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COMPARATIVE ANALYSIS OF THE SELENIUM CONCENTRATION IN GRAINS OF WHEAT AND BARLEY SPECIES

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`Abstract

Macro and micro nutrients are essential for human health and growth development. It is reported that about three million people are suffering from nutrient deficiencies all over the world. Various sources are available like: vegetables, fruits, fish, meat and cereals to overcome these deficiencies. Among cereals, wheat and barley are main source to meet the requirement of this dietary element. Two year studies were conducted to investigate the Se concentration in grains of different wheat (*T. aestivum* L., *T. turgidum* L. and *T. durum* L.) and barley (*H. spontaneum* L. and *H. vulgare* L.) species originated from different parts of the world. Results indicated that the durum and emmer wheat grains contain higher Se level in both studied years (70.5 and 72.9µg kg^{-1} in 2012 and 74.1 and 73.2 µg kg^{-1} in 2013 respectively). Among *H. spontaneum* L. collected from six populations, Mahola population of barley showed remarkable variations in grain Se concentration ranged from 88.3-437.2 and 90.2-439.5µg kg^{-1} in 2012 and 2013 respectively. The information obtained from the findings helps in identifying the lines of wild barley that have more Se uptake and accumulation capability. According to the conclusion of the study that *H. Spontaneum* L. had greater genetic variation for Se as compare to other species of wheat and barley.

Key words: Wheat and barley species, Selenium avaialability, Genetic variation.

Introduction

Selenium (Se) is an essentialcomponent needed for human being's growth and all human beings gets Se through from fruit, vegetable, fish, meat and cereals (Zafar *et al.,* 2008). According to the surveys and different reports;Se consumption by human has been decreased as before (Welch & Graham, 2002; Graham *et al.,* 2007), due to growing high grain yield crops to feed hunger world rather than to focus on nutritional value (Welch & Graham, 2002; Morris & Sands, 2006; Garvin *et al*., 2006; Oury *et al*., 2006). Due to less consumption of Se by human beings; nearly3 million people of the world, (specially the areas where the soil is deficient in selenium) are suffering from Se deficient diseases: week immunity and thyroid functions, male infertility, viral infections, asthma and inflammatory diseases, occurrence of cancer and Keshan in young women and children, cardiovascular disorders (Tamas *et al*., 2010).

The main reason behind is selenium deficiency and low availablity in human diet, mostly people get their nourishment from wheat and barley products (Anon., 2001;Graham *et al*., 2001). The availability of Selenium depends on genetic back ground of the cultivar and on availability of Selenium in soil, where these grown (Anonymous, 2001; Bugel *et al*., 2002; Rayman, 2002; Lyons *et al*., 2003; Cakmak, 2008). To meet the requirements of human for proper diet, the two reliable practices are commonly applicable to increase Selenium concentration in wheat and barley such as breeding of efficient cultivar and encirhment of selenium fertilization. Breeding of cereal with increased selenium concentration requires knowledge of the variation among the available germplasm. Several studiesshowing the existence of influential variation of micronutrient concentration in grains of barley and wheat (Nevo, 2004; Liu *et al*., 2006; Morgounov *et al*., 2007). Cakmak *et al*., 1999a; Bakht *et al*., 2015a find out that ancient wheat provided a considerable genetic resource for increasing Se, Fe, Zn and Starch efficiency as compared to modern wheat cultivars. This statement was also supported by Seregina *et al*. (2001) that commercial wheat cultivars may vary in their ability to accumulate Selenium. Furthermore research is required in this orientationto determine whether sufficient genetic variation in grain Se density in wheat or barley species exists to enable the selection of this trait for plant breeding purposes. Exploiting the genetic variation in crop plants for micronutrient density is likely to be an effective method to improve the nutrition of entire populations.

The another practice to increase Se concentration in human diet is to increase Se availability in soils, which depends on different factors like: soil pH, redox potential, calcium carbonate level, cation exchange capacity, organic carbon, iron (Fe) and aluminium (Al) levels by application of fertilizers (Graham *et al*., 2007; Cakmak, 2008; Muhammad & Faisal, 2014). However, it tends to be expensive and require ongoing inputs. Furthermoreit often fails to reach the target (Welch & Graham, 2004; Uauy *et al*., 2006; Nestel *et al*., 2006; Zhao *et al*., 2009; Lyons, 2010).

The prime objective of this study was to evaluate the selenium content in two major cereal crops.In this study a survey was conducted to analyze variation of Se concentration in grain of wheat and barley linesand select high Se containing genotype as a donor parents for the breeding of Seleniumfortified wheat and barley cultivars. Another objective was to find out the correlation between micronutrient concentrations and other agronomic observation related grain quality traits.

Materials and Methods

Seed accession and experimental site: A field experiments were organized during 2011-2012 and 2012-2013 at the experimental site of Northwest A&F University, Shaanxi Province, northwestern China at latitude of 34°20'N, longitude of 108°04'E and elevation of 466.7m above sea level. The soil in the top 1.2 m wasEum-

Orthrosols (Chinese soil Taxonomy) soil. The soil was moderately deep and well drains with loamy sand to sandy clay loam texture. The area was uniform in terms of fertility with approximately pH 8.5. Experimental area has a temperate climate with hot, humid summers, cold, dry winters, and dry springs and autumns. Most of the annual precipitation is delivered from July to late October. To evaluate Se content in wheat and barley accession, 99 wheat species (50 *T. aestivum* L., 38 *T. turgidum* L. and 11 *T. durum* L.) and 78barley accession (60 *H. spontaneum* L. and 18 *H. vulgare* L.)were collected from ICARDA, Israel, Jordan and different location of world including China.

Crop cultivation and fertilization: In the month ofNovember, seed of barley and wheat were sown in different rows of 10 meter lengths by hand drilling after conventional tillage operation. The experiments were planted in normal recommended sowing dates with normal seeding rate. Field management and timing of management practices including fertilization were generally followed by local commercial production practices. Field was irrigated equally with flooding irrigation system under managed system of irrigation and equally look after was done for weed management and disease control.

Plant sampling and analysis: In the month of May five fully mature spikes were randomly selected from each cultivar as a plant sample for analyse, at the harvesting stage. The samples were harvested and cleaned manually to avoid any contamination of mineral element concentration. These all samples were labeled properly, putted into paper envelopes and shipped to laboratory. Samples were air dried threshed and grain was oven dried at 72°C for 24 hours to remove extra moisture content from the grain of barley and wheat.

Flour sample preparation and selenium determination methods: Grain sample were processed after grinding by using Tekpa Laboratory milling system JFS-13A (with sieve 0.5 mm). The mill was cleaned between samples. About (200 mg) were used to analyse Se nutrient by digesting samples in high purity HNO_3 for 10 hours following a modified protocol by Zhu *et al.* (2008). The grain Se concentration was determined by using Atomic Fluorescence Spectrometer AFS-390 (Beijing Titan Instrumentals Co. Ltd, China).

Soil sampling and analysis: After crop harvest, soil samples were collected randomly at the depths of 0-15 and 15-30 cm from experimental site with stainless steel auger. Collected soil samples sealed in plastic sampling bags and shipped to laboratory. Soil samples were air dried at room temperature for six days to remove ambient moisture. A small proportion of soil sample was sieved from <2 mm sieve oven dried at 105°C for 12h and further ground and sieved from (0.15 mm) sieve for chemical analysis.

Statistical analysis: Mean date was processed in statistical software (SAS Institute 2005). The compression between population mean followed by student t-test at (<0.05%). Correlation coefficient studies were conducted to assess the association among Se and various plant traits. Analysis of variance was employed to test the genetic diversity between and within populations, using a nested block design model, with population and accession. Principal component analysis (PCA) was used to determine the associations among the Se concentrations and field traits. PCA was based on a correlation matrix and was presented as biplot ordinations of populations (PC scores). Two components were extracted using Eigenvalues1 to ensure meaningful implementation of the data by each factor.

Results

This study was carried out to check grain Se concentration in cereal species (bread, durum, emmer wheat, wild barley and barley cultivars), such type of survey has provided the range and commonly occurring concentrations of grain Se. In this study, a wide range with high grain Se concentration was found in wheat and barley species. The availability of Se among tested cereals is to enclose both deficient and sufficient levels.

Chemical properties of soil: The general chemical characteristics of soil are shown in Table 1. The table includes nutrient related properties etc.

Genetic diversity of Se and its availability in barley: Results indicate a grater variability in selenium content in sixty genotypes of six populations of barley (*H. spontaneum* L.)in both (2012 and 2013) studied years (Table 2). Se concentration in *H.spontaneum* during 2012 was ranged from 6.5-437.2 µg kg^{-1}, with average value of 146.2 µg kg^{-1} while during 2013 it was increased from 7.8 to 439.5 µg kg^{-1} with increased average 146.9 µg kg^{-1} as compared to first year study. 'Mahola-22-24' (originated from Mahola population, Israel) was with highest grain selenium concentration, while 'Iribid sal Hs 5' (Jordan) had the lowest selenium concentration (Table 5) in both studied years.

The mean value of grain selenium concentration in each population was almost same in studied years; it varied from 48.2-266.8µg kg^{-1}. Mean Grain selenium concentration of the TBBS population, was highest among all six populations with 266.8µg kg^{-1} and followed by Maholla population in 2012 and 2013 experiments, both populations are originated from Israel. While Irbid population from Jordan possessed the lowest mean grain selenium concentration (48.2 and 49.4µg kg^{-1}) in 2012 and 2013 respectively. Mean squares from one-way ANOVA showed highly significant differences in grain selenium concentration among six populations at p<0.001 level for both experiments Table 2 (Fig. 1). The population C.V showed large difference among all populations ranging from 36-54% in first experiment while 40-55% in second experiment. Same variation ratio was also found between and within population Table 3.

The range for grain selenium concentration of eighteen *H.vulgare* was same in both studied years (from 68.9-387.2µg kg^{-1}). *H.vulgare*, 'Colter' from America had lowest, while as 'Chapinis' from Canada had the highest selenium concentration 387.2µg kg^{-1},followed by 'Noga' (Norway) and 'Clipper' (Australia) Table 4. The CV for the eighteen *H. vulgar* was 50-57.1% for both conducted experiments (Table 2). The CV for eighteen *H.vulgare* was also lower as compared to *H. spontaneum* population. As expected, the *H.vulgare* contains a narrow grain selenium concentration range with less diversity than *H. spontaneum*.

Se availability in wheat: The maximum range and mean average for grain selenium concentration was noticed in thirty eight *T. turgidum* (ICARDA and Israel) for both studied year followed by *T. durum* while *T. aestivum* was with minimum range of Se. Overall, three species of wheat performed same in both experiments conducted during 2012 and 2013 Table 2 (Fig. 3). The maximum 256.9µg kg^{-1}grain selenium concentration among all 99 accessions of three species of wheat was observed in *T. turgidum* 'Nahef 32-25-19' originated from northern part of Israel while *T. durum* 'Golden Ball' from South Africa was with lowest 2.0µg kg^{-1}grain selenium concentration among three species of wheat Table 2 (Fig. 3).

Comparison between wheat and barley species for Grain Se concentration: One-way ANOVA of two years study indicated highly significant difference in grain selenium concentration for *T. turgidum*, *T. durum* ($p<0.001$) there was no any significant difference observed for Se concentration in *T. aestivum* Table 2 (Fig. 1). Surveys included diverse wheat germplasm as well as other cereals found grain Se concentrations in the range 5-720 µg kg^{-1}. *T. aestivum*, *T. turgidum*,*T. durum* wheat tested in this study, *T. turgidum* had significantly higher grain Se concentrations than other wheat, but no significant genetic variability was detected among commercial *T. aestivum* varieties (Fig. 1).

Associations among grain nutrients and productivity traits of wheat and barley: No any significant correlation was found in 2012 experiment for grain selenium concentration with morphological traits viz., number of spiklets $spike^{-1}$, awn length (cm), pendicule length (cm), flag length (cm) and tillers $plant^{-1}$ exceptspike length (cm) Table 4, while a negative correlation was observed between Se concentration and plant characters like: plant height, awn length and flag width among *T. aestivum*, *T. turgidum*, *T. durum* and *H. vulgare* (Table 4). In the second year experiment (2013) plant traits like: plant height, pendicule length and tillers $plant^{-1}$ were significant at $p<0.01$ level for Se concentration, while as awn length and flag width were negatively correlated with Se concentration (Table 4).

Principal component-1 (PC1, X-axis, Fig. 2) explained 27.9% of the data set variation, and was loaded positively with plant height, spike length, number of spikelet $spike^{-1}$, penducile length, tillers plant in Karak faqo, Mahola and Giloba populations. PC2 (Y-axis, Fig. 2) explained 16.9% of the dataset variation and was positively loaded by Se, spike length, awn length and flag width TBBS, Giloba, Mahola, Karak faqo and Karak Mmth, populations. A closer look at the PCA (Fig. 2) shows strong associations between the components representing productivity.

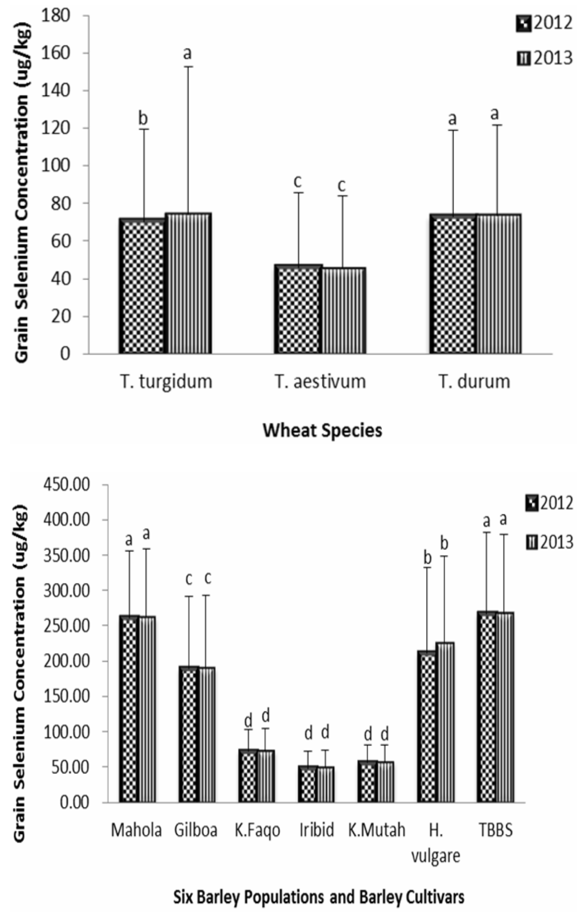

Fig. 1. Comparison of Grain Se concentration (µg kg^{-1}) in six *H. spontaneum* populations and*H vulgare*(right) and between three different wheat populations (left) for two years. Different letters above bars indicate significant differences at p<0. 05 level by TukeyKramer HSD test. Symbols and bars represent he mean±SD (n = 3).

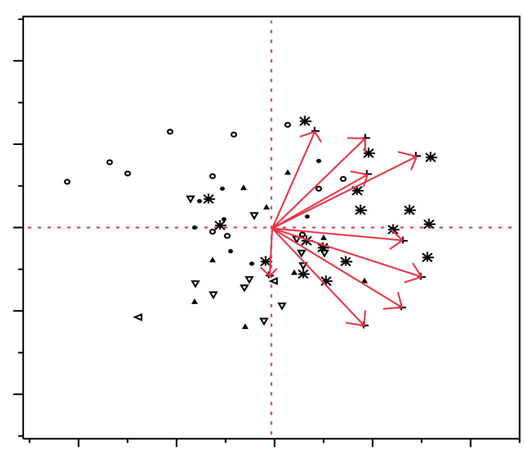

Fig. 2. Principle Components analysis (based on correlation matrix) of continuous plant traits recorded on 6 *H. Spontaneum*populations. Biplot vectors are trait factor loadings for principle component 1(PC1) and PC2. (o=TBBS, ▲=Giloba, *=Mahola, Δ=KArak Faqo, ●=Karak Muth and▼ =Irbid).

Table 2. Grain Se content (µg kg⁻¹) of six *H. spontaneum* Populations, eighteen *H. vulgare*, fifty *T. aestivum*, thirty eight *T. turgidum*, and *T. durum* during 2012 and 2013.

Populations/Species	# Samples	Se content (µg kg^{-1})		Range (µg kg^{-1})		CV%		ANOVA			
								F value	P value	F value	P value
		2012	2013	2012	2013	2012	2013	2012		2013	
Mt.Giloba	12	189.0±102.9	190.4±103.3	69.5-383.6	62.2-389.9	54.5	50.9				
Mahola	10	260.6± 95.7	262.2±96.3	88.3-437.2	90.2-439.5	36.8	40.6				
TBBS	08	266.8±115.8	266.9±112.3	62.2-415.9	68.3-412.5	43.2	44.2				
Karak Faqo	09	72.7±30.4	72.9±31.3	25.6-123.0	23.0-124.5	41.8	50.1	15.2	***	10.4	***
Karak 2 Muth	11	56.9±24.0	56.8±24.0	12.1-99.1	15.7-96.9	42.2	44.8				
Iribid sal	10	48.2±24.4	49.4±24.2	6.5-90.02	7.8-92.2	50.6	55.6				
Sum of *H. spontaneum*	60	146.2±117.3	146.9±116.4	6.5-437.2	7.8-439.5	80.1	76.7				
H. vulgare	18	211.4±121.5	225.6±123.3	68.9-387.2	68.6-386.2	57.1	50.1	15.1	***	16.6	***
T. aestivum	50	45.1±39.6	45.2±39.1	8.6-164.02	8.83-167.6	87.2	70.2	41.5	NS	55.6	NS
T. turgidum	38	70.54±48.8	74.12±78.5	22.7-256.9	27.9-286.0	69.2	65.4	3.4	***	11.2	***
T. durum	11	72.9±46.3	73.2±48.3	2.0-144.7	2.0-148.0	64.1	64.2	3.0	***	5.7	***

** = p<0.01 levels, *** = p<0.001 levels, NS = Non significant

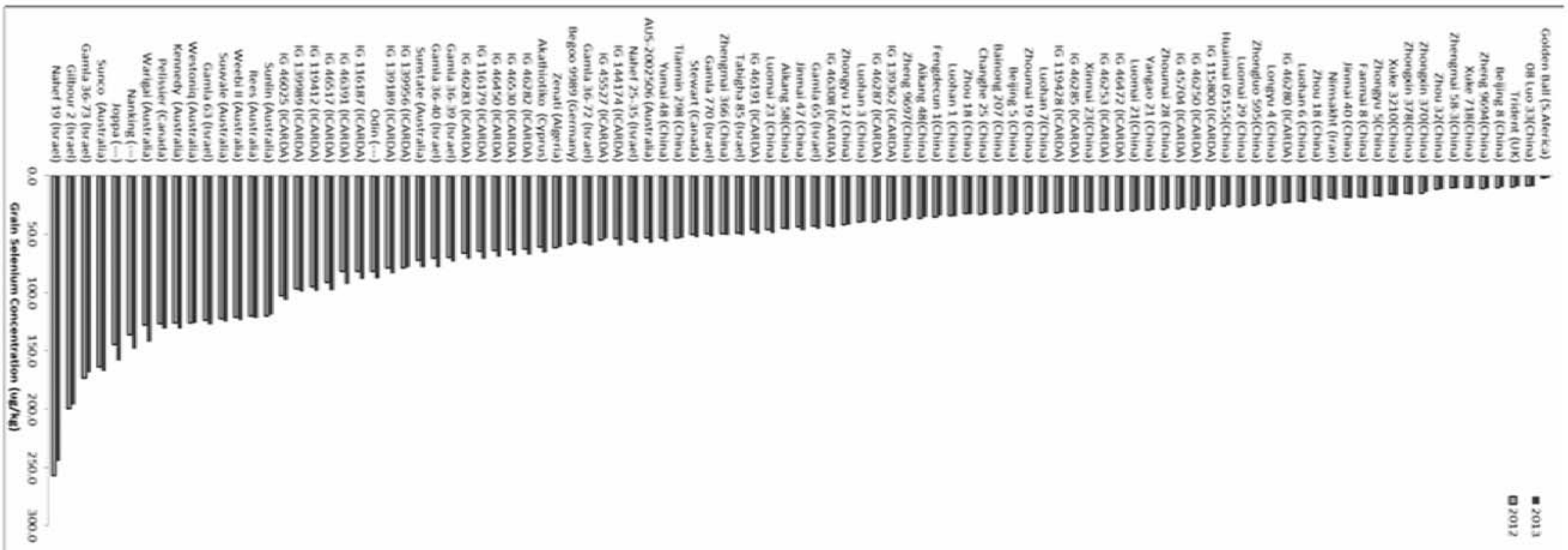

Fig. 3. Grain Se concentration (µg kg⁻¹) for fifty *T. aestivum*, thirty eight *T. turgidum* and eleven *T. durum*, values are means of three replicates during 2012 and 2013.

Table 1. Soil properties and nutrient content of field.

Location	Depth	Cu mg kg^{-1}	Fe mg kg^{-1}	Zn mg kg^{-1}	Mn mg kg^{-1}	P mg kg^{-1}	K mg kg^{-1}	OM g kg^{-1}	pH	ECe us m^{-1}
NWA & F University	0-15	3.41	16.60	4.06	59.41	21.77	146.76	6.08	8.83	124.55
	15-30	3.48	14.97	4.69	46.81	19.63	150.33	7.46	8.67	167.00

Cu = Copper (mg kg^{-1}); Fe = Iron (mg kg^{-1}); Zn = Zinc (mg kg^{-1}); Mn = Manganese (mg kg^{-1}); K = Potassium (mg kg^{-1}); P = Phosphorus (mg kg^{-1}); Organic matter (g kg^{-1}); pH; EC = Electrical conductivity (us m^{-1}), NWA & F = North West Agriculture and Forestry

Table 3. Genetic variationbetween and within six *H. spontaneum* populations for grain Se content (µg kg^{-1})during 2012 and 2013.

Populations	Se variation between population				Se Variation within populations	
	2012		2013		ANOVA	
	Mean	ANOVA	Mean	ANOVA	2012	2013
Mt Giloba	189.0b	14.7***	190.4b	15.1***	6.5***	5.9***
Mahola	260.6a		262.2a		6.5***	5.9***
TBBS	266.8a		266.9a		3.5*	4.8*
Karak Faqo	72.7c		72.9c		4.0*	4.0*
Karak 2 Muth	56.9c		56.8c		7.3***	7.0***
Iribid	48.2c		49.4c		8.5**	8.5**

* = p<0.05 levels, ** = p<0.01 levels, *** = p<0.001 levels

Table 4. Coefficient of correlation (r) between grain Se concentration (µg kg^{-1}) and plant characters.

Traits	Se	PH	SL	NS	AL	PL	FL	FW	Tillers
Se	1								
	1								
PH	-0.089	1							
	0.274**	1							
SL	0.267*	0.315*	1						
	0.046	0.160	1						
NS	0.187	0.343**	0.515**	1					
	0.462**	0.532**	0.246*	1					
AL	-0.359**	-0.272*	-0.393**	-0.375**	1				
	-0.355**	-0.428**	-0.186	-0.577**	1				
PL	0.228	0.665**	0.397**	0.480**	-0.590**	1			
	0.507**	0.681**	0.228*	0.791**	-0.700**	1			
FL	0.117	0.104	0.417**	0.290*	-0.088	0.257*	1		
	-0.269**	-0.324**	-0.127	-0.447**	0.522**	-0.439**	1		
FW	-0.320*	-0.260*	-0.184	-0.323*	0.734**	-0.441**	0.197	1	
	-0.399**	-0.478**	-0.185	-0.665**	0.775**	-0.713**	0.688**	1	
Tillers	0.411	0.385**	0.609**	0.548**	-0.649**	0.478**	0.277*	-0.473**	1
	0.341**	0.374**	0.196	0.700**	-0.449**	0.600**	-0.222*	-0.438**	1

PH = Plant height (cm), SL = Spike length (cm), NS = No. of spiklets $spike^{-1}$, AL = Awn length (cm), PL = Pendicule length (cm), FL = Flag length (cm), FW = Flag width (cm) and Tillers = Tillers $plant^{-1}$ in wheat speciesduring 2012 and 2013
The upper and lower numbers refer to the 2012 and 2013 experiments, respectively
Asterisks indicate significance at * = p<0.05, ** = p<0.01 and *** = p<0.001, * = p<0.05 level (2-tailed)

Discussions

In this study, *T. aestivum* L., *T. turgidum* L., *T. durum* L., *H. spontaneum* L., *H. vulgare* L. accessions from different regions of the world including China were used to find out cultivar containing maximum level of Se for food source of human according to the criteria of (Anon., 2001) to fulfill the necessities of Se. Garvin *et al*. (2006), Hawkesford & Zhao (2007), Sarwar *et al.* (2009) and Kafeel *et al.* (2009) reports that the Se concentration of plant is related with Se availability in soil, which is influenced by different factors like: level of extractable Se, the chemical properties of Se, pH, iron oxides and sulphate concentration. In different reports, in cereal germplasm Se ranged from 5-720 µg kg^{-1}, it was mostly due to available soil Se level.

Our results indicate great variability for selenium content in wheat and barley species for both years, Which are support the conclusion of Lyons *et al*. (2005) that genotypic differences may exist in modem wheat varieties; they are likely to be small in comparison with background soil variation in Se availability. Among sixty genotypes of *H. spontaneum* from six populations, three *H. spontaneum* (one from Mahola and two from TBBS population) were higher in grain Se concentration than that of the highest cultivar

'Chapinis' from Canada Table 5, this phenomena was supported by Jun*et al*., 2011. Reilly 2006 and Bakht *et al*., 2015b; reported that availability of Se content in the source of cereal foods can be vary, not only country to country but also region to region within a country and also cultivar to cultivar.Our findings indicated large differences between and within populations Table 3 (Fig. 2). On the other hand mean Se grain concentration compared with each other TBBS population of *H. spontaneum* contain higher amount of grain selenium concentration as compare of *T. aestivum, H.vulgare, T. turgidum*and*T. durum* (Fig. 1). None of the population was that were considered to be genetically high in grain Se as high as TBBS population. Three species of wheat performed same in both experiments conducted during 2012 and 2013 Table 2 (Fig. 3). *T. turgidum* was from ICARDA and Israel with maximum range and mean average for grain selenium concentration for both studied year followed by *T. durum* . Grain Se concentration of wheat grown in Mexico was mostly in the range 30–200 µg kg^{-1}, while South Australian-grown wheat was commonly in the range 70–280 µg kg^{-1}(Lyons *et al*., 2005) which is higher than that of most wheat-growing countries, but lower than North America. The wheat grain Se concentrations found in the current South Australian survey are generally higher than those of New Zealand, China, UK and Europe, but lower than those of Canada and the USA (Adams *et al*., 2002; Lyons *et al*., 2003). PCA of the 60 *H.spontaneum* accessions extracted two major principal components (Eigenvalues >1) that accounted collectively for 44.8 of the variance for the grain selenium concentration (Fig. 3). These results were supported by (Garvin *et al*., 2006; Oury *et al*., 2006; Morgounov *et al*., 2007; McDonald *et al*., 2008).

Table 5. Grain Se concentration (µg kg^{-1}) for sixty *H.spontaneum*, eighteen *H. vulgare*, values are means of three replicates during 2012 and 2013.

Accessions	Origin	Grain Se content		Accessions	Origin	Grain Se content	
		2012	2013			2012	2013
				Wild barley			
Gilboa-3-3	Israel	226.3	230.0	Faqo-3	Jordan	64.3	67.1
Gilboa-3-4	Israel	287.5	281.8	Faqo-8	Jordan	123.0	124.5
Gilboa-3-9	Israel	220.0	216.5	Faqo-13	Jordan	45.8	46.3
Gilboa-3-12	Israel	136.7	137.4	Faqo-18	Jordan	61.3	59.3
Gilboa-3-13	Israel	383.6	389.9	Faqo-23	Jordan	70.2	72.9
Gilboa-3-19	Israel	329.5	330.3	Faqo-30	Jordan	79.1	79.5
Gilboa-3-22	Israel	181.1	185.9	Faqo-33	Jordan	71.8	69.0
Gilboa-3-25	Israel	73.5	62.2	Faqo-36	Jordan	113.8	114.
Gilboa-3-26	Israel	125.1	126.3	Faqo-38	Jordan	25.7	323.0
Gilboa-3-27	Israel	151.6	157.5	K. Mutah-4	Jordan	12.1	15.7
Gilboa-3-34	Israel	83.6	89.9	Mutah-7	Jordan	46.9	41.2
Gilboa-3-37	Israel	69.5	76.7	Mutah-8	Jordan	53.2	60.2
Mahola-22-5	Israel	360.0	363.6	Mutah-9	Jordan	55.2	59.0
Mahola-22-15	Israel	250.2	249.4	Mutah-10	Jordan	74.6	71.8
Mahola-22-16	Israel	269.1	271.1	Mutah-12	Jordan	82.2	83.7
Mahola-22-18	Israel	246.6	253.5	Mutah-13	Jordan	71.9	75.6
Mahola-22-20	Israel	178.7	175.1	Mutah-14	Jordan	49.7	42.1
Mahola-22-22	Israel	261.8	251.6	Mutah-22	Jordan	99.8	96.9
Mahola-22-23	Israel	211.0	218.5	Mutah- 24	Jordan	36.0	33.1
Mahola-22-24	Israel	437.2	439.5	Mutah- 27	Jordan	44.4	45.2
Mahola-22-25	Israel	302.6	310.0	Iribid-1	Jordan	40.0	44.6
Mahola-22-28	Israel	88.32	90.2	Iribid-4	Jordan	90.0	92.2
TBBS-54	Israel	255.1	259.1	Iribid-5	Jordan	6.5	7.8
TBBS-55	Israel	181.9	186.6	Iribid-10	Jordan	67.5	69.7
TBBS-56	Israel	301.6	308.6	Iribid-18	Jordan	30.3	31.8
TBBS-57	Israel	407.4	401.8	Iribid-19	Jordan	28.6	30.9
TBBS-65	Israel	239.9	231.4	Iribid-21	Jordan	59.6	60.3
TBBS-73	Israel	270.3	267.2	Iribid-23	Jordan	41.2	39.9
TBBS-74	Israel	416.0	412.5	Iribid-25	Jordan	47.2	46.5
TBBS-75	Israel	62.2	68.3	Iribid-29	Jordan	72.3	70.0
				Barley cultivars			
Harringlon	Canada	76.0	80.7	B.Kapoter	-------	352.6	354.8
Schooners	Australia	186.2	182.4	Kinorri-309	--------	175.3	180.8
Stirling	Australia	360.6	363.8	Gairdner	Australia	332.1	332.2
Chopais	Canada	119.7	115.7	Clipper	Australia	371.4	375.8
Colter	USA	68.9	68.6	Grimnett	Australia	85.8	90.2
Khrahya	-------	117.8	118.6	Ta pgolbori	-------	77.0	79.4
Palls	Sweden	325.7	327.8	Prior	Europe	348.9	344.7
Atahulpa	ICARDA	156.4	155.3	Chapinis	Canada	387.2	386.2
Euerkki	Canada	121.0	119.6	Noga	Norway	385.0	383.2

Conclusion

It is concluded from our findings that the large number of lines from different populations of barley and wheat accessions have been identified which possesses high grain Se concentration. The material selected on the basis of higher Se concentration will be further evaluated in future breeding programs (Nevo & Chen, 2010). The considerable biodiversity among these genotypes could be the result of genetic background or adaptations to local environmental conditions in microhabitat and ecological factors like: intensity of rainfall, temperature, humidity, soil type and depth, soil slope and its direction, composition of soil, soil reactions, and other factors (Jun *et al*., 2011; Gutterman, 2002).

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