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The Effects of Wheat Straw used as Mulch on Some Chemical Properties of the Soil and Grain Yield in Durum Wheat

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ABSTRACT

The experiment was carried out in Kahramanmaras University Field Crops Department Experiment Area (37°35'38.2"N, 36°48'51.2"E) and Randomized Completely Block Design (RCBD) was used according to factorial arrangement with 3 replications. The application of mulch was done immediately after seeding and the treatment was completed after 7 months. As a result of wheat straw mulch application, the change in the levels of calcium (Ca), magnesium (Mg), manganese (Mn), iron (Fe), zinc (Zn) and copper (Cu) of the soil had a statistically insignificant effect on the grain yield. On the other hand straw mulch had a significant statistical effect on phosphorus (P) and potassium (K) levels in terms of grain yield. Depending on the increase in the mulch level, it was determined that the grain yield increased, the highest grain yield was obtained from 900 kg da-1 mulch application (700 kg da-1) and the lowest grain yield was obtained from the control application (510 kg da-1). Mulch application ensured the preservation of soil moisture; accordingly it had a positive effect on the yield by increasing the exchangeable phosphorus (P) and potassium (K). According to correlation coefficient analysis positive and important relationships were found between grain yield and K (r=0.969), grain yield and P (r=0.986), K and P (r=0.983), Ca and Mg (r=0.968), Cu and Fe (r=0.980)

Introduction

The area covered by arid and semi-arid regions in the world is approximately 30% and the scarcity of water in these regions is the biggest obstacle to social and economic development (Wang et al., 2008). They are arid and semi-arid areas with an area of approximately 6.1 billion ha in the world. 6.1 billion ha of arid areas are composed of 5.1 billion arid and semi-arid areas and 1 billion ha of very arid areas (Urgenc, 1998). Turkey's average annual precipitation is about 640 mm. While in some regions in Turkey to 3000 mm rainfall reaches some level, but some regions cannot exceed 250 mm of rainfall levels. The severe water scarcity in recent years has increased its social, environmental and economic importance. There are multiple parameters limiting agricultural production in arid and semi-arid areas. One of the most important of these is water scarcity caused by low precipitation and high evaporation. Optimal planning is required for water resources required for sustainable socio-economic development in agriculture.

Mulch application is an important application to reduce moisture loss for sustainable agriculture. Straw mulches that help preserve soil moisture prevent capillarity and reduce water evaporation from the soil, so they are used in arid and semi-arid regions (Xie et al., 2010; Ma and Li, 2011; Keesstra et al., 2016; Jimenez et al., 2017). Increasing the organic matter content of the soil is the best method without preserving soil moisture as an environmentally friendly approach. Organic mulch application; It is an environmentally friendly application and contributes to weed control, prevention of erosion, preservation of soil moisture, increase of yield, increase of microorganism activity and diversity in the soil, a more regular soil temperature, an increase in the organic matter content of the soil, and prevention of nutrient losses (Chalker and Scott, 2007; Bandyopadhyay et al., 2009).

Recycling of wastes generated in crop production as mulch for agricultural production has positive effects on both the soil and the environment (Benito et al., 2006; Erdel, 2013; Usman et al., 2014). Proper evaluation of stubble and plant residues is of great importance in terms of sustainable agriculture and environmental quality. It is of great importance to recycle plant residues to the soil in terms of soil improvement and moisture efficiency, and such applications are increasing gradually (Anderson, 2005).

The aim of this study is; to investigate the effects of plant mulch (wheat straw) application amount on grain yield of durum wheat and some chemical properties of soils under Mediterranean climate conditions.

Material and Method

Research Area and Climate Characteristics

This study was conducted in Kahramanmaras Sutcu Imam University Field Crops Department research area

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(37°35'38.2 "N, 36°48'51.2" E) (Figure 1). Kahramanmaras is a city where the Mediterranean climate is dominant, rainy winters, dry and hot summers, and little temperature difference between day and night. According to the results of climate data covering the years 1975-2009, it was reported that the highest average temperature in Kahramanmaras was August and July (28.3°C), and the average lowest temperature was January. The total annual precipitation amount covering the long years of Kahramanmaras (1980-2018) was 650.8 mm.The average temperature of Kahramanmaras between 1980 and 2018 was reported as 12.6 °C (KMIM, 2018).

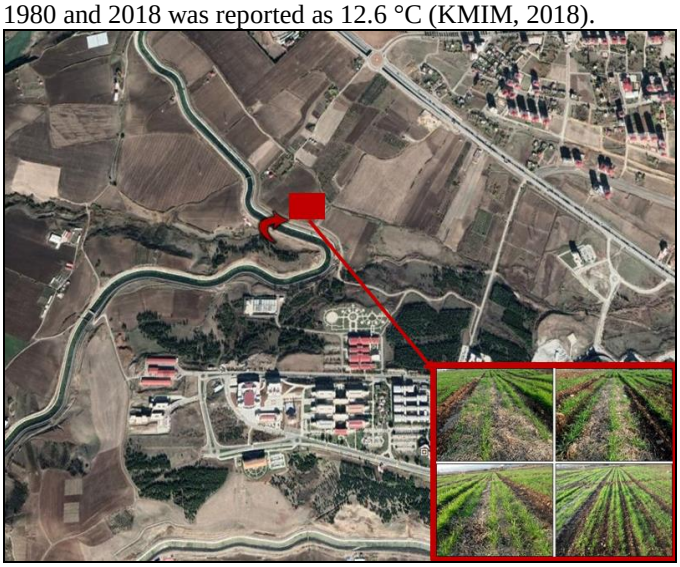

Figure 1. View of field treatment area from satellite

Field Treatment

Fuatbey durum wheat variety was used in the study and the treatment was carried out in 3 replications according to the randomized complete blocks design (RCBD). Wheat straw as mulch was applied to each plot as 0 kg da-1, 300 kg da-1, 600 kg da-1 and 900 kg da-1. The trial started on November 2 and ended on June 10. Mulch application was made 20 days after sowing. And this mulch cover was kept in the field for 7 months. After the harvest of the experiment, soil samples were taken and the following analyzes were made.

Physical analysis of soil samples

The structure analysis of soils was determined according to the bouyoucus hydrometer method (Gee and Bauder 1986). Volume weight of soils was determined according to the steel cylinder method (Black, 1965).

Chemical analysis of soil samples

Soil reaction was determined by pH meter (Thomas, 1996). The total lime content of the soils was determined according to the method developed by Caglar (1949). According to the method determined by Nelson and Sommers (1996), the organic matter content of the soils was determined. Available phosphorus content in soil determined by Olsen et al. (1954) method. The content of exchangeable Ca, Mg, K and Na in the soil was determined according to the Helmke and Sparks (1996) method. Also the microelement (Fe, Mn, Zn and Cu) analyzes determined as the method developed by Lindsay and Norvell (1969).

Measurements on plants

Grain yield (kg da-1): Wheat plants in each plot area were harvested and it was calculated by converting kg da-1 and the grain yield of wheat was determined (Akçin, 1988)

Statistical analysis

Correlation analysis of the analyzed parameters was performed. Anova test was performed to determine the effect

Table 1. Some physico-chemical analysis results of the treatment area soils

Clay	Silt	Sand	OM	$CaCO_3$	pH	HA	Ec 25	K	Ca	P	Mg	Mn	Cu	Fe	Zn
%	%	%	%	%		gcm^{-3}	dS/m	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
33.45	17.43	49.12	1.41	4.13	7.70	1.44	3.27	98.25	4856	7.75	1100.3	0.53	0.99	0.76	0.38

Table 2. Correlation coefficient values of the data obtained in the treatment.

	Grain yield	K	Ca	P	Mg	Mn	Cu	Fe	Zn
Grain yield	1								
K	**0.969***	1							
Ca	0.923	0.887	1						
P	**0.986***	**0.983***	0.858	1					
Mg	0.846	0.758	**0.968***	0.747	1				
Mn	0.436	0.641	0.421	0.514	0.196	1			
Cu	-0.323	-0.12	-0.116	-0.299	-0.221	0.618	1		
Fe	-0.302	-0.07	-0.165	-0.246	-0.309	0.697	**0.980***	1	
Zn	0.798	0.849	0.927	0.755	0.841	0.680	0.258	0.217	1

Table 3. Anova test result of the measurement parameters

Parameters	Degrees of freedom	Sum of squares	Mean of squares	F value
Grain yield	3	57656.250	19218.750	420.082**
K	3	8025.000	2675.000	61.494**
P	3	90.136	30.045	170.068**
Ca	3	33434840.250	11144946.750	
Mg	3	19460.250	6486.750	
Mn	3	0.003	0.001	
Cu	3	0.008	0.003	
Fe	3	0.005	0.002	
Zn	3	0.150	0.050	

Table 4. Duncan multiple comparison test results for measurement parameters

Application	Grain Yield	K	P	Ca	Mg	Fe	Mn	Cu	Zn
Control	510**d**	100**d**	7.97**d**	4863a	1100a	1.00a	0.54a	1.00a	0.4a
300kg/da	595**c**	130**c**	10.07**c**	4950a	1187a	0.96a	0.52a	0.96a	0.5a
600kg/da	640**b**	150**b**	13.10**b**	5050a	1200a	1.01a	0.56a	1.01a	0.6a
900kg/da	700**a**	170**a**	15.10**a**	5020a	1190a	0.94a	0.55a	0.95a	0.5a
Means	611.25	137.5	11.56	4970	1171	0.98	0.54	0.98	0.5

of application doses on variables. As a result of the Anova test, the Duncan multiple comparison test was performed for the variables whose F value was found to be significant (Yurtseven, 1984).

Results and Discussion

Some physical and chemical analysis results of the soils taken as samples before the treatment were given in Table 1.

The soils used in the experiment were in the class of $CaCO_3$% calcareous, slightly alkaline pH (Saglam, 2008) and low organic matter content (Gucdemir, 2006). The plant nutrients K, P, Zn, Mn and Fe content of soils were insufficient (FAO, 1990). There was a positive relationship between the grain yield values obtained from Fuatbey wheat variety and the changeable K and changeable P contents from the chemical properties of the soil (Table 2). However, the relationships between the other chemical properties of the soil (Ca, Mg, Mn, Cu, Zn, Fe) and the grain yield were found to be insignificant (Table 2). According to correlation coefficient analysis, positive and important relationships were found between grain yield and K (r=0.969), grain yield and P (r=0.986), K and P (r=0.983), Ca and Mg (r=0.968), Cu and Fe (r=0.980) (Table 2).

Anova test results of the analyzed parameters are given in Table 3. Grain yield, changeable K and changeable P values were found to be statistically significant according to Anova test result ($p < 0.001$). Other variables (Ca, Mg,Cu, Fe, Zn, Mn) were not found statistically significant (Table 3; Table 4).

The Effect of Wheat Straw Application on the Potassium Content of Soils

The effect of the amount of wheat straw applied in different amounts on the changeable K content of soils is presented in Table 4. Accordingly, the lowest variable K content (100 µg/g) was obtained from the control application, while the highest K content (170µg/g) was obtained from 900kg of straw application per decare (Fig. 2). They reported that wheat straw applied to rice plants improved nitrogen, phosphorus and potassium intake (Yan et al., 2018). They stated that the crop straw improved the potassium content in the soil and the quality of the cultivated land (Noack et al., 2014). Potassium in the soils is carried to the roots by diffusion. As the water content in soils decreases, the thickness of the water films on the surface of soil particles becomes thinner. For this reason, the diffusion of the elements (K and P etc.) coming to the root zone with the diffusion becomes difficult.

In addition to being a source of potassium of straw mulch, mulch increases the availability of potassium ions by balancing the soil temperature and increasing the soil moisture content.

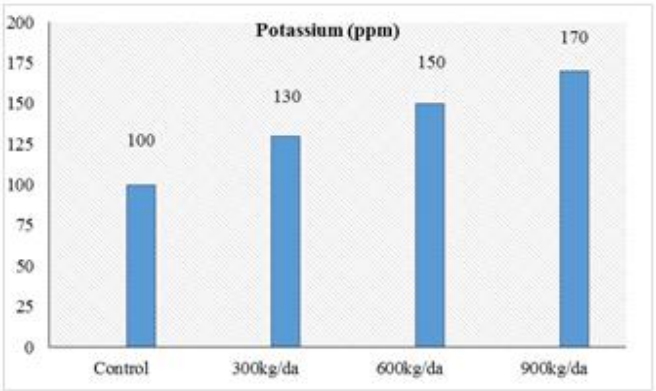

Figure 2. Variation of Potassium (K) level according to mulch applications.

The Effect of Wheat Straw Application on Phosphorus Content of Soils

Variable P content of soils depending on the application is given in Table 4. While the lowest exchangeable phosphorus content (7.97 µg/g) of the soils was observed in the control application, the highest P content (15.10 µg/g) was obtained from 900 kg da-1 mulch application (Table 4).

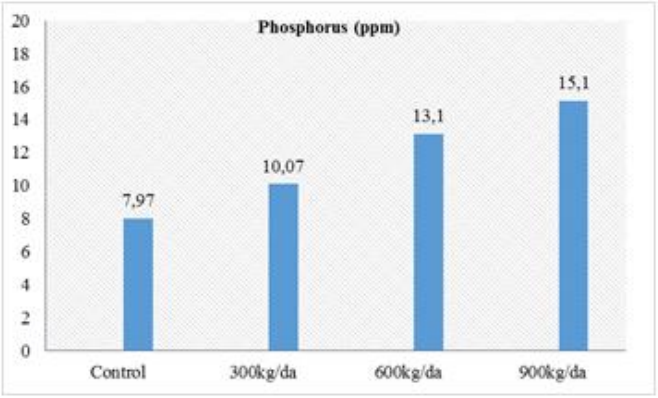

Figure 3. Variation of Phosphorus (P) level according to mulch applications

Phosphorus ion in soils is similar to potassium, it has a close relationship with soil moisture content. As seen in Table 4, the use of straw mulch increased the availability of phosphorus in soils according to the control application (Fig 3). It has been reported by many researchers that mulching materials increases the moisture content of soils as well as being the P source (Akter et al., 2017; Gonoment and Cagasan 2020; Kara et al., 2021). The findings we have obtained are in parallel with other researchers.

The Effect of Wheat Straw Application on the Grain Yield of Wheat

The effect of wheat straw applied in different amounts in the experiment on grain yield can be observed in Figure 4.

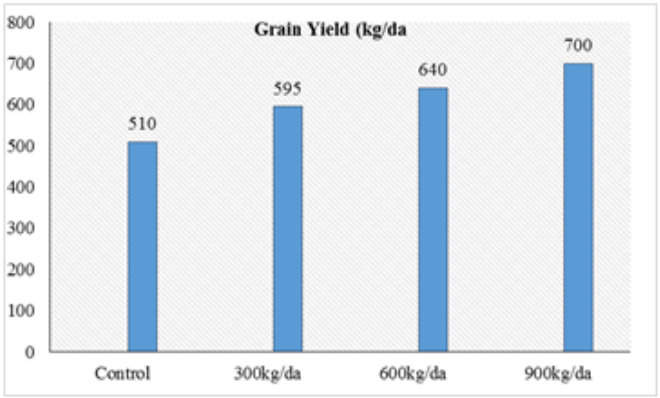

Figure 4. Variation of grain yield according to applications

While the lowest grain yield was observed in the control application (510 kg da-1), the highest grain yield was seen in 900 kg wheat straw application per decare (700 kg da-1). In addition, it is seen that the grain yield increases depending on the application amount (Fig.1).

Borresen (1999) reported in his study that straw mulcher increased the grain yield. Many researchers reported that mulch applications had positive effects on grain yield in their study (Chen et al., 2019; Shah et al., 2013; Tolk et al., 1999).Organic wasters is a source of N, P and K, and on the other hand they increase soil moisture content; Accordingly, the availability of nutrients (P and K etc.) increases. As a result, the grain yield increases (Saglamtimur et al., 1996; Huang et al., 2008; Huang et al., 2012; Kara et al., 2021).

Conclusion

The effects of different amounts of straw mulch on Ca, Mg, Fe, Zn, Cu and Mn were not found to be statistically significant. On the other hand straw mulch application caused a change in the P and K amount of the soil and this situation was found to be statistically significant ($p < 0.01$). The lowest available K and P content of the soils was obtained from the control application, the highest K and P content was obtained from the straw mulch application of 900 kg per decare.

The effect of mulch applications on the grain yield of durum wheat was found to be significant ($p<0.01$). While the lowest grain yield was observed in the control application (510 kg/da), the highest grain yield was seen in 900 kg wheat straw application per decare (700 kg/da).

The research results are based on one-year data. It is recommended that the research would be conducted in different locations or in different years to make more reliable results.

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