Scientia Horticulturae 218 (2017) 87–94

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Spraying foliar selenium fertilizer on quality of table grape (*Vitis vinifera* L.) from different source varieties

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ARTICLE INFO

Article history:
Received 10 November 2016
Received in revised form 7 February 2017
Accepted 10 February 2017

Keywords:
Selenium fertilizer
Grape source
Fruit quality
Table grape
Heavy metals

ABSTRACT

Table grape is a fruit well suited for consumption as fresh-cut product. Selenium (Se) is an essential mineral nutrient for human growth, and Se-deficiency is a worldwide nutrition problem. Meanwhile, with Se-enriched fruits is becoming more and more popularity, improving Se content and fruit quality in grape is especially important for human health. Se content of grape berries was increased by Se fertilizer application, the maximum Se content and raise ratio of European and American species was 34.96 ug kg^{-1} FW and 36.88% respectively, higher than those of Eurasian species 19.46 ug kg^{-1} FW and 21.40%. In addition, Se fertilizer increased nutrition quality, including soluble sugar, Vc, soluble protein, soluble solid, reduced organic acid, while it had no effect on polyphenol antioxidants of Eurasian species. K and Ca content of grape berries was significantly increased, and reduced accumulation of heavy metals Pb, Cr, Cd, As, Ni. Se in fruits was positively related to fruit quality, and negatively correlation of heavy metals. In conclusion, Se fertilizer can be used to increase Se content of grape, especially for European and American species, with significant effect of increasing grape nutrition quality and an effective means of lowering heavy metals.

1. Introduction

Table grape is a fruit well suited for consumption as fresh-cut product because of their high quality, attractiveness and numerous nutritional facts. It contains soluble sugar, soluble protein, vitamins, organic acid, resveratrol and procyanidins that possess anti-carcinogenic properties (Dai et al., 2010; Shinomiya et al., 2015). But grape quality depends on many factors including vineyard treatments, cultivar and harvest time et al. (Rizzuti et al., 2015; Segade et al., 2013). With potential market value of different grape variety is gradually discovered, exploring grape quality and special medicine effect has important theoretical and practical significance for table grape cultivation in future.

Se is an essential trace elements in human nutrition that has been implicated in reducing the risk of cancer (Kiskova et al., 2014), scavenging free radicals (Bors and Saran, 1987), resisting to membrane lipid peroxidation, preventing aging (Rice-Evans, 2001), enhancing the immune function in men (Keskinen et al., 2009). But approximately two-thirds of the cultivated soil is Se-deficient in China, and Se deficiency is still a very serious nutritional and health problem (Zhang et al., 2014). So developing the function of Se-enriched agricultural and fruit is very important.

As people demand for high quality grape and deeper understanding of Se on human nutrition, researchers have developed several methods to improve fruit quality, such as agronomical practices (irrigation, fertilization, pruning etc.) (Delgado et al., 2004; Hera et al., 2007) and foliar spray nutrient (Vashistha et al., 2010). Se fertilizer was also beginning to apply in all kinds of fruits, vegetables and crops (Hlušek et al., 2005; Hu et al., 2003). Researchers have found that foliar Se fertilizer application can improve photosynthesis in pear, grape and peach (Feng et al., 2015). Selenate-enriched urea was a highly effective fertilizer for Se biofortification of rice (Premarathna et al., 2012). Researches have studied the method of Se fertilizer application (selenium seed coating, "selcote" commercial granular fertilizer, and foliar spray of sodium selenate solution) (Grant et al., 2007), the effect of application rate and number on crop quality and Se concentration (Tremblay et al., 2015; Zhang et al., 2014). Meanwhile, some researches began focusing on the use of Se fertilizer on grape in China, including the effect of Se fertilizer on fruit quality and leaf physiological indexes (Zheng et al., 2013), grape for exogenous Se absorption, distribution and transport characteristics, fruit quality and photosynthetic characteristics

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http://dx.doi.org/10.1016/j.scienta.2017.02.025
0304-4238/

under Se fertilizer treatments and water stress condition (Zhao et al., 2011). But most of those studies selected sodium selenite (Na_2SeO_3) and sodium selenate (Na_2SeO_4) as the main forms of Se fertilizer. In addition, study of spraying Se fertilizer on fruit quality of different source varieties had not been reported in detail. Foliar spray was also found to be a safe, effective, convenient and low-cost means to increase the Se content of rice (Hu et al., 2002). Thus, our study adopt the organic amino acid-chelated Se-enriched foliar fertilizer as a source of Se fertilizer. In addition, the previous studies have primarily demonstrated that the application of Se fertilizer would increase Se content of grape, but little focused on nutritional quality changes of different source varieties under Se fertilizer treatments, meanwhile, an alternative means to facilitate production of Se-enriched grape might be to select varieties.

Above all, this research pursued three main aims. Firstly, the nutritional quality changes of table grape from different source varieties under Se fertilizer treatments. Secondly, effects of Se fertilizer application on the content of nutritional elements Se, K and Ca as well as heavy metals of grape berries from different source varieties. Thirdly, the correlation between the Se content of grape berries and fruit quality and heavy metals of different source varieties as affected by spraying Se fertilizer. From these results, choosing appropriate Se-enriched and high fruit quality table grape varieties.

2. Materials and methods

2.1. Experiment design

The experiments were carried out in 2014 and 2015 at an orchard (Defeng, forestry and fruit industry demonstration orchard of grapes), a traditional fruit tree culture region, located at Xianyang (34°21′N and 108°38′ E), Shaanxi province of China. The soil texture was cumulic cinnamon soil; 0–30 cm soil bulk density was 1.29 $g\,cm^{-3}$; soil water holding capacity was 240 $g\,kg^{-1}$ (mass basis); organic matter content was 9.80 $g\,kg^{-1}$; total N content was 0.56 $g\,kg^{-1}$; total P content was 0.72 $g\,kg^{-1}$; available N (1 $mol\,L^{-1}$ NaOH hydrolysis) was 9.63 $mg\,kg^{-1}$; available P (0.5 $mol\,L^{-1}$ $NaHCO_3$) was 26.93 $mg\,kg^{-1}$; available K (1 $mol\,L^{-1}$ neutral NH_4OAc) was 162.37 $mg\,kg^{-1}$; selenium content (flame atomic absorption method) was 68 $ug\,kg^{-1}$.

There were four cultivars of grape, including two Eurasian species grape Crimson Seedless (the California state Davies agricultural fruit tree genetics and breeding research) and Red Barbara (Japan), two European and America species grape Summer Black(Yamanashi orchards proving ground of Japan) and Hutai No.8 (Xi'an institute of grapes). Each cultivar had two treatments, conventional practice (CK, pure water) and Se fertilizer treatment (S, amino acid-chelated Se-enriched foliar fertilizer, contains Se, Ti and a variety of chelating trace elements, $Cu + Fe + Mn + Zn + B \geq 100\,g\,L^{-1}$, organic $Se \geq 60\,g\,L^{-1}$, and it was provided by Shaanxi Yangling Macao bond biological science Co., LTD.). Spraying Se fertilizer that diluted 500 times on the leaf of S treatments in young fruit and fruit swelling period after 17:00–18:00, totally three times, with an interval of 10–15 days. Meanwhile, spraying pure water on CK. So all treatments included Crimson Seedless (CK1, S1), Red Barbara (CK2, S2), Summer Black (CK3, S3) and Hutai No.8 (CK4, S4). There were 32 plots in 2014 and 2015 respectively, plot size was 26.4 m long and 4.8 m wide, using a randomized block design with four replications, age of all the vines were the third year of fruit bearing time in 2014. Also the plantation was managed following the usual local procedures. On average, three supplementary irrigation in germination, fruit swelling, berries coloring period respectively with drip irrigation system, according to 90% of field capacity to fill up, when soil water content under 60% of field capacity using Time Domain Reflectometry (TDR) measurement. Fertilizer was given priority to organic fertilizer.

2.2. Measurement methods of grape sample

At maturity, samples of Crimson Seedless were collected on 26 October 2014 and 19 October 2015, samples of Red Barbara were collected on 12 August 2014 and 16 August 2015, samples of Summer Black were collected on 20 July 2014 and 28 July 2015, samples of Hutai No.8 were collected on 15 August 2014 and 22 August 2015. Twenty clusters fruits were gathered randomly in the same position of each treatment to avoid fruit position effect, and 10 fruits were selected randomly in the middle of each cluster. Rinsed with distilled water three times and dry out surface water at normal temperature, then pressed into homogenate by a juicer and put in glass bottle in 4 °C refrigerator to prep using.

All reagents used were of analytically pure reagents, and deionized water was used for all chemical preparations and dilutions. Soluble solid concentration (°Brix) was determined using an ATAGO PR-101 digital refractometer (Bron and Jacomino, 2006) .Molybdenum blue colorimetric method was used to determine the content of vitamin C (Vc). The content of soluble protein was measured by ultraviolet spectrophotometry. Soluble sugar content was determined by phenol-sulfuric acid method. NaOH titration method was used to determine the content of organic acid. Procyanidins content was measured with molysite catalytic colorimetry (Gao, 2006). The content of resveratrol was measured with potassium permanganate fading spectrophotometry (Delgado et al., 2004). The content of Se and heavy metals was determined by ICP-MS according to Toaldo (Toaldo et al., 2013). Potassium (K) and calcium (Ca) content was determined with flame atomic absorption method (Oliveira et al., 2010).

2.3. Statistical analysis

The date were analyzed with Statistica, version 20.0 of SPSS. Statistical significant differences ($p < 0.05$) from different treatments was revealed after one-way analysis of variance (ANOVA), and multiple comparison followed by Duncan test. Graphs were plotted using SigmaPlot 12.5.

3. Results

3.1. Nutritional quality of grape berries

The soluble sugar content of grape berries had significant difference between Eurasian species (CK1, CK2) and European and American species (CK3, CK4) besides CK2 and CK3 in 2014, and the soluble sugar of European and American species was higher than those of Eurasian species under control treatments besides CK2 in 2014 (Fig. 1). Foliar Se fertilizer application both significantly increased the soluble sugar content in either year, and the soluble sugar of European and American species was higher than those of Eurasian species under Se fertilizer treatments besides S4 in 2014 (Fig. 1).

The soluble protein content of grape berries had significant difference between Eurasian species (CK1, CK2) and European and American species (CK3, CK4), and the soluble protein of European and American species was higher than those of Eurasian species under control treatments (Fig. 2). Similar to soluble sugar content, spraying Se fertilizer significantly increased protein content besides Summer Black in 2014 and the protein content of European and American species (S3, S4) was higher than Eurasian species (S1, S2) (Fig. 2).

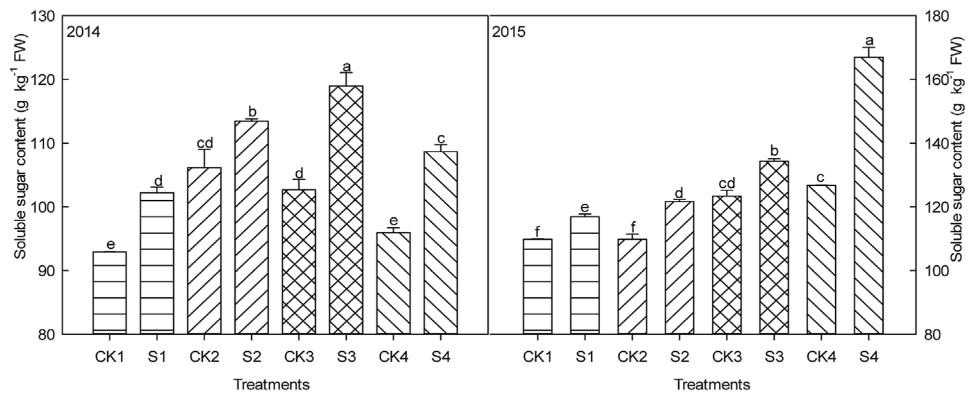

Fig. 1. Soluble sugar content of grape berries under different treatments.
Note: CK, control treatments; S, selenium fertilizer treatments. 1, Crimson Seedless; 2, Red Barbara; 3, Summer Black; 4, Hutai No.8. The same letter above pillars show no significant differences ($p > 0.05$).

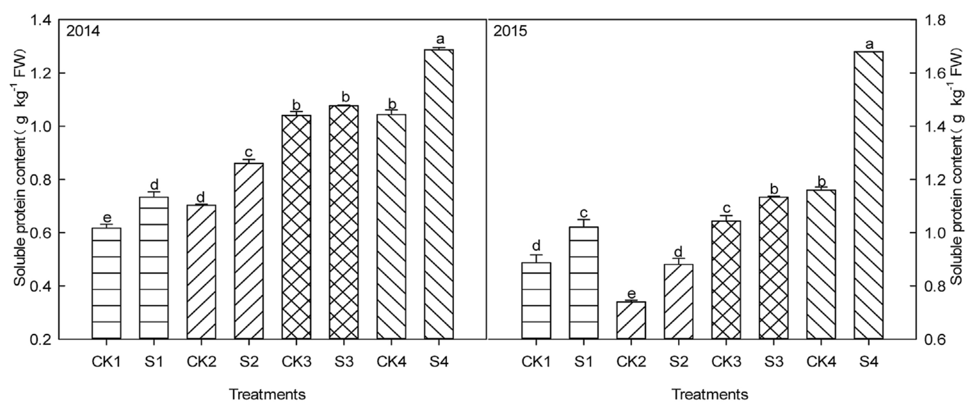

Fig. 2. Soluble protein content of grape berries under different treatments.
Note: CK, control treatments; S, selenium fertilizer treatments. 1, Crimson Seedless; 2, Red Barbara; 3, Summer Black; 4, Hutai No.8. The same letter above pillars show no significant differences ($p > 0.05$).

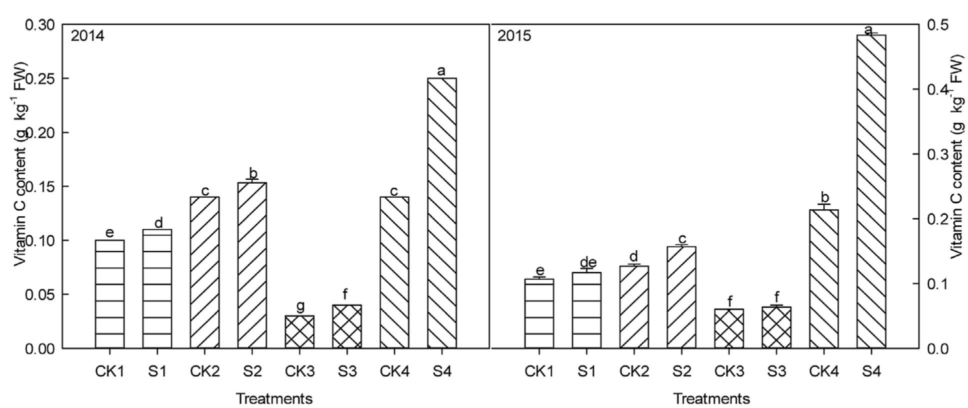

Fig. 3. Vc content of grape berries under different treatments.
Note: CK, control treatments; S, selenium fertilizer treatments. 1, Crimson Seedless; 2, Red Barbara; 3, Summer Black; 4, Hutai No.8. The same letter above pillars show no significant differences ($p > 0.05$).

Foliar Se fertilizer application increased Vc content both for Eurasian species (CK1, CK2) and European and American species (CK3, CK4), and Vc content of grape berries had significant difference between Eurasian species (S1, S2) and European and American species (S3, S4). For Crimson Seedless and Summer Black, Vc content had no significant difference between Se fertilizer treatment and control in 2015 (Fig. 3).

Spraying Se fertilizer significantly increased soluble solid content (Fig. 4), meanwhile decreased the organic acid content (Fig. 5). The soluble solid content of grape berries had significantly difference between Eurasian species (CK1, CK2) and European and American species (CK3, CK4), also soluble solid content of European and American species (CK3, CK4) was significantly higher than Eurasian species (CK1, CK2) in 2015.

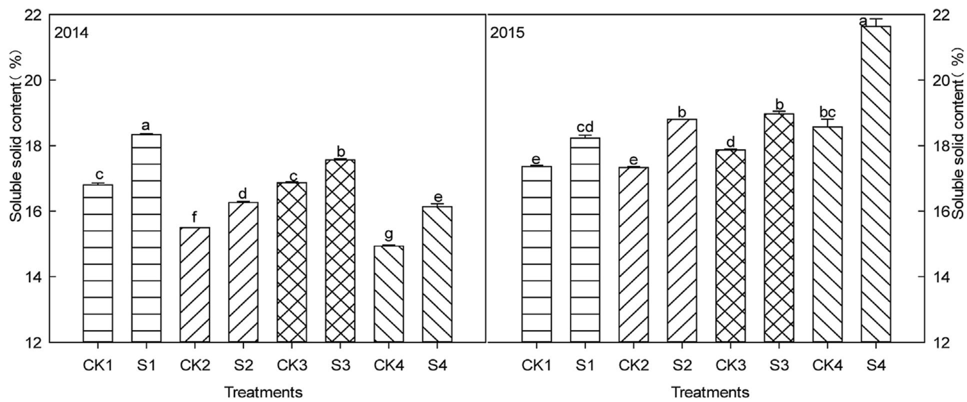

Fig. 4. Soluble solid content of grape berries under different treatments.
Note: CK, control treatments; S, selenium fertilizer treatments. 1, Crimson Seedless; 2, Red Barbara; 3, Summer Black; 4, Hutai No.8. The same letter above pillars show no significant differences (p > 0.05).

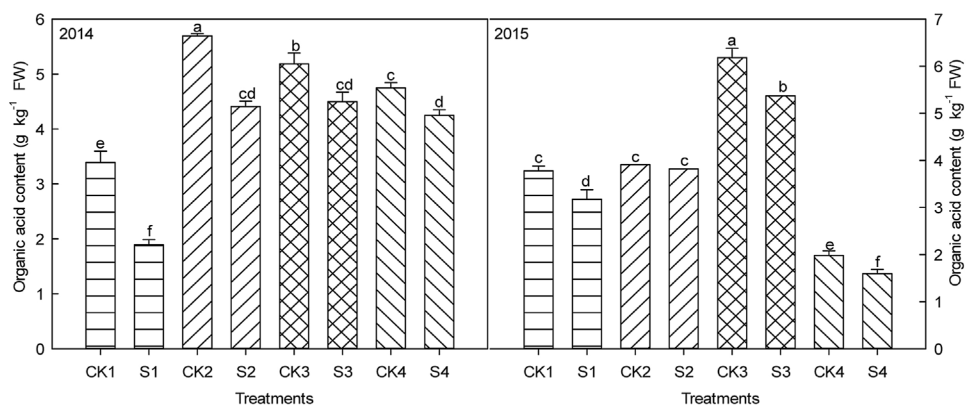

Fig. 5. Orangic acid content of grape berries under different treatments.
Note: CK, control treatments; S, selenium fertilizer treatments. 1, Crimson Seedless; 2, Red Barbara; 3, Summer Black; 4, Hutai No.8. The same letter above pillars show no significant differences (p > 0.05).

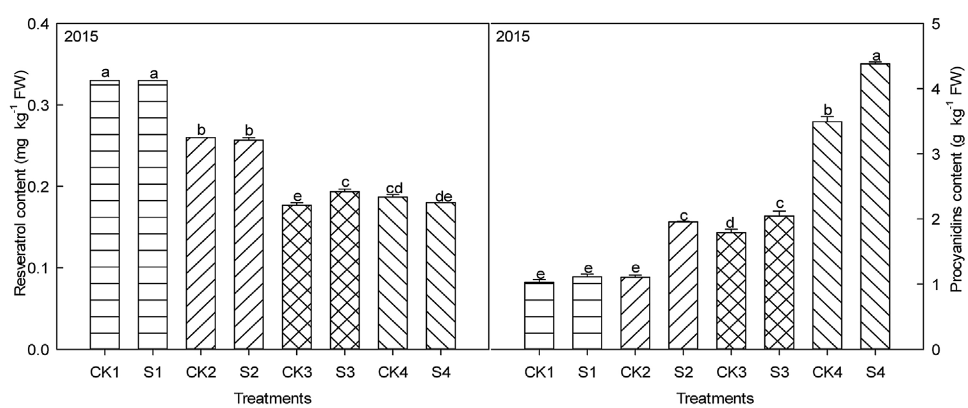

Fig. 6. Resveratrol and Procyanidins content of grape berries under different treatments.
Note: CK, control treatments; S, selenium fertilizer treatments. 1, Crimson Seedless; 2, Red Barbara; 3, Summer Black; 4, Hutai No.8. The same letter above pillars show no significant differences (p > 0.05).

3.2. Polyphenol antioxidants in grape berries

The resveratrol and procyanidins content of grape berries had significant difference between Eurasian species (CK1, CK2) and European and American species (CK3, CK4). Meanwhile, the resveratrol content of Eurasian species was significantly higher than European and American species, but the procyanidins content of Eurasian species was significantly lower than European and American species (Fig. 6). For Eurasian species, the resveratrol content had no significant difference between Se fertilizer treatments and the control treatments, besides the procyanidins content increased under Se fertilizer treatments, but CK1 and S1 had no significant difference. For European and American species, the resveratrol content had significant difference between CK3 and CK4, and spraying Se fertilizer significantly increased the resveratrol content of Summer Black, but there was no significant difference of Hutai No.8; in addition, the procyanidins content had significant difference between CK3 and CK4, spraying Se fertilizer significantly increased the procyanidins content. As a result, from the aspect of variety source, Eurasian species grape can be called a high-resveratrol grape variety, but spraying Se fertilizer cannot increase the resveratrol content of grape berries; on the contrary, European and American species was a good choice to produce table grapes that rich in procyanidins content.

3.3. Selenium content in grape berries

Se content of grape berries had significant difference between Eurasian species (CK1, CK2) and European and American species (CK3, CK4), and Se content of CK3, CK4 treatments was higher than those of CK1, CK2 (Table 1). Spraying Se fertilizer increased the Se content among all varieties, and Se content of S3, S4 was still higher than those of S1, S2. Meanwhile, the raise ratio of Se in European and American species was higher than Eurasian species. In terms of European and American species, spraying Se fertilizer significantly increased Se content, also CK3 and CK4 treatments had significant difference. Therefore, European and American species was easier to absorb and accumulate exogenous Se than Eurasian species, European and American species was preferred in Se-enriched grape production.

In terms of Eurasian species, Se content had no significant difference between CK1 and S1, but spraying Se fertilizer significantly increased the Se content of Red Barbara. In addition, the raise rate of Se in grape berries of Red Barbara was higher than Crimson Seedless. Therefore, for Eurasian species grape, Red Barbara was more conducive for grape berries to absorb and accumulate exogenous Se than Crimson Seedless.

3.4. K and Ca content in grape berries

K and Ca content of grape berries had significant difference between Eurasian species (CK1) and European and American species (CK4), also K and Ca content of Eurasian species was higher than those of European and American species (Fig. 7). For Eurasian species and European and American species, spraying Se fertilizer significantly increased K and Ca content of grape berries.

3.5. Heavy metal elements concentration in grape berries

The plumbum (Pb), arsenic (As), nickel (Ni) content of grape berries had significant difference between Eurasian species (CK1) and European and American species (CK4) (Table 2). For Eurasian species, chromium (Cr) and mercury (Hg) were not detected in all treatments, and foliar Se fertilizer application significantly reduced the heavy metals content of Pb, cadmium (Cd), As and Ni. For European and American species, in addition to Hg was not detected in all treatments, the heavy metals content of Pb, Cr, Cd, As and Ni in grape berries under Se fertilizer treatments all significantly reduced compared to the control (Table 2).

3.6. Correlations between Se content and fruit quality, heavy mentals in grape berries

Through the correlation analysis between Se content in grape berries and fruit quality from different varieties, it can be seen that the Se content were mainly significant positive correlation with soluble sugar, soluble protein, Vc and soluble solid, but organic acid were mostly significant negative correlation in either year (Table 3). In addition, Organic acid was significantly negative related to soluble sugar, soluble protein, Vc and soluble solid, but soluble sugar, soluble protein, Vc and soluble solid was significantly positive correlation each other (The data did not show).

Through the correlation analysis between Se content and heavy metals in grape berries from different varieties, it can be seen that the Se content were mainly significant negative correlation with Pb, Cr, Cd, As and Ni, heavy metals were mostly significant positive correlation each other (Table 4). Thus, a kind of effective ways to reduce the heavy metals in grape berries was that increasing the Se content of grape berries.

4. Discussions

4.1. Effect of Se fertilizer application on fruit nutritional quality

Fruit quality was a complex concept which mainly refers to berry chemical composition, including sugars, acids, phenolics and other aroma compounds (Dai et al., 2010). But researches cannot contain all quality indexes in the process of evaluation. This study took soluble sugar, vitamin C, organic acid, soluble protein, soluble solid as well as the important secondary metabolites procyanidins and resveratrol as grape nutritional quality index. Study shown that spraying Se fertilizer improved amino acid and protein content in rice (Premarathna et al., 2012), Dhillon and Dhillon (2009) did similar research on wheat, which improved the nutritional quality of crop such as protein, soluble solid, soluble sugar content (Dhillon and Dhillon, 2009), the result was consistent with our study. In addition, additional of Se fertilizer reduced the organic acid in grape berries, and it was confirmed in kumquat fruit (Luo et al., 2011), and then increased the fruit sugar-acid ratio.

Considering the different source varieties had different growth characteristics that determined by genotype (Li et al., 2006), photosynthesis of European and American species was generally higher than Eurasian species (Hui et al., 2005), and this research indicated the influence of Se fertilizer on fruit quality had significant difference between European and American species and Eurasian species, and soluble sugar and soluble protein of European and American species was higher than Eurasian species, it may be caused by the high photosynthetic rate of European and American species. Foliar Se fertilizer application had no effect on resveratrol and procyanidins content of grape berries for Eurasian species, besides it significantly increased the procyanidins content of CK2. For European and American species, spraying Se fertilizer also significantly increased procyanidins and resveratrol content, except CK4. Studies had showed that the grape seed contains more procyanidins than the rest parts of grape (Ma et al., 2006). In addition, both Crimson Seedless and Summer Black were seedless, thus Hutai No.8 had the highest procyanidins content.

4.2. Enhanced Se content of grape berries by foliar Se fertilizer application

Many studies had shown that Se fertilizer application can effectively increase Se content of crop edible part, Wang et al. (2013a,b) and Broadley et al. (2010) by increasing Se fertilizer on rice, wheat and maize, Se content increased 51 and 10 folds in rice and wheat grains compared with the control respectively, also both soil application and foliar spray significantly improved Se content in corn (Broadley et al., 2010; Wang et al., 2013a; Wang et al., 2013b). But those studies mostly selected sodium selenite (Na_2SeO_3) and sodium selenate (Na_2SeO_4) as the main forms of Se fertilizer. On account of sodium selenite is a kind of inorganic Se source, it is difficult to be absorbed by plants and the recovery of elemental Se is low, indeed excessive exposure will cause poisoning to human body. Also with Se dual effects on plants, the excessive Se addition inhibited plant growth, Se application at a rate of 2.5 and 5.0 mg kg^{-1} were resulting in reduced plant growth and a high mortality rate (Pezzarossa et al., 2009). So inorganic Se fertilizer was not suitable for Se fertilizer application. This study concluded that spraying 500 times dilution of amino acid-chelated Se-enriched foliar fer-

Table 1
Selenium content of grape berries under different treatments.

Varieties	2014			2015		
	CK [a] (ug kg^{-1} FW)	S [a] (ug kg^{-1} FW)	Raise rates (%)	CK(ug kg^{-1} FW)	S(ug kg^{-1} FW)	Raise rates (%)
Crimson Seedless	15.84f [b]	16.98ef	7.20	11.97f	14.00ef	16.96
Red Barbara	16.02f	17.57de	9.68	16.03de	19.46c	21.4
Summer Black	18.35d	21.20c	15.56	18.33 cd	23.94b	30.61
Hutai No.8	24.61b	32.75a	33.08	25.54b	34.96a	36.88

Note: [a] CK, control treatments; S, selenium fertilizer treatments. [b] Values followed by the same letter show no significant differences ($p > 0.05$).

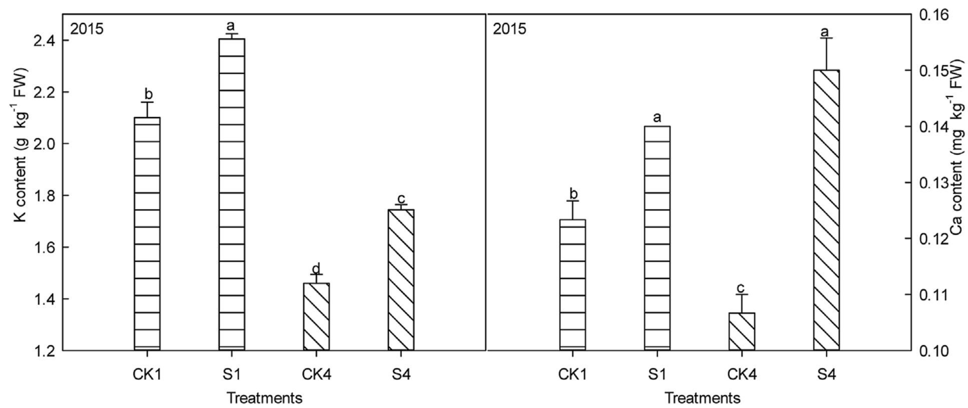

Fig. 7. K and Ca content of grape berries under different treatments.
Note: CK, control treatments; S, selenium fertilizer treatments. 1, Crimson Seedless; 4, Hutai No.8. The same letter above pillars show no significant differences ($p > 0.05$).

Table 2
Content of heavy metals in grape berries under different treatments.

Treatments	Pb(ug kg^{-1})	Cr(ug kg^{-1})	Cd(ug kg^{-1})	Hg(ug kg^{-1})	As(ug kg^{-1})	Ni(ug kg^{-1})
CK1 [a]	84.0a [b]	ND [c]	3.7a	ND	12.1a	7.1c
S1	1.8d	ND	0.5c	ND	9.8b	3.9d
CK4	54.9b	59.0a	3.7a	ND	8.2c	23.5a
S4	7.5c	18.3b	2.3b	ND	6.9d	18.1b

Note: [a] CK, control treatments; S, selenium fertilizer treatments. 1, Crimson Seedless; 4, Hutai No.8. [b] Values followed by the same letter show no significant differences ($p > 0.05$). [c] ND, not detected.

Table 3
Correlations between Se content in grape berries and fruit quality of different varieties.

Year	Varieties	Soluble sugar	Soluble protein	VitaminC	Soluble solid	Organic acid
2014	Crimson Seedless	0.811	0.906*	0.508	0.734	−0.529
	Red Barbara	0.606	0.939**	0.729	0.873*	−0.849*
	Summer Black	0.836*	0.790	0.784	0.855*	−0.926**
	Hutai No.8	0.968**	0.987**	0.990**	0.994**	−0.867*
2015	Crimson Seedless	0.963**	0.861*	0.501	0.972**	−0.791
	Red Barbara	0.948**	0.965**	0.932**	0.966**	−0.966**
	Summer Black	0.852*	0.839*	0.504	0.925**	−0.750
	Hutai No.8	0.924**	0.947**	0.949**	0.877*	−0.713

Notes: ** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.05 level.

Table 4
Correlations between Se content in grape berries and heavy metals of different varieties.

Varieties		Se	Pb	Cr	Cd	As
Crimson Seedless	Pb	−0.996**	1			
	Cr	–	–	1		
	Cd	−0.980**	0.992**	–	1	
	As	−0.889*	0.874*	–	0.841*	1
	Ni	−0.969**	0.982**	–	0.994**	0.859*
Hutai No.8	Pb	−0.951**	1			
	Cr	−0.951**	0.999**	1		
	Cd	−0.928**	0.929**	0.919**	1	
	As	−0.767	0.923**	0.918**	0.843*	1
	Ni	−0.934**	0.995**	0.991**	0.926**	0.939**

Notes: ** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.05 level.

tilizer, which plants absorbed easily and no harm for plants and human, was contribute to increasing the Se content of grape berries. (Table 1).

However, crop variety affect Se efficiency in plants (Rengel et al., 1999), and the sensitivity of different species to Se fertilizer was different (Hu et al., 2002). This research shown that European and American species were more easier to absorb exogenous Se, besides Se content were positive correlation with soluble sugar, soluble protein, Vc and soluble solid (Table 3), thus it should be a more rational choice for Se-enriched grape production. To the contrary, Eurasian species were not suitable for Se-enriched grape production due to the low Se content raise rates of grape berries (Table 1), and foliar Se fertilizer application almost had no effect on polyphenol antioxidants (Fig. 6).

4.3. *Effect of Se application on nutrient elements and heavy metals in grape berries*

Foliar Se fertilizer application increased K and Ca nutrients content in grape berries (Fig. 7), at the same time reduced accumulation of heavy metals Pb, Cr, Cd, As, Ni (Hg was not determined) (Table 2). A field experiment shown that low concentration of Se fertilizer application increased K and Ca nutrients content in greens. Also Põldma et al. (2011) suggested that the influence of foliar Se application on K and Ca content in garlic was related to the Se rate (Põldma et al., 2011). But some studies had shown that Se application had no significant effect on nutrient elements absorption (Drahonovsky et al., 2016; Wang et al., 2013a), may be due to the different Se tolerance of different species lead to Se affect nutritional quality was not consistent.

Research of Srivastava et al. (1998) shown that Se had inhibitory effect on spinach (*Spinacea oleracea*) plant Cr absorb (Srivastava et al., 1998). Fargašová et al. (2006) and Hu et al. (2014) studies had shown that Se can significantly reduce the Cd and Pb in mustard (*Sinapis alba* L.) and lettuce (*Lactuca sativa* L.) accumulation of aerial parts (Fargašová et al., 2006; Hu et al., 2014). Similarly, Zhao et al. (2013) study shown that Se can antagonism Hg in garlic (*Allium sativum*) transfer from root to aboveground so as to reduce accumulation of Hg in aboveground (Zhao et al., 2013). The negative correlation between Se content and heavy metals (Table 4) proved the antagonism between Se and heavy metal, but it was affected by many factors, such as the concentration and forms of Se and heavy metals (Chen et al., 2014). On the contrary, some studies had reported that not only Se cannot antagonism accumulation of heavy metals, may even increase heavy metals content in plants. This may be caused by unreasonable additive amount of Se or different crop variety and other factors.

In short, scientific and rational Se fertilizer application not only improve Se and nutrition elements level of edible part, but also reduce accumulation of heavy metals, thus reducing human health risk caused by heavy metals. Se and heavy metals existed unequivocal antagonism, but in order to study the interaction mechanism of heavy metals and Se, vast field experiments were needed, so as to reduce accumulation of heavy metals in fruits and improve Se and nutrition elements level of edible parts.

5. Conclusion

Foliar Se fertilizer application increased soluble sugar, Vc, soluble protein, soluble solid nutrition quality, and reduced the organic acid for both Eurasian species and European and American species, while it had less effect on resveratrol and procyanidins content of Eurasian species. Se content of grape berries was increased by foliar spray Se fertilizer, as well as Se content and raise ratio of European and American species was higher than those of Eurasian species. K and Ca nutrients content in grape berries was significantly increased, at the same time reduced accumulation of heavy metals Pb, Cr, Cd, As, Ni. Therefore, Se fertilizer can be used to increase Se content of grape, especially for European and American species, with significant effect of increasing grape nutrition quality and an effective means of lowering grape heavy metals.

Acknowledgments

This work was financially supported by the National Science and Technology Support Program (No. 2014B AD14B006) and Science and Technology Support Program of Shaanxi province Academy of Science (No. 2014K-03).

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