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SOME ECOPHYSIOLOGICAL CHANGES IN WHEAT PLANT (*TRITICUM DURUM* CV. *GONEN*) GROWN IN GYPSUM SOILS

M. GEMICI*, A. GUVENSEN AND M. KOYUNCU

Department of Botany,
Faculty of Science, Ege University, Izmir, Turkey

Abstract

In our studies, gypsiferous soils were compared with garden soil. Five research groups were formed with gypsiferous soils from Middle Anatolia of Turkey. When plant lengths were compared in all groups, there was a decrease in gypsum. When the results were evaluated according to weights, there was a decrease in root weight in all groups compared to control soil and when spike weights were evaluated, there was a decrease of 17.57% in gypsum. Maximum seed weight per root was found to be in control group. When all groups were evaluated in terms of total chlorophyll content, the gypsum + soil mixture groups had more photosynthetic chlorophyll content than control. As for harvest, the best development in stem length, spike weight, seed number per root and seed weight per root were observed in soil without gypsum. Better yields in 100 seed weight, spika lenght, root weight and root lenght were observed in wheat groups where low gypsum mixtures were used. There was a decrease in amounts of salt (%) and beneficial K_20 in all study groups at harvest when compared with the beginning values, whereas organic material and $CaCO_3$ (%) amounts increased.

Introduction

There are vast areas with gypsum in the world. Worldwide, soils with gypsum cover 186 million ha, representing 1.5% of world land surface (Anon.,1993), including countries of the Middle East (72.626 million ha), Eurasia (51.567 million ha), the Mediterranean belt (37.322 million ha), Africa (22.339 million ha), North America (2600 million ha) and Australia (23 million ha). Gypsiferous soils are usually found in the middle and lower parts of the landscape and have a potential for agricultural development under both rainfed and irrigated farming. Turkey, which lies in the Mediterranean belt, contains 395.000 ha gypsiferous soil (0.05% of its surface area) (Anon., 1990; Mashali, 1993; Boyadgiev & Verheye, 1996). Gypsiferous soils are soils that contain sufficient quantities of gypsum (Calcium sulphate) to interfere with plant growth. Soils with gypsum of pedogenic origin are found in regions with ustic, xeric and aridic moisture regimes (Nettleton *et al*., 1982). They are well represented in dry areas where sources for the Calcium sulphate exist. They do not usually occur under wet climates. In most cases the gypsum is associated with other salts of calcium and salts of sodium and magnesium.

Gypsiferous soils have been described in the field in many countries, eg., in Spain by Peres-Arias *et al.* (1984); in Tunisia by Osman & Ilaiwi (1980); in the Soviet Union by Ryding (1978); in Algeria by Boyadgiev (1975); in USA by Gonzalez (1978). Some studies on these soils have been carried out by; Kovda (1954), Bureau & Roederer (1960), Akhvlediani (1962), Smith & Robertson (1962), Hernando *et al*., (1963), Amami *et al.*, (1967), Van Alphen & de los Rios Romero (1971), Boyadgiev (1974), Devaux (1980), Barzanji *et al*., (1975), Sayegh *et al.*, (1981), Fritz *et al.*, (1984), Sillanpaa & Vlek (1985), Hazzah *et al.*, (1986), Nafie (1989), Mardoud (1996), Mashali (1996), Jarwal, *et al*., (2001) and Hamza & Penny (2002).

*Corresponding author: E-mail: gemicim@sci.ege.edu.tr, aykutguven@yahoo.com

Gypsum is calcium sulfate dihydrate. When dissolved in water, gypsum becomes calcium ions and sulfate-sulfur ions. Both of these ions are required nutrients for growing plants. In addition to being a major plant nutrient, calcium also plays a vital role in establishing and maintaining good chemical balance in soil, water and plants. Gypsum is one of the most useful and widely used minerals of the 20th century. It is used in sheetrock/wallboard, cements, plaster of paris, molds and castings, tiles and blocks, paper filler, fluxing agents, food and beverages, pharmaceuticals and as a soil additive for the lawn and garden industry and agriculture. Gypsum deposits are sediments from ocean brine and ancient inland seas. Time, heat, pressure, moisture, movement and mixing with other elements produces various forms of gypsum. Problem-soils are frequent in arid and semi-arid environments, including soils with high amounts of gypsum. World population is projected to rise from 5.3 billion people in 1990 to 8.5 billion in 2025 and 10 billion by 2050 (Bongaarts, 1994). With increasing population, land management needs to be improved to increase and sustain crop yields.

In this context, study groups have been formed to help use of gypsiferous soils which form a large part of Middle Anatolian (Turkey) soils and on which wheat is grown. Firstly, gypsiferous soils have been compared with garden soil. The obtained results have been evaluated by statistical analysis and graphics.

Materials and Methods

Studies have been carried out in green houses of Ege University Science Faculty, Department of Biology Herbarium Research Center. Five research groups were formed with gypsiferous soils from Middle Anatolia of Turkey. Only gypsiferous soil was used in first group and only garden soil (as control) was used in second group of study. In other groups, ½ gypsum + ½ garden soil, 1 gypsum + 3 garden soil, 3 gypsum + 1 garden soil were used. *Triticum durum* cv. *gonen* seeds, obtained from Ege University Agricultural Faculty Seed Research and Application Center, were sown in 50 pots of 5 kg, using 5 repeats for each study groups, on 19-03-2002. Watering was carried out by tap water. Each group was watered with the same amount of water every other day. During the research, two harvests were carried out. I. harvest was carried out before the spikes were mature and when seedlings reached 30 cm in lenght, whereas II. harvest was carried out when spikes matured totally. Root, stem lengths and dry, living weights of 50 plants were measured for each harvest. During I. harvest, photosynthetic pigment analysis of plants were carried out according to Witham *et al.*, (1971). Additionally, physical and chemical analysis such as total salt %, $CaCO_3$, P_2O_5, K_2O, organic matter %, variable Na^+, K^+, Mg+, K^+ ve Ca^{++} were carried out on soil mixtures at the beginning of studies and after the harvest (Anon., 1951). All results are expressed as mean values ± standart deviation. Statistical significance was evaluted with the analysis of variance, ANOVA.

Results and Discussison

Evaluating the results of first harvest, it was found that in all gypsum applications, except in the group where 3 gypsum + 1 garden soil was used, there was an increase in root lenght compared to control. However there was a decrease in stem lengths. 1 soil+ 3 gypsum and 3 soil+ 1 gypsum between the mean difference is significant at the $p<0.05$ level (Fig.1; Table 1). In Figure 2, where root live weights in I. harvest are shown, there is an opposite situation compared to root lenghts. The decrease in stem lenghts compared with soil can be seen in stem live weights. Especially stem dry weight is significantly more in soil than other applications**.** Soil and gypsum, 1/2 soil+ 1/2 gypsum, 3 soil+ 1 gypsum between the mean difference is significant at the $p<0.05$ level (Fig. 2; Table 2).

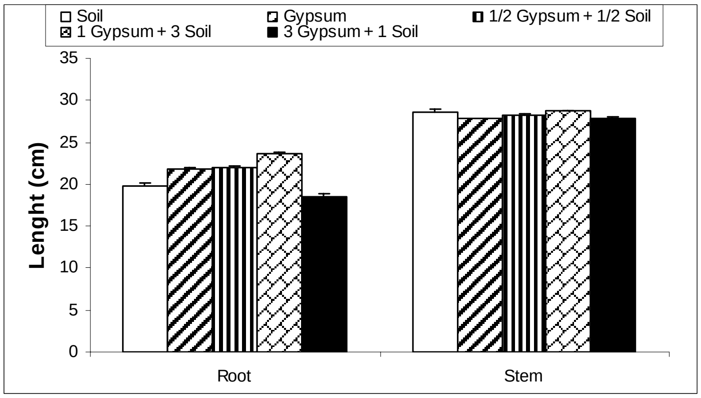

Fig. 1. Root and stem lenghts of *Triticum durum* cv. *gonen* seedlings grown in different media at I. harvest. Bars in columns show standard deviations.

Table 1. ANOVA of root and stem lenghts of *Triticum durum* cv. *gonen* seedlings grown in different media at I. harvest.

Source	S.S	D.F	M.S	F	p
Length (cm)	204.777	4	51.194	0.851	p<0.494
Error	19732.673	328	60.161		
Total	239020.512	333			
Corrected total	19937.450	332			

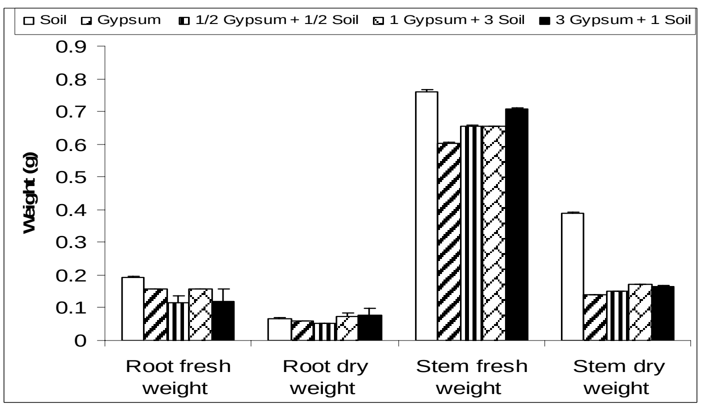

Fig. 2. Root and fresh and weights of *Triticum durum* cv. *gonen* seedlings grown in different media at I. harvest. Bars in columns show standard deviations.

Table 2. ANOVA of root and fresh and weights of *Triticum durum* cv. *gonen* seedlings grown in different media at I. harvest.

Source	S.S	D.F	M.S	F	p
Weight (g)	1.006	4	0.251	2.119	p<0.077
Error	77.261	651	0.119		
Total	124.506	656			
Corrected total	78.266	655			

According to II. harvest results; root, stem and spike lenghts are similar to previous harvest (Fig. 3). When plant lenghts are compared, there was a decrease in gypsum and all other groups compared to soil, whereas both root and stem have values similar to control in 3 gypsum+ 1 soil group. However, this increase was not observed in spike lenght and now ½ gypsum + ½ soil mixture has values closest to control. The mean difference is not significant at the $p<0.05$ level (Fig. 3). Only dry weights were measured in II. harvest, due to the fact that the plants dried in their media. When the results were evaluated according to weights; there was a decrease in root weight in all groups (except in ½ gypsum + ½ soil mixture) compared to control (soil). As for stem weight; values close to control were obtained, except for the gypsum. In gypsum, there was an increase of 82.6 % compared to soil. And when spike weights were evaluated; it is interesting to note that spike weight of control is more than gypsum and there was a decrease of 72 % in gypsum. The mean difference is not significant at the $p<0.05$ level (Fig. 4).

When all groups were evaluated in terms of total chlorophyll content; it was determined that gypsum + soil mixture groups had more photosynthetic chlorophyll content than control. However, there was a decrease of 7.31 % in total chlorophyl value of gypsum compared to soil. This shows that, photosynthetic pigments increase parallel to stem shortening (Fig. 3 & 5 ;Table 3).

When soil was compared with application groups in II. harvest in terms of yield; 100 grain weight was determined to be the most in 1 soil + 3 gypsum. In seed count in a spike; there was a decrease of 17.57 % in gypsum, a decrease of 13.69 % in ½ soil+ ½ gypsum and a decrease of 8.44 % in 3 soil+ 1 gypsum, compared to soil. Gypsum is not productive on its own. Good productivity is obtained only when it is mixed with soil and the best mixture is found to be 1 soil+ 3 gypsum (6.5% increase). The most seed weight per root was found to be in control group. Soil and gypsum, 1/2 soil+ ½ gypsum, 1 soil + 3 gypsum between the mean difference is significant at the $p< 0.05$ level (Fig. 6; Table 4).

In the studies carried on gypsiferous soils in other countries; from field observations in the Ebro Valley of Spain, that plant growth was reduced where the gypsum content exceeds 20 to 25 % (Van- Alphen & Romero, 1971). From intensive field observations of gypsiferous soils in Iraq, Smith & Robertson (1962) found that root growth was inhibited where the gypsum content of soil was over 10 %. This is apparently because of the poor transmission of air and water caused by poor structure. They also found that soils containing more than 25 % gypsum in the rooting zone give poor growth. Wheat grows least well when the gypsum content in soils is around 25 % (Hernando *et al.,* 1963). Agricultural production on gypsiferous chernozem and chestnut soils is not affected when the gypsum content is between 15 and 30 % (Akhvlediani 1962). Bureau & Roederer (1960), reported that 30 % gypsum content in soils of Tunisia is toxic to plant growth. According to Van-Alphen & Romero (1971), up to 2 % gypsum in the soil favours plant growth, between 2 and 25 % has little or no adverse effect if in powdery form, but more than 25 % can cause substantial reduction in yields.

In the present study we found soils without gypsum in I. harvest has the most weight in terms of root live weight, stem dry and fresh weights (Fig. 2). The group with 1 gypsum + 3 soil showed maximum growth in root and stem length (Fig. 1). In the group with 3 gypsum + 1 soil, there was a decrease especially in root length (Fig.1), root fresh weights and stem fresh and dry weights (Figs. 1& 2). As for II harvest, the best development in stem length, spike weight, seed number per root and seed weight per root were absorved in soil (Figs. 3, 4 & 6). It was noted that the gypsum group has the most stem weight (Fig. 4).

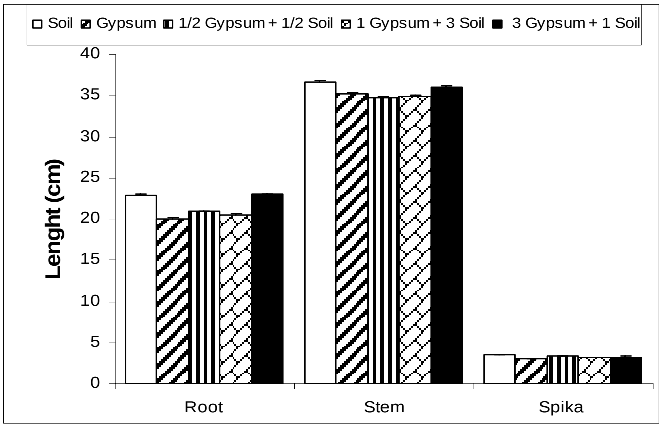

Fig. 3. Root and stem lenghts of *Triticum durum* cv. *gonen* seedlings grown in different media at II. harvest. Bars in columns show standard deviations.

Table 3. ANOVA of photosynthetic pigment contents of *Triticum durum cv. gonen* seedlings grown in different media at I. harvest.

Source	S.S	D.F	M.S	F	p
Pigment amount (mg/g)	1.398	4	0.349	0.299	p<0.878
Error	64.345	55	1.170		
Total	148.585	60			

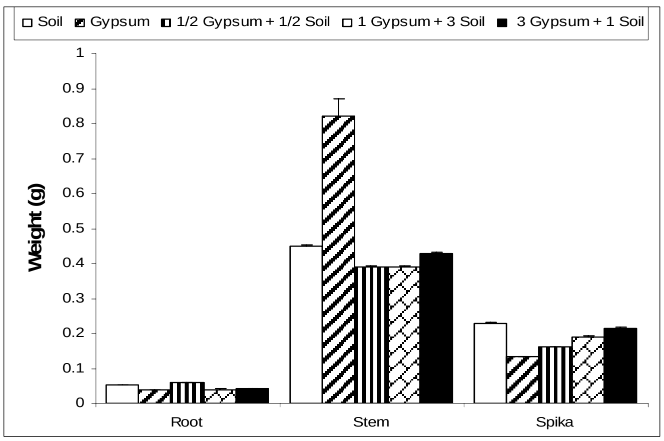

Fig. 4. Root and stem lenghts of *Triticum durum* cv. *gonen* seedlings grown in different media at II. harvest. Bars in columns show standard deviations.

Table 4. ANOVA of spika of *Triticum durum* cv. *gonen* seedlings grown in different media at II. harvest (at 100 seed weight).

Source	S.S	D.F	M.S	F	p
Weight (g)	0.426	4	0.106	19.755	p<0.000
Error	5.387E-02	10	5.387E-03		
Total	48.009	15			
Corrected total	0.480	14			

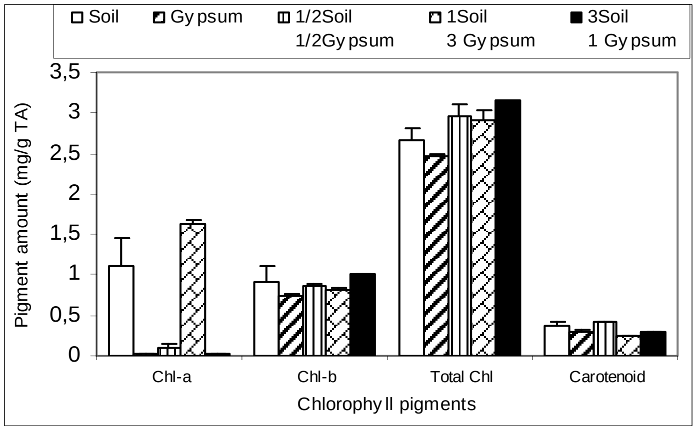

Fig. 5. Photosynthetic pigment contents of *Triticum durum* cv. *gonen* seedlings grown in different media at I. harvest. Bars in columns show standard deviations.

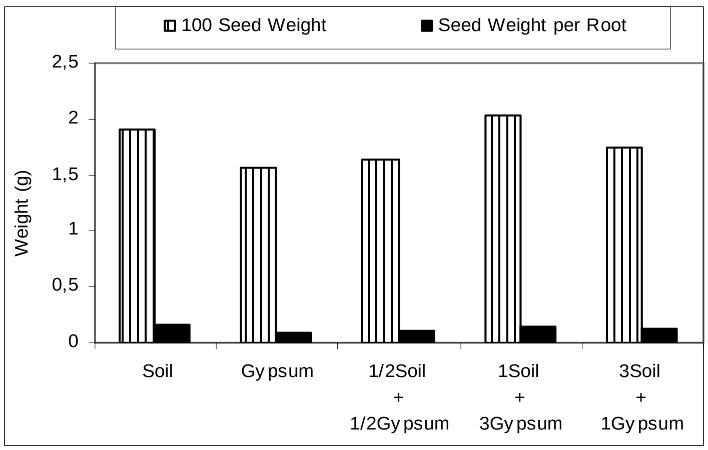

Fig. 6. Spike of *Triticum durum* cv. *gonen* seedlings grown in different media at II. harvest.

Results of physical and chemical analysis carried out on the study soil groups before the sowing of the seeds and after the harvest are shown in Table 5. As can be seen, % salt amount in soil group was reduced from 0.074 at the beginning of the study to 0.064 at the end of the study. In gypsum the drop rate is bigger; from 0.071 to 0.038. We can conclude that the drop in salt (%) amount is the result of watering. Furthermore, the application of gypsum provides nutrients for plant growth, increases the infiltration of water into soil, can reduce salt concentrations in soils (Carr & Munn, 1997). Furthermore, these values drop parallel to increase of gypsum in soil mixture. pH is higher in gypsum compared to soil. Since gypsum contains Calcium sulfate dihydrate, pH values increase parallel to increase of gypsum in soil mixture. When $CaCO_3$ values were examined, it was noted that the value in soil, which was very low at the beginning (4%), increased significantly at the end of the study (10.3%). The organic material difference between the beginning and at the harvest time was 1.7%.

Table 5. The results of physical and chemical analysis of soil belonging to *Triticum durum* cv. *gonen* groups at the beginning and at the end of study.

Study groups	Total salt (%)	pH	$CaCO_3$ (%)	Beneficial to plants		Organic matter (%)	Exchangable %			
				P_2O_5 (Kg/da)	K_2O (Kg/da)		Na^+	K^+	Ca^{++}	Mg^{++}
Soil (harvest)	0.064	7.81	10.3	32.9	192.6	1.8	1.53	3.88	64.78	29.8
Gypsum (harvest)	0.038	8.12	38.0	3.0	51.2	1.5	2.82	9.62	71.19	16.35
1/2 soil + 1/2 Gypsum) (harvest	0.047	8.0	38.0	9.4	94.8	1.7	1.27	5.98	90.74	19.96
1 Gypsum + 3 Soil (harvest)	0.059	7.85	33.4	14.9	112.8	1.4	0.87	7.91	58.62	32.58
3 Gypsum + 1 Soil (harvest)	0.04	8.06	38.0	7.2	79.7	1.6	1.41	6.88	58.19	33.50
Garden Soil (the begining of study)	0.074	7.59	4.0	11.2	204.6	0.1	0.64	5.39	80.32	13.63
Gypsum (the begining of study)	0.071	8.07	34.4	2.0	49.7	1.2	0.98	3.30	74.10	21.60

Organic materials increased in soil group with a ratio of 1.7 % (Table 5). The decrease of beneficial K_20 in all study groups at harvest can be explained by usage of this material by plants. In gypsum groups, there is not much of a difference between the values at the beginning and those at the end. According to Van- Alphen & Romero (1971) the reductions are due in part to imbalanced ion ratios, particularly K:Ca and Mg:Ca ratios. In general, at equal content of exchangeable K, the concentration of potassium in the soil solution varies considerably depending on pH, amount and type of $CaCO_3$, amount and type of clay, and amount and form of gypsum present (Anon., 1990). The K:Ca and Mg:Ca ratios in the soil solution are very low when the gypsum content is high, resulting in a very low uptake of K and Mg from the soil solution, which accounts for low crop yields (Van- Alphen & Romero, 1971). According to our results; the highest Mg:Ca ratios during harvest time were found in 1 gypsum + 3 soil and in 3 gypsum + 1 soil groups. On the other hand, the highest K:C ratios were found in 3 gypsum + 1 soil and in 3 gypsum + 1 soil groups. These results suggest that K and Mg uptake at gypsum soils were not that much low (Table 5). In second harvest, better yields in 100 seed weight, spika lenght, root weight and root length were observed in low gypsum wheat groups, only when compared to gypsum groups (Fig. 3, 4 & 6).

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