Study on the Strengths and Weaknesses of Agricultural Climate Resources during Summer Drought in Guizhou Province

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Abstract In order to quantitatively assess the objective impact of light, heat and water agricultural climate resources on food crops during summer drought, this paper uses the assessment methods for light and temperature potential productivity, and light, temperature and water potential productivity of food crops, performs the comparative analysis of the difference between the food production potential and the average climate state during summer drought, and objectively analyzes the strengths and weaknesses of agricultural climate resources in Guizhou Province during summer drought. Studies show that under summer drought in Guizhou Province, the light and temperature potential productivity of rice and corn is generally about 10% higher than in normal climate years, and the strengths of light and heat resources are obvious; the light, temperature and water potential productivity of rice and corn is generally 30% to 40% lower than in normal climate years, and the weaknesses of water resources hamper the crop growth. Rational development and efficient use of water resources and good light and heat conditions for crops during drought, are more conducive to agricultural production.

Key words Summer drought, Climate resources, Crop production potential, Strengths and weaknesses

Light, heat and water are three basic meteorological elements in agricultural production. Summer is the key season to agricultural production, and summer drought is the most important meteorological disaster for agricultural production. In the years with summer drought, the light and heat conditions are good, and through the rational development and efficient use of water resources, the crop's water needs can be met during the drought. Good light and heat conditions are very beneficial to agricultural production. For the quantitative assessment of objective impact of light, heat and water and other agricultural climate resources on food crop production during summer drought, this paper adopts the light and temperature potential productivity and light, temperature and water potential productivity assessment methods for food crops, to conduct a comparative analysis of deviation of food production potential from the average climate state during summer drought. It objectively and quantitatively analyzes the strengths and weaknesses of agricultural climate resources in Guizhou Province during summer drought, and the study can provide a scientific reference for fully understanding the strengths of agricultural climate resources during summer drought and making up for the weaknesses of climate. Currently, the assessment methods for the food production potential in China can be summarized as three categories: plant growth mechanism analysis, influencing factor analysis and food production forecasting trends [1]. And the assessment method based on plant growth mechanism is on the basis of photosynthesis of green plants, and photosynthesis is the basis for the formation of comprehensive grain production capacity [2-5]. In this study, from the photosynthetic production potential of major food crops in Guizhou Province, we use the assessment method based on plant growth mechanism to analyze the strengths and weaknesses of agricultural climate resources during summer drought in Guizhou Province.

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1 Data sources and research methods

1.1 Data sources During the summer drought, the daily meteorological data concerning 85 meteorological stations in Guizhou Province in 2013 are used as the agro-climatic data. The average climate values in Guizhou Province during 1981 -2010 are used as the average climate state, and the data are from Bureau of Meteorology in Guizhou Province.

1.2 Calculation methods of light and temperature potential productivity This paper selects the AEZ (Agricultural Ecology Zone) method provided by FAO [6]. When the water is unrestricted in growth period G, the light and temperature potential productivity (Y_t) is as follows:

$$Y_t = Y_0 \times C_L \times C_N \times HI \times G \times A$$

where Y_0 is the total dry matter yield of crops (kg/hm^2 · d^{-1}); C_L is the revised coefficient for leaf area; C_N is the revised coefficient for net dry matter production; HI is the revised coefficient for harvest; G is the length of crop growth period (d); A is the unit conversion factor.

It includes the following steps: (i) calculating the crop biomass (Y_0); (ii) revising the crop varieties and temperature; (iii) revising the crop development time and leaf area (CL); (iv) revising the net dry matter production (CN); (v) revising the harvest part (HI).

1.3 Calculation methods of light, temperature and water potential productivit Under rainfed conditions, the key of using AEZ model to estimate the climate production potential lies in determining the crop's water needs and water balance within the whole growth period. It mainly includes the following steps: (i) using Penman method to calculate potential evapotranspiration (ET_0); (ii) calculating the crop's water demand (T_m, mm/10 d); (iii) calculating the available soil moisture reserves before sowing (S_a, mm); (iv) calculating the actual crop water consumption (T_a, mm/10 d). The yield reduction percentage at different growth stages (Y_{ract}) is calculated as follows:

$$Y_{ract} = K_y (1 - T_a / T_m) \times 100\%$$

where K_y is the yield response factor.

Yield index I: production index at growth stage n = (yield reduction percentage at growth stage $n-1$) × (1 − yield reduction percentage at growth stage n).

Then the climate production potential (Y_w) is calculated as follows:

Y_w = light and temperature potential productivity Y_t × production index at the final growth stage.

2 Results and analysis

2.1 Comparative analysis of light and temperature resources According to the average annual solar radiation and temperature data in Guizhou Province, using the above method, we calculate the light and temperature potential productivity of rice and corn under normal weather background in 84 weather stations (Fig. 1). It is found that the light and temperature potential productivity of rice and corn shows a general decreasing trend from the southern and eastern regions to northwestern regions[7]. The light and temperature potential productivity of rice is highest in the southern and eastern parts of Guizhou Province (more than 15000 kg/ha), followed by central and northern regions, and it is lowest in the northwestern regions (14000 kg/ha). The light and temperature potential productivity of corn is also highest in the southern and eastern parts of Guizhou (more than 16000 kg/ha), followed by the central and northern regions, and it is lowest in the northwestern region (15000 kg/ha).

Based on the sunshine and temperature data in 2013 for calculation, under the summer drought in 2013, the light and temperature potential productivity of rice and corn in Guizhou Province was significantly increased, and showed a decreasing trend from southern and eastern regions to western and northern regions (Fig. 2). The light and temperature potential productivity of rice is highest in the southern regions (more than 17000 kg/ha), followed by the eastern regions, and it is lowest in the central and western regions (16000 kg/ha). The light and temperature potential productivity of corn is highest in the southern regions (more than 18000 kg/ha), followed by the eastern regions, and it is lowest in the north – central and western parts (17000 kg/ha).

By comparing the light and temperature potential productivity of rice and corn under normal climate and summer drought in 2013, it is found that due to long sunshine hours and high temperature during summer drought, the light and temperature potential productivity of rice and corn is generally 10% higher in the province, about 5% higher in the southeastern and northeastern regions and 10% higher in the central and western regions (Fig. 3).

2.2 Comparative analysis of light, temperature and water resources In accordance with the average annual precipitation and potential evapotranspiration data in Guizhou Province, we use the above method to calculate the light, temperature and water potential productivity of rice and corn in 84 meteorological stations under normal climate (Fig. 4). It is found that the light, temperature and water potential productivity of rice and corn shows a general decreasing trend from the southern and southeastern regions to the western and northern regions[7]. The light, temperature and water potential productivity of rice is highest in the southern part (more than 15000 kg/ha), followed by the eastern and central regions, and it is lowest in the northwestern part (13000 kg/ha). The light, temperature and water potential productivity of corn is highest in the southern part (more than 16000 kg/ha), followed by the eastern and central regions, and it is lowest in the western and northern regions (14 000 kg/ha).

It is calculated based on the sunshine, temperature and precipitation data in 2013. The light, temperature and water potential productivity of rice and corn in the context of summer drought in 2013 is significantly lower than in the context of normal climate, due to uneven distribution of rainfall in Guizhou. The light, temperature and water potential productivity of rice is more than 11000 kg/ha in some southwestern and southeastern regions, and about 9000 kg/ha in the northern, eastern and southern regions with long duration of summer droughts; the light, temperature and water potential productivity of corn is more than 11000 kg/ha in the southwestern and southeastern regions, and about 8000 kg/ha in the northern, eastern and southern regions with long duration of summer droughts (Fig. 5).

By comparing the light, temperature and water potential productivity of rice and corn in the context of normal climate and summer drought in 2013, it is found that due to a serious shortage of water during the summer drought, the light, temperature and water potential productivity of rice and corn generally decreases by 30% to 40% in the province in the context of summer drought (about 30% for the southeastern regions and 40% for the northern, eastern and southern regions) (Fig. 6).

3 Conclusions and discussions

Based on the light, temperature and water data in Guizhou Province, this paper uses AEZ method provided by FAO to calculate the light and temperature potential productivity, and the light, temperature and water potential productivity of rice and corn in Guizhou Province, in order to objectively reflect the impact of agricultural climate resources on agriculture in Guizhou Province.

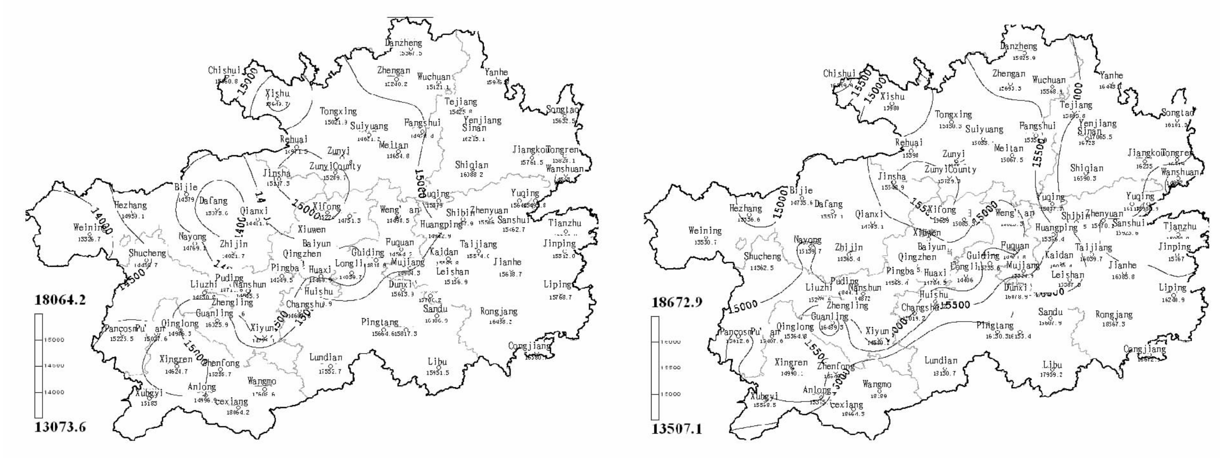

Fig. 1 The light and temperature potential productivity of rice and corn in Guizhou Province under normal climate background (kg/ha)

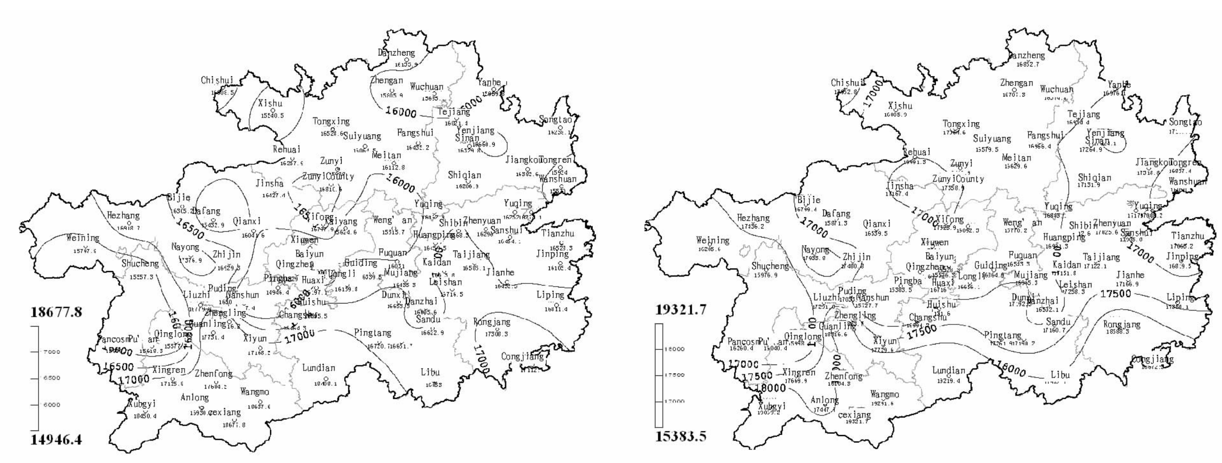

Fig. 2 The light and temperature potential productivity of rice and corn in Guizhou Province under summer drought in 2013 (kg/ha)

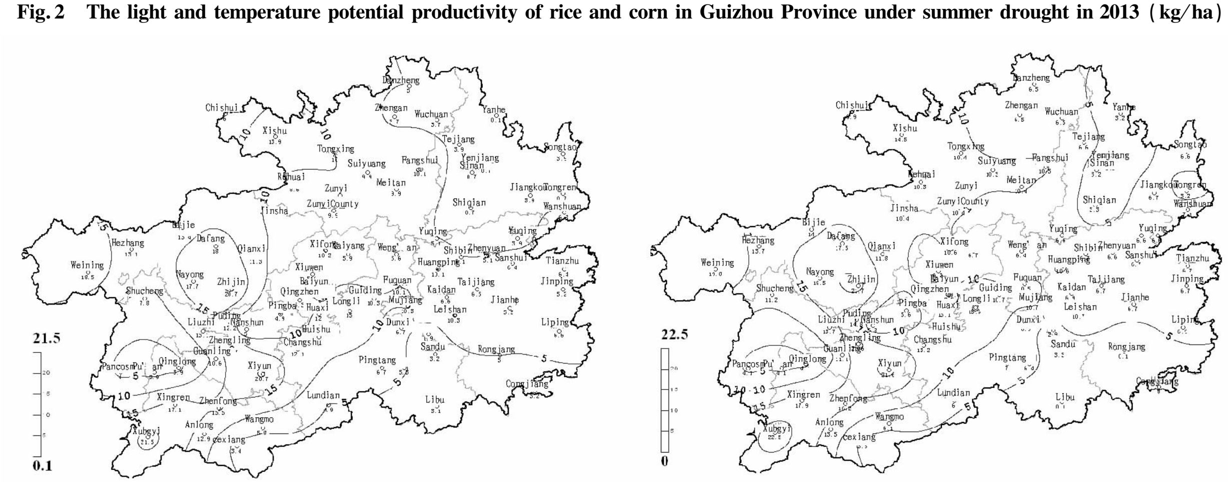

Fig. 3 The comparison of light and temperature potential productivity of rice and corn under summer drought and normal climate (%)

The light and temperature potential productivity of rice and corn shows a general decreasing trend from the southern and eastern regions to northwestern regions; the light, temperature and water potential productivity of rice and corn shows a general decreasing trend from the southern and southeastern regions to the western and northern regions. By comparing the light, temperature and water potential productivity or light and temperature potential productivity of rice and corn in the context of normal climate and

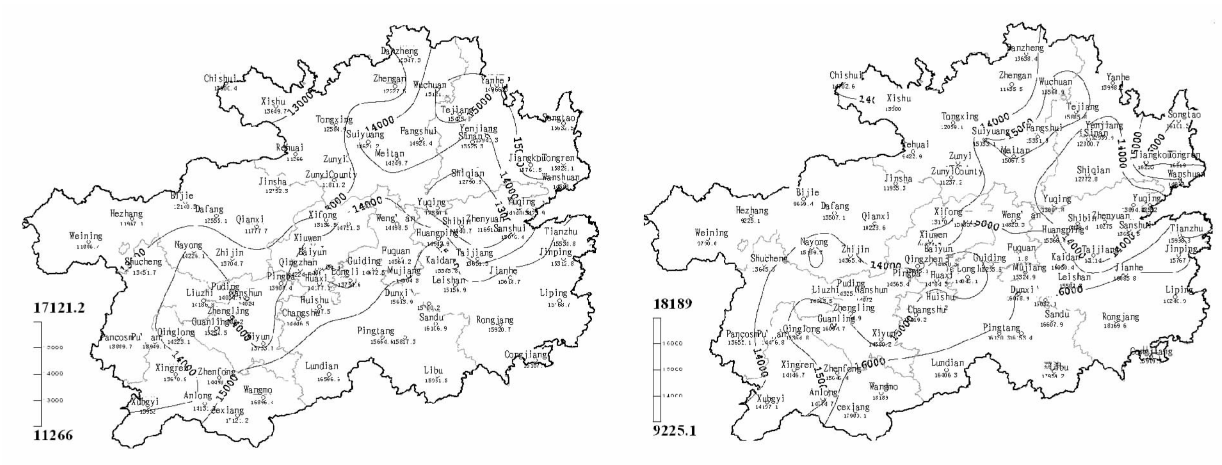

Fig. 4 The light, temperature and water potential productivity of rice and corn in Guizhou Province under normal climate (kg/ha)

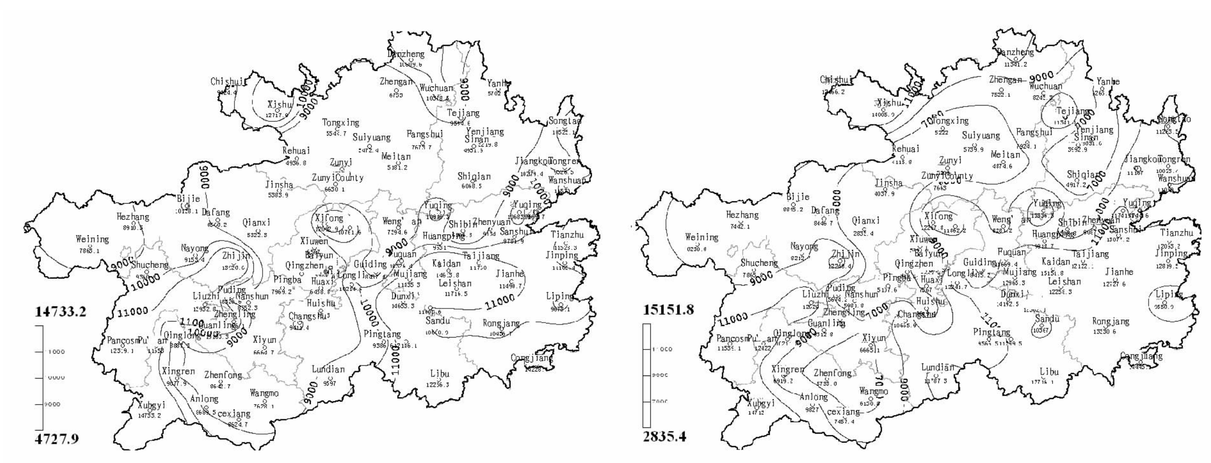

Fig. 5 The light, temperature and water potential productivity of rice and corn in Guizhou Province in the context of summer drought in 2013 (kg/ha)

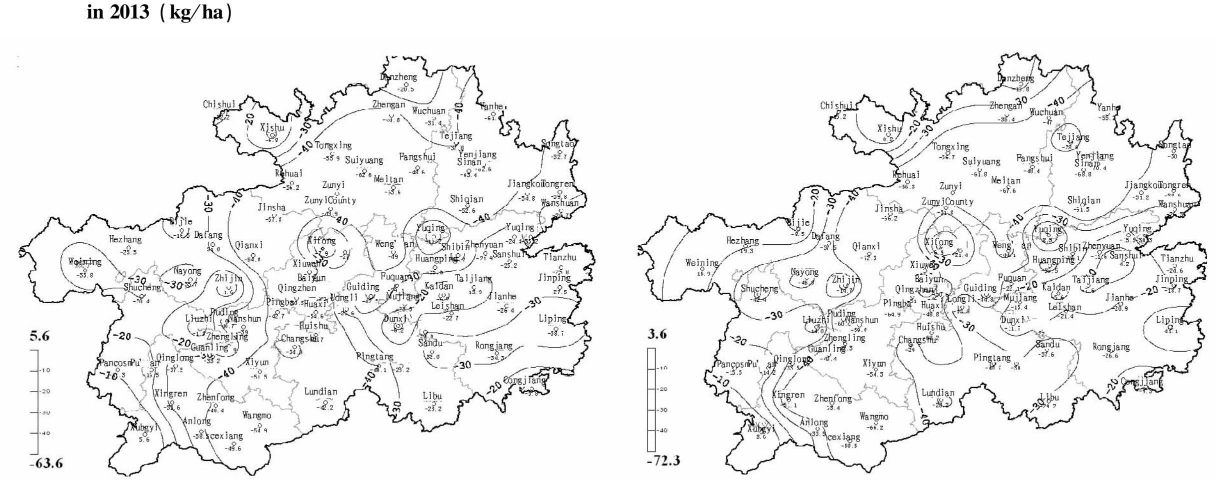

Fig. 6 The comparison of light, temperature and water potential productivity of rice and corn in the context of normal climate and summer drought (%)

summer drought in 2013, it is found that due to a serious shortage of water during the summer drought, the light, temperature and water potential productivity of rice and corn generally decreases by 30% to 40% in the province in the context of summer drought, and water resource disadvantage limits crop growth; due to long sunshine hours during summer drought, the temperature is relatively high and the light and temperature potential productivity of

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corporate exchange and introduction of African germplasm resources into Sino-African agricultural exchange and cooperation scope. Through survey and analysis, it is recommended to collect various plant germplasm resources, to provide reference for China making exchange of germplasm resources and further improving crops, forage grass, vegetable, livestock, and poultry, *etc.* It is recommended to include introduction and exchange of germplasm resources into Sino-African agricultural cooperation scope.

4.2 Making pertinent introduction of African resources and realizing best use of introduced varieties Five provinces of central China are hot in summer and have frequent rainstorms, similar to rainy season of African countries. It is badly needed to cultivate high stress resistant and high quality varieties to solve problems such as bad harvest and weak growth. Therefore, in line with practical situations and long-term demands of agricultural production in five central provinces of China, it is recommended to collect excellent crop germplasm resources from African countries with similar summer climate, make innovative use of those resources, improve current crop varieties of five central provinces, and strengthen demonstrative extension and application of improved crops. This is the necessity for China innovating crop resources, and also the necessity for African countries ensuring grain security. Through introducing excellent germplasm resources and setting up international sci-tech cooperation and exchange platform, it is expected to open up new channels for agricultural sci-tech exchange and cooperation, and cultivate agricultural scientific research teams with international competitive power, so as to boost international influence of China in agricultural scientific researches.

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rice and corn generally increases by 10% in the context of summer drought in the whole province, indicating that there are significant strengths of light and temperature climatic resources. Therefore, it is necessary to rationally develop and use climate resources for scientific distribution of agricultural industries, actively develop water – saving irrigation techniques, efficiently use water resources to meet crop's water needs during summer drought, and transform the weaknesses of drought into the strengths of climate resources for the development of specialized agriculture. Good light and heat conditions may be more conducive to agricultural production.

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