第五届
国际葡萄与葡萄酒学术研讨会论文集

Proceedings of the Fifth International Symposium on Viticulture and Enology

（中国杨凌，2007，4，20-22 Yangling, China, 20-22, April, 2007）

李 华 主编 Editor Dr. Li Hua

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前　言

近年来，中国葡萄酒产量和消费量都有了大幅度提高，葡萄酒产业取得了长足发展，葡萄与葡萄酒方面的科研、教学、技术推广也取了巨大进步，中国葡萄与葡萄酒产业已经步入了发展的快车道。

VINEXPO－IWSR 的统计数据表明，2001-2005 年，中国人均葡萄酒消费量由 0.46 升提高到了 0.60 升，增长幅度为 30.43%；中国在 2004 至 2005 年间葡萄酒消费量上升了 13.06%，达到 4.232 亿升，已成为世界第十大葡萄酒消费国。有关资料预测表明，2005 至 2010 年，全球葡萄酒消费量将增长 4.8%，达到 238.825 亿公升，市场发展空间很大；2005 至 2010 年间，中国人均葡萄酒消费量会增长 35.44%，达到 0.7 升/人。在全球一体化及葡萄酒市场竞争日益激烈的形势下，我国葡萄与葡萄酒产业必须以科学发展观为指导，在保护环境的前提下，继续走可持续的发展道路，以进一步提高中国葡萄与葡萄酒产业在国际市场上的核心竞争力。

为进一步增进学术交流、提高我国葡萄与葡萄酒的科研水平、使科研成果和高新技术，尽快服务于经济建设，促进中国葡萄与葡萄酒产业的快速、健康、持续发展，今年 4 月在杨凌召开第五届国际葡萄与葡萄酒学术研讨会，该会议由国际葡萄与葡萄酒组织（OIV）、中国原产地域产品保护办公室、中国食品工业协会、中国酿酒工业协会、中国杨凌农业高新技术产业示范区管委会和西北农林科技大学共同主办，会义主题是：葡萄酒产业可持续发展。为了便于学术交流，大会学术委员会从收到的百余篇会议论文中筛选出五十余篇编辑成册，由陕西人民出版社出版，以期推动葡萄与葡萄酒产业持续生产的研究和发展。

值此会议开幕和论文集出版之际，特向本次大会的组织者、赞助单位和与会代表表示衷心的感谢！

向为本次会议付出辛勤劳动的葡萄酒学院全体员工及陕西人民出版社表示诚挚的谢意！

大会秘书长、西北农林科技大学副校长、葡萄酒学院院长
OIV 亚洲葡萄与葡萄酒科技发展中心主任　　李　华

2007 年 3 月 26 日

Preface

In recent years, Chinese grape and wine industry has achieved great development. The wine production and consumption gained an enhancement. We have made great progress in teaching, scientific research and technology extension with regard to viti-viniculture. Now Chinese wine industry is in fast lane.

According to VINEXPO—IWSR data, from 2001 to 2005, the Chinese wine consumption per capital increased about 30.41% , that is from 0.46 liters to 0.60 liters. Total national wine consumption increased 13.06% from 2004 to 2005, amounting to 0.4232 billion liters. Now China becomes one of the ten largest wine consumption nations. According to statistics, it is predicated that, from 2005 to 2010, the worldwide wine consumption will increase to 23.8825 billion liters by an increment rate of 4.8%, and the average Chinese wine consumption will increase to 0.7 liter by an increasing rate of 35.44%. Therefore, the wine market margin is still promising.

In the face of globalization and intensive worldwide competition of wine market, we should set up scientific development conceptions to guide grape and wine industry and take environmental protection and respect of human rights into consideration, thus to achieve sustainable development and to improve the core competition power of Chinese grape and wine industry.

So the *Sustainable Development of Grape and Wine Industry* is taken as the theme of the 5th International Symposium on Viticulture and Enology in Yangling this year, sponsored by Organization International de la Vigne et du Vin (OIV), National Protection Office for Geographic Produces of General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China (NPOGP-AQSIQ), China National Food Industry Association (CNFIA), China Alcoholic Drinks Industry Association (CADIA), Yangling Agricultural High-tech Industry Demonstration Zone and Northwest A & F University, organized by College of Enology of Northwest A & F University and Sci-Tech Development Center of Vitiviniculture in Asia of OIV. The Academic Committee of the Symposium selected about 50 papers out of more than 100 contributors to be published as symposium corpus by Shaanxi People's Publishing House. I hope the corpus would serve to promote the research in the sustainable viticulture and the development of wine industry.

I am extremely grateful to all of the participants, the organizers and auspices units who have contributed so much to the Symposium. Acknowledgements are also given to my colleagues of College Enology and Shaanxi People's Publishing House for their cordial hospitality and generosity.

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Dr. Li Hua
Mach 26th，2007

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Effect of Frost Indexes Change on Chinese Viticulture Zoning in Recent 45 Years

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Abstract Based on the analysis of nationwide climatic data in recent 45 years, the software *Arcgis* was adopted to map the variation of Frost Free Period (FFP), Last Frost Day (LFD), First Frost Day (FFD) and minimum temperature. The effect of those changes on Chinese viticulture zoning was studied; and based on the trend of FFP change rate, the distribution of FFP in 50 years was projected. By the research we found that: in recent 45 years, especially after 80^{th}, the duration of FFP was increased, LFD was advanced, FFD was delayed, and the bury line of -15℃ moved northwards, the variation of LFD was more significant than FFD; the variation of frost indexes was influenced by the step-terrain of China, in the same step, the acreage suffered from frost indexes change was wider, but in the areas where the step rose, the change of those frost indexes were more significant. The projection of the future showed us: the whole territory of northern china was suitable for grapevine growing, except handful of areas.

Key words Climate change Frost indexes Bury line Viticulture zoning

1 Introduction

Global warming is an undisputable fact now, as many researches (IPCC, 2001; Ding, *et al.*, 2006; Yu, 2005) shown. Global warming will affect ecological system (Xu, *et al.*, 2004; Zheng, *et al.* 2003), national economy, and agriculture bear the brunt of it. Grapevine, which belong to genus *Vitis*, is one of the most planted and highest yielded fruit of the world (Li, 2001). The acreage of Chinese viticulture area had reached 450, 000 ha. in 2004 (Federico, 2005). High quality grapevine usually distributes in lesser area, can economically bear fruit over 50 years, hence, compared to other annual or perennial plants, it's more apt to suffer from climate change (Ramakrishna, *et al.* 2001). Frost is one of the restricting factors in grapevine production: spring frost will injure the buds, which will subsequently affect the yield and quality of the berries. Sufficient FFP length is the guarantee of full grapevine berries ripeness and one of the factors decide the suitability of variety chosen. Insufficient early autumn frost will reduce the capacity of carbohydrate, which will affect the ripeness of berries, decline the accumulation of nutrition in the shoots and affect their safety of live through the winter. The shoots of *V. vinifera* just can stand the extreme temperature of -15℃ in winter, if there were occurrences of -15℃, bury is needed (He, 1999; Li, 2001). Many of researches focus on climate change issue on viticulture could be found abroad

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(Ramakrishna, *et al.*, 2001; Gregory, *et al.* 2005; Scott, 2002; Gregory *et al.*, 2000; Iñaki, *et al.* 2006; Webb *et al.* 2005; White, *et al.* 2006), but as China referred, most of their researches were focus on filed crop (Zhang *et al.*, 2001; Zhang *et al.*, 2001; Xiong *et al.* 2005). In my research ,statistical method was adopted to study the variation of FFP, bury line, LFD, and FFD, the software *Arcgis* was adopted to illustrate the variation, and the effect of climate change on Chinese viticulture was analyzed to support the decision-making of related Chinese government.

2 Data and method

2.1 Data

The meteorological data was downloaded from the website of Climatic Information Centre of China Meteorological Administration. After eliminated island weather stations far away from continent, the weather stations which had history of station transition, and those whose time series were shorter than 45a, and those stations abruptly higher than ambient environment, there were 504 weather stations available (Fig. 1). If there were missing data observations less than 10d in the time series, the average value fore-and-aft the missing ones will be chose to replace the missing data.

2.2 The chosen of frost indexes

FFP, LFD, FFD and the extreme annual minimum temperature were adopted as frost factors. FFD was defined as the length of days from the last occurrence of spring frost fall to the first appearance of frost fall in autumn, sufficient FFD could guarantee the grapevine berries ripeness, and the full accumulation of carbohydrate in new shoots to stand winter coldness (He, 1999; Li, 2001). Generally, suitable FFD length for grapevine production range from 160d to 220d in China; the areas where FFD is shorter than 160d is not suitable for grapevine growing; theoretically the place where FFD is longer than 220d is suitable for any type of variety, but the wine quality will suffer (Li, *et al.* 2005). LFD was the time of the last occurrence of 0℃ in spring, and FFD was defined as the first of 0℃ appearance in fall. Late spring frost will freeze the buds, and the variation of LFD and FFD will affect the suitability of viticulture. The criterion of bury was: if there were occurrences of -15℃, bury is needed (He, 1999; Li, 2001).

2.3 The treatment of frost indexes

Based on daily minimum temperature observation, the length of FFD of each weather station in the past 45a was calculated to obtain a 45a FFD time series, and linear regression was conducted to obtain the regression coefficient as tendency index for recent 45a, the equation is following: $y=a+bt$, and b was the tendency index. Based on the tendency index of all weather stations, the software *Arcgis* was adopted to map the distribution of FFD variation tendency for China in recent 45a. The average FFD data of 10a length (1964-1973, 1974-1983, 1984-1993, 1994-2003) was mapped also by the software *Arcgis* to reflect the evolution of FFD in 10a span. The same treatment was applied to LFD and FFD to reflect the effect of climate change.

14 current grapevine growing regions and microclimate grapevine growing regions were chosen (Table 1) to study the effect of climate change on wine regions, according to current wine production of China. The daily meteorological data were averaged by region, and were subtracted to create series anomalies of 45a, and then the time series were analyzed for trends using linear regression. Regression coefficients were adopted to reflect the tendency of the FFD in those grapevine growing regions. The same treatment was applied to analyze the variation of LFD and FFD in regional range.

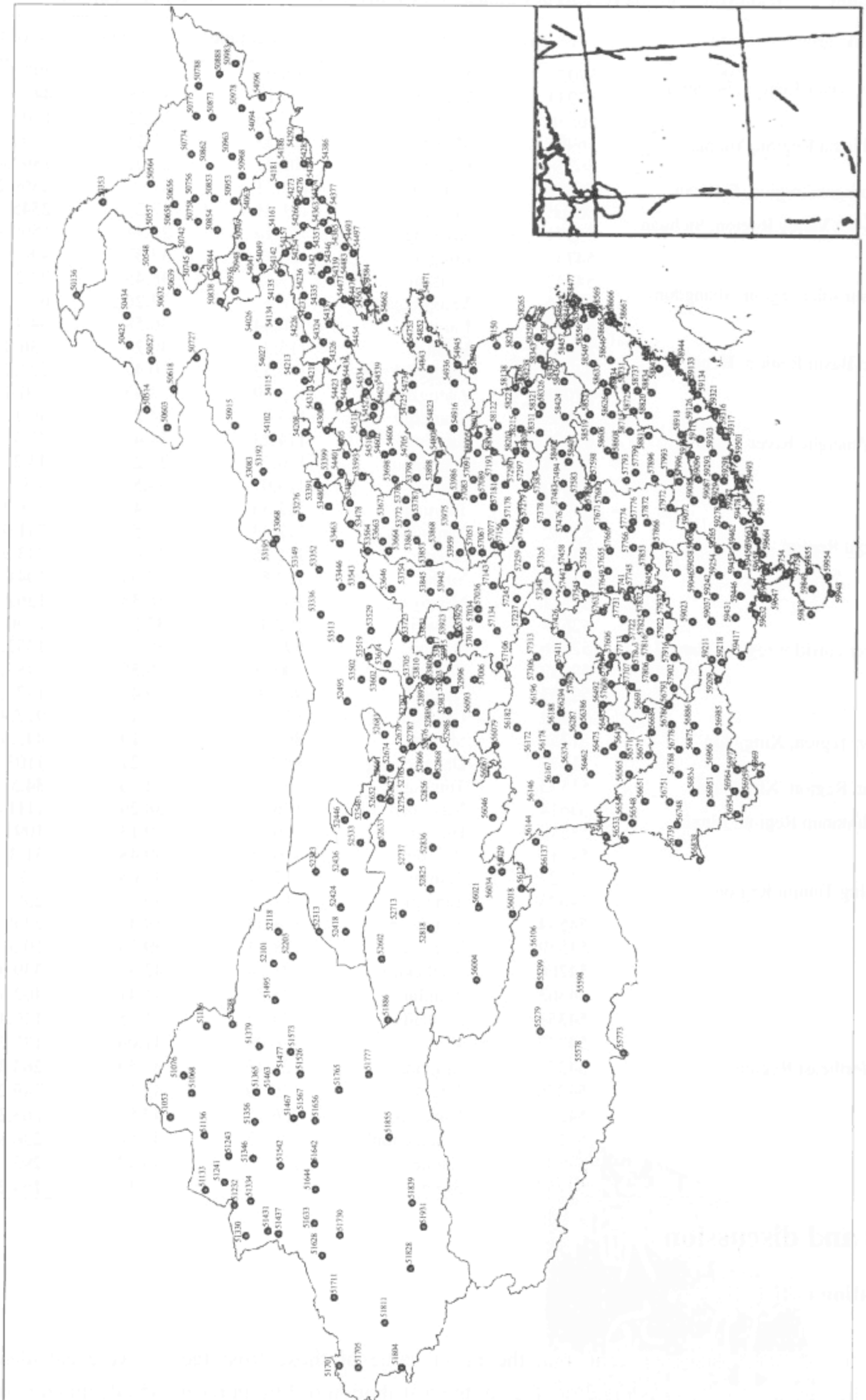

Fig. 1 The distribution of weather stations

Table 1 Grapevine growing regions of China and the representative weather stations adopted

Grapevine growing region	Ws No.	Ws names	Longtitude	Latitude	Altitude
Northern Wei River Region, Shannxi	57036	Xi'an	108.93	34.3	397.5
	57034	Wugong	108.13	34.15	447.8
Yunnan Plateau Region, Yunnan	56886	Luxi	103.46	24.32	1704.3
	56985	Menzi	103.23	23.23	1300.7
	56778	Kunming	102.41	25.01	1892.4
Xiaojin ecological region, Sichuan	56178	Xiaojin	102.21	31	2369.2
Southwest Dry-hot Valley Region, Sichuan	56565	Yanyuan	101.31	27.26	2545
	56571	Xichang	102.16	27.54	1590.9
Shangdong Peninsular region, Shangdong	54753	Longkou	120.19	37.37	4.8
	54843	Weifang	119.11	36.45	22.2
	54736	Yangjiaogou	118.4	37.26	6
	54852	Laiyang	120.44	36.58	54.4
Huaizhuo Basin Region, Hebei	54405	Huailai	115.3	40.24	536.8
	54401	Zhangjiakou	114.53	40.47	724.2
Former Huanghe River Region	57083	Zhengzhou	113.39	34.43	110.4
	58005	Shangqiu	115.4	34.27	50.1
	57091	Kaifeng	114.23	34.46	72.5
	58015	Shanshan	116.2	34.25	43.2
	58040	Ganyu	119.07	34.5	3.3
Qingxu Region, Shanxi	53772	Taiyuan	112.33	37.47	778.3
	53782	Yangquan	113.33	37.51	741.9
	53863	Jiexiu	111.55	37.02	743.9
	53787	Yushe	112.59	37.04	1041.4
Western river corridor region, Gansu	52681	Mingqin	103.05	38.38	1367
	52679	Wuwei	102.4	37.55	1530.9
	52546	Gaotai	99.5	39.22	1332.2
	52652	Zhangye	100.26	38.56	1482.7
	52533	Jiuquan	98.29	39.46	1477.2
Shihezi region, Xingjiang	51463	Urumchi	87.37	43.47	917.9
	51356	Shihezi	86.03	44.19	442.9
	51477	Dabancheng	88.19	43.21	1103.5
Tulufan Region, Xingjiang	51573	Tunufan	89.12	42.56	34.5
Henan Mountain Region, Linxia	53614	Yinchuan	106.13	38.29	1111.4
	53519	Huinong	106.46	39.13	1091
Beijing Tianjin Region	54511	Beijing	116.28	39.48	31.3
	54527	Tianjin	117.04	39.05	2.5
	54623	Tanggu	117.43	39	2.8
	54534	Tangshan	118.09	39.4	27.8
	54539	Yueting	118.53	39.26	10.5
Northeast Region	54266	Meihekuo	125.38	42.32	339.9
	54363	Tonghua	125.54	41.41	402.9
	54351	Zhangdan	124.05	41.55	120.4
	54377	Ji'an	126.09	41.06	177.7
	54273	Linjiang	126.45	42.59	263.3
	54276	Jingyu	126.49	42.21	549.2
	54273	Huadian	126.45	42.59	263.3
	54161	Changchun	125.13	43.54	236.8
	54181	Jiaohe	127.2	43.42	295
	54157	Siping	124.2	43.11	164.2

3 Results and discussion

3.1 The variation of frost factors

3.1.1 Outline

Based on the climatic data of recent 45a, the mean value of those frost factors were calculated, and illuminated by the Software *Arcgis*. As Fig.2 (a) shown: the distribution of FFP in recent 45a declined northwards and westwards. The FFP of Tulufan Region, Southwest Dry-hot Valley Region, Yunnan Plateau Region, Former

Huanghe River Region surpassed 220d; the FFP of Shangdong Peninsular region, Northern Wei River Region and Beijing Tianjin Region were range from 200d to 220d; the FFP of Qingxu Region, Huaizhuo Basin Region and Changli were between 180-220d; the length of FFP of Shihezi region, Western river corridor region and Henan Mountain Region were range from 160-180d; the FFP of Northeast Region was shorter than 160d, was only suitable for those wild grapevine *V. amurens* (Maxim.) Rupr. of strong resistance of coldness and relatively short growing length to produce wild grapevine wine The distributions of LFD and FFD in recent 45a were shown in Fig. 2 (b) and Fig. 2 (c) respectively. We could found that the distributions of LFD and FFD were similarly: the wine regions situated in the same LFD span were usually situated in the same FFD span, which indicated that these two factors were strongly coherent.

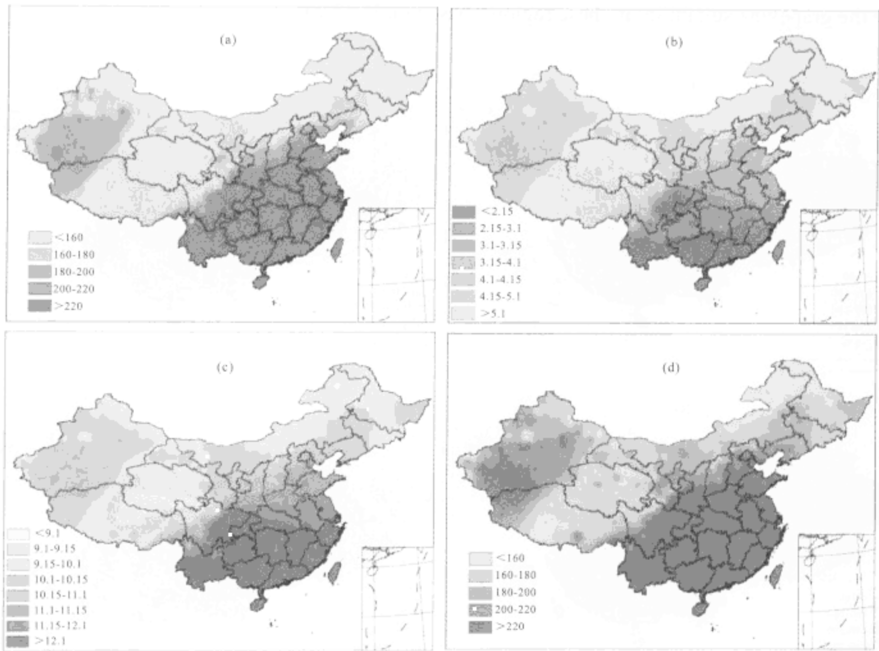

Fig.2 The maps of average values of main frost indexes distribution in past 45a and the projection of FFD distribution from 2054-2063 for China

(a) The average distribution of FFP in past 45a; (b) The average distribution of LFD in past 45a

(c) The average distribution of FFD in past 45a; (d) Estimate distribution of FFP from 2054-2063

3.1.2 The variation of FFP

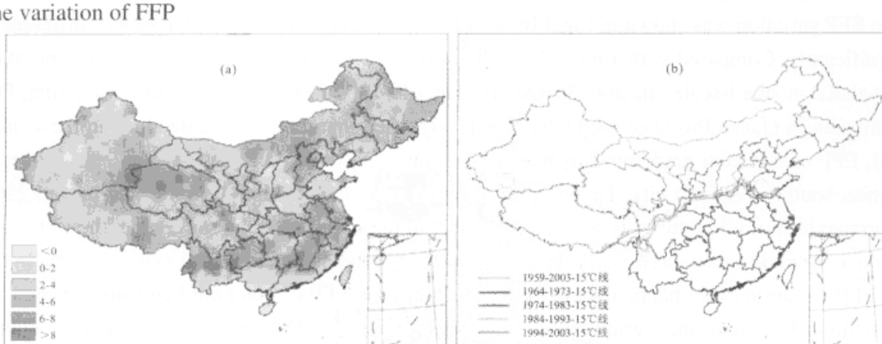

Fig.3 (a) The trend of FFP distribution and (b) the variation of -15℃ bury line in the past 50a for China

Fig.3 (a) showed the tendency of FFP over the past 45a. As the map showed, there was no clear rule for FFP variation; and the variation of FFP was different even in the same grapevine growing region. The FFP in Yunnan Plateau Region varied most significantly, and its change rate surpassed 8d/10a; the change rate in Huaizhuo Basin Region, Tunufan Region and Xiaojin Ecological Region reached 6-8d/10a; Beijin, Yantai in Shangdong Province, Former Huanghe River region, Meihekou and Liaoyuan in Jilin Province reached 4-6d/10a; the FFP in Changli region, Northern Wei River Region, Shangdong Peninsular Region and most of Northeast Region reached 2-4d/10a; the FFP of Qingxu Region, Henan Mountain Region and Shihezi Region varied not sharply, just reached 0-2d/10a; but at the same time, in some areas of Qingxu Region and Shihezi Region, the FFP declined. We could find out that: in most of grapevine growing region of China, the FFP increased 10d-20d in the past 45a, which could change the grapevine suitability in these regions, based on Fig.2(a).

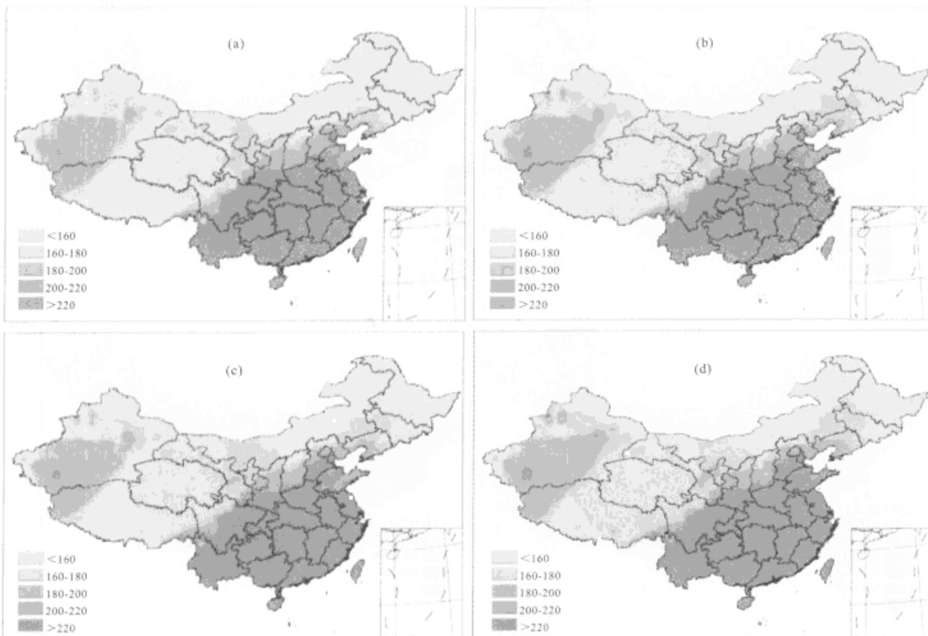

Fig.4 The variation of FFP from 1964-2003 in 10a stage for China

(a) the distribution of FFD from 1964 to 1973(b) the distribution of FFD from 1974 to 1983

(c) the distribution of FFD from 1984 to 1993 (d) the distribution of FFD from 1994 to 2003

10a span FFP variation was shown in Fig.4 In recent 40a, especially after 1984, the FFP of different gradients increased significantly. Compared with 1960s, the variation of FFP in 1970s was not significant, only the areas in Northeast expanded in small-scale, meanwhile, the areas of 160-180d FFP in western Inner Mongolia, Dunhuang, Wuwei and Jiuquan in Gansu Province withdrew largely, signified that temperature declined in these areas. From 1983 to 2003, FFP of different gradients expanded significantly northwards and westwards, the FFP in southern Heibei Province, southern Beijing city, Tianjin city and most areas of Shandong Province surpassed 220d, which implied that grapevines of all maturity type were culturable in these areas. At the same time, the FFP of 160-180d in Western Inner Mongolia recovered to the level of 1960s, and the areas recovered expanded much wider. The most violent FFP variation event happened in Northeast China, and FFP in Liaoning Peninsula reached 180-200d, means that medium-late maturing variety could mature in this area. The FFP in Three Rivers Plain reached 160-180d, theoretically, early and medium maturing varieties were plantable, but because it is too cold in winter in this area, freezing injury in winter and frost attack in spring should be take care. Meanwhile, the variation of FFP in Xingjiang Province was not significant. China is a step-terrain country, the altitude increases gradually westwards. The distribution of FFP is significantly effected by the step-terrain, the expansion of FFP in the areas where altitude raise quickly was restrained (the transition regions from Southwest China to Tibet Plateau, the transition regions from Shaanxi Province and Shanxi Province to Loess Plateau; and the transition regions from Hebei Province to Mongolia Plateau. etc.), but in the same step, where the terrain was relatively plain, the variation of FFP was very remarkable in acreage.

3.1.3 The variation of LFD

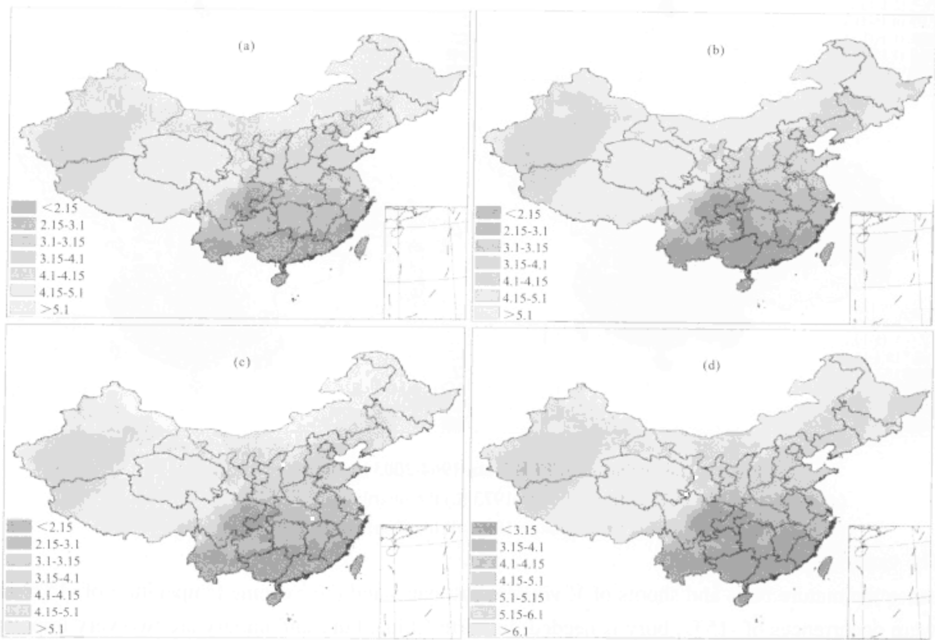

Fig.5 The variation of FFP from 1964-2003 in 10a stage for China

(a) the distribution of LFD from 1964 to 1973 (b) the distribution of LFD from 1974 to 1983

(c) the distribution of LFD from 1984 to 1993 (d) the distribution of LFD from 1994 to 2003

The variations of LFD in 10a span were shown in Fig. 5. Similar with FFP, the LFD of Inner Mongolia, Gansu Province and Xingjiang Province were largely delayed. Different from the changing rule of FFP, of which the variation were not significant, the LFD in Shangdong Province, Henan Province and Shanxi was advanced. In 1990s, the variation of LFD in Northeast were among the most significant, the last frost of western Jilin Province, southwest Heilongjiang Province were and Three River plain were advanced to the span from 15th Apr. to 1th May. The rule of LFD variation were similar with the rule of FFP, but even in the 1990s, the LFD of Gaotai and Dunhuang in Gansu province did not recovered to the level of 1960s. Similar with FFP, the variation of LFD was significantly restricted by the terrain.

3.1.4 The variation of FFD

After study Fig. 6, we could found out that the variation of FFD was more constantly than that of LFD. Different from the shrunk of FFP and LFD in 1970s, FFD was constantly delayed nation wide, but the variation were much gently than those of FFP and LFD, which implied that the warming-up in fall was less acutely than LFD, so, the length of FFP were largely due to LFD.

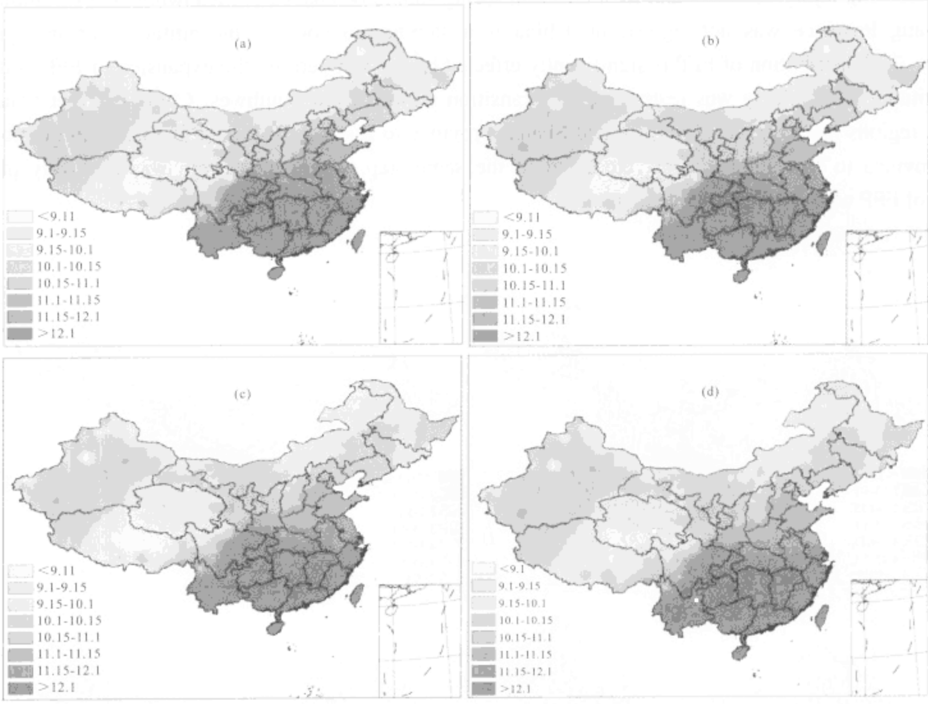

Fig.6 The variation of FFD from 1964-2003 in 10a stage for China

(a) the distribution of FFD from 1964 to 1973 (b) the distribution of FFD from 1974 to 1983

(c) the distribution of FFD from 1984 to 1993 (d) the distribution of FFD from 1994 to 2003

3.1.5 The variation of bury line

Because the mature buds and shoots of *V. vinifera* just can stand the extreme temperature of -15℃ in winter, if there were occurrences of -15℃, bury is needed. In north China, bury and unbury are two very important parts of annual work programme, and they are also very expensive, which take up 2/3 of annual budget. The variation of FFD will directly influence the arrangement of annual work programme and cost of wine production. The variation of bury line in recent 40a was shown in Fig.3 (b). As the Figure shown, the bury line wriggled along the transition areas of first and second step of China. There were no significant variation before 1984, and the middle and western part of the line was much more stable than any other part of it. In 1980s, the bury line moved northwards in southern Heibei Province and western Shangdong Province, but meanwhile, the line in southwest retreated. In 1990s, the bury line thoroughly moved northwards. The line moved northwards largely in eastern Tibet and western Sichuan Province, and moved northwards in small scale in Gansu, Shaanxi and Shanxi Province. The eastern part of the line varied much more significantly, which freed the vast areas of southeast Shanxi, the whole territory of Shangdong Province, southeren Hebei and the southernmost Beijing of bury, furthermore, an small area in Hetian in southern Xinjiang Province did not need to bury their grapevine in winter anymore.

3.1.6 The projection of FFP from 2044 to 2053

Based on the FFP change rate of recent 45a, the distribution of FFP from 2044-2053 was projected and mapped Fig.2 (d) The map showed us that: in most areas of China, except some in northeast Inner Mongolia and northwest Heilongjiang, will be viticulturable. Most current wine regions' FFP will surpass 220d, which means any variety will be culturable. The FFP in Qingxu Region will achieve 200-220d; the FFP of Western River