Italian–Chinese cooperation for a fruitful management and utilization of hazelnut (*Corylus* spp.) genetic resources

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Abstract

Species of the genus *Corylus* are found widespread in China, and some wild accessions in high-elevation areas of Sichuan Province, including *Corylus kweichowensis* Hu, *Corylus chinensis* Franch., *Corylus yunnanensis* (Franch.) A. Camus, *Corylus mandshurica* Maxim., *Corylus ferox* and *Corylus fargesii* encourage the development of breeding and selection programs. To select cultivars suitable for cultivation in this area and regions with similar climate and site conditions, Sichuan Academy of Forestry has been evaluating eight hybrids of *Corylus heterophylla* Fisch. and *Corylus avellana* L. at low-elevation (500 m a.s.l.) experimental bases in Sichuan province since 2012. This study presents preliminary results on morphological characterization using international descriptors of hybrids and will discuss possible perspectives on hazelnut cultivation in Sichuan province. With the intention to exchange the expertise on hazelnut cultivation and improve the breeding program, Sichuan Academy of Forestry has created a collaboration with ENEA and UNITUS under a Memorandum of Understanding (MoU). The goals and the activities of MoU will be debated as a model to build long-term cooperation among the Enterprise-University-Research Institutes on a fruitful management and utilization of hazelnut (*Corylus* spp.) genetic resources.

Keywords: *Corylus avellana* L., *Corylus heterophylla* Fisch., hybrids, international descriptors, breeding programs

INTRODUCTION

The hazelnut (*Corylus* spp.) is a genus of deciduous trees and large shrubs placed in the family Betulaceae. There are eight species and two varieties found in China, mainly in the northern area of the Yangtze River (Liang, 2005). The genus can be widely cultivated in China, as various regional trials showed that area between 32° N and 45° N is suitable (Shi et al., 2001). The northernmost cultivation site reported is Jiamusi University Botanic Garden, Jiamusi, Heilongjiang Province, 45°46′N 129°8′E (Li et al., 2005). There are wild accessions of *Corylus* spp. in the southern areas of the Yangtze River such as Sichuan, Yunnan and Guizhou Province but no reported artificial cultivation or introduction of *Corylus* spp. cultivars (Molnar, 2011).

There are wild accessions distributed in Sichuan Province, including *Corylus kweichowensis*, *Corylus chinensis*, *Corylus yunnanensis*, *Corylus mandshurica*, *Corylus ferox*, *Corylus fargesii* and *Corylus ferox* var. *thibetica* (Xie, 2014; Wang et al., 2017). The most commonly found species is *Corylus kweichowensis* in shrubs on the shady-slopes of mountains with an altitude between 1000-2000 m above sea level (Wang et al., 2017). Most are found on the barren slopes between 1300-2500 m a.s.l. in alpine gorge areas of west Sichuan and mountain areas of southwest Sichuan, spreading in clumps by suckering (Wang et al., 2014). The species produces small and uneven nuts with high level of kernel astringency (Gou et al., 2014).

It is potential to do crossing using the endemic species *Corylus kweichowensis* as a parent (Huo et al., 2014). To improve upon local species and to enrich Sichuan hazelnut

accessions by breeding suitable cultivars, Sichuan Academy of Forestry has been evaluating eight hybrids of *Corylus heterophylla* Fisch. and *Corylus avellana* L. at low-elevation experimental bases in Heilongtan, Renshou, Meishan, Sichuan province since 2012 with assistance from Economic Forestry Institute of Liaoning Province on cultivar introduction.

MATERIALS AND METHODS

The main experimental site is on Qinglongzui Island, North of Heilongtan Reservoir, Renshou, Meishan, Sichuan Province, which is 76 kilometers from Chengdu, 32 kilometers from Meishan downtown and 32 kilometers from Renshou downtown. The site is located at 30°15′N 104°4′E with an altitude between 450-500m. Mid-subtropical climate brings a mean annual temperature of 17.4°C, an extreme low temperature of -4.2°C, and an extreme high temperature of 39.9°C. The frost-free period is over 300 days. The mean annual rainfall is 1074 mm, 60% of which is distributed from July to September. Soil types include purplish sandy loams, which are suitable for tree growing.

The hybrids were introduced from Dalian, Liaoning Province. The climatic factors from the hybrids' provenance and the experimental site are shown in Table 1, and the considerable difference in factors such as mean annual temperature can be seen from it.

The introduced plants were one-year-old layers of eight hybrids with cultivar numbers 85-41, 84-69, 84-237, 85-524, 84-254, 84-226, 83-33 and 82-11. These were chosen as experimental materials together with one-year-old acclimatized *Corylus kweichowensis* plants propagated from suckering of wild accessions on slopes of Mao County at 1400 meters, standard growing, pest-free individuals with a ground diameter of 1-1.2 cm.

The plants were transplanted to a 2.6-hectare experimental stand in March, 2012. Fifty plants of each type of the eight hybrids and one *Corylus kweichowensis* (control group) were planted randomly spacing 2m×3m, and three replications were made. The soil was covered by 0.004 mm recyclable black plastic film and irrigation was applied. A planting map was drawn as pruning, fertilization, irrigation and pest control were applied, which follow current hazelnut management techniques. The morphological characters such as flower bud development, nut development, trunk growth and crown size were recorded as plants grew.

In August, 2017 the tree growth, nut size, shell thickness, blank rate, and nut plumpness data were measured. Catkins' behavior in response to fungal disease between different cultivars were recorded. Some of the international descriptors including tree growth habit, vigour, and nut colour, shape, size, roundness index, shell thickness, weight, and kernel/nut ratio were used.

RESULTS AND DISCUSSION

Adaption of hybrids

As the trees grew, the cold tolerance, heat tolerance, pest and disease resistance were observed. As is shown in Table 2, the parameter evaluating catkins' behavior in response to fungal disease was calculated: infect rate (%) = (number of infected catkins/total number of catkins) x 100. Data from 90 plants of each cultivar were averaged.

As is shown in Table 2, all the hybrids showed heat and cold tolerance while no damage was observed. But cultivars 85-41, 84-69, 84-237, 84-254 and 84-226 showed catkin fungal infection with an infection rate between 76% to 99%, which was much more than what was observed of *C. kweichowensis* (2%). As for pests, defoliators and Asian long-horned beetle may have transferred from other plantations nearby, causing leaf and bark damage on four of the hybrids. No tree death or severe disturbance of tree shape was observed.

Growth of hybrids

After 68 months of growing, on 31st, August, 2017 the ground diameter, height and crown size of eight hybrids were measured. In each of the three replications, 30 plants of each cultivar were measured. Data from 90 plants of each cultivar were averaged. Results are shown in Table 3.

As is shown in Table 3 and Figure 1, after five years of growing, under the same

management, cultivar 85-41 attained the greatest height at 412.50 cm while *C. kweichowensis* was shortest at 206.00 cm. Cultivar 85-41 also had the largest crown growth, reaching 329.70 cm, which is 154.50% of the *C. kweichowensis*. As is shown in Table 3, cultivar 84-69 had the largest diameter at 8.190 cm while *C. kweichowensis* had the least at 1.889 cm. The *C. kweichowensis* tended to grow spreading and with much suckering.

Nut traits

Nuts were harvested after ripening and the cluster was removed after drying. Nut shape was recorded as shown in Table 4.

For each cultivar, 30 nuts were chosen and the nut height, width, thickness, shell thickness, weight, blank rate, kernel/nut ratio, and average yield of nuts per tree (30 trees per cultivar were measured) were recorded in Table 5.

CONCLUSIONS

According to the 5-year-observation of the trials, hybrids showed regular vegetative growth with no cold or heat damage observed. A preliminary conclusion can be drawn that hybrids of *Corylus heterophylla* Fisch. and *Corylus avellana* L. can be cultivated in Renshou region under mid-subtropical monsoon climate.

The female flowers of hybrids could develop and grow normally, while catkins were gradually infected by fungi, beginning in July, leaving less than 5%-10% catkins next January to meet pistillate anthesis. The high temperature and humidity in summer were inferred to be the main reason for defected nuts. This would be the primary issue encountered if hazelnuts were to be planted in Sichuan Province.

European hazelnut (*Corylus avellana* L.) is one of the most important economic tree species with advantages in large nut size, high nut quality and industrial value. The worldwide hazelnut industry has been developed over a hundred years while related research in Sichuan still need to be conducted. According to the recorded data of the introduced hybrids, nuts are given upon the third year, with the highest single tree yield of 2.15 kg upon the fourth year. The cultivars most suitable for growing in Sichuan Province can be found by crossing *Corylus avellana* L. and local wild accessions.

With the intention of exchanging expertise on hazelnut cultivation and improving breeding efforts, Sichuan Academy of Forestry has created a collaboration with ENEA and UNITUS under a Memorandum of Understanding in August, 2016.

The goals and the activities of MoU will be debated as a model to build long-term cooperation among the Enterprise-University-Research Institutes on a fruitful management and utilization of hazelnut (*Corylus* spp.) genetic resources.

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Tables

Table 1. Contrast on main climatic factors between hybrids' provenance and the experimental site.

Site	Elevation (m)	Mean Annual Temp (°C)	Extreme Temp (°C)		Mean Annual Rainfall (mm)	Mean Annual Sunshine Hours (h)
			Low	High		
Dalian, Liaoning	200-1500	10.5	-19.13	37.8	607	2500
Renshou, Sichuan	450-500	17.4	-4.2	39.9	1074	1202

Table 2. Adaptive traits of introduced hybrids, average of 90 plants.

Cultivars	Cold/ Freezing Damage	Heat Injury	Fungal Disease		Pest		Other Plantations Nearby
			Infection	Rate	Defoliator	ALB	
85-41	None	None	Jul-Aug	99.00%	Slightly	Slightly	Y
84-69	None	None	Jul-Aug	72.00%	Slightly	Slightly	Y
84-237	None	None	Jul-Aug	76.00%	Slightly	Slightly	Y
85-524	None	None	Jul-Aug	39.29%	Slightly	Slightly	Y
84-254	None	None	Jul-Aug	97.27%	VS	None	N
84-226	None	None	Jul-Aug	90.90%	VS	None	N
83-33	None	None	Jul-Aug	15.90%	VS	None	N
82-11	None	None	Aug	2.33%	VS	None	N
C. k.	None	None	Aug	2.00%	Slightly	None	N

ALB = Asian long-horned beetle (*Anoplophora glabripennis*)

VS = Very slightly

C. k. = *C. kweichowensis*

Table 3. Growth of eight hybrids upon the 5th year, average of 90 plants.

Cultivars	Average Ground Diameter (cm)	Average Height (cm)	Average Crown Size (cm)	Growth Habit*	Vigour*
85-41	5.865	412.50	329.70	Intermediate	High
84-69	8.190	376.00	274.10	Intermediate	Very high
84-237	5.892	388.80	236.70	Upright	High
85-524	5.865	344.60	275.00	Intermediate	High
84-254	4.241	333.00	196.99	Upright	Intermediate
84-226	5.099	278.00	179.00	Upright	High
83-33	3.923	288.40	191.30	Upright	Intermediate
82-11	4.695	286.40	204.90	Intermediate	Intermediate
C. k.	1.889	206.00	213.40	Spreading	Weak

* International descriptors

C. k. = *C. kweichowensis*

Table 4. Nut shape traits, average of 30 nuts.

Traits / Cultivars	Colour*	Shape*	Nut Top	Nut Bottom	Shell Veins
85-41	Light brown	Flat	SP	Slightly flat	Shallow
84-69	Light brown	Globular	SP	Round	Intermediate
84-237	Dark brown	Globular	SP	Flat	Shallow
85-524	Dark brown	Flat	SP	Flat	Intermediate
84-254	Dark brown	Conical	Pointed	Round	Deep
84-226	Dark brown	Globular	Pointed	Round	Intermediate
83-33	Dark brown	Long cylindrical	Pointed	Flat	Intermediate
82-11	Dark brown	Conical	SP	Flat	Shallow
C. k.	Light brown	Flat	Pointed	Flat	Shallow

* International descriptors

SP = Slightly pointed; *C. k.* = *C. kweichowensis*.

Table 5. Nut traits of the 9 cultivars, average of 30 nuts.

Cultivars	Size*			RI*	ST* (cm)	Weight*(g)	BR (%)	KR* (%)	AY (kg)
	Height(cm)	Width (cm)	Thickness(cm)						
85-41	1.950	2.075	1.991	1.04	0.135	2.31	3.33	44.8	1.060
84-69	2.331	2.322	2.092	0.95	0.174	3.46	6.67	41.0	0.875
84-237	2.035	2.307	2.100	1.08	0.153	2.35	10.10	43.5	1.150
85-524	2.031	2.272	2.086	1.07	0.163	2.77	23.33	40.5	1.000
84-254	2.098	1.886	1.812	0.88	0.172	2.41	2.34	40.2	0.940
84-226	2.478	1.951	1.836	0.76	0.136	2.69	19.44	48.1	1.767
83-33	2.345	2.092	2.017	0.88	0.158	2.65	2.86	39.5	0.563
82-11	1.944	1.937	1.929	0.99	0.177	2.45	2.78	41.5	1.020
C. k.	1.391	1.282	1.255	0.91	0.155	1.04	0	36.0	0.737

* International descriptors

RI = Roundness index; ST = Shell thickness; BR = Blank rate; KR = Kernel ratio; AY = Average yield per tree.

C. k. = *C. kweichowensis*

Figures

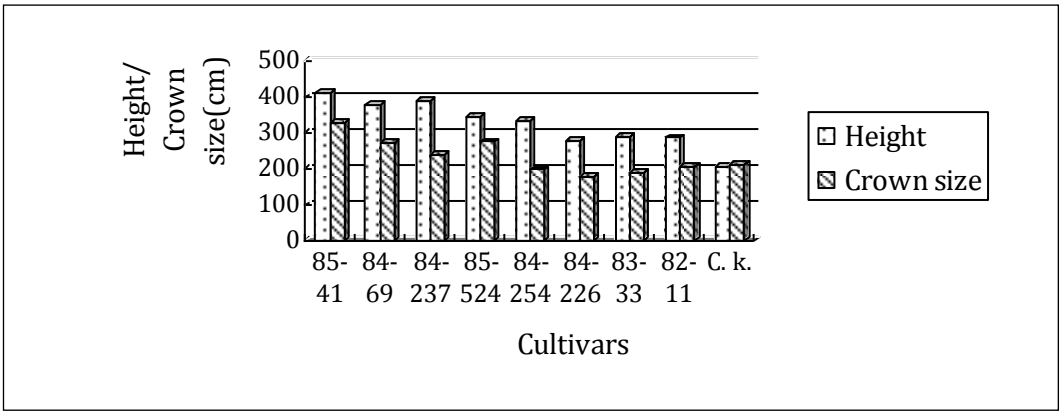

Fig. 1. Contrast on height growth and crown size growth of the 9 cultivars upon the 5th year.