b	71.2 ab
LSD	6.04	0.11	3.32
	Spike Length (cm)	Kernel Number per Spike	Grain Yield (kg/ha)
CA	8.37 b	35.55 c	3431 b
SA	9.92 a	39.50 a	3835 a
SC	9.66 a	38.03 b	3558 b
SC+BA	9.59 a	38.57 b	3911 a
SC+HA	9.47 a	38.57 b	3846 a
LSD	0.58	0.71	140.5
	Protein Ratio (%)	Sedimantation values (ml)	
CA	13.3 c	38.2 d	
SA	14.6 a	46.6 b	
SC	14.0 b	48.7 a	
SC+BA	14.3 ab	45.6 b	
SC+HA	14.3 ab	42.1 c	
LSD	0.46	1.16	

It is determined that the highest plant height was 73.7 cm obtained from SC+BA Nano S application. This application was followed by application to SA with 73.4 cm, SC with 71.6 cm and SC+HA with 71.2 cm, respectively. The lowest plant length was determined in CA with 68.7 cm. The lowest spike length of 8.37 cm was determined in CA, and the highest spike length of 9.92 cm was determined in SA. SA applications were increased spike length of 13.14-18.52% compare to CA. The lowest mean values in terms of kernel number per spike were found in control plots (35.55) and this was followed by seed coat, seed coat+bolting period and seed coat+heading period application of Nano S. The best kernel numbers per spike with 39.5 in all of applications was Nano S application to soil. Eraslan (2006) was reported that increasing doses and application methods of S were positively affected and increased plant length, spike length and kernel number in spike in two wheat cultivars. It was reported by meant earlier researchers that increased the plant height in some crop plants such as rapeseed (Rehman et al., 2013), fenugreek (Tunçtürk et al., 2011; Verma et al., 2014) sunflower (Demir, 2009), chickpea (Togay et al., 2008; Kamiloğlu, 2008).

The lowest grain yield of 3431 kg/ha was obtained in CA but this was not significantly lower than SC (Table 2). The highest grain yield of 3911 kg/ha was determined SC+BA application. This grain yield increases was 14% higher than the CA. Although the highest grain yield was obtained from the application of Nano S in seed coat+booting period plots; three applications (SA, SC+BA, SC+HA) were also economically suggestible because they were in the same statistical group. İnal et al. (2003) were indicated that sulphur applications significantly contribute to yield and yield factors in wheat. A lot of researchers were found to increased grain yield with application of Sulfur (Jackson, 2000; Khan, Samiullah, 2005; Eraslan, 2006; Zhao et al., 2008; Tonguç et al., 2017).

All of the Nano-S applications have significantly increased protein ratio of bread wheat. The highest protein ratio was determined in SA, which was increased protein ratio about 10% (Table 2). The minimum protein ratio of 13.3% was observed in the CA. Since protein ratio is an important factor in terms of flour quality and unit price in wheat purchase scale, it is very important to determine the applications of increasing protein ratio. Eraslan (2006) reported similar results regarding to protein ratio. Nitrogen and Sulfur were compounds of proteins and so, a balance between N and S is very important in bread quality of wheat (Randall, Wrigley, 1986). Ryant and Hrivna (2004) were indicated that sulfur does not only affect nitrogen use and protein quality, but also plays an important role in cooking quality. Singh (2003), was reported that S deficiency in cereal crops is a limiting factor not only on plant growth and yield, but also on the poor quality of crops. Because sulfur is taken place in a lot of main compounds some of structure such as cysteine, methionine, coenzymes, thioredoxin and sulfolipids, it is so important that sufficient amount or beneficial form of S need to be applied or need to be found in the plant growth environment. Sulfur application, amino acid composition was changed especially sulfur-containing cysteine and methionine ratios. Ali et al. (1990) were reported sulfur had an essential role in the synthesis of proteins and of a wide variety of metabolites that are critical for plant growth.

Gluten content and sedimentation value are important in terms of flour quality in bread wheat. All of Nano-S applications was significantly increased the sedimentation value. Nano-S applications were also positively influenced sedimentation value as compared to control plots. As a matter of fact, the lowest sediment value of 38.2 ml was determined in the CA and it was ranked in the middle class sedimentation value (middle class is value between 20-40 ml). The highest sediment value of 48.7 ml was determined in SC and it was taken place very strong class in terms of sediment value in flour (Table 2). The lowest sedimentation value was observed in CA. Kınacı and Kınacı (2004) found the highest sedimentation value (33-36 ml) with $ZnSO_4$ applications rather than other chemical fertilizers. Dizlek et al. (2013), were reported 30 kg/ha S application was increased sedimentation value. These results demonstrate that Nano-S applications in terms of flour quality may have adverse effects decreased sunn sucking and the preparation can be used effectively in struggle against the sun.

CONCLUSIONS

When the results of the research were evaluated collectively the application of Nano-S in all the examined traits resulted in significant increases as compared to the control plots. Generally the CA was followed by the SC, while other Nano S applications had the highest average. In most of the traits, the SA has the highest traits values; especially grain yield and protein ratio properties. For this reason, to increase of grain yield and grain quality of bread wheat SA and SC+BA treatments were applicable. If it is possible SC+HA treatments were also suggestable.

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