EJED 1(1) 2018: 54-72
Ethiopian Journal of Environment and Development
http://www.du.edu.et/duj

Asian *Vitis* Species for Modern Grapevine Breeding and Wine Industry: A Review

Dargie Tsegay Berhe[1]

[1] Dilla University, College of Agriculture and Natural Resources, Horticulture Department, Dilla, Ethiopia Email: tsegadar@yahoo.com Mobile: +251-9-12-74-34-89

Received: xxxxxx /Accepted: May 2019

Abstract

Viticulture is one of the major horticultural industries of the world, with the area of grapevines cultivated exceeding 7.9 million hectare. The grapevines belong to the family Vitaceae, which are mostly woody, tree-climbing vines, though a few have a shrubby growth habit. They have tendrils and inflorescences opposite the leaves. The grapevine fruit is used in a wide variety of products, ranging through fresh fruit, preserves, juice, wine and raisins. This review paper attempts to address a potential Asian Vitis species, as there was no sufficient information and most of the species were ignored in modern viticulture and enology. Vitis amurensis, Vitis heyneana, Vitis davidii, and Vitis yeshanensis are the most common and most popular species in Asia. The Vitis genus contains more than 70 species, with centres of origin in South Europe, Asia Minor, East Asia, and North and Central America. Asia is one of the major gene centres of origin for more than 37 Vitis species. Asian Vitis species have strong resistance against such diseases like Anthracnose, Ripe Rot, Powdery Mildew, Crown Gall and they can withstand environmental stress. Their germplasms can easily be crossed with V. vinifera and American Vitis species. Additionally, the berries of Asian wild Vitis species do not have the undesirable "foxy" flavour compounds commonly existing in the berries of American Vitis species. As the European grapevines are not well tolerant to different diseases, Asian wild Vitis have captured scientists and breeders' attention in the grapevine breeding and wine industry.

Key words: Grape berry, grapevine, raisin, *Vitis* species, wine

Introduction

There are 12 genera within the Vitaceae family including *Vitis*, *Ampelocissus*, *Clematicissus*, *arthenocissus* (Virginia creeper), *Ampelopsis* and *Cissus* (kangaroo vine). The genus *Vitis* is the part of that family in which the grapevine industry is most interested and it consists of two subgenera, *Euvitis* and *Muscadinia* (Creasy and Creasy, 2009). The subgenera are distinct because they have different chromosome numbers (38 for *Euvitis* and 40 for *Muscadinia*) and morphological features (Einset and

Pratt, 1975). There are three named species in this group *Muscadinia rotundifolia, Muscadinia munsoniana* and *Muscadinia openoei*. Because of their different chromosome number, plants in this subgenus will not naturally interbreed with *Euvitis* species. However, some crossing is possible through tissue culture techniques (Alleweldt and Possingham, 1988). This may be important from the standpoint of producing grapevines with enhanced disease resistance or other desirable characteristics. *Euvitis* has many species, including Amur grapes (*Vitis amurensis*- the most popular Asian grapevine species), Common grapes (*Vitis vinifera*- the most widely grown grape species in the world) and *Vitis labrusca*, which is native to North America (Creasy and Creasy, 2009).

Eco-Geographic Distribution and Morphological Traits

Some species such as *Vitis pentagona*, *Vitis flexuosa*, *Vitis davidii*, and *Vitis wilsonae* have a wide eco-geographic distribution. Others, such as *Vitis hancockii*, *Vitis bellula*, and *Vitis sinocinerea* are known to have a narrow distribution. Species located mainly in subtropical middle China have tolerance to high moisture and have little cold-hardiness. *V. adenoclada, V. romanetii, V. wilsonae*, and *V. davidi* are examples of such species. Species with strong moisture and heat tolerance such as *V. pseudoreticulata, V. chunganensis, V. balanseana* and *V. retordii are* mainly found in Southeast China. The species *V. piasezkii*, *V. bryoniaefolia* and *V. yeshanensis* have strong winter hardiness as indicated by their distribution in North China. *V. amurensis*, the most cold-hardy species, concentrates in Northeast China. Species, such as *V. romanetii, V. seudoreticulata, V. balanseana, V. adenoclada and V. davidi* have a high resistance to grape diseases epidemic in warm-humid areas such as powdery mildew and ripe rot (Kong, 2004). Some species like *Vitis davidii* are known to have resistance to disease and abiotic factors such as cold or drought and some others like *Vitis pentagona* have fair disease resistance and good enological traits related to berry quality while still others like *Vitis amurensis* have strong winter hardiness and good wine quality (He, 1999a).

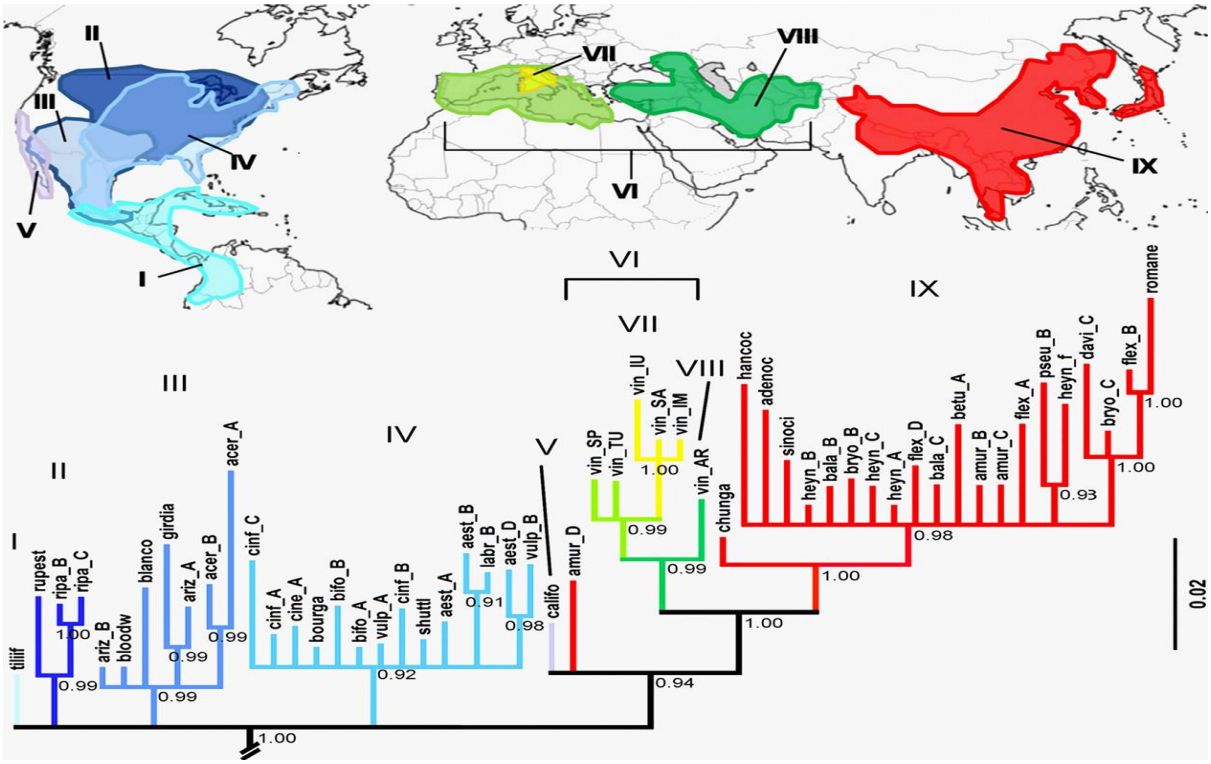

Figure 1. Phylogeny and geographic distribution of wild grapes (subg. Vitis). Blue tones=American species; red = Asian species; dark green=Caucasian wild grapevine; light green=Mediterranean wild grapevines (except Italian accessions); yellow=Italian wild grapevines.

Wild grapes show a marked geographic disjunction between the 34 American species (including subgroup *Muscadinia*), the 37 Asian species and the rare European–Middle Asian wild grapevine (*V. vinifera* subsp. *sylvestris*) which is believed to be the living ancestor of modern grapevine cultivars (This *et al.*, 2006). Asian grape species have two or more scientific names since scientists described the same species at different times, not recognizing that they were dealing with a species that had already been identified. For example, these species had been first named *Spinovitis davidii in 1881 and were later named Vitis davidii in 1886.* However, the latter is mainly used to refer the species as it is well described. To clarify the situation, it is important to prepare a list of primary scientific names of Asian wild grapes and their synonyms (Zecca *et al.*, 2012; Table 1).

Geographic isolation is the only factor that could lead to reproductive isolation between species within subgenus Vitus. Ecological and phenological barriers such as preferences for markedly different habitats or shifted flowering time, are the most probable causes for promoting and maintaining isolation between sympatric species. The old world grapes were grouped into two main sister clades. The largest one (IX in

Fig. 1) includes all Asian accessions except one individual of *Vitis amurensis* (amur-D); the smallest one (VI in Fig. 1) encompasses only *Vitis vinifera* subsp. *sylvestris* accessions. In the Asian clade, *Vitis chunganensis*, a species from south-eastern China, was found to be sister to the remaining species. Due to its strong moisture and heat tolerance, *Vitis chunganensis* might represent a preferential source of environmental stress resistance genes for grapevine cultivars. The Armenian wild grapevine specimen (VIII in Fig. 1) was found to be the oldest lineage of *Vitis vinifera* subspecies *sylvestris* (Wan *et al.*, 2008).

Table 1: Some of the annotated species of Asian wild grapes by morphological traits (Li et al., 2009; Wan et al., 2008; Fengqin et al., 1996)

Species Name	***Synonyms***
Vitis davidii	*Spinovitis davidii, Vitis armata, Vitis prunisapida*
Vitis romanetii	*Vitis rutilans*
Vitis balanseana	*Vitis flexuosa* var. *gaudichaudii*
Vitis betulifolia	*Vitis tricholada, Vitis hexamera, Vitis shimenensis*
Vitis piasezkii	*Parthenocissus sinensis, Vitis piasezkii*. var. *baroniana, Vitis tiubaensis*
Vitis pilosonerva	*Vitis davidii* var. *brachytricha*.
Vitis wilsonae	*Vitis reticulate, Vitis marchandii, Vitis flexuosa*
Vitis hancockii	*Vitis fagifolia, Vitis wentsaiana*
Vitis tsoii	*Vitis embergeri*
Vitis flexuosa	*Vitis wallichii, Vitis purani, Vitis parvifolia, Vitis vulpina* L.var. *parvifolia, Vitis flexuosa*
Vitis amurensis	*Vitis vinifera* L. var. *amurensis, Vitis amurensis* var. *genuine, Vitis thunbergii*
Vitis yeshanensis	*Vitis amurensis* var. *yanshanensis*
Vitis pentagona	*Vitis heyneana, Vitis lanata, Vitis ficifolia* var. *pentagona, Vitis kelungensis, Vitis coignetiae*
Vitis heyneana subsp. *ficifolia*	*Vitis ficifolia, Vitis thunbergii, Vitis labrusca* L. var. *ficifolia*
Vitis retordii	*Vitis lanata*
Vitis bellula var. *pubigera.*	*Vitis pentagona* var. *bellula* *Vitis quinquangularis* var. *bellula*
Vitis sinocinerea	*Vitis thunbergii* var. *cinerea* *Vitis thunbergii* var. *taiwaniana* *Vitis thunbergii* var. *adstricta*
Vitis bryoniaefolia	*Vitis adstricta, Vitis flexuosa* var. *mairei, Vitis thunbergii* var. *adstricta, Vitis novisinensis, Vitis thunbergii* var. *mairei, Vitis bryoniaefolia* var. *multilobata*
Vitis bryoniaefolia var. *ternate*	*Vitis adstricta* var. *ternate*
Vitis lanceolatifoliosa.	*Vitis piasezkii* var. *angustata*

Common Asian Vitis Species: Vitis amurensis (Amur Grape)

Phenology:

Vitis amurensis species commonly known as "Amur Grape" is native to the Asian continent, including parts of Siberia, China, Russia and Korea (Xiong and Zhang 2007). It is a kind of woody liana and is dioecious with light green, blunt and alternate simple leaves, rough leaf surface with soft, velvety white stinging hairs on the back and saw-toothed leaf margin (Fig. 2; Peng *et al.,* 2000). *Vitis amurensis* has high drought resistance; for example, the water efficiencies of spring, summer and autumn are 1.635, 1.174 and 4.347 mmol CO_2 $mmol^{-1}$ H_2O, respectively (Zhuang, 2008).

Figure 2: Vitis amurensis Species

Vitis amurensis has an extensive root system, which enables it to grow on lands of different soil types. However, it grows much better when planted in rich organic, ventilated and permeable soils. It gives maximum yields of high-quality berries when planted in sandy soils with a pH value of 6-7 (Song *et al.*, 2009). *Vitis amurensis* is more cold stress resistance than other species of the genus Vitis and can safely survive long, cold winters. Its branches have a relatively lower respiratory intensity with a lower active metabolism and longer dormancy compared with that of *V. vinifera* and *Vitis labrusca* (Peng *et al.*, 2000). *Vitis amurensis* is also resistant to fungus-caused grapevine diseases such as grape white rot, grape anthracnose, grape bitter rot and downy mildew (Xie, 2007).

Cultivation

Due to lack of hermaphrodite flowers, it is difficult to grow *Vitis amurensis* commercially in other countries such as Russia, Korea, Japan, Yugoslavia and the Czech Republic. It is known that only China has the hermaphrodite flower germplasm resource (Song *et al.,* 2009). Since the 1960s, studies on genetic resources of *Vitis amurensis* have been intensively carried out in China (Song *et al.,* 2002). In 1963, a survey of wild *Vitis amurensis* resources was evaluated botanical, biological and cytological characteristics of *Vitis amurensis* and it analysed the specie's genetics and resistance to adverse environments and pathogens. In this survey, a hermaphrodite flower cultivar 'Shuang Qing' was found (Song *et al.,* 1996), the discovery of which contributed to major developments in the viticulture and breeding of *V. amurensis*. Successful delivery of this cultivar led to the use of pollinisers in commercial production and considerably enhanced the productive potential of *V. amurensis*. In nearly 50 years, more than 380 vines of wild *Vitis amurensis* germplasm with different traits of flowers (hermaphrodite flower, female flower, male flower and some types between male and female flower) and leaves, cluster shapes and sugar contents have been collected and preserved (Shen *et al.,* 2006).

By the middle of the 1980s, another female flower cultivar, *'*Zuo Shan 1*',* was released and the next generation called 'Zuo Shan 2' was successfully selected from the wild *Vitis amurensis* resources. Since then, these two cultivars have been extensively cultivated in northeast China and greatly promoted the development of the *Vitis amurensis* industry. Using hermaphrodite flower genotypes as female parents and *'*Shuang Qing' as male parents for intraspecific crossing, research institutions in China achieved a number of elite cultivars containing bisexual flowers such as *'*Shuang Feng', *'*Shuang You' and 'Shuang Hong'. Breeding by interspecific crossing and backcrossing with *Vitis vinifera* cultivars such as 'Muller', 'Merlot', 'White Riesling', 'Cabernet Sauvignon' and 'Chenin Blanc', resulted in the production of numerous novel cultivars such as *'*Bei Chun', 'Bei Hong', 'Bei Mei', etc. Some cultivars such as 'Gong Zhu Bai' came from crossing between *Vitis amurensis* and *Vitis labrusca* (Song *et al.,* 2002). In China, *Vitis amurensis* is cultivated mostly in northeast areas, but Luo *et al.* (2009) reported that 'Shuang Hong' and 'Shuang You' can live through the winter without burying in the Gobi regions of western China, which have the worst environment for the European-Asian grapevine cultivars.

Thirty-eight *Vitis amurensis* hybrids were successfully selected by interspecific crossing of *Vitis amurensis* and *Vitis vinifera* in 2009. These new cultivars have a relative high sugar content (120-160 g/L) and low acid content (9-12 g/L), and can safely survive the cold winters of north China, such as in Heibei Province, without burying, and the extreme cold winters of Heilongjiang, Liaoning and Jilin Provinces by simply winter proofing (Li *et al.,* 2009). Cultivars of *Vitis amurensis* have diverse products for instance, 'Zuo You Hong' cultivar is mainly used for making dry red wine, while 'Shuang Hong' and 'Shuang You' is used for sweet red wine, and 'Bei Bing Hong' for ice wine. So far, China has the largest quantity of the preserved vines and cultivated areas of *Vitis amurensis* in the world (Fang, 2003).

Winemaking:

The main characteristics of *Vitis amurensis* grape vines are high acidity, high tannin and polyphenols, high dry extract and high nutrition; low sugar, low juice yield, and low fermentation temperature. (Li *et al.,* 2009). The average organic acid and sugar contents are 17.5 g/L and 140.6 g/L, respectively (Jie, 2008). Wines of *Vitis amurensis* are high in nutrition and contain abundant minerals such as phosphorus, iron, carotene, vitamin B, vitamin C, natural polyphenols, free amino acids, etc. Large amounts of tannin

and pigments come from the peel of *Vitis amurensis* berries make the wine darker in colour with a strongly astringent taste. A special dry red wine is successfully produced a nice ruby red colour, pleasant sweet flowery and fruity taste, greatly reduced bitterness and astringency (Wang *et al.,* 2008).

There are no major differences between making wine from *Vitis amurensis* and general wine making techniques. The only difference is *Vitis amurensis* needs de-acidification of free run juice before fermentation and then mixing it with pomace for further fermentation due to its high acidity and low sugar content (Lv *et al.,* 2005a). Jiang *et al.* (2008) used four physical and biological methods for de-acidification of wines from *Vitis amurensis*: cryothermal treatment, acid-decreasing yeast, extending the fermentation period and anion exchange high performance liquid chromatography column (HPLC). *Vitis amurensis* grapes have become more popular for making high-quality red wines due to their high nutritional value, unique fruit fragrance and distinctive taste. *Vitis amurensis* wines have a bright ruby red colour, fine fragrant aroma, a mellow and full-bodied taste compared with wines made from *Vitis vinifera* and are high in bioactive substances. To make high-quality dry red wines that do not taste very sour, producers try to reduce the acidity of the grapes and wines by delaying the picking time, girdling in different periods, root restriction, lactic fermentation and low-temperature treatment (Peng *et al.,* 2000).

Low-alcohol and non-alcoholic wines have been introduced in the past several years. More and more consumers, especially women, elderly people, and people who are allergic to alcohol prefer these wine products. These wines have changed the market trend from high-alcohol wines to low-alcohol or no-alcohol wines.However, brewing low-alcohol wine from *Vitis vinifera* grapes coastly because they have relatively high sugar content. *Vitis amurensis* is famous to making low-alcohol wines based on its unique characteristics. Low-alcohol dry red wine with an alcohol content of 8-9%, brilliant ruby red colour and perfect taste has been brewed from *Vitis amurensis* (Lv *et al.,* 2005b). *Vitis amurensis* is also an ideal grape to resist cold and make ice wine. Under rigorous ice-wine making standards, ice wine with a pleasant aroma and fine mouth-feel is made from *Vitis amurensis* (Jin *et al.,* 2004). It is also used for making functional juice, beverage, vinegars honeysuckle wine (Chi and Jiang, 2009) and functional juice beverage with nightshade (Yang *et al.,* 2010).

Assimilates

The main nutrients such as total sugars, vitamin C, pigments and free amino acid increased all the time, while tartaric acid and tannin are decreased (Li *et al.,* 2001). Research by Jiao *et al.* (2004) also confirmed the above results. They used the ^{14}C isotope method to follow the transportation and ration manner of accumulated ^{14}C-assimilates in different parts of *Vitis amurensis* vines and found that the distribution centre of the assimilates was in the leaves from florescence to beginning of veraison and then moved to the fruits. After harvesting, the main branches and roots turned to be the centres due to the backflow of nutrients. Song *et al.*(2009) also reported that, the separation of the progenies from intraspecific and interspecific hybridization (F_1-F_4) of *V. amurensis* trended to a continuous distribution of high acid and low sugar, the more parents with high acid and low sugar characteristics in cross combination, the more single vine with high acid and low sugar characteristics separated, and resulted as a quantitative inheritance controlled by polygene.

Bioactive Compounds:

Leaves, shoots and roots of *Vitis amurensis* have been used in conventional Chinese medicine. These parts of the plant and wines derived from the berries contain abundant bioactive natural substances, such as polyphenols, anti-oxidation and anti-aging capabilities, lower human blood pressure, and prevent cardiovascular disease (Zhang *et al.,* 2007; Gerogiannaki-Christopoulou *et al.,* 2006). Phenolic compounds in grapes are responsible for organoleptic properties of grape berries and wines, such as colour, bitterness, astringency, clarity, stability and aroma. Polyphenols of *Vitis amurensis* can prevent the formation of formazan, inflammation of endothelial cell, reduce hypertension, and also play a protective role in myocardial ischemia and chronic diseases (Zhao *et al.,* 2011; Zhang *et al.,* 2007).

Because of its phenols, tannin, (+) catechin, (-) epicatechin, gallic acid (in the forms of free radical, ester and glycoside), and two phenolic acids (caffeic acid and p-coumaric acid) at very low levels plays as a strong anti-free radical activities (Weidner *et al.,* 2007). Stilbenes and oligostilbenes found in *Vitis amurensis* have the physiological and pharmacological effects of anti-oxidation, anti-inflammatory, antitumor, platelet aggregation and nerve cell apoptosis inhibition, nerve structure protection and blood-lipid metabolism regulation. (Hou *et al.,* 2008; Dopico-Garcia *et al.* 2007). Four oligostilbenes, two resveratrol trimers of amurensins C and D and two resveratrol pentamers of amurensins E and amurensins F, separated from the roots of *Vitis amurensis* are also playing a great role in inhibiting biosynthesis of leukotriene B4 (Huang *et al.,* 2000). Yim *et al.* (2010) found that nine stilbenes polyphenols and oligostilbenes isolated from the leaves and stems of *Vitis amurensis* had the antimicrobial effects on the two oral pathogens, *Streptococcus mutans* and *Streptococcus sanguis*, which are associated with caries and periodontal disease, respectively. These results suggest that natural antimicrobial compounds derived from *Vitis amurensis* may help oral health as plaque-control agents and prevent dental caries and periodontal disease.

By-Products:

Compared to other grapevine species, *Vitis amurensis* have much higher procyanidin /condensed tannin/ and a member of phenolic polymer (Shen *et al.,* 2006). Procyanidin has multiple physiological functions, such anti-oxidation, anti-tumour and protecting vascular endothelial cells, etc. Further studies showed that the average and highest colour units from 116 vines of *Vitis amurensis* were 25.31 and 134, much higher than those of common grapes (Jie, 2008). *Vitis amurensis* berries are used as major materials for producing natural pigments, and anthocyanins extracted from the pomace are used as textile dyeing (Bechtold *et al.,* 2007). During winemaking process, up to 75% of the pomace from *vitis amurensis* may be seeds, are discarded (Zhao, 2008). However, Polyphenols in pomaces and seeds of *Vitis amurensis* have an outstanding anti-aging effect and have 14-20% oil. Maier *et al.* (2009) further reported that grape seed oil is also nontoxic, harmless and meets the required standards of food health and food application.

Vitis heyneana

Vitis heyneana species is endemic to Asia and is found in shrubby or forested areas from sea-level to 3200 meters above. It is known by its two subspecies: *Vitis heyneana* ssp. *Heyneana (*Fig. 3*)* and *Vitis heyneana* ssp. *ficifolia*. The former is called 'wool grape' with oval, ovate-oblong, to ovate-quinqu angular shaped leaves. The second subspecies is called 'mulberry-leaf grape', and its leaves are usually trilobate to cleft (Hei and Wen, 2007; Li *et al.*, 1996).

Figure 3.Vitis heyneana Species

Vitis davidii (Spine Grape)

Spine grape (*Vitis davidii* Foex), also known as Chinese 'bramble grape', belongs to the East Asian *Vitis* spp. As one of the main wild grape species growing in the East Asian region, its shoots are densely covered by spines at 1-2 mm long (Fig. 4), and become thick and hard on one or two-year-old canes. The spine grape is mainly distributed in the Lohsiao and Xuefeng mountain ranges, which are covered by the subtropical rainforest to the south of the Yangtze River (Hui and Wen, 2007; Kong, 2004). Because the spine grapes originate from the humid areas of Southern China, they are resistant to diseases such as spot anthracnose, white rot disease, and anthracnose (Meng *et al.*, 2013).

Varietal aromatic of *Vitis davidii* is one of the most important quality parameters due to their direct influence on important flavour characteristics. The distinctive aroma of spine grape fruits mainly manifests as wild rose, violets and wild strawberries (Noguerol-Pato *et al.*, 2012; Bao, 2010).

Figure 4: Vitis davidii Species

Vitis davidii is excellent tolerant of humid, shaded conditions as well as hot and dry climates. It is also long lived species and gives high yield. It is resistant to scab, anthracnose and other grapevine diseases and insect pests. In Nanjing Sun Yat-sen Botanical Garden of China, *Vitis davidii* has been used as a pollen parent in breeding for different grapevine diseases (Liu *et al.*, 2012; Fengqin *et al.*, 1996).

Vitis flexuosa (Creeping Grape)

Vitis flexuosa is a species of liana in the grape family. It has a very large native range in Asian tropical and temperate climate zones, including East Asia (Taiwan; and the Chinese provinces of Anhui, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Henan, Hubei, Hunan,Jiangsu, Jian gxi, Shaanxi, Shandong, Sichuan, Yunnan and Zhejiang; the Japanese prefectures of Hokkaido, Honshu, Kyushu, Shikoku and the Ryukyu Islands; and the Koreas), Indochina (Laos; Thailand; and Vietnam), the Indian Subcontinent (The Indian states of Assam, Himachal Pradesh, Jammu and Kashmir, Manipur, Uttar Pradesh and West Bengal); Nepal; and north Pakistan), and Malesia in the Philippines.

Figure 5: Vitis Flexuosa species

Vitis flexuosa has biological characteristics of cane scent young shoot, slender vine, thin and long tendril, small leaf with wide cord-form or near truncate at the base, undulate leaf margin with uneven teeth (Fig. 5). *Vitis flexuosa* has a great sprouting potential, tolerates humid and hot climate, lives long, and is less resistant to scab than *Vitis davidii* and *Vitis adstrica* (Hui and Wen, 2007; Fengqin *et al.*, 1996).

Vitis ficifolia

Vitis ficifolia is a species of liana in the grape family native to the Asian temperate climate zone. The leaves of *Vitis ficifolia* are thick, scabrous, dark green, finely serrated, 11-25 cm long, most with 3 shallow lobes or entire (Fig. 6), and 5 deep lobes at lower part of vines (Chonghuai *et al.*, 2014; Hui and Wen, 2007; Fengqin *et al.*, 1996). *Vitis ficifolia* tolerates a temperature up to -20^{o}C. It is resistantce to scab, powdery and downy mildews. It is also a good high-yield, hardy and disease resistance parent for breeding (Hui and Wen, 2007; Fengqin *et al.*, 1996).

Figure 6: Vitis ficifolia Species

Vitis pentagona

Vitis pentagona has narrow ovate or pentagonal leaves, with or without three obscure lobes. The margin teeth are thin, shallow and obtuse (Fig. 7); It is resistant to scab and can be used as breeding material for disease resistance (Hui and Wen, 2007; Fengqin *et al.*, 1996).

Figure 7: Vitis pentagona species:

Vitis piasezkii

*Vitis piasezkii i*s native to loess plateau of Eastern Gansu province, China, used as a rootstock for wine grapes and table grapes. It has very high cold-resistance as well as good graft compatibility in grafting. Furthermore, it survives through low temperatures in winter without soil coverage and has good fruit quality of the cultivars grafted (Zhang *et al.*, 2009; Zhang *et al.*, 2006).

The young shoot and leaf stalks of *Vitis piasezkii* are covered with brown, puberulent and globular hairs. Almost all shoots sprouted from the canes bear fruit. Leaves are very variable in shape, either simple or compound on the same shoot. It has coarse teethed leaf margin, dark green upper leaf surface, light green with yellowish-brown tomentum lower surface (Fig. 8). It is resistant to fungus disease and besides for eating and wine making it is valuable for breeding (Liu *et al.*, 2012; Wan *et al.*, 2008; Hui and Wen, 2007; Fengqin *et al.*, 1996).

Figure 8: Vitis piasezkii species:

Vitis adstricta

Vitis adstricta is a synonym of *Vitis bryoniifolia* var. *bryoniifolia*. It is slender with ferruginous or pale pubescence young shoots, small leaf, entire and with few obtuse teeth (Fig. 9) and the lower surface is covered with rusty or cane scent pubescence. It is resistant to scab, and can be used as a parent for breeding new cultivars which are of good production and resistant to humid, hot climates and also to diseases (Liu *et al.*, 2012; Hui and Wen, 2007; Fengqin *et al.*, 1996).

Figure 9: Vitis adstricta species

Vitis pseudoreticulata

Vitis pseudoreticulata is Chinese wild grapevine having anti-fungal property under different abiotic stresses especially to *E. necator.* Wild grapevine germplasm resources of *Vitis pseudoreticulata offer* an opportunity to mine novel disease-resistance genes and so accelerate the genetic improvement of our existing *V. vinifera* germplasm resources. It is also of *excellent* resistance *to Powdery mildew* and strongly inhibit the growth of *B. cinerea* (Xu *et al.,* 2014; Wang *et al., 2014;* Weng *et al.,* 2014; He *et al.,* 2013; Xu *et al.,* 2011; Xu *et al.,* 2010).

Figure 10: Vitis pseudoreticulata species

Vitis pseudoreticulata has puberulent young shoots that are changed to glabrous during maturation. The leathery leaf is large, cordiform, cordate-pentagonal or reniform and margin entire with fine teeth. This species is well adapted and tolerant to humid and hot climate; it is useful for breeding new cultivars adapted to the climatic conditions of south China (Hui and Wen, 2007; Fengqin *et al.,* 1996; Fig. 10).

Vitis romanetii

This species is a sturdy woody climber, which grows vigorously. The leaf is large, thick obscurely shallow trilobed or entire, leaf margin is finely teethed; the tip is spiny; the upper surface is dark green, the lower surface is covered with light ferruginous, dense pubescence (Fig. 11) The species tolerates humid and hot climate and resist anthracnose (Liu *et al.,* 2012; Wan *et al.,* 2008; Fengqin *et al.,* 1996).

Figure 11: Vitis romanetii species

Vitis wilsonae

Vitis wilsonae is wild grape in Vitaceae family with heart-shaped (8-15 cm length, 5-10 cm width) leaves and 4-7 cm petiole (Fig. 12). *Vitis wilsonae* is a sun-loving vine, which does not tolerate shade and wet condition, but is resistant to fungus disease (Hui and Wen, 2007; Fengqin *et al.*, 1996).

Figure 12: Vitis wilsonae species

Vitis yunnanensis (Yunnan Grape)

Vitis yunnanensis is a species of liana in the grape family. It has small and thin leaf with coarse and large teethed margin. *Vitis yunnanensis* species tolerates drought and cold up to 25^{o}C and is resistant to diseases such as scab, white rot, downy mildew and anthracnose (Wan *et al.*, 2008; Fengqin *et al.*, 1996). There are also other Asian *Vitis* species including *Vitis mengziensis* (Mengzi Grape), *Vitis ruyuanensis* (Ruyuan Grape), *Vitis tsoii, Vitis adenoclada, Vitis balansana, Vitis barbata, Vitis betulifolia, Vitis chunganensis, Vitis chungii* (Fujian Jianxi Grape), *Vitis coignetiae* (Crimson Glory Vine), *Vitis fengqinensis* (Feng king Grape), *Vitis hui* (Mount Lushan Grape), *Vitis menghaiensis, Vitis silvestrii* (Hubei Grape), *Vitis sinocinerea* (Small-Leaved Grape) and *Vitis Wuhanensis* (Wuhan grape).

Conclusion

European and American grapevines are not well tolerant to different diseases and environmental stresses. Therefore, the Asian wild *Vitis* have captured scientists' attention in vine-wine industry as they have high yield potential, best quality and can withstand various environmental stresses.

References

Alleweldt G. and Possingham, J.V. (1988). Progress in grapevine breeding. *TAG Theoretical and Applied Genetics*, 75(5): 669-673.

Bao R. F. (2010). Study on the aroma components of V. didii. Foex fruit and V. didii. Foex wine. (MSc dissertation). Changsha, China: *Hunan Agricultural University*, 15-46.

Bechtold T., Mahmud-Ali A. and Mussak R. (2007). Anthocyanin dyes extracted from grape pomace for the purpose of textile dyeing. *J. Sci. Food Agric*., 87: 2589-2595.

Chi J. and Jiang D. W. (2009). The development of honeysuckle Amurensis wine. *Modern Agric. Sci.,* 6: 211-212.

Chonghuai L., Xiaohe M. and Gang W. (2014). Grape varieties in China. *China agricultural press, Beijing*.

Creasy G. L. and Creasy L. L. (2009). Grapes: In Crop production science in horticulture series. *CABI, UK, ISBN: 978-1-84593-401-9.*

Dopico-Garcia M. S., Valentao P., Guerra L., Andrade P. B. and Seabra R. M. (2007). Experimental design for extraction and quantification of phenolic compounds and organic acids in white ''Vinho Verde'' grapes. *Anal. Chim. Acta.,* 583: 15-22.

Einset J. and Pratt C. (1975) Grapes. In: Janick, J. and Moore, J.N. (eds) *Advances in Fruit Breeding*. *Purdue University Press, West Lafayette, Indiana,* 130–153.

Fang Z. (2003). Wild grape and wild grape wine. *Liquor making Sci. Technol.*, 6(120): 93-94.

Fengqin Z., Fangmei L. and Dabin G. (1996). Studies on germplasm resource of wild grape species (vitis spp.) in China. Beijing Botanical Garden, Institute of Botany, *Chinese Academy of Science, Beijing 100093, China.*

Gerogiannaki-Christopoulou M., Athanasopoulos P., Kyriakidis N., Gerogiannaki I. A. and Spanos M. (2006). Trans-resveratrol in wines from the major Greek red and white grape varieties. *Food Control.,* 17: 700-706.

He M.Y. Xu Y. Cao J.J. Zhu Z.G. Jiao Y.T. Wang Y.J. Guan X. Yang Y.Z. Xu W.R. and Fu Z.F. (2013.) Subcellular localization and functional analyses of a PR_{10} protein gene from *Vitis pseudoreticulata* in response to *Plasmopara viticola* infection. *Protoplasma, 250,* 129-140.

Hou Q., Li L. C., Guo Y., Bai J. Y., Lin M. and Cheng G. F. (2008). Inhibitory effects of Vam4 on inflammatory cells in vitro. *Strait Pharm., J.* 2: 21-23.

Huang K. S., Lin M., Yu L. N. and Kong M. (2000). Four novel oligostilbenes from the roots of *Vitis amurensis*. *Tetrahedron.,* 56: 1321-1329.

Hui R. and Wen J. (2007). *Vitis Linnaeus,* Sp. *Flora of China,* 12: 210-222.

Jiang Z. D., Nan H. L. and Li H. (2008). Study on acid degradation of dry wild grape wine. *Liquor-Making Sci. Technol.,* 12: 47-49.

Jiao P. J., Li C. J. and Zhang Y. F. (2004). Study on the re-translocation of accumulated ^{14}C-assimilates of *Vitisamurensis* Rupr. *Sino-overseas Grapevine & Wine.,*1: 9-11.

Jie M. (2008). The study on polyploid breeding technology of V. amurensis. *M. Sc. thesis, Jilin Agricultural University, Jilin, China.,* 10.

Jin Y. J., Zhan J. J., Cheng Y. B. and Dong Y. D. (2004). Study on ice wine of *Vitis amurensis*. *Liquor Making.*3: 100-101.

Kong Q. S. (2004). Chinese ampelography. Beijing: *Chinese Press of Agricultural Science and Technology.*

Kong Q. S. (2004). Flora of Chinese Grapes. *China Agric. Sci. Technol. Press, Beijing.*

Li H. Y., Feng Y. C., Dong S. L., Wang M., Huang F. C. and Liu H. Z. (2001). Changes of respiration intensity and main nutritional components of fruit of *Vitis amurensis* during maturation. *J. Jilin Agri. Univ.,* 23(1): 46-49.

Li W. Ding L. Lit B. and YAO-Zu Chen Y. (1996). Oligostilbenes from *Vitis Heyneana. Phytochemist,* 42(4): 1163-1165.

Li X. H., Yang Y. M., and Zhang Y. F. (2009). Effect of different leaves pinching of bearing branches on fruit quality and yield in new variety ‘‘Bei Bing Hong’’ of Amurensis Rupr. Spec. *Wild Econ. Anim. Plant Res*., 4: 19-21.

Liu C., Fan X., Jiang J., Guo D., Sun H., Zhang Y. & Feng J. (2012). Genetic Diversity of Chinese Wild Grape Species by SSR and SRAP Markers, *Biotechnology & Biotechnological Equipment,* 26(2): 2899-2903.

Luo S., Guo X. D., Zhao J. M., Guo W. H., Li W. and Cao Z. Y. (2009). Cultivation traits of Shuang Hong and Shuang You cultivars of V. amurensis Rupr. On Gobi in China’s west region. *Chi. Hortic. Abstr.,* 25(11): 16-19.

Lv H. J., Feng L. G. and Yan Y. L. (2005b). New technology of low alcohol dry red wine of *Vitis amurensis* Rupr. *Sinooverseas Grapevine & Wine.,* 5: 52-53.

Lv H. J., Feng L. G. and Yan Y. L. (2005a). Study on the new techniques for decreasing the acidity of *Vitis amurensis* Rupr. *Sino-overseas Grapevine & Wine.,* 1: 42-43.

Maier T., Schieber A., Kammerer D. R. and Carle R. (2009). Residues of grape (*Vitis vinifera* L.) seed oil production as a valuable source of phenolic antioxidants. *Food Chem.,* 112: 551-559.

Meng J. Xu T. Song C. Li X. Yue T. Qin M. Fang Y. Zhang Z. and Xi Z. (2013). Characteristic free aromatic components of nine clones of spine grape (*Vitis davidii* Foex) from Zhongfang County (China). *Food Research International,* 54: 1795-1800.

Noguerol-Pato R., González-Barreiro C., Cancho-Grande B., Santiago J. L., and Martínez M. C. (2012). Aroma potential of Brancellao grapes from different cluster positions. *Food Chemistry,* 132: 112-124.

Peng H. X., Huang R. L. and Pan R. S. (2000). Characteristics and viticulture of wild *Vitis amurensis* Rupr. *Guangxi Agric. Sci.,* 1: 30-34.

Shen Y. J., Zhao S. L., Yang Y. M., Li X. H., Song R. G. and Lu W. P. (2006). The research and utilization on Amur Grape (*Vitis amurensis* Rupr.) germplasm resources in China. *Spec. Wild Econ Anim. Plant Res.,* 3: 53-57.

Song R. G., Ai J., Li X. H., Yan Y. M. and Shen Y. J. (2009). Industrial development and countermeasure V. amurensis Rupr. *Sino-overseas Grapevine & Wine,* 11: 64-69.

Song R. G., Li C. Y., Ai J., Lu W. P., Wang J., Guo T. J. and Shen Y. J. (2002). Industrial development and countermeasure *Vitis amurensis* Rupr. *Sino-overseas Grapevine & Wine,* 4: 6-9.

Song R. G., Lu W. P. and Sun K. J. (1996). Achievements and prospect on wine grape breeding in China. *Northern Horti.,* 129(6): 36-38.

This P. Lacombe T. Thomas M. (2006). Historical origins and genetic diversity of wine grapes. *Trends Genet.,* 22: 511–519.

Wan Y, Schwaninger H., Li D., Simon C., Wang Y. and Zhang C. (2008). A review of taxonomic research on Chinese wild grapes. *Vitis,* 47(2): 81-88.

Wan Y., Schwanninger H., Li D., Simon C.J., Wang Y. and He P. (2008). The eco-geographic distribution of wild grape germplasm in China. *Vitis,* 47: 77-80.

Wang E. F., Jiao S. P. and Yin G. C. (2008). Effects of polyphenols of *Vitis amurensis* Rupr. On erythrocyte immune function of irradiated mice. *J. Beihua Univ. (Natural Sci.),* 1: 32-33.

Wang L. Wei J. Zou Y. Xu K. Wang Y. Cui L. and Xu Y. (2014). Molecular Characteristics and Biochemical Functions of VpPR10s from *Vitis pseudoreticulata* Associated with Biotic and Abiotic Stresses. *Int. J. Mol. Sci.,* 15: 19162-19182.

Weidner S., Karamac M., Amarowicz R., Szypulska E. and Gol gowska A. (2007). Changes in composition of phenolic compounds and antioxidant properties of *Vitis amurensis* seeds germinated under osmotic stress. *Acta Physiol. Plant.,* 29: 283-290.

Weng K. Li Z. Liu R. Wang L. Wang Y. and Xu Y. (2014). Transcriptome of Erysiphe necator-infected Vitis pseudoreticulata leaves provides insight into grapevine resistance to powdery mildew. *Horticulture Research*, 49: 56-80.

Xie L. F. (2007). Studies on cold resistance identification and mechanism of grapevine rootstocks. *M.Sc. thesis, Inner Mongolia Agricultural University, Inner Mongolia, China.* 11.

Xiong Y. and Zhang W. M. (2007). Research and utilization of cold resistance of chinese wild Vitis. *J. Anhui Agric. Sci.* 35(11): 3238-3239.

Xu T.F. Zhao X.C. Jiao Y.T. Wei J.Y. Wang L. and Xu Y. (2014). A pathogenesis related protein, VpPR-10.1, from *Vitis pseudoreticulata*: An insight of its mode of antifungal activity. *PLoS One, 9*.

Xu W. Yu Y. Zhou Q. Ding J. H. Dai L. M. Xie X.Q. Xu Y. Zhang C. H. Wang Y. J. (2011). Expression pattern, genomic structure, and promoter analysis of the gene encoding stilbene synthase from Chinese wild *Vitis pseudoreticulata*. *J. Exp. Bot., 62*: 2745-2761.

Xu Y. Yu H. He M.Y. Yang Y.Z. and Wang Y.J. (2010). Isolation and expression analysis of a novel pathogenesis-related protein 10 gene from Chinese wild *Vitis pseudoreticulata* induced by *Uncinula necator*. *Biologia*, 65: 653-659.

Yang Y. M., Li X. H. and Lin X. G. (2010). Genetic analysis of resistance to Plasmopara viticola disease in progenies (F1-F4) derived from interspecific hybridization with *Vitis amurensis*. *J. Fruit Sci.*, 25(1): 33-39.

Yim N. H., Ha D. T., Trun T. N., Kim J. P., Lee S. M., Na M. K., Jung H. J., Kim H. S., Kim Y. H. and Bae K. H. (2010). The antimicrobial activity of compounds from the leaf and stem of *Vitis amurensis* against two oral pathogens. Bioorg. *Med. Chem. Lett.*, 20: 1165-1168.

Zecca G. Abbott R. Sun W. Spada A. Sala F. and Grassi F. (2012). The timing and the mode of evolution of wild grapes (Vitis).*Mol Phylogenet Evol.*, 62(2): 736-747.

Zhang J., Wang S., Xu R., Cao Z. and Ren J. (2006). Factors affecting in vitro propagation of a Chinese wild grape (*Vitis piasezkii* var. pagnucii): shoot production and rhizogenesis. *New Zealand Journal of Crop and Horticultural Science*, 34 (3): 217-223.

Zhang L. C., Ann Z. and Yu, C. L. (2007). The effect on the activity of NADPH oxidase of hypertension rat treated by V. amurensis polyphenols. *Chin. Med. Factory Mine*.5: 62-463.

Zhang L. J., Cao Y. Z. and Ma F. J. (2009). Screening of cold-resistant seedlings of a Chinese wild grape (*Vitis piasezkii Maxim var. pagnucii*) native to loess plateau of eastern Gansu province, China, as rootstocks. *Scientia Horticulturae*, 122(1): 125-128.

Zhao Q., Duan C. Q. and Wang J. (2011). Anthocyanins profile of grape berries of *Vitis amurensis*, its hybrids and their wines. *Int. J. Mol. Sci.*, 11: 2212-2228.

Zhao W. (2008). A study on the extraction and microcapsule of the amur grape seed oil. *M.Sc. thesis, North-East Forestry University, Heilongjiang, China.* 8.

Zhuang Y. (2008). Study on the physiological ecological characteristics of eight vines. *M.Sc. thesis, Anhui Agricultural University, Anhui*, 14.