甘肃省近 58 年春旱的气候特征及其对农业的影响

林婧婧，申恩青，刘德祥

(1.中国气象局兰州干旱气象研究所，甘肃省干旱气候变化与减灾重点实验室，中国气象局干旱气候变化与减灾重点开放实验室，甘肃 兰州 730020；2.兰州区域气候中心，甘肃 兰州 730020)

摘 要：利用甘肃省 80 个气象观测站 1951～2008 年的春季(3～4 月)历年降水量距平百分率确定干旱标准，统计分析历年春旱发生的频率和范围。结果表明：甘肃省春旱发生频率比较高，其频率范围为 30%～50%，河西走廊为 40%～50%，陇中北部和陇东为 40%左右，陇中南部、陇南和甘南高原为 30%左右。全省春旱频率呈增加趋势，河西、陇东和陇南呈增加趋势，陇中趋势平稳，2000～2008 年全省及各地春旱次数都在迅速增加。在近 58 年中，全省春旱范围的历年变化呈逐渐扩大趋势，陇东和陇南与全省相同，河西和陇中呈逐渐缩小趋势。

关键词：甘肃省；春旱频率；春旱变化；农业

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在全球气候变暖的背景下，甘肃省 20 世纪 90 年代气温普遍呈显著升高趋势；全省年平均降水量总体呈明显减少趋势，河东(以黄河为界，下同)呈明显减少趋势。气候呈现暖干化趋势，气候变暖导致极端干旱事件频繁发生。在近 18 年(1991～2008 年)中，有 14 年出现不同程度的干旱，其中 8 年为严重干旱年。气候暖干化对甘肃农业和生态环境产生的不良影响，引起了政府决策部门和公众的广泛关注。近年来，有关专家对西北和甘肃省的气候变化研究比较多[1～6]，为人们增强对气候变化的认识做出了有益贡献。气候变化对甘肃省农业生产的影响也有不少研究[7～10]，对提高人们认识气候变暖对农业生产的利弊影响做出了贡献。甘肃省大部分地方为干旱和半干旱气候，特别是河东雨养农业区，既是气候变化敏感区，又是生态环境脆弱带，农业生产对降水量的变化响应最为敏感。本文主要深入研究气候变化对春旱发生的频率、范围、严重程度、变化规律及其农业生产的影响。其目的是为了提高干旱监测、预测和影响评估的能力，也对防旱减灾、粮食安全生产、农业可持续发展、应对气候变化方案制定都有十分重要的意义。

1 资料与方法

本文利用甘肃省 80 个气象观测站 1951～2008 年春季(3～4 月)历年降水量资料，计算了降水量距平百分率，平均值根据世界气象组织规定用 1971～2000 年的资料计算。春旱标准采用气候业务中常用的标准，其标准是 3～4 月降水量距平百分率在 -50%～-20%之间为轻旱；< -50%为重旱。将某区域在该时段 25%站以上达到春旱标准确定为区域春旱。依据上述标准，考虑到资料开始年份的一致性，每个气象台站的春旱频率用 1971～2008 年资料计算，然后根据单站历年春旱的情况，分别统计了全省轻旱和重旱的站数，表示其范围。

2 春旱的空间分布特征

甘肃省春旱发生的频率比较高，其频率在 30%～50%之间(图 1)。其中河西走廊春旱发生的频率为 40%～50%，是春旱发生频率最高的区域，由于是灌溉农业区，只要上年冬前灌溉比较好，对春播作物的影响并不十分严重。陇中北部和陇东发生频率为 40%左右，是春旱发生频率次高的区域；陇中南部、陇南和甘南高原发生频率为 30%左右，是春旱发生频率较小的区域。河东是旱作农业区，农作物所需的水分主要依靠自然降水，是春旱对农业生产影响最严重的区域，春旱往往影响春播作物的按时播种和出苗，也影响冬小麦、牧草正常返青生长，给农业生产造成严重影响，也使牲畜春乏加重。

3 春旱的年代际变化

3.1 春旱频率的年代际变化

全省春旱频率在上世纪 60 年代至 2008 年呈增

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作者简介：林婧婧(1984—)，女，新疆精河人，助理工程师，从事干旱气候变化和影响评估研究。E-mail：lin_jingjing_2003@126.com。

加趋势。河西春旱频率在20世纪50年代至80年代呈增加趋势,其中60年代有所减少。陇中春旱频率在60~90年代变化平稳,陇东和陇南在20世纪50年代~90年代呈增加趋势。2000~2008年全省及各地春旱次数都在迅速增加,尤其是陇中、陇东、陇南自2000年以来平均一年左右就有春旱发生(表1),这与1990年以来河东降水量的迅速减少有关。

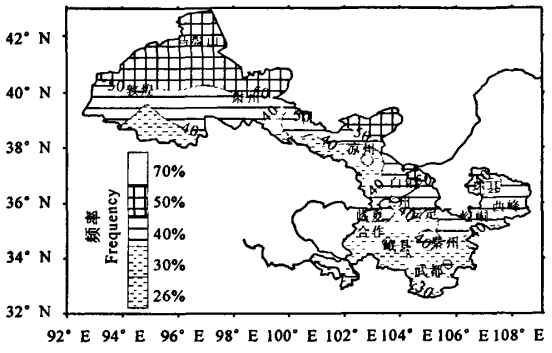

图1 甘肃省1971~2008年春旱年频率

Fig.1 The frequency of spring drought year in Gansu Province between 1971 and 2008

表1 甘肃省各年代区域春旱出现频率

Table 1 The frequency of spring drought in Gansu Province in past years

年代 Year	频率 Frequency(%)				
	全省 Whole province	河西 Hexi	陇中 Longzhong	陇东 Longdong	陇南 Langnan
1950s	78	89	67	33	44
1960s	60	60	50	30	40
1970s	70	80	50	40	40
1980s	60	100	50	50	60
1990s	60	50	50	40	50
2000~2008	80	60	70	80	70

3.2 春旱范围的变化

全省春旱范围在近58年中的历年变化呈逐渐扩大趋势(图2),在近58年中仅有2年没有出现春旱,春旱范围比较小(春旱站数占总站数的百分比在10%以下,下同)的共4年,大范围(春旱站数占总站数的百分比在40%以上,下同)的共27年,平均2年左右出现一次大范围的春旱。

在近58年中各地春旱范围的变化趋势略有不同。河西春旱范围呈逐渐缩小趋势(图略,下同),在近58年中仅有2年没有出现春旱,春旱范围比较小的共4年,大范围的春旱共36年,平均2年左右出现一次。

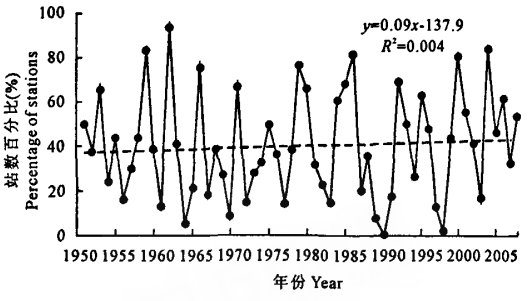

图2 甘肃省1951~2008年春旱站数占总站数的百分比历年变化

Fig.2 The yearly variations of spring drought stations as percentage of the total stations in Gansu Province between 1951 and 2008

陇中春旱范围呈微弱的缩小趋势,在近58年中仅有6年没有出现春旱,春旱范围比较小的共9年,大范围的春旱共28年,平均2年左右出现一次。

陇东春旱范围呈逐渐扩大趋势,在近58年中有17年没有出现春旱,春旱范围比较小的共8年,大范围的春旱共21年,平均3年左右出现一次。

陇南春旱范围呈逐渐扩大趋势,在近58年中仅有16年没有出现春旱,春旱范围比较小的共7年,大范围的春旱共25年,平均3年左右出现一次。

表2 甘肃省各年代春旱站数占总站数百分比的平均值(%)

Table 2 The average of spring drought stations as percentage of the total stations in years

年代 Year	全省 Whole province	河西 Hexi	陇中 Longzhong	陇东 Longdong	陇南 Langnan
1950s	44	47	49	30	31
1960s	37	50	37	24	36
1970s	36	48	40	33	24
1980s	41	58	34	36	39
1990s	33	33	38	27	32
2000~2008	52	43	47	73	56

全省春旱范围年代际变化,20世纪60年代至80年代呈增加趋势,90年代有所缩小(表2)。河西在20世纪50年代至80年代呈增加趋势,90年代有所缩小。陇中、陇东和陇南在20世纪60年代至90年代呈增加趋势,其中陇东90年代有所缩小。2000~2008年全省及各地春旱范围迅速扩大。全省和各地春旱范围的年代际变化与春旱频率变化基本一致,在春旱范围扩大的年代,干旱频率也在增加。

4 春旱对农业的影响

近50多年来春旱是危害甘肃农业的主要气象灾害,平均三年一小旱,十年一大旱。春旱较轻的年

份,影响春播作物不能按时播种或出苗,影响冬小麦、牧草正常返青生长。春旱严重的年份,使春播作物不能播种或出苗后枯死,也使冬小麦和牧草枯萎或枯死,使一些地方颗粒无收,给人民生活造成严重影响。进入 20 世纪 90 年代以来,在气候变暖的背景下,甘肃气候的暖干变化趋势,使春旱对农业影响的范围、程度都显现出扩大和加重之势,也使人、畜饮水困难加重(表 3)。如 1995 年出现全省性严重春旱,干土层普遍有 8 ~ 20 cm,不少地方干土层达 30 cm 左右。全省各河流来水量减少 2 ~ 9 成,河水锐减,小溪普遍断流。有近百座小型水库干涸。全省 2.9 万眼机井水位下降 1 ~ 3 m,造成 23.34 万 hm^2 水浇地失灌。全省粮食受旱面积达 187.06 万 hm^2,其中夏粮受旱面积为 134.14 万 hm^2,占夏粮播种面积的 78.2%。粮田失种 15.34 多万 hm^2,其中夏粮失种 2.27 万 hm^2,大秋田失种 13.34 多万 hm^2。全省 300 多万人,200 多万头牲畜饮水极度困难。在省中部、陇东有 40 多万人需翻山越岭到 10 ~ 40 km 外取水度日,每桶水价高达 5 ~ 10 元。2007 年在河东出现的严重春旱,使旱作区夏粮生产受到严重威胁,泾河断流 70 多天。全省农作物受旱面积 102.57 万 hm^2,其中绝收 8.656 万 hm^2,134.42 万人、73 万头牲畜饮水困难,221.54 万人缺粮。

表 3　甘肃省严重春旱年对农业的影响

Table 3　The influence of the serious spring drought years on agriculture in Gansu Province

年份 Year	春旱情况 Situation of spring drought
1953	全省农作物受旱面积 836 千 hm^2,全省夏粮减产 57%。The area of drought-stricken farmland was 836 000 hectares, resulting in 57% output reduction of summer crops.
1959	全省农作物受旱面积 68.7 千 hm^2,40 县缺口粮的灾民 162 万人,浮肿等病人增至 9.6 万人,外流达 7 万人,死亡人口近 1 万。The area of drought-stricken farmland was 68 700 hectares, 1.62 million people in 40 counties suffered shortage of food, 96 000 people were sick because of hunger, 70 000 people had to flowed out, and nearly 10 000 people died.
1960	全省有 47 县受灾,农作物受旱面积 1178 千 hm^2,100 万人严重缺乏口粮。The area of drought-stricken farmland was 1.178 million hectares in 47 counties, and 1 million people suffered serious shortage of food.
1961	农业受灾面积 221.9 千 hm^2,受灾人口 124.3 万人。粮食减产 0.75 亿 kg。The area of drought-stricken farmland was 221 900 hectares, resulting in a reduction of 75 million kg of grain output, and 1.243 million people were involved.
1963	全省 26 县市受旱,农业旱灾面积 548.67 千 hm^2。The area of drought-stricken farmland was 548 670 hectares in 26 counties.
1966	全省农业旱灾 980.0 千 hm^2。The area of drought-stricken farmland was 980 000 hectares.
1971	全省农业旱灾面积 1154 千 hm^2,成灾面积达 886.7 千 hm^2。The area of drought-stricken farmland was 1.154 million hectares, of which 886 700 hectares suffered badly.
1974	农业旱灾面积 573 千 hm^2,460 万人缺口粮。The area of drought-stricken farmland was 573 000 hectares, and 4.60 million people suffered food shortage.
1979	受旱 70 县,旱灾面积 874.0 千 hm^2。全省粮食减产约 65907.5 万 kg,减产棉花 19.3 万 kg,死羊 21.7 万只。The area of drought-stricken farmland was 874 000 hectares, resulting in a reduction of output of 659.075 million kg of grains and 193 000 kg of cotton, and the death of 217 000 head of sheep.
1980	全省农业旱灾面积 584.05 千 hm^2,减产粮食约 54442.7 万 kg,减产棉花 8.46 万 kg,减产油料 1068.90 万 kg,特重灾民 79.33 万人,重灾民 255.24 万人,死亡大牲畜 1.5 万多头,死亡羊只 13.5 万多只。The area of drought-stricken farmland was 584 050 hectares, resulting in a reduction of the output of 544.427 million kg grains, 84 600 kg cotton, 1.0689 million kg oil-bearing stuff. Some 2.5524 million people suffered the disaster and 79 330 people suffered badly, and 15 000 head of heavy livestock died, the death of 135 000 head of sheep.
1984	农作物受旱面积 1192.7 千 hm^2,减产粮食 1341 万 kg。The area of drought-stricken farmland was 1 192 700 hectares, resulting a reduction of the output of 13.41 million kg grains.
1985	全省农业旱灾面积 175.1 千 hm^2。The area of drought-stricken farmland was 175 100 hectares.
1986	旱灾 614.49 千 hm^2,减产 5 成以上的有 289.3 多千 hm^2,因灾死亡大家畜 2.9 万多头,死亡羊 17.6 万多只。The area of drought-stricken farmland was 614 490 hectares, of which 289 300 hectares had 50% reduction of output, and over 29 000 head of big livestock and 176 000 head of sheep died.
1990	全省受旱面积 313.5 千 hm^2,近 200 千 hm^2 旱地农作物大幅度减产或绝收。The area of drought-stricken farmland was 313 500 hectares, of which nearly 200 000 hectares had large range of output reduction or even no output.
1992	全省农作物受旱面积 196.2 千 hm^2,天水市冬麦因旱灾死苗需改种有 17.4 千 hm^2。The area of drought-stricken farmland was 196 200 hectares, of which 17 400 hectares in Tianshui suffered seedling death.
1995	全省农作物受旱面积为 1340 千 hm^2,125 万人、117 万头牲畜饮水发生困难。The area of drought-stricken farmland was 1.34 million hectares, and 1.25 million people and 1.17 million head of livestock had not enough water do drink.
1997	全省有 52 个县受干旱影响,农作物受灾面积 312.1 千 hm^2。The area of drought-stricken farmland was 312 100 hectares in 52 counties.

续表3

年份 Year	春旱情况 Situation of spring drought
1999	全省冬小麦翻种或改种达163.3千 hm^2,死苗37.3千 hm^2,绝收45.3千 hm^2。Some 163 300 hectares of winter wheat had to be ploughed out to sow again or sow other crops. Seedlings in 37 300 hectares died and no harvest was got in 45 300 hectares.
2000	全省农田受灾面积1622.3千 hm^2,1390千 hm^2 成灾,85.3万人及63万头牲畜饮水困难。The area of drought-stricken farmland was 1 622 300 hectares, and 853 000 people and 630 000 head of livestock had not enough water do drink.
2001	全省农作物受旱面积达601.7千 hm^2,其中严重受旱554.7千 hm^2。12万人、11万头牲畜饮水困难。The area of drought-stricken farmland was 601 700 hectares, of which 554 700 hectares suffered badly, and some 120 000 people and 110 000 head of livestock had not enough water do drink.
2003	全省农作物受旱面积1233.3千 hm^2,其中重旱约660千 hm^2,27万人饮水难。The area of drought-stricken farmland was 1 233 300 hectares, of which 660 000 hectares suffered badly, and 270 000 people had not enough water do drink.
2005	全省农作物受旱面积325.7千 hm^2,10多万人、30多万头大家畜饮水困难。The area of drought-stricken farmland was 325 700 hectares, and some 100 000 people and 300 000 head of livestock had not enough water do drink.
2006	全省农作物受灾面积为118.4千 hm^2,有98300人和143200头牲畜饮水困难。The area of drought-stricken farmland was 118 400 hectares, and some 98 300 people and 143 200 head of livestock had not enough water do drink.
2007	全省农作物受旱面积1025.7千 hm^2,绝收86.56千 hm^2,134.42万人、73万头牲畜饮水困难,221.54万人缺粮。The area of drought-stricken farmland was 1.0257 million hectares, of which 86 560 hectares had no harvest, and some 1.3442 million people and 730 000 head of livestock had not enough water do drink, meanwhile 2.2154 million people suffered food shortage.
2008	河西106.7千 hm^2 地不能正常灌水,浅山雨养农田受旱面积18千 hm^2,牧区草场受旱面积2.58万 km^2,约22万人和68万头(只)牲畜饮水困难。Some 106 700 hectares of farmland in Hexi Corridor could not get regular irrigation, and the drought-stricken area of farmland in mountainous rain-fed regions was 18 000 hectares, while that of grassland was 25 800 km^2. About 220 000 people and 680 000 head of livestock had not enough water do drink.

5 小 结

1)甘肃省春旱发生频率比较高,其频率在30%~50%之间,河西走廊为40%~50%,陇中北部和陇东发生频率为40%左右,陇中南部、陇南和甘南高原发生频率为30%左右。

2)全省春旱频率在20世纪60年代至2008年呈增加趋势。河西、陇东和陇南呈增加趋势,陇中趋势平稳,2000~2008年全省及各地春旱次数都在迅速增加。

3)在近58年中,全省春旱范围的历年变化呈逐渐扩大趋势,河西和陇中呈逐渐缩小趋势,陇东和陇南春旱范围呈逐渐扩大趋势。

4)进入20世纪90年代以来,春旱对农业影响的范围、程度都显现出扩大和加重之势,也使人、畜饮水困难加重。

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Simulation of the development of apple in Tianshui

HU Li-ping[1,2], PEI Gu-e[3], YAO Yan-feng[1], AN Jing[1], LIU Xiao-qiang[1]

(1. *Tianshui Meteorological Bureau, Tianshui, Gansu 741018, China*; 2. *Agrometeorological Experiment Station of Tianshui, Tianshui, Gansu 741020, China*; 3. *Meteorological Bureau of Wushan, Wushan, Gansu 741300, China*)

Abstract: Using experimental data in Maiji area of Tianshui in the valley of Weihe River, a simulation model for apple development was developed based on the concept of physiological development time (PDT) and the photo-thermal reactions of apple in Tianshui. The model was validated by independent experimental data from Qin'an of the north of Wei River and Qingshui of the area of Guanshan Mountains. The results showed that the model could predict better the time of emergence and the sustained number of days of various developmental stages simulated results agreed well with the measured ones. The absolute forecast error of the model is typically less than 7 days in the various development stages of apple, the root mean squared error(RMSE) of simulated and observed values is respectively 2.4, 0.9, 2.7, 4.0, 4.0 days when apple reaches leaf bud open, unfolds leaf peak, flowering peak, fruit mature period and leaf starts to change color development period, the forecast error of sustained the number of days in various development stages is respectively 2.4, 2.0, 2.3, 4.0, 3.4 days.

Keywords: Tianshui; apple; physiological development time; simulation model

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Climatic characteristics of drought and it's influence on agriculture in Gansu Province in the past 58 years

LIN Jing-jing, SHEN En-qing, LIU De-xiang

(1. *Institute of Arid Meteorology of China Meteorological Administration, Key Laboratory of Arid Climatic Change and Reducing Disaster of Gansu Province, Key Open Laboratory of Arid Climate Change and Disaster Reduction of CMA, Lanzhou, Gansu 730020*; 2. *Lanzhou Regional Climate Center, Lanzhou, Gansu 730020, China*)

Abstract: The frequency and range of yearly spring drought were calculated based on the data of precipitation in spring season (March to April) of 1951 – 2008 from 80 meteorological observations in Gansu Province. The precipitation anomaly percentage was the measure of spring drought. The following results were obtained: Gansu had a high frequency of spring drought that ranged from 30 to 50 percent. The frequency of spring drought in Hexi Corridor was from 40 to 50 percent. In the north of Longzhong and Longdong regions, the frequency was nearly 40 percent. In the south of Longzhong, Longnan and Gan'nan plateau, the frequency was nearly 30 percent. The frequency of spring drought in Gansu Province and in Hexi Corridor, Longdong, Longnan regions showed increasing trend, but it showed smooth trend in Longzhong. The number of spring drought was on rapid increase over the province and in different regions from 2000 to 2008. In the past 58 years, the yearly variations of spring drought range showed gradually expanding trend in Longdong and Longnan regains and the whole province, but showed gradually narrowing trend in Hexi Corridor and Longzhong regions.

Keywords: Gansu Province; frequency of spring drought; change of spring drought; agriculture