Mesopotamia Journal of Agriculture, Vol. 50, No. 2, 2022 (77-93)

Mesopotamia Journal of Agriculture

https://magrj.mosuljournals.com

THE ASSESSMENT OF SOIL AVAILABILITY AND WHEAT GRAIN STATUS OF MANAGNESE AND IRON IN CALCAREOUS SOILS AND IMPLICATION FOR HUMAN SAFETY IN IRAQI KURDISTAN

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Article information
Article history:
Received:14/2/2022
Accepted:24/6/2022
Available:30/6/2022

Keywords:
Manganese, Iron, wheat grain, micronutrients availability, concentration

DOI:
https://10.33899/magrj.2022.132812.1161

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ABSTRACT

Manganese (Mn) and iron (Fe) are the two vital micronutrients for plants and moreover essential nutritional health components in humans. Iron deficiency is common in humans and causes many health issues. In this survey, wheat grains of two major wheat cultivars were analyzed for their Mn and Fe concentrations beside the natural gradient of micronutrient availability across Sulaymaniyah province, Iraqi Kurdistan. However only 20% and 7.5% of the soils samples were Mn and Fe deficient or below recommended level. The considered micronutrient concentrations in the grains of wheat were in the acceptable range which are reported globally (range 41.3 and 37.6 mg kg-1 respectively). Furthermore, high application of nitrogen and phosphorus fertilizer in the studied calcareous soils could be strongly affected on the studied micronutrients concentration in the studied grain samples. The results indicate that adequate levels of Mn and Fe in the surveyed grains is a beneficial guide for quality of grains associated with human healthiness, where wheat grain bread is an essential food.

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INTRODUCTION

Manganese (Mn) and iron (Fe) are vital micronutrients for plants and moreover essential dietary health components in humans (George *et al*., 2014; Li and Yang, 2018; Sousa *et al*., 2019). Iron deficiency is widespread in humans and causes several health issues (Zulfiqar *et al*., 2021). But, in difference to Fe deficiency which is dependable for main health problems, Mn deficiency is rare (Alejandro *et al*., 2020). Manganese and Fe are used by humans and plants for playing various biological functions (Li and Yang, 2018; Sousa *et al*., 2019). They participate in the structural fraction of enzymes (Sousa *et al*., 2019). In developed countries, anemia is mainly due to insufficient intake of Fe but it causes about 50% of the anemia in developing countries (Abbaspour *et al*., 2014), where malabsorption or chronic blood loss is the extremely common causes (Besarab and Hemmerich, 2018). While, Mn is the main element that is required in the control of the use of lipids and glucose and for activation of several enzymes (Li and Yang, 2018), increase of rate in the protein production, vitamin C and B; catalysis of hematopoiesis; adaptation of the endocrine; and increase in impervious function (Chen *et al*., 2018). Thus, in the human body, Mn deficiency reduces growth and productivity (Shi *et al*., 2020). Symptoms related to Mn deficiency involve deficiency of physical endurance, fatigue, reduced metabolism of cartilage and bone, the fingernails and hair slow growth, dermatitis, loss of weight, decreased fertility, improved inflammation, and allergic sensitivities *(*Ayodele and Bayero, 2010).

Insufficient dietary intake is a major factor that correlates with the increase of Mn and Fe deficiencies. Because only a small amount of dietary Mn absorbs and it is excreted rapidly into the gut through bile (Sousa *et al*., 2019; Zulfiqar *et al*., 2021). In the calcareous soils of the semi-arid areas, the deficiency of plant-available Mn and Fe fractions are widespread (Ghasemi-Fasaei and Ronaghi, 2008). Their bioavailability is extremely affected by the soil calcium carbonate content, high soil pH value, and drought (Nikolic *et al*., 2016). The two main sources of micronutrients in the soil are soil parent material and organic forms within humans, but Mn and Fe deficiencies can be attributed with parent material (Mathew *et al*., 2016). The bioavailability of metals is controlled mainly by sorption-desorption process, the soil components responsible for the sorption of cation metals include soil organic matter, phyllosilicate, microorganisms, carbonate, organo-mineral complexes (Caporale *et al*., 2016). Rengel, (2015) reported that plant available Mn decrease in alkaline soil due to immobilization and chemical and microbial oxidation, this is cause change Mn into plant-unavailable Mn oxides (Schmidt *et al*., 2019).

Also, Fe availability mainly controlled by oxidation and precipitation processes which forms highly insoluble ferric oxides and hydroxides minerals (Moreover, the amount of nutrients in the soil solution is affected by soil type, topography, climate and management practice (Mathew *et al*., 2016). But, In this type of soil, low availability of micronutrients rather than low nutrient content is one of the main influences for the common plant nutrient deficiency (Soaud *et al*., 2011). Thus, Mn and Fe deficiencies negatively affect wheat growth and its yield due to the high sensitivity of wheat to their deficiencies *(*Zulfiqar *et al*., 2021). Globally, about half of wheat-production zones have soil with low amount of plant available Fe (Nikolic *et al*., 2016), and about 15% wheat grown areas contain a low amount plant available Mn (Wang *et al*., 2016b).

This soil is typically found in low-income countries, where people highly depend on wheat as a source of their daily calorie intake (Jhanji *et al*., 2014). Overall, the wheat grain contains a low amount of these types of micronutrients including Mn and Fe (Cu *et al*., 2020), and high amounts of these nutrients' lost during white flower processing. Furthermore, the wheat grain contains various complexes which reduce the availability of micronutrients in the human ingestion system involving phytic acid and oxalic acid (Ayodele and Bayero, 2010; Samtiya *et al*., 2020*)*. And also, the competition between nutrients also affects this nutrient availability (Uygur *et al*., 2017). As a result of deficiency motivated cereal established foods, Mn and Fe deficiencies ranking as the 6th and 11th main reasons of disease and illnesses in several low-income countries (Avila *et al*., 2013). Manganese and Fe deficiencies in staple food crops are worldwide documented not simply as a trouble of decreased harvests however additionally as a critical community health issues with extensive social budgets (Cu *et al*., 2020; González-Guzmán *et al*., 2020; Li and Yang, 2018; Pahlavan-Rad and Pessarakli, 2009; Samtiya *et al*., 2020).

In Iraqi Kurdistan, though, the nation's knowledge on this problem is even absent. Wheat is the essential food and the important crop in relation to produced site and whole production. Normal daily cereal intake is around 400 g per person and provides 53% of total dietary energy consumed (Food deprivation in Iraq, 2010). The mean wheat grain yield in Iraqi Kurdistan is relatively low, below 3 t ha^{-1} (Statistical Office of Iraq, 2020). All cultivated soil area in Iraqi Kurdistan is calcareous soils, where the amount of chemical fertilizers used in the production of wheat are very high. But, although the implication of wheat in the food intake of the extensive common of the population, not at all regular study of Mn and Fe availability in soils and in grains of wheat has been commenced in Iraqi Kurdistan. Thus, this survey is the initial article of the level of Mn and Fe elements in soils and grains in the main wheat grown zones in the province. Moreover, to study variation of Mn and Fe concentrations in the grain among diversities of the wheat cultivated in Sulaymaniyah province, Iraqi Kurdistan.

METHODS AND MATERIALS

Study area

Sulaymaniyah city (Lat. 34º32 to 36º30´N and Long. 44º33 and 46º20´E) is located in the north-eastern part of Iraq bordering Iran. The annual precipitation in Sulaymaniyah is between 600-1000 mm and has a mainland, semi-arid to sub-humid environment with one wheat growing season from October to end of May. Ten locations

Table (1): The wheat diversities were sampled at ten different sites in Sulaymaniyah province.

Loctaion	No. of samples	Adana	Aras
Halabja	13	8	5
Sirwan	8	6	2
Khormal	5	3	2
Sharazoor	12	6	6
Said Sadiq	20	7	13
Barznja	8	1	7
Piramagrun	10	5	5
Chamchamal	8	4	4
Darbandikhan	9	3	6
Kalar	13	12	1
Total	106	55	51

were selected for sampling which covered the province area include Halabja, Sirwan, Khormal, Sharazoor, Said Sadiq, Barznja, Piramagrun, Chamchamal, Darbandikhan and Kalar (Fig.1). The codes and number of wheat grains samples including Adana and Aras cultivars for each location are given in (Table 1).

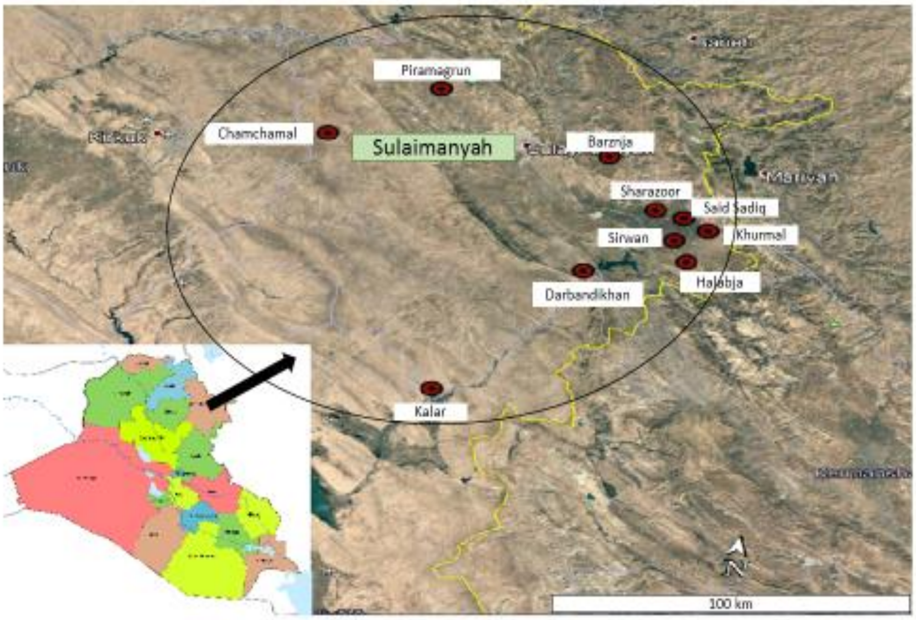

Figure (1): Surveyed wheat and corresponded soil samples locations in Sulaymaniyah province, Kurdistan region, Iraq.

Wheat grain and soil sampling

The winter bread wheat grain (Triticum aestivum L.) of two cultivars Adana and Aras were collected in the major wheat yielding areas in Sulaymaniyah province, Iraqi Kurdistan (Fig. 1). Both assessed cultivars, publicized by the ministry of Agriculture and water sources of Iraqi Kurdistan government, are developing extremely common with the Iraqi Kurdistan agriculturalists and their use is gradually rising, the current study involved 106 soil and wheat grain samples in 10 sites through Sulaymaniyah province (Fig. 1), 3 sited were in Garmian in the south of province (the region has high annual temperature and low rainfall), and 7 were distributed through the low temperature and high rainfall in the north of the province. All the surveyed fields had similar managing, i.e., no irrigation, same wild plant control, fall fertilization with 50–200 kh ha^{-1} (15:15:15) of NPK and without application of micronutrients fertilizers. The wheat grain samples were collected at harvesting time (May-June 2017). Soil sampling was done at the same time from each location in sub sites, composite soil samples were also collected from fields in the depth of 0-15 cm (the number of soil samples were dependent on the location size. All soil samples were stored in clean polythene bags and were brought to the laboratory. The soil samples were air-dried, ground and passed through 2 mm sieve for physicochemical and micronutrients analysis.

Soil analysis

Soil analysis followed the procedure mentioned by (Nazif *et al*., 2015). The pH values of soil were determined in soil: water suspension (1:2.5) using a pH meter with combined Ag/AgCl glass electrode (Model pH 209, HANNA instruments, Bedford, UK). The extractable Fe and Mn in the studded soil samples, we used the subsequent method: DTPA-extractable metals were determined by shaking about 2.0 g of soil sample with 8 mL of 0.005 M diethylenetriaminepentaacetic acid (DTPA) + 0.01M $CaCl_2$ + 0.01 M triethanolamine for 2 h (Quevauviller, 1998). The samples and the extraction solution were shaken on a vertical shaker and centrifuged at 3500 rpm for 30 min and then the supernatant was filtered. Manganese and Fe concentrations in the extracts were determined by (ICP-MS,). Soil total calcium carbonate content was measured by the Collins' Calcimeter method as described by (Zhu *et al*., 2021). Loss on ignition was used to determine the amount of soil organic matter following the procedure explained by (Hoogsteen *et al.*, 2018). The average values of soil pH, organic matter content and calcium carbonate were shown in table (2).

Table (2): The average values of pH, soil organic matter and calcium carbonate contents in surveyed soils in the studied area.

Location	pH	OM	$CaCO_3$
		%	
Halabja	7.95	9.16	43.8
Sirwan	8.05	10.1	49.4
Khormal	8.03	10.3	40.7
Sharazoor	7.97	10.7	35.0
Said Sadiq	7.97	9.28	53.2
Barznja	7.87	10.4	61.9
Piramagrun	8.01	10.7	52.1
Chamchamal	8.08	6.36	25.0
Darbandikhan	8.13	5.45	53.5
Kalar	8.17	4.75	19.2

Grain analysis

The wheat grains were cleaned from glumes, awns and pale and then washed with deionized water, air dried at 70 °C and powdered. And then about 0.2 g of grain digested under microwave heating (Anton Parr, Multiwave 3000) for about 45 mins at 2 MPa in 4.0 mL of 68% TAG HNO_3 and 2mL H_2O_2 for grains and the samples were subjected to multi-elemental analyses by inductively coupled plasma mass spectrometry (ICP-MS;). The certified reference material (wheat grain flour) was used to evaluate the correctness and accuracy of the analysis.

Statistical analysis

Concentrations of micronutrients in soils and grains samples were exposed to one-way analysis of variance (ANOVA) or by Least of Significant Deference (LSD), using the SPSS program (version, 26). This is to assess the difference considerably between the varieties of wheat grains and soils. The significant level considered when ($p<0.05$).

RESULTS AND DISCUSSION

Manganese and Fe concentrations in wheat grains and soils in the surveyed areas are shown in (Fig. 2). The studied micronutrients concentrations in grains and soils did not significantly vary among the studied wheat cultivars (Fig. 2). In most of the studied soils, the availability of Mn in soils was extremely high (8.43 ± 3.47 mg kg^{-1}), and only 20% of soil samples were under the accepted critical level of 5.5 mg kg^{-1} (Fig. 2c). Fe availability for plants was sufficient (8.86 ± 3.58 mg kg^{-1}, Fig. 2a) and in about 7.5% of the studied soil samples the available Fe was under the recommended level of 5 mg kg^{-1}. The Mn concentration in grains was relatively modest; average value was 43.3 mg kg^{-1}, ranging from 25.9 to 69.1 mg kg^{-1} (Fig. 2d) for cv. Adana was 39.1 mg kg^{-1}, ranging from 23.0 to 82.8 mg kg^{-1} for cv. Aras. The average Fe concentration in grains was

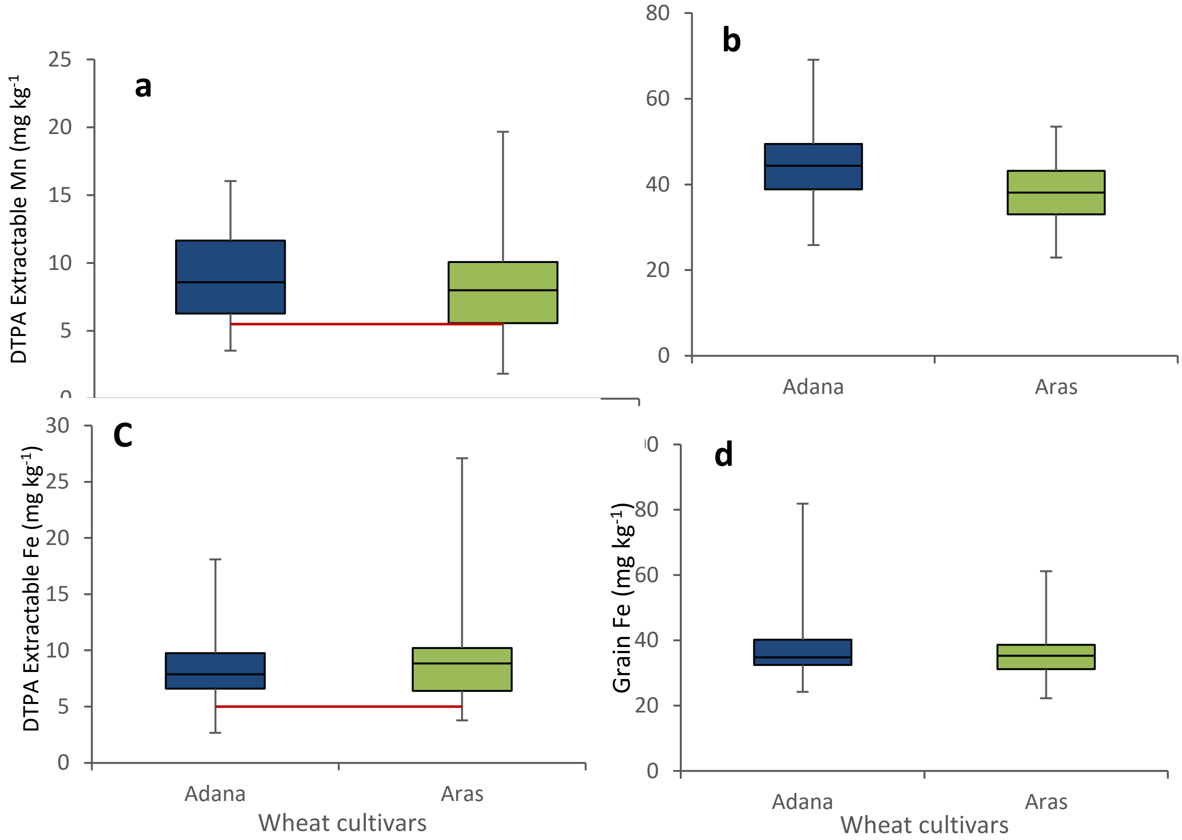

Figure (2): Regularity distribution of Mn and Fe in soil and wheat grain samples in wheat-production sites in Sulaymaniyah province. A, C. plant available (DTPA extractable concentrations of Mn and Fe in soils respectively); B, D: Mn and Fe concentrations in differ for both cultivars; 24.2-81.8 mg kg^{-1} in cv. Adana, and 22.3-40.6 mg kg^{-1} in cv. Aras (Fig. 2b). The mean concentration of Fe for all samples was 37.4±10.4 mg kg^{-1}, median only 34.6 mg kg^{-1}. The results also indicate that both Mn and Fe concentrations are higher in Aras cultivar than Adana cultivar. wheat grains respectively. Critical deficiency restricts are showed by red rushed lines. Outliers diverge by more than 2 interquartile ranges.

The average of soil pH values of the wheat fields studied in Sulaymaniyah province from 8.02±0.17 (ranged from 7.46 to 8.67). The average total $CaCO_3$ concentrations were 16.3±9.23 g kg^{-1}. The average of soil organic matter ranged from 3.15 to 20.9 % with an average of 8.64%. Liner regression showed that the extractable Fe negatively correlated with pH and total $CaCO_3$ concentration (Fig. 3b, f), and these two parameters had stronger correlation with Fe availability than Mn availability. The influence of soil organic matter content positively correlated with DTPA extractable Fe but negatively with extractable Mn (Fig. 3d, c). The soluble amount of Mn and Fe in soil samples increased with increasing Mn and Fe concentrations, but it was highly correlated between soluble and available Mn than soluble and available Fe (Fig. not shown). The total Fe and Mn concentrations had a nominally meaningful influence on the availability of Mn and Fe accounting however for only about 1% of the total Fe and Mn.

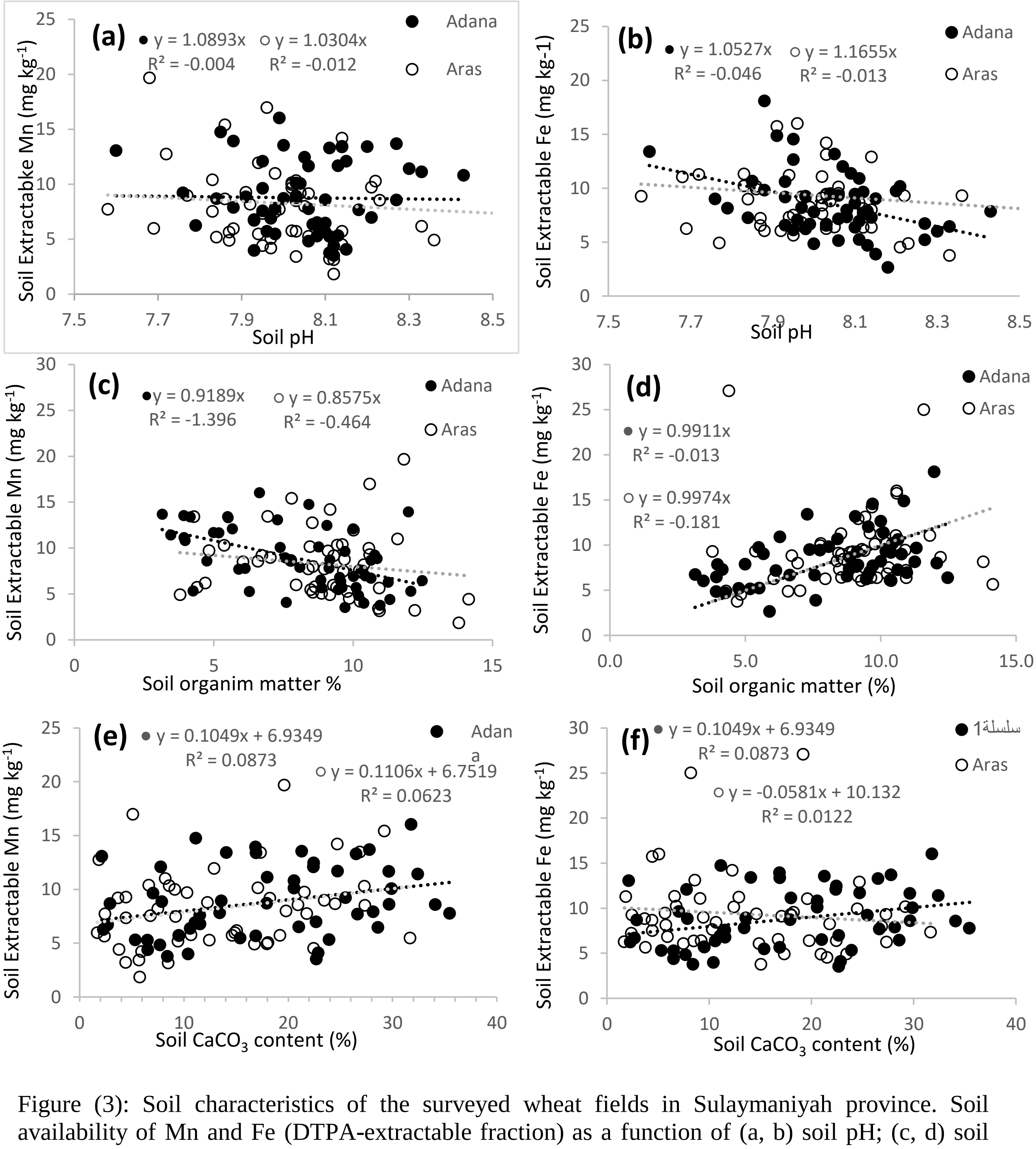

Figure (3): Soil characteristics of the surveyed wheat fields in Sulaymaniyah province. Soil availability of Mn and Fe (DTPA-extractable fraction) as a function of (a, b) soil pH; (c, d) soil organic matter and (e, f) soil total $CaCO_3$ content are showed. average of the two analyzed wheat cultivars (23 ± 9.54 and 22.3 ± 8.78 mg kg^{-1} for Mn and Fe respectively).

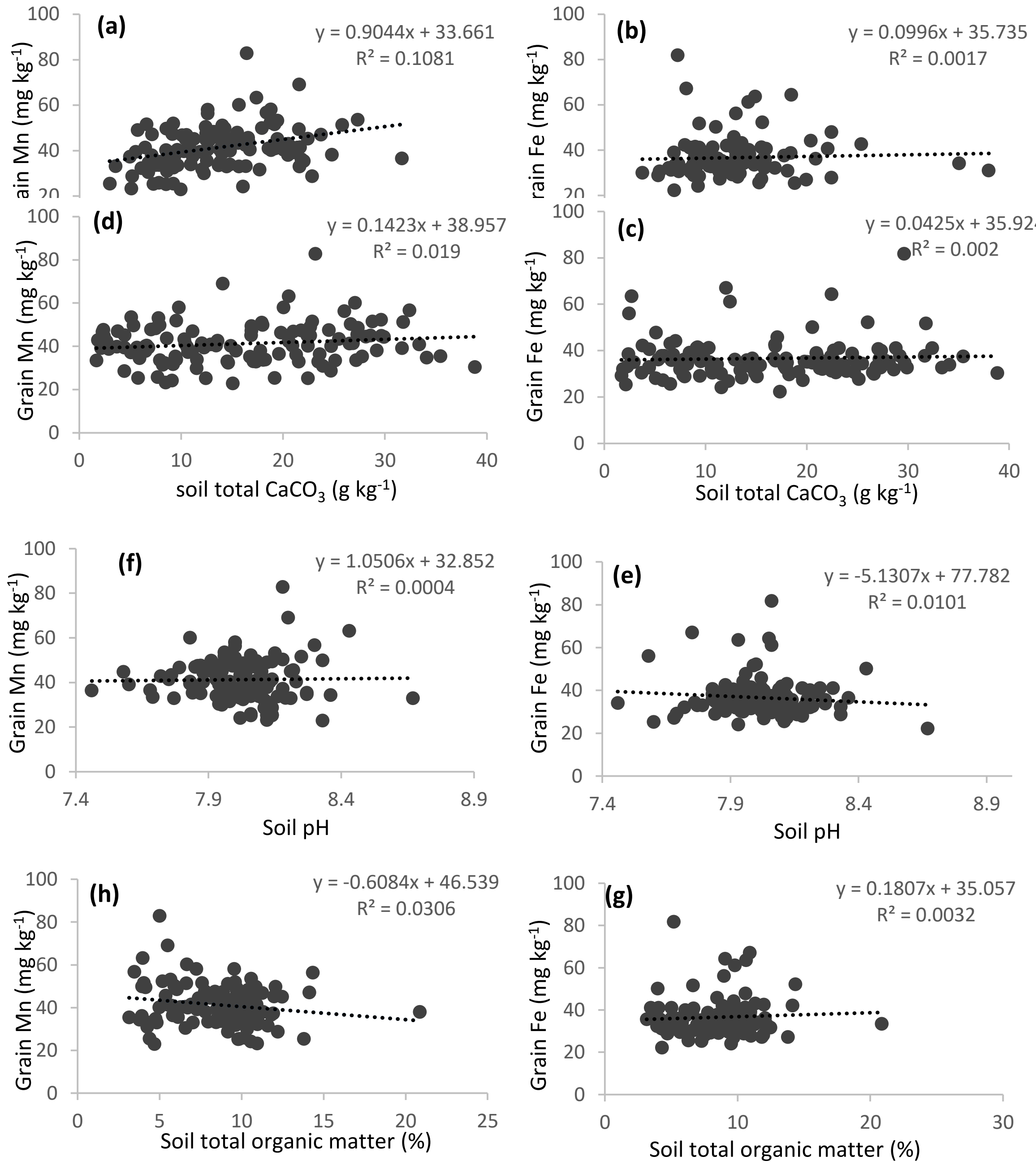

Figure (4): Manganese and iron concentrations of the surveyed wheat grains throughout Sulaymaniyah province. Grain concentrations of Mn and Fe as a function of the measured soil properties (a, b) Soil available Mn and Fe; (c, d) soil $CaCO_3$ content; (e, f) soil pH; and (h, g) are showed.

Manganese and Fe concentrations in wheat grains samples as a function of assessed soil characteristics are shown (Fig. 4). The concentration of Mn in grain samples of the two studied wheat cultivars were slightly influenced by Mn availability in soils (Fig. 3a), while soil organic matter showed a negative effect on the difference in Mn concentration in grains samples (Fig. 4h). While total soil calcium carbonate content and pH value of soil could individually be a particular significant predictor of the status of Mn in grain (Fig. 43d, f). Iron concentrations in the two studied wheat cultivar grains were mainly controlled by soil pH (Fig. 4e). Also, the effect of soil calcium carbonate and soil organic matter on the concentration of Fe in grains were not observed (Fig. 4c, g). Generally, the assessed soil characteristics accounted for only around 6% of the detected difference in the concentration of Fe in grains (linear regression analysis was not significant, not shown). Finally, the co-incidence of higher available Mn and Fe concentrations of soil with higher total calcium carbonate and pH value (Fig. 3 and 4d, c, f, e) had a spatially specific tendency through the province. These three studied soil characteristics higher in the south part of the province than north part.

Moreover, a high amount of calcium carbonate was discovered in all the studied soil samples in the province (wherever average pH value of 8.03). Concurrently, the concentrations of Mn and Fe in grain samples of the province are considered as the (Alloway, 2008; Aref, 2012). Iron availability was negatively correlated with total calcium carbonate and high soil pH value (Fig. 4a, b), but available Mn was completely by total $CaCO_3$ content and negatively with the value of soil pH and soil content of organic matter (Fig. 4d), due to the high ability of soil organic matter to Mn fixation (Rashed *et al.*, 2019), by its binding sites because of the presence the high amount of inositol phosphates in it which have potential to fix Mn (George *et al.*, 2014). Aref (2012) reported that increasing soil pH increases amorphous and crystal forms of Mn which are unavailable forms of Mn. The results of this survey are also in agreement with those reported by (Habibah, 2014).

Inverse to the reports from around another country where reducing the deficiency of Fe has been documented as a national health problem, the extractable Mn and Fe fractions in the studied arable soils of Sulaymaniyah province were not under the critical deficiency limits (Fig. 2a, c). For example, the deficiency of Mn was reported in China as a common element deficiency in calcareous soils and in alkaline soils of Iran (Alejandro *et al*., 2020; Bityutskii *et al*., 2017; Wang *et al*., 2016a). And about 30% of soils globally are Fe-deficient (Aref, 2012). In the surveyed wheat soils, no deficiency of Mn and Fe was found (Fig. 2b). What accorded with total calcium carbonate content, soil pH values, and soil organic matter (Fig. 3). As assumed from the other study affected Assessment of the bread wheat succession for the concentrations of Mn and Fe in the grain have been seriously achieved on a worldwide level *(*Pahlavan-Rad and Pessarakli, 2009; Stepien *et al.*, 2019).

Generally, Mn and Fe concentrations in the wheat grain could be range from 2.4 to 4.1 mg kg^{-1} for Mn, and 15–22 mg kg^{-1} for (study of 11 soft spring wheat cultivars in agriculture soils in Russia, *(*Bityutskii *et al.*, 2017). In Iran, 137 wheat cultivars grown in the calcareous soils with Fe deficiency had the grain concentration ranged between 21.1-96.6 mg kg^{-1} (Karami *et al.*, 2009). Surveying in China performed by collecting 438 wheat grain samples from two regions that were categorized on soil pH (non-acid pH>7, and acid pH<7), showed that the average concentration of Mn was 43.7 mg kg^{-1} (ranging from 13.9 to 98.3 mg kg^{-1}) (Shi *et al.*, 2020). Average concentrations in (mg kg^{-1}) of 13.0 for Mn and 66.7 for Fe in wheat grain reported by (Mohammed and Ahmad, 2014). In different countries, the concentration of Fe in wheat grain ranged between 23.0 and 73.0 mg kg^{-1} *(*Melash *et al.*, 2016). In the calcareous soils in Turkey, Fe concentration in grains ranged between 8.0 and 61.0 mg kg^{-1} (Cakmak *et al.*, 2004). Results of a study achieved from 2009 to 2011 on 655 spring wheat cultivars on a wide range of environmental condition found a mean grain Fe concentration of 48.2 mg kg^{-1} (Liu *et al.*, 2014). Also, in a research involving 150 wheat genotypes the concentration of Mn and Fe ranged between 18.1-65.6 and 9.20-49.7 mg kg^{-1} individually (Pandey *et al.*, 2020). The average concentration of Fe was 37.2 mg kg^{-1} for wheat grain grown in Mexico (Welch and Graham, 2004). Compared to these reports, the results in the current survey (average values of 43.3 mg kg^{-1} for Mn and 39.1 mg kg^{-1} for Fe, Fig. 2b, c) present that the concentration of the two micronutrients in grain of the studied bread wheat grown in Sulaymaniyah province are in the acceptable range level reported worldwide.

To estimate the wheat grain micronutrients concentration with regard to human food and harvest, two important issues need to be thought about. First, reliance on a cereal-based diet (Nikolic *et al.*, 2016). And second, the insufficiency of these micronutrients can reduce crop yields and impair the characteristic deprived of every individual sign, therefore affecting so-called "hidden hunger" which frequently disappoints to be referred (Alloway, 2008). Populations in Iraqi Kurdistan are on a cereal-based regime, where cereals are staple food. In individuals, the daily consumption of bread wheat is very high and reaches about 400g as average per capita by Food Deprivation in Iraq (Food Deprivation in Iraq, 2010). For this style of regime, the concentrations of these micronutrients should be considered due to its public health. But, the acceptable Mn and Fe concentrations in Iraqi Kurdistan wheat cultivars with average range of 43.3 and 39.1 mg kg^{-1} were confirmed respectively in the current study (Fig. 1), suggesting that the possibility of Mn and Fe deficiencies in Iraqi Kurdistan population may have been underestimated.

However, in the country and the province particularly the wheat yield is below 3 t ha^{-1}, and "hidden hunger" of wheat grain for Mn and Fe has not been considered. While micronutrients deficiencies in matured grains are not basic to found, vital Mn and Fe concentrations 25 and $\geq$30 mg kg^{-1} have been recommended individually *(*Curtin *et al.,* 2008; Rashed *et al.*, 2019). In the current study, 3% and 20% of the grain samples had Mn and Fe concentrations below 25 and lower than 30 mg kg^{-1}, respectively (Fig. 2). These results indicate that Mn and Fe deficiencies could be ignored, reducing the reason for wheat production in the province. To better impact of Wheat grain on human health, increasing the recent average concentrations of Mn and Fe is a good strategy. Because adequate levels of Mn and Fe in wheat grain, for the population surviving on cereal-based regime, could be high. There are various of approaches that are used to reduce minerals deficiency in food crops involving dietary diversification, biofortification, and fortification (Zulfiqar *et al.*, 2020), but fertilization as foliar is a main and convenient method for rising Mn and Fe concentrations and increase the quality of wheat grains (Niyigaba *et al.*, 2019; Pahlavan-Rad and Pessarakli, 2009). Moreover, lower micronutrient concentrations are occurring due to extreme producing wheat cultivars improved to demanding agriculture environments, and producing wheat grains with micronutrient contents especially Fe could be particularly difficult *(*Dolijanovic *et al.*, 2019; Nikolic *et al.*, 2016). The main two common highly producing wheat cultivars investigated in the current survey (Adana and Aras) all the two cultivars adapted with environmental condition in the province but Aras cultivars was mainly used to suggest resistance to more drought than Adana cultivars, High sensitivity of Adana cultivars to drought condition formulates it a perfect wheat cultivar not revised to low rainfall.

However, the major agronomic interference in rising micronutrients content in grains is due to application of mineral fertilizers (Cakmak, 2008; Nikolic *et al.*, 2016). The current survey shows that wheat grain concentration of Fe was not influenced by soil extractable Fe or by other soil factors that affect the availability of Fe (Fig.3b), which is fundamentally in agreement with results reported by (Nikolic *et al.*, 2016).

The grain content of Fe is not increased by soil application of Fe fertilizer in the calcareous soils (Prasad *et al.*, 2014), this is due to the presence of a high amount of $CaCO_3$ which causes decreasing the availability of Fe in this type of soil (Alam and Ansari, 2001). Thus, foliar fertilization of Fe could raise the concentration of Fe in the wheat grain to about 35%, due to the limitation of transporting of Fe to the endosperm *(*Zhang *et al.*, 2020). Pahlavan-Rad and Pessarakli (2009) found that foliar application of 1% of $FeSO_4$ increased about 21% of Fe concentration in the wheat grain. However, wheat grain Mn concentration in the current study was affected by Mn availability in the soil while decreased with increase soil organic matter, this is may be due to capacity of organic matter to rapid fix of Mn *(*Rashed *et al.,* 2019), while not affected by other soil factors (Fig. 3). They also demonstrated that application of Mn fertilizer as $MnSO_4$ or MnO, doubled the yield in Australian`s Mn-deficient alkaline soil.

The vital factor for achieving high yield and high quality of product are optimum application of fertilizers. A stabilized application of NPK fertilizer is required to improve wheat production (Pandey *et al.*, 2020*)*. In the Kurdistan region, farmers often have access due mainly to cheap cost and poor availability of nitrogen (N) and phosphorus (P), they apply high amounts of these two fertilizers. But among these two mineral nutrients, N has the maximum significant role in forming the yield (Dolijanovic *et al.*, 2019), value and utilizable value of the wheat grain *(*Lan *et al.*, 2021). Several studied have shown that by application of N fertilizer could encourage the increase of Mn and Fe micronutrients in the wheat grain (Singh et al., 2018; Stepien *et al.*, 2019). This is clarified by the fact that the adequate amount of N rises the grain protein content, and the protein is where Mn and Fe are accumulated (Lan *et al.*, 2021; Uygur *et al.*, 2017). Stepien *et al.* (2019*)* found high correlation (r=0.356) between N applied and Fe concentration in the wheat grain. (Shiwakoti *et al.*, 2019) they studied the effect of N fertilizer application on micronutrient concentrations and found that in organic N application increased accumulation of Mn in wheat grain. Thus, presence of acceptable levels of Mn and Fe in the surveyed wheat grains may be related to application high amount of N fertilizer in the region.

On the other hand, in calcareous soils, the deficiency of P is very common (Boukhalfa-Deraoui *et al.*, 2015). Thus, phosphorus fertilizer application in wheat grown fields is common this is to increase in the wheat grain yield (Dhaliwal and Mandal, 2019; Zhang *et al.*, 2020), while it could affect micronutrients concentration in the wheat grain. In this survey, regression analysis showed a significant correlation ($r^2= 0.143$, $p\leq 0.001$) between Mn and P concentrations in the wheat grain. Wang et al. (2016b) studied the effect of NP fertilization on Mn availability in semiarid soil on crops and found that NP application significantly increased exchangeable and carbonate-bond Mn which is the main available Mn source in the soil. Also, the regression analysis showed a high positive correlation ($r^2=0.39$, $p\leq 0.001$) between Mn and Ca concentrations in wheat grains. In contrast, Zhang *et al.* (2020) resulted in P application to calcareous soil not affected by decreasing the wheat grain Fe concentration. Singh *et al.* (2018*)* studied N fertilization on the concentration of Fe in the wheat grain and found that split application of 160 kg ha^{-1} is an effective agriculture practice to improve Fe content of grain. However, Dhaliwal and Mandal (2019) reported that high application of NPK fertilizers caused Mn and Fe deficiencies in high yielding cultivars of wheat. Karimian and Hashemi

(2001) concluded that Fe concentration in the wheat grain decreased with an increase in the rate of applied P in the calcareous soils. Presence enough amount of available of Fe in the studied soil not caused high accumulation of this micronutrient in the wheat grain. This is may be due to the effect of high P application to the studied fields.

CONCLUSION

The current survey presented that there is no major Mn and Fe deficiencies in the wheat grown fields in Sulaymaniyah province and also the studied micronutrients concentrations in the grain were acceptable, which is a vital diet in the country, were sufficient. Resulted in this study suggest that Mn and Fe deficiencies in the wheat grain not occur and the quality of grain related to human health is good in Sulaymaniyah province, Iraqi Kurdistan. To protect this quality at a country level, a long term involvement with Mn and Fe foliar fertilization must be considered with breeding program this is to improve micronutrient efficiencies of the main bread wheat cultivar is required. Also, application of high amount of N and P fertilizers into the main wheat growing areas in calcareous soils is studied and added reason of regulating Mn and Fe accumulation in the grain.

ACKNOULEGEMENT

Dr. Scott D. Young and Dr. Saul Vazquez-Reina it thanked for his help with sample analysis by ICP-MS.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

تقييم جاهزية التربة وحالة حبوب القمح من المنغنيز والحديد في التربة الكلسية وانعكاسات ذلك على السلامة البشرية في كردستان العراق

محمد سعيد رشيد

الكلية التقنية للعلوم التطبيقية-حلبجة/ الجامعة التقنية/ السليمانية/ اقليم كردستان/ العراق

الخلاصة

المنغنيز (Mn) والحديد (Fe)عنصـران مغذيان حيويان للنباتات بالإضـافة إلى كونها من العناصـر التغذوية المهمة لصحة الانسان. يعد نقص الحديد من المشاكل الصحية الشائعة عند البشر ويسبب العديد من المشكلات الصحية. في هذا المسح، تم دراسة تركيز المنغنيز والحديد في حبوب القمح لاثنين من أصناف القمح الرئيسـية، بالإضـافة الى دراسـة التدرج الطبيعي لتوافر المغذيات الدقيقة في جميع أنحاء محافظة السليمانية، كردستان العراق. أظهرت النتائج أن 20٪ و 7.5٪ فقط من عينات التربة كانت تعاني من نقص المنغنيز والحديد وعلى التوالي، كما أظهرت النتائج أن تراكيز المنغنيز والحديد في حبوب القمح كانت ضـمن المدى المقبول عالميا والذي يتراوح بين 41.3 – 37.6 مغم / كغم. أضـافة الى ذلك، فإن الاسـتخدام العالي لسماد النيتروجين والفوسفور في التربة الجيرية المدروسة يمكن أن يؤثر بشدة على تركيز المنغنيز والحديد في

عينات الحبوب. أن تواجد المستويات الكافية من المنغنيز والحديد في الحبوب التي تم مسحها في هذه الدراسة هو دليل هام لأهمية تأثير الحبوب على صحة الإنسان، حيث يعتبر خبز حبوب القمح غذاءً أساسياً للإنسان.

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