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ORIGINAL PAPER

CHANGES IN THE MINERAL COMPOSITION IN SOYBEANS (*GLYCINE MAX* L.) DEPENDING ON CULTIVATION FACTORS

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Abstract

Legumes, including soybeans, are essential for sustainable agriculture. From the perspective of sustainability, this research has been planned with the main purposes of exploring food supply potential, researching alternative production systems, and determining food product quality. A field trial was carried out with three replications in two years (2017, 2018) to investigate the effect of two sowing dates (July 1st, July 15th) as second cropping of five soybean varieties (Arisoy, Ataem, Derby, Safir, S-312) grown as a second crop. Changes in the mineral composition and their relationships were investigated. The results revealed that the sowing date had a statistically significant effect on Fe, Ni, Mo and Mn. The second sowing date (July 15th) increased the content of Ca, Fe, Cu Mn, Ni, Mo while decreasing the Zn and B content. A soybean variety as a factor had a statistically significant effect on the elemental composition of all the investigated minerals except Fe. Changes in the soybean seed mineral content as a result of late sowing are highlighted in this paper. The content of Ca increased in the Ataem and Derby varieties. Zn increased in the Ataem variety. Fe increased in the Ataem, Derby, Safir and S-312 varieties. Ni increased in all the varieties. Cu increased in the Arisoy, Ataem, Derby and Safir varieties. Mo and Mn increased in all the varieties. B increased in the Ataem and S-312 varieties. Interaction of sowing time x variety was statistically significant (p<0.01) for all of the detected minerals except Mn. Relationships between the investigated minerals were significant for Fe and Cu, Fe and Mo, Ni and Mo at the significance level of 1%. According to the results, late sowing caused an increase in the Ca, Fe, Cu Mn, Ni, Mo content. Furthermore, the Arisoy variety had the lowest and the highest content of boron depending on the sowing time. Farming techniques as well as the crop's variety, mineral status and health need to be pun in the focus in order to comply with the sustainability principles.

Keywords: functional food, legumes, cultivar, sowing time, seeds, chemical composition.

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INTRODUCTION

In recent years, with the increasing awareness in the society about food production, the demand for cleaner, nutritious and chemical residue-free food has emerged. Consumers pay higher prices for foods they think are safer and healthier. On the other hand, farmers aim to use their lands more effectively and to ensure continuity in production. In this context, legumes are of great importance for ensuring food safety, healthy nutrition and as a plant species that can be grown as a second crop, including in crop rotation and able to improve the soil quality.

Legumes (pulses) are primarily a protein source owing to its 20-25% protein content. Soybean [*Glycine max* (L.) Merill] is a legume including 32-45% protein, which makes it a unique crop, grown at low cost and providing protein that nutritionally and biologically resembles animal protein. There are various soybean products in world markets and therefore it is essential to optimize to soybean cultivation and quality with appropriate farming techniques and nutrition. There are important reports about application techniques (Krzebietke, Sienkiewicz 2010), types of fertilizer (Jankowski et al. 2015), agricultural treatments (Kahraman 2017) such as a change of the sowing date, which may induce very important changes in the elemental composition of plants, same as the genetic structure.

Undoubtedly, the emergence of yield and quality potentials of plants are directly related to agricultural practices. It is possible to prevent reductions in yield and quality by determining the most suitable planting time and variety, which can be considered as agricultural measures that are easy to implement.

Konya grows 30% of Turkey's legume seed production. After wheat and barley harvest, the second crop is sown, which is why it is crucial to determine some quality characteristics of the existing soybean varieties and to evaluate alternative plants in crop rotation are the main objectives. The objective of this study was to address the deficiencies noted for both producers and consumers by testing the soybean varieties widely grown in Konya, which has the biggest agricultural area in Turkey, and to determine the effects of a variety and sowing time on some mineral components.

MATERIALS AND METHODS

In the present research, five soybean varieties Arisoy, Ataem, Derby, Safir, and S-312 obtained from BATEM-Antalya/Turkey were used as the experimental material. The soybean varieties were chosen for such traits as stability, wide adaptation ability, quality and preference among farmers.

Field trials were rcarried out in two years 2017 and 2018. The fields were located in the Saray, a village near the town Yunak, in the region

Konya (Turkey). Means from the two years were used for statistical analysis. Sowing of seeds took place on two dates: 1st of July and 15th of July, in both growing seasons (sowing dates were determined by taking into account the harvest of barley and wheat, which are widely cultivated in the region). The evaluation of the used soybean varieties showed that the growing period was almost same as the mean values (109 days).

Table 1 presents climatic data. According to Table 1, monthly average temperature, monthly average relative humidity and total precipitation during the plant growing season were lower in 2017.

Table 1

Climatic data of Konya, Yunak town*

Months	Monthly average temperature (°C)		Monthly average relative humidity (%)		Monthly total precipitation (mm)	
	2017	2018	2017	2018	2017	2018
July	23.7	24.5	39.1	41.5	2.2	2.4
August	22.1	24.4	48.7	36.3	24.8	11.0
September	22.3	20.3	29.1	42.0	1.2	0.0
October	12.1	14.6	51.0	61.8	30.4	87.0
November	6.9	8.6	60.8	70.0	38.2	28.0
Average/Total	17.4	18.5	45.7	50.3	*96.8*	*128.4*

* Climatic data provided by the Turkish State Meteorological Service.

Characteristics of the soil are presented on Table 2. The soil particle size composition was determined according to Foth (1943). K, Ca, Mg, and Na were determined as extractable elements, while the remaining minerals were determined in plant-available forms. As seen in Table 2, the soil had neutral reaction, pH 7.2, no salinity problem, normal level of organic matter, the content of phosphorus, calcium and magnesium was sufficient, but the content of potassium was insufficient. In this study, potassium was not applied as a fertilizer because soybean was grown as a second crop. Fertilization was carried out before sowing, and it was composed of 100 kg ha^{-1} DAP (Di-ammonium phosphate: 18% nitrogen and 46% phosphorus). Also, there was no fertilization other than DAP in order to simulate the real conditions. Irrigation through sprinklers was made five times in 2017 and four times in 2018.

The field experiments were set up according to the randomized block design with three replications. Main plots consisted of the sowing dates, and sub-plots were composed of soybean varieties. Each plot was 2.5 m width x 3.0 length in size, with 0.5 m space between plots and 2.0 m space between blocks.

The mineral composition was determined by ICP-AES (Burt 2014). Statistical analyses were made in JUMP computer program, in which mean

Table 2

Chemical and physical characteristics of soil in the experimental area

Analyze	Unit	Result	Comment	Suggested fertilizer and amount	Reference
Texture		Loam			*Soil survey manual* (1951)
pH		7.20	neutral		Jackson (1962)
EC (Salt)	(μS cm^{-1})	281	low	no salinity problem	
$CaCO_3$ (Lime)	(%)	3.00	little lime		Hizalan, Unal (1966)
Organic matter	(%)	2.05	medium		Smith, Weldon (1941)
Inorganic nitrogen	(mg kg^{-1})	7.70	low	50 kg N ha^{-1}	Kjeldahl
Phosphorus	(mg kg^{-1})	20.6	sufficient	60 kg P_2O_5 ha^{-1}	Bayrakli (1987)
Potassium	(mg kg^{-1})	68	in- sufficient	100 kg K_2O ha^{-1}	
Calcium	(mg kg^{-1})	2755	sufficient		
Magnesium	(mg kg^{-1})	180	sufficient		
Sodium	(mg kg^{-1})	46	sufficient		
Copper	(mg kg^{-1})	0.62	sufficient		
Boron	(mg kg^{-1})	0.75	sufficient		Lindsay, Norwell (1978)
Iron	(mg kg^{-1})	0.84	in- sufficient	10 kg Fe ha^{-1}	
Manganese	(mg kg^{-1})	3.04	sufficient	2.5 kg Mn ha^{-1}	
Zinc	(mg kg^{-1})	0.52	medium	2.5 kg Zn ha^{-1}	

values showing significant *F* values were divided to groups by Student's *t* test (Kahraman 2017).

RESULTS AND DISCUSSIONS

The analysis of variance presented in Table 3 showed that there was statistical significance at the level of 1% ($p<0.01$) for the following parameters: Ca (variety, sowing date x variety interaction), Fe (sowing date, sowing date x variety interaction), Cu (variety, sowing date x variety interaction), Mn (variety, sowing date x variety interaction), Zn (variety, sowing date x variety interaction), Ni (variety, sowing date x variety interaction), Mo (sow-

Table 3

Variance analyses (*F* values) of the investigated minerals

Source of variance	Sowing time	Variety	Sowing time x variety interaction
Calcium	0.1701	9.60**	6.32**
Iron	2411.25**	2.21	9.64**
Copper	13.01	9.63**	17.43**
Manganese	36.36*	65.98**	2.89
Zinc	3.17	8.12**	13.43**
Nickel	20.30*	23.09**	10.30**
Molybdenum	902.45**	12.02**	4.78**
Boron	6.01	3.64*	9.84**

** $p<0.01$, * $p<0.05$

Table 4

Correlations between the investigated minerals

Minerals	Fe	Cu	Mn	Zn	Ni	Mo	B
Ca	0.423*	0.306	0.392*	0.264	0.055	-0.143	0.136
Fe	–	0.638**	0.370*	-0.129	0.439*	0.478**	0.050
Cu		–	0.298	-0.039	0.405*	0.449*	-0.354
Mn			–	0.139	0.238	0.076	-0.143
Zn				–	0.316	-0.175	0.066
Ni					–	0.740**	-0.171
Mo						–	-0.249

** $p<0.01$, * $p<0.05$

ing date, variety, sowing date x variety interaction) and B (sowing date x variety interaction). Furthermore, the following parameters presented statistically significant difference at 5% ($p<0.05$): Mn (sowing date), Ni (sowing date) and B (variety).

The correlation analysis, with the results contained in Table 4, showed statistically significant relationships at 1% ($p<0.01$) between: Fe and Cu ($r=0.638$**), Fe and Mo ($r=0.478$**), Ni and Mo ($r=0.740$**). Additionally, statistically significant correlation values were determined at 5% ($p<0.05$) between: Ca and Fe ($r=0.423$*), Ca and Mn ($r=0.392$*), Fe and Mn ($r=0.370$*), Fe and Ni ($r=0.439$*), Cu and Ni ($r=0.405$*), Cu and Mo ($r=0.449$*).

Means of the investigated parameters and Student's *t* test groups are in Table 5.

Calcium content of the used soybean varieties was higher on the second sowing date (1611.69 mg kg^{-1}) than the first one (1592.61 mg kg^{-1}). The high-

Table 5

Mean values (mg kg^{-1}) and Student's *t* test groups for content of the investigated minerals*

Calcium content			
Parameter	July 1	July 15	mean
Arisoy	1595.27*bcd*	1466.53*de*	1530.90*b*
Ataem	1378.23*e*	1671.77*bc*	1525.00*b*
Derby	1532.43*cd*	1621.57*bc*	1577.00*b*
Safir	1863.33*a*	1724.73*ab*	1794.03*a*
S-312	1593.77*bcd*	1573.83*bcd*	1583.80*b*
Mean	1592.61	1611.69	1602.15

Zinc content			
Parameter	July 1	July 15	mean
Arisoy	50.76*b*	48.20*bc*	49.48*b*
Ataem	44.11*de*	50.57*b*	47.34*bc*
Derby	59.20*a*	46.32*cde*	52.76*a*
Safir	49.83*bc*	47.76*bcd*	48.79*b*
S-312	47.98*bcd*	43.08*e*	45.53*c*
Mean	50.38	47.19	48.79

Iron content			
Parameter	July 1	July 15	mean
Arisoy	62.06*bcd*	47.98*ef*	55.02
Ataem	39.02*f*	71.64*abc*	55.33
Derby	42.94*f*	74.72*ab*	58.83
Safir	50.94*def*	79.87*a*	65.41
S-312	46.50*f*	60.80*cde*	53.65
Mean	48.29*b*	67.01*a*	57.65

Nickel content			
Parameter	July 1	July 15	mean
Arisoy	6.33*ef*	7.59*bc*	6.96*b*
Ataem	5.85*ef*	9.22*a*	7.54*a*
Derby	7.57*bc*	8.29*b*	7.93*a*
Safir	5.05*g*	7.15*cd*	6.10*c*
S-312	5.70*fg*	6.49*de*	6.09*c*
Mean	6.10*b*	7.75*a*	6.93

Copper content			
Parameter	July 1	July 15	mean
Arisoy	26.38*ef*	26.95*de*	26.67*c*
Ataem	25.92*f*	29.14*b*	27.53*b*
Derby	26.56*ef*	28.20*bc*	27.38*b*
Safir	26.78*def*	30.25*a*	28.52*a*
S-312	27.55*cd*	26.56*ef*	27.06*bc*
Mean	26.64	28.22	27.43

Molybdenum content			
Parameter	July 1	July 15	mean
Arisoy	1.47*de*	2.47*a*	1.97*ab*
Ataem	1.68*cd*	2.52*a*	2.10*a*
Derby	1.27*e*	2.29*ab*	1.78*b*
Safir	0.87*f*	2.03*bc*	1.45*c*
S-312	1.34*de*	1.54*de*	1.44*c*
Mean	1.33*b*	2.17*a*	1.75

Manganese content			
Parameter	July 1	July 15	mean
Arisoy	22.22	31.68	26.95*b*
Ataem	8.13	20.05	14.09*c*
Derby	31.96	36.01	33.98*a*
Safir	26.33	37.67	32.00*a*
S-312	31.41	36.87	34.14*a*
Mean	24.01*b*	32.46*a*	28.24

Boron content			
Parameter	July 1	July 15	mean
Arisoy	20.77*a*	13.74*e*	17.26*bc*
Ataem	17.54*c*	18.27*bc*	17.91*ab*
Derby	17.60*c*	16.59*cd*	17.09*bc*
Safir	17.51*c*	14.86*de*	16.19*c*
S-312	18.05*bc*	20.10*ab*	19.08*a*
Mean	18.29	16.72	17.51

* Student's *t* test grouping of significant *F* values; indicated by letters.

est Ca value was obtained from var. Safir (1794.03 mg kg^{-1}), and var. Ataem variety had the lowest value (1525.00 mg kg^{-1}). As the mean of variety x sowing date interaction, var. Safir presented the highest Ca content (1863.33 mg kg^{-1}) on the first sowing date and var. Ataem exhibited the lowest content (1378.23 mg kg^{-1}) on the first sowing date as well. It was detected that changes in the Ca content of the varieties varied because var. Arisoy, Safir and S-312 showed a decrease due to late sowing and the other varieties presented an increase in the Ca content when sown on the later date. Okara, which is a kind of soybean product, had a Ca content varied from 2600.00 mg kg^{-1} to 4280.00 mg kg^{-1} (Van der Riet et al. 1989). In some former studies on the Ca content of soybean seeds, the following values were reported: 3300.00 - 3950.00 mg kg^{-1} (Elsheikh et al. 2009), 1710.00-3354.00 mg kg^{-1} (Andrade et al. 2010), 2000.00-4000.00 mg kg^{-1} (Bellaloui et al. 2012), about mg kg^{-1} 3200.00-5000.00 (Wijewardana et al. 2019), while Kahraman (2017) reported 1083.00-1419.00 mg kg^{-1} in soybean grown in the same climatic conditions as in the current study. First and foremost, different amounts are thought to be due to climatic conditions. Additionally, a variety and its interaction with sowing time may also affect the Ca content, as shown by significant effects in this experiment.

Iron content of the soybean varieties increased due to late sowing, from 48.29 mg kg^{-1} to 67.01 mg kg^{-1}. The change ratio was calculated as 38.77%. The highest Fe content was accumulated in var. Safir (65.41 mg kg^{-1}) whereas var. S-312 had the lowest Fe content (53.65 mg kg^{-1}). As for the mean of variety x sowing tdate interaction, the highest value (79.87 mg kg^{-1}) for Fe in the soybean seed was obtained for var. Safir x July 15th sowing, and the lowest value (39.02 mg kg^{-1}) was achieved by var. Ataem x July 1st. The rate of change in the Fe content was 204.68%. Overall, the change in the Fe content depending on tested interactions, a considerable increase was found relative to late sowing for all varieties except for var. Arisoy which showed a 29.34% decrease in Fe content. The soybean product Okara had the Fe content value of 62.00-82.00 mg kg^{-1} (Van der Riet et al. 1989). Previous studies on the soybean Fe content reported the ranges from 83.50-117.00 mg kg^{-1} (Elsheikh et al. 2009), 223.00 to 400.00 mg kg^{-1} (Andrade et al. 2010), from 84.40 to 86.80 mg kg^{-1} (Bøhn et al. 2014), from 45.80 to 73.30 mg kg^{-1} (Bellaloui et al. 2015) from 79.90 mg kg^{-1} to 97.90 (Kahraman 2017), around 65.00-100.00 mg kg^{-1} (Wijewardana et al. 2019). Variations between the studies may be attributed especially to agricultural technologies, including the sowing date, which also caused significant changes in the present research.

The copper content in seeds of the soybean varieties showed an increase on the later sowing date, as it varied from 26.64 mg kg^{-1} when sown on July 1st to 28.22 mg kg^{-1} when sown on July 15th. The Cu content was highest in var. Safir (28.52 mg kg^{-1}) and the lowest in var. Arisoy (26.67 mg kg^{-1}). In the present research, the interaction variety x sowing date varied from 25.92 mg kg^{-1} in var. Ataem x first sowing date to 30.25 mg kg^{-1} in var. Safir x second sowing date for the Cu content. Late sowing caused an increase in the Cu content in all the soybean varieties except S-312. The interaction with the sowing date caused noticeable changes in the Cu content. Okara, a soybean product, was reported to contain 11.00-12.00 mg Cu kg^{-1} (Van der

Riet et al. 1989), which in similar in other, comparable studies. Soybean seeds had the amount of Cu between 12.70-26.40 mg kg^{-1} (Elsheikh et al. 2009), 28.80-31.40 mg kg^{-1} (Andrade et al. 2010), 2.00-12.10 mg kg^{-1} (Bellaloui et al. 2012), 10.40-11.30 mg kg^{-1} (Bøhn et al. 2014), 22.10-35.60 mg kg^{-1} (Kahraman 2017), ca 1.00-11.00 mg kg^{-1} (Wijewardana et al. 2019). According to previous studies, changes in the Cu values may be explained primarily by varietal traits and climatic conditions.

The manganese content of soybean seeds was significantly increased by late sowing, with 24.01 mg kg^{-1} when sown on July 1st and 32.46 mg kg^{-1} when sown on July 15th, which corresponded to a 35.19% change. The content of Mn was the highest in var. S-312 (34.14 mg kg^{-1}), and this variety was in the same group with var. Derby (33.98 mg kg^{-1}) and var. Safir (32.00 mg kg^{-1}). Those varieties were followed by var. Arisoy (26.95 mg kg^{-1}) and var. Ataem (14.09 mg kg^{-1}), which had the least manganese. The comparison of the soybean varieties for the Mn content showed a difference of 242.30%. Mean values of the interactions varied from 8.13 mg kg^{-1} (Ataem x July 1st sowing date) to 37.67 mg kg^{-1} (Safir x July 15th sowing date) for the Mn content. Comparison of the Mn content values demonstrated a 463.35% ratio. When an overall assessment was made for the Mn content, an increase was observed in all soybean varieties of the variety x sowing interaction. Other scholars (Van der Riet et al. 1989) reported the Mn content in Okara, which is a type of soybean food, in the range from 23.00-31.00 mg kg^{-1}, which agrees with the collected data. Our results for the Mn content of soybean seeds are consistent with the previous data, which were in a range of 25.30-38.00 mg kg^{-1} (Elsheikh et al. 2009), 8.00-35.00 mg kg^{-1} (Bellaloui et al. 2012), 22.80-24.50 mg kg^{-1} (Bøhn et al. 2014), about 28.00-41.00 mg kg^{-1} (Wijewardana et al. 2019) while another study (Kahraman 2017) conducted in a similar location reported different values, at 3.60-18.90 mg kg^{-1}. Herewith, the basic difference is attributed to the genetic variation of soybean varieties.

The zinc content decreased due to late sowing in the soybean seeds, from 50.38 mg kg^{-1} (July 1st sowing) to 47.19 mg kg^{-1} (July 15th sowing). The Derby variety had the highest Zn content (52.76 mg kg^{-1}) and S-312 had the lowest content (45.53 mg kg^{-1}), which means a 15.88% difference. Values for the Zn content due to the interaction of variety x sowing time changed from 43.08 mg kg^{-1} (S-312 X July 1st sowing date) to 59.20 mg kg^{-1} (Derby X July 1st sowing date), i.e. by 37.42%. In general, a decrease in the Zn content of soybean seeds was detected due to late sowing in all varieties except var. Ataem. Another study, which focused on the mineral composition of Okara, a soybean product, reported the content of Zn equal 35.00-64.00 mg kg^{-1} (Van der Riet et al. 1989). In previous research carried out the Zn content of soybeans, the reported ranges were 20.00-46.00 mg kg^{-1} (Elsheikh et al. 2009), 74.00-83.00 mg kg^{-1} (Andrade et al. 2010), 16.00-56.00 mg kg^{-1} (Bellaloui et al. 2012), 30.40-37.00 mg kg^{-1} (Bøhn et al. 2014), 62.30-85.30 mg kg^{-1} (Kahraman 2017), nearly 44.00-61.00 mg kg^{-1} (Wijewardana et al. 2019).

Partially difference between the results are thought emerged from the genetic diversity of the soybean varieties primarily.

The nickel content in seeds of the soybean varieties was increased by late sowing asits amount was 6.10 mg kg^{-1} (July 1^{st} sowing) and 7.75 mg kg^{-1} (July 15^{th} sowing) on average, and the change was calculated as 27.05%. The soybean varieties had the Ni content in seeds in a range from 6.09 mg kg^{-1} (S-312) to 7.93 mg kg^{-1} (Derby) while the amounts in S-312 and Safir were almost the same (6.10 mg kg^{-1}). According to the variety x sowing date interaction for the Ni content, the mean values varied from 5.05 mg kg^{-1} (Safir x July 1^{st} sowing) to 9.22 mg kg^{-1} (Ataem x July 15^{th} sowing). A remarkable change in the Ni content was detected in var. Ataem (57.61% difference). Data for the Ni content in the seeds showed a considerable increase in response to late sowing in all soybean varieties. Former studies revealed the content of Ni in soybean seeds of 8.40-16.70 mg kg^{-1} (Ozcan, Al Juhaimi 2014) and 3.80-10.90 mg kg^{-1} (Ramamurthy et al. 2014), which are partly in line with the present research. Small differences are thought to have originated from the genetic variation, apart from besides cultivation practices.

The molybdenum content of the soybean seeds increased in response to late sowing, with 1.33 mg kg^{-1} in seeds of soybean plants sown on July 1^{st} sowing and 2.17 mg kg^{-1} on July 15^{th}. This meant a 63.16% increase. The molybdenum content in seeds of the soybean varieties was between 1.44 mg kg^{-1} in S-312 and 2.10 mg kg^{-1} in Ataem. The difference in the Mo content among the soybean varieties was 45.83%. Mean values for the Mo content in the variety x sowing time interaction ranged from 0.87 mg kg^{-1} (Safir x July 1^{st} sowing) to 2.52 mg kg^{-1} (Ataem x July 15^{th} sowing), which corresponded to a 289.66% difference. The mean values for the tested interactions showed that the Mo content of all the soybean varieties increased when soybean was sown on the later date. Some former studies on the Mo content of soybeans detected the following ranges 2.45-3.76 mg kg^{-1} (Ozcan, Al Juhaimi 2014), 2.40-30.50 (Ramamurthy et al. 2014), which displays an extremely large difference for the maximum value. This huge difference is thought to be caused by the heterobeltiosis mechanism. The minimum Mo content was 3.50 mg kg^{-1} and the maximum one was 30.50 mg kg^{-1}, with the 9.10 mg kg^{-1} mean value. The cited authors concluded that it is possible to increase substantially the concentrations of minerals in edible segments of plants to produce bio-fortified foods.

The boron content in the seeds of soybean varieties decreased by late sowing, as it equalled 18.29 mg kg^{-1} in seeds of soybean plants sown on July 1^{st} and 16.72 mg kg^{-1} – for July 15^{th} sowing date. Seeds of the soybean varieties had the B content ranging from 16.19 mg kg^{-1} (Safir) to 19.08 mg kg^{-1} (S-312). The variety x sowing time interaction for the B content showed the mean values between 13.74 mg kg^{-1} (Arisoy x July 15^{th} sowing) and 20.77 mg kg^{-1} (Arisoy x July 1^{st} sowing), which corresponded to the difference of 51.16%. The variety Arisoy had the lowest and highest values of the change due to the sowing date. There was no distinct effect of the sowing date on the soybean varieties in terms of the (increasing or decreasing) B content. Previously, the content of B in soybeans was reported to be 41.30-73.00 (Bellaloui et al. 2010), 30.90-48.50 mg kg^{-1} (Ozcan, Al Juhaimi 2014), 26.60-48.50 mg kg^{-1} (Bellaloui et al. 2015), 36.00-39.00 mg kg^{-1} (Wijewardana et al. 2019). Our results show lower values than obtained previously. It has been suggested that insufficiency and sufficiency of B might be seen in the plants only in one growing season (Reisenauer et al. 1973). Those findings are consistent with the present results.

In other studies, the sowing time affects the mineral composition of plants due to its effect on lighting, temperature and harvest time; sowing time and plant density have significant effects on seed quality (Firoz et al. 2009). Sowing time and harvest time affect yield and quality and cause changes in the amounts of N, P, K, Ca, Mg, Fe, Mn, Cu and Zn (Eryilmaz Acikgoz 2011), early sowing in general increases mineral matter and protein content, genotype and environment affect quality (Pal et al. 1983), mineral matter intake is dependent on genetic structure and growth environment (Ashok et al. 2012), Fe, Zn and Mn decreases with increasing temperature. (Horrocks, Yang 1983), and N, P, K, Ca, Fe, and Zn also increases with increasing temperature (Velu et al. 2011).

Thus, it has been reported that seeds are the input that determines the yield and quality of most in the plant production process. In addition, it has been emphasized that the adaptation of a variety, the optimum level of climate and soil conditions, the place where the variety can be produced economically are of great importance, and the yield and quality are significantly affected by agricultural practices (Kahraman 2017, Akcan 2019).

CONCLUSIONS

As a result of the research, it has been determined that the sowing time and the variety used have significant effects on the nutritional composition of soybean. Elemental composition of soybean varieties increased in response to late sowing in general, although the amount of zinc and boron were decreased. The Arisoy variety was most demonstrably affected by the sowing time. It is possible to modify the elemental composition of soybean seeds by agricultural practices, including the selection of varieties, growing soybean as the second crop, and adjusting the sowing date.

Considering the results of this research, in which effects of varieties and sowing time on nutritional properties are determined, it is obvious that studies should be carried out in different regions and for longer periods in order to gain the information useful for farmers and consumers.

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