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Review article

Food security and sustainable crops production with considering climate change in China

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Abstract. Increase in the mean seasonal temperature can reduce the duration of many crops which may lead to final yield reduction. China needs to cope with the adverse effects of climate change by developing heat and drought resistant high yielding varieties and cultivars to ensure food security in China. Farmers should adapt to climate change strategies which integrate traditional experience and indigenous knowledge with scientific researches and government polices as key factors. Climate change will extend growing seasons for some crops and make shorter growing seasons for other crops in Northern part of China and will bring less reliable rains, soils that retain less water, the spread of dangerous pests and unwanted weeds. The catastrophic consequences of climate change can be avoided if all countries work and cooperate together towards significant reduction in the emission of greenhouse gases.

Key words: climate change, sustainability, agricultural production, China

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Introduction

China encompasses various climate regimes from northern boreal to southern tropical and from western arid to eastern and southern humid climate zones. China has played a crucial role in advancing key elements of the foundations for future development and the global agenda by taking major steps to advance international cooperation, especially on climate change.

Materials and methods

This short communication included randomized control experiments, review articles, observational and analytical designs which have been surveyed in Google Scholar, Scopus, Research Gate and PubMed by using keywords including climate change, sustainability and its influence on agricultural production in China. All relevant papers in both English and Chinese language were searched. All authors screened the articles first by reviewing related titles, then abstracted and after that going through the whole manuscripts.

Results and discussion

The climate change scenarios considered in their study, agricultural net revenues would increase in most regions of China, except for the Northwest, the Southwest and parts of the Northeast, as a result of the projected increase in temperatures and precipitation levels. Li et al. [1] found that the climate change has a universally negative effect on Chinese agriculture and implies that a higher flexibility of maize producing timing and a better regional adaptation to climate change in Southwest region could offset or even to outweigh the potential reduction of maize production in Northeast region. Chen et al. [2] revealed that climate change would have major negative impacts on crop production, particularly for wheat in northern China, rice in South China and maize across the major cultivation areas due to a decrease in crop growth duration and an increase in extreme events. Tao and Zhang [3] concluded that a moderate increase in mean temperature and the increase in solar radiation would promote the yield increase by enhancing crop canopy photosynthesis and consequently biomass accumulation and yield. Zhu et al. [4] mentioned that a question relevant for the world as a whole is how the development of Chinese food consumption and production, given future socio-economic changes and climate change, will impact on the country's net crop trade and related net virtual water trade. Wang et al. [5] stated that the increase in effective irrigation by upgrading the irrigation system would help to maintain the current production of maize level, but in the long run, the maize cultivars need to be introduced in line with the future warming climate. In order to sustain agriculture industry, the Chinese government should take measures on environmental pollution and degradation, climate change and replace with new policies with the environment and ecology-friendly agricultural technologies. Li et al. [6] reported that western China was the most vulnerable area, where climate sensitive dry land agriculture was the primary economic activity. The Loess Plateau is a home to an estimated population upwards of 108 million, of which more than 70% are reported to be living and working in agricultural areas. Notable climate change has been observed on the Loess Plateau in recent decades, with air

temperature rising by 0.6 °C and annual precipitation decreasing by 3 mm per decade. Jiahua et al. [7] concluded that was is necessary to clarify development-oriented and incremental adaptation to climate change in China. Li et al. [8] explained that the expansion of maize was closely related to warming, although some variation in the distribution was noticed across zones in relation to the warming, indicating that maize in northeast of China have adapted successfully to the climate change. Yan et al. [9] claimed that by 2030, climate change was projected to increase water supply and demand gap for irrigation in Northeast China, and due to the increase in water scarcity, irrigated areas would decrease, and the cropping pattern would be adjusted by increasing maize sown areas and decreasing rice sown areas, and as a result, the total output of crops and profits would clearly be reduced. Wang et al. [5] reported that the government's major efforts should be in the developing new technologies, reforming extension system and enhancing institutional capacity, and farmers should adapt to climate change, but their adaptation measures can not fully offset the negative impacts of climate change. Options for adaptation to climate change include no action and accepting crop loss associated with the reduction in evapotranspiration or breeding new cultivars that would maintain or increase crop productivity and result in an increase in evapotranspiration. Chen et al. [10] found recently that climate change negatively impacted corn and soybean yield; they also stated that the effects of climate change on corn and soybean yields followed an inverse U shape, increasing up to a key temperature threshold and then decreasing thereafter, with thresholds of an average growing season temperature at 29 °C for corn and at 28 °C for soybeans. Wang et al. [11] mentioned the impacts of climate on Hunan Province crop yields, decomposing effects into three components: trends, annual fluctuations, and extreme events. Kan et al. [12] proved that climate change was expected to have a positive impact on the growth of Chinese fir in the Fujian region of China. Guo et al. [13] indicated that, warming of climate in Northeast China was expected to impact negatively spring maize production, especially in Liaoning province; in their view, spring maize cultivation would likely need to shift northward and expand eastward to make efficient use of future agricultural climatic resources. Ecosystems in northern and western parts of China are more vulnerable to climate changes than those in eastern China, while ecosystems in the east are more vulnerable to land use changes other than climate changes. Cropping systems based on biodiversity and sustainable soil management and using less chemical inputs could result in a satisfying compromise between food production, adaptation and mitigation to climate change. Future climate change may have very different effects from the past climate change since future climate changes are expected to be much larger. Considering climate change and population growth, water shortages will become more serious in northern areas such as Qinghai, Shanxi, Shaanxi, Ningxia, Xinjiang and Gansu. Guo et al. [14] noticed that the climate change had a significant adverse impact on climatic potential productivity of maize from 1961 to 2010 in China. According to Yu et al. [15] research, the rice yields in China are predicted to decrease in the 2040s by 0.22 t/ha due to climate change, to increase by 0.44 t/ha due to a constant growing season and to increase by 1.65 t/ha due to CO_2 fertilization. They do believe that the benefits of crop adaptation would completely offset the negative impact of climate change. Advanced inter-regional contracts and cooperation of policies to stabilize regional agricultural labour force could be

a cost-efficient risk mitigation strategy to mitigate the potential reduction of overall national maize production [16—26]. China's surface air temperature will continue to rise, with northern areas set to experience a greater increase than those in the south. Precipitation variability will increase, and extreme weather events will intensify. Extreme cold spells will begin to decline in China, whilst extreme hot weather will increase. The north-eastern, northern and north-western parts of China will experience hotter and drier summers, displaying clear signs of aridification. On the other hand, Central, eastern and southern China will experience markedly wetter summers but drier winters. Drier winters will be especially noticeable in southern China where summer floods and winter droughts will occur alternately. It remains necessary for local farmers to build a system of adaptive climate change strategies that combines traditional experience and indigenous knowledge with scientific researches and government polices as key factors.

Conclusions

As China is a leader in shaping the global agenda of sustainable development and managing climate change, it can be also an important leader in driving forward the new growth to overcome poverty, confront climate change and address natural resource and environmental challenges. Climate change may cause reduction in crop yields and agricultural productivity, increase cost of food distribution, increase pest attacks, limit the availability of water, exacerbate the drought periods, reduce soil fertility, decrease livestock productivity and increase production cost, decrease health profile population, and increase tensions and conflict in different regions. Some activities like agricultural activities such as rice production, synthetic fertiliser use, livestock rearing, change in land use patterns such as deforestation and waste disposal have contributed to the increased atmospheric concentration of greenhouse gases. Climate change can lead to discern potential regional imbalances between supply and demand of agricultural products. With increasing of negative influence of climate change on agricultural production, a crop yield may decline which can lead to increase in agricultural product prices and finally, it may cause malnutrition. Strategies such as water-saving plans, water rationing and recycling of contaminated water with engineering projects can be implemented in China. Although, climate change may bring both positive and negative effects on agricultural production in China, but negative influence tend to dominate. Agricultural crop production systems are extremely sensitive to climate changes such as changes in temperature and precipitation which can lead to increase in number of pests and diseases, thereby reducing harvest index and finally affects the food security of Asian countries, especially China. Improving water productivity and keep sustainable relations with environment may decrease the adverse effect of climate change. In future, China should reduce the pressure on land and the resulting greenhouse gas emissions. The global cooperation is important for China to cope with the adverse impacts of climate change on food security and safety. Developing a strategy for food security may enhance availability through various climate agricultural responses and enhance sources for progress. The future researches in China should be for a better understanding of the responses of crops to changes in climate and influence of climate change on agricultural products, diseases, pests, and atmospheric constituents.

References

1. Li X, Takahashi T, Suzuki N, Kaiser HM. Impact of climate change on maize production in Northeast and Southwest China and risk mitigation strategies. *APCBEE Procedia*. 2014; 8:11—20. doi: 10.1016/j.apcbee.2014.01.073
2. Chen Y, Zhang Z, Tao F. Impacts of climate change and climate extremes on major crops productivity in China at a global warming of 1.5 and 2.0 °C. *Earth System Dynamics*. 2018; 9(2):543—562. doi: 10.5194/esd-9-543-2018
3. Tao F, Zhang Z. Climate change, wheat productivity and water use in the North China Plain: A new super-ensemble-based probabilistic projection. *Agricultural and Forest Meteorology*. 2013; 170:146—165. doi: 10.1016/j.agrformet.2011.10.003
4. Zhuo L, Mekonnen MM, Hoekstra AY. Consumptive water footprint and virtual water trade scenarios for China- with a focus on crop production, consumption and trade. *Environment International*. 2016; 94:211—223. doi: 10.1016/j.envint.2016.05.019
5. Wang JX, Huang JK, Yang J. (2014). Overview of impacts of climate change and adaptation in China's agriculture. *Journal of Integrative Agriculture*. 2014; 13(1):1—17. doi: 10.1016/s2095-3119(13)60588-2
6. Li X, Philp J, Cremades R, Roberts A, He L, Li L, Yu Q. Agricultural vulnerability over the Chinese Loess Plateau in response to climate change: Exposure, sensitivity, and adaptive capacity. *The Royal Swedish Academy of Sciences*. 2015; 45(3):350—360. doi: 10.1007/s13280-015-0727-8
7. Jiahua P, Yan Z, Markandya A. Adaptation approaches to climate change in China: an operational framework. *Economia Agraria y Recursos Naturales*. 2011; 11(1):99—112. doi: 10.7201/earn.2011.01.05
8. Li Z, Tan J, Tang P, Chen H, Zhang I, Liu H, Wu W, Tang H, Yang P, Liu Z. Spatial distribution of maize in response to climate change in northeast China during 1980—2010. *Journal of Geographical Sciences*. 2016; 26(1):3—14. doi: 10.1007/s11442-016-1250-y
9. Yan T, Wang J, Huang J, Xie W, Zhu T. The impacts of climate change on irrigation and crop production in Northeast China and implications for energy use and GHG emission. *Proc. IAHS*. 2018; 379:301—311. doi: 10.5194/piahs-379-301-2018
10. Chen S, Chen X, Xu J. Impacts of climate change on agriculture: Evidence from China. *Journal of Environmental Economics and Management*. 2016; 76:105—124. doi: 10.1016/j.jeem.2015.01.005
11. Wang Z, Shi P, Zhang Z, Meng Y, Luan Y, Wang J. Separating out the influence of climatic trend, fluctuations, and extreme events on crop yield: A case study in Hunan Province, China. *Clim. Dyn*. 2018; 51(11—12):4469—4487. doi: 10.1007/s00382-017-3831-6
12. Kang H, Seely B, Wang G, Cai Y, Innes J, Zheng D, Chen P, Wang T. Simulating the impact of climate change on the growth of Chinese fir plantations in Fujian province, China. *New Zealand Journal of Forestry Science*. 2017; 47:20. doi: 10.1186/s40490-017-0102-6
13. Guo J, Zhao J, Yuan B, Ye M. Evaluation of agricultural climatic resource utilization during spring maize cultivation in Northeast China under climate change. *Acta Meteorologica Sinica*. 2013; 27(5):758—768. doi: 10.1007/s13351-013-0508-x
14. Guo J, Zhao J, Wu D, Mu J, Xu Y. Attribution of maize yield increase in China to climate change and technological advancement between 1980 and 2010. *Journal of Meteorological Research*. 2014; 28(6):1168—1181. doi: 10.1007/s13351-014-4002-x
15. Yu Y, Zhang W, Huang Y. Impact assessment of climate change, carbon dioxide fertilization and constant growing season on rice yields in China. *Climatic Change*. 2014; 124(4):763—775. doi: 10.1007/s10584-014-1129-9
16. Shahrajabian MH, Wenli S, Qi C. The power of natural Chinese medicine, ginger and ginseng root in an organic life. *Middle-East Journal of Scientific Research*. 2019; 27(1):64—71. doi: 10.5829/idosi.mejsr.2019.64.71

17. Shahrajabian MH, Wenli S, Qi C. A review of goji berry (*Lycium barbarum*) in traditional Chinese medicine as a promising organic superfood and superfruit in modern industry. *Academia Journal of Medicinal Plant*. 2018; 6(12): 437—445. doi: 10.15413/ajmp.2018.0186
18. Shahrajabian MH, Soleymani A, Ogbaji PO, Xue X. Impact of different irrigation managements on soil water consumption, grain yield, seed protein, phosphorus and potassium of winter wheat. *Cercetari Agronomice in Moldova*. 2017; 50(3):5—13. doi: 10.1515/cerce-2017-0021
19. Shahrajabian MH, Soleymani A. A lysimeter study, a unique tool for botanists, agronomists and other plant scientists. *Asian Research Journal of Agriculture*. 2017; 4(2):1—9. doi: 10.9734/ARJA/2017/32492
20. Shahrajabian MH, Soleymani A, Ogbaji PO, Xue X. Survey on qualitative and quantitative traits of winter wheat under different irrigation treatments using weighing lysimeter in north China plain. *International Journal of Plant & Soil Science*. 2017; 15(4):1—11. doi: 10.9734/IJPSS/2017/32778
21. Ogbaji PO, Shahrajabian MH, Xue X. Changes in germination and primarily growth of three cultivars of tomato under diatomite and soil materials in auto-irrigation system. *International Journal of Biology*. 2013; 5(3):80—84. doi: 10.5539/ijb.v5n3p80
22. Shahrajabian MH, Xue X, Soleymani A, Ogbaji PO, Hu Y. Evaluation of physiological indices of winter wheat under different irrigation treatments using weighing lysimeter. *International Journal of Farming and Allied Sciences*. 2013; 2(24):1192—1197.
23. Shahrajabian MH, Sun W, Cheng Q. The influence of traditional Iranian and Chinese medicine on western and Islamic countries. *Asian Journal of Medical and Biological Research*. 2019; 5(2):94—99. doi: 10.3329/ajmbr.v5i2.42490
24. Shahrajabian MH, Sun W, Cheng Q. Clinical aspects and health benefits of ginger (*Zingiber officinale*) in both traditional Chinese medicine and modern industry. *Acta Agriculturae Scandinavica, Section B-Soil & Plant Science*. 2019; 69(6):546—556. doi: 10.1080/09064710.2019.1606930
25. Shahrajabian MH, Sun W, Cheng Q. A review of ginseng species in different regions as a multipurpose herb in traditional Chinese medicine, modern herbology and pharmacological science. *Journal of Medicinal Plants Research*. 2019; 13(10):213—226. doi: 10.5897/JMPR2019.6731
26. Shahrajabian MH, Sun W, Cheng Q. Modern pharmacological actions of Longan fruits and their usages in traditional herbal remedies. *Journal of Medicinal Plants Studies*. 2019; 7(4):179—185.

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Научная статья

Продовольственная безопасность и ведение устойчивого сельского хозяйства с учетом изменения климата в Китае

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Аннотация. Приведен краткий обзор исследований климатических изменений и их негативного влияния на растениеводство в регионах Китая. Повышение показателей средней температуры в течение сезона может повлиять на продолжительность вегетации многих культур, вызвав тем самым снижение урожайности. В северной части Китая увеличится продолжительность вегетационного периода у одних культур и сократится у других. Кроме того, изменения коснутся и количества осадков, увлажненности почв, распространения опасных вредителей и сорняков. Результаты анализа исследований обосновывают необходимость разработки жаростойких и засухоустойчивых высокопродуктивных сортов и сортов, способных обеспечить продовольственную безопасность страны. Рекомендуется адаптировать фермерские хозяйства к стратегиям, объединяющим традиционный опыт и знания коренных народов с научными исследованиями и государственной политикой, в качестве ключевого фактора успешного преодоления неблагоприятных последствий изменения климата. Отмечена важнейшая роль сотрудничества всех стран в целях значительного сокращения выбросов парниковых газов.

Ключевые слова: изменение климата, устойчивость, сельскохозяйственное производство, Китай

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