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CLIMATE-SMART RICE PRODUCTION: A REVIEW

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ABSTRACT

Rice is one of the world's most important crops and the primary source of nutrition for the world's more than half population. Currently, the world rice production is 495.78 million tons, while it will increase to 525 tons in 2050, which is not sufficient for the world's increasing population. At the same time, various climatic factors affect rice production, such as air temperature, atmospheric CO_2, light, water, and soil nutrients. For instance, high temperature was the main climate factor that caused yield variation by affecting the rice maturity periods, spikelet fertility, and spikelet number. Thus, it is an urgent need to improve rice production and reduce the negative effects of climate change on rice production. In order to solve above-mentioned problem, one of the most important options is using climate-smart practices, which are planting improved rice varieties, soil and water conservation techniques, and adjusting planting and harvesting dates. The importance of adapting climate smart practices is an increase in rice yield by 15.87%. Climate-smart rice production and climate-smart practices in rice needs still to be investigated widely. The review objective is to describe climate-smart practices in rice cultivation, in order to mitigate the negative effects of climate change on rice production.

Keywords: Climate Change, Climate Smart-Practices, Climate Smart-Rice, Rice Production

INTRODUCTION

Rice is one of the world's most important crops, and the primary source of nutrition (Wang et al., 2011). Rice is also consumed by more than half of the world's population, living in Asia (Khush, 2005). Furthermore, projections indicate that the world population will reach 8.5 billion by 2030 and 9.7 billion by 2050 (UN, 2019). It was also projected to increase rice production by 40% by 2030 (Khush, 2005). Currently, milled rice production in the world is about 495.78 million tones (Shahbandeh, 2021). While in estimation, the net demand for rice will increase to 525 million tons by 2050 (Abdullah & Adhana 2006).

Climate change is the main cause of biotic and abiotic stresses, which have adverse effects on the world's crop production (Begna, 2022). Climatic factors are temperature, rainfall, drought, humidity, and solar radiation (Hossain et al., 2019). Various climatic factors affect rice production, such as air temperature, atmospheric CO_2, light, water, and soil nutrients (Patindol et al., 2015). High CO_2 and high temperatures have affected rice growth stages, especially tillering and grain filling (Liu et al., 2017). Furthermore, temperature and radiation were the main climate factors that caused yield variation by affecting the rice maturity periods (Xu et al., 2018).

Climate-smart practices include planting improved rice varieties, soil and water conservation techniques, adjusting planting and harvesting dates, irrigation, and appropriate application of fertilizer (Onyeneke et al., 2021). Furthermore, climate change adaptation response, including climate-smart agriculture participation, played a crucial role in improving the technical efficiency of rice production by 13%–14% compared to no adaptation response (Ho & Shimada, 2019). Adopting both adaptive and mitigatory climate-smart practices increases rice yield by 15.87% (Liang et al., 2021).

Recently, the demand of rice increasing continuously, and rice production negatively affected by climate change. Thus, it is an urgent need to increase rice production and mitigate the negative effects of climate change on rice production. The effects of climate-smart agriculture on rice production have been investigated in specific areas, however, climate-smart rice production has not been stated yet. This review aims to describe practices, and technologies in rice cultivation, that affected positively rice cultivation. The objective of the review is to investigate the best climate-smart practices adopted in rice cultivation. The review also focuses on those smart practices in rice farming that increased rice production.

FACTORS OF CLIMATE CHANGE

Climatic factors are temperature, rainfall, drought, humidity, and solar radiation (Hossain et al., 2019). Furthermore, climate change is the main cause of biotic and abiotic stresses, which have adverse effects on the world's crop production and productivity (Begna, 2022). Among stresses, abiotic stress is caused due to moisture, temperature, minerals, salinity, and soil acidity/soil pH (Begna, 2022). Drought is one of the most detrimental factors in arid and semiarid regions, causing a significant decrease in plant growth and yield in most species. (Abdelaal et al., 2021). Moreover, drought impacts on rice (*Oryza sativa* L.) production present a major threat to future global food security (Guo et al., 2021). Meanwhile, projections indicated that by 2100, CO_2 concentrations will reach 950 parts per million, temperatures will climb by 3.5 to more than 8°C, sea level will rise by more than 2.4 meters, and the average farmland drought risk index will increase from 52.45 to 129 (Ul et al., 2023). In addition, average precipitation will increase by 1%– 3% in some areas and atmospheric water vapor will increase by 6%– 7% (Ul et al., 2023).

EFFECTS OF CLIMATE CHANGE ON RICE GROWTH AND YIELD

Climate change negatively affected the growth duration of rice (Sarwary et al., 2023). For instance, average temperature had the greatest effect on rice phenology (Chen et al., 2021). Furthermore, the increasing temperature consistently advanced the phenological dates and shortened the phenological stages of rice (Chen et al., 2021). The phenological trends of revealed that mean dates of sowing, milk ripening, and maturity were delayed (Chen et al., 2021). Moreover, temperature is the dominant contributor, which accounted for more than 50% of the change in rice phenology (Chen et al., 2021).

Climate change also affected rice yield (Kawasaki & Herath, 2011). Furthermore, climate change, especially the rising temperature, adversely affects the rice yield (He et al., 2020). Moreover, temperature and radiation were the main climate factors that caused yield variation by affecting the rice maturity periods, spikelet fertility, and spikelet number (Xu et al., 2018). It is also reported that climate change has affected rice production significantly in China (Saud et al., 2022). However, both higher levels and lower levels of temperature may decrease rice yield due to spikelet sterility and higher respiration losses (Hossain et al., 2019).

CLIMATE-SMART PRACTICES IN RICE

Farmers use a variety of climate-smart practices and technologies to respond to climate events (Onyeneke et al., 2021). Such climate-smart practices include planting improved rice varieties, planting different crops, soil and water conservation techniques, adjusting planting and harvesting dates, irrigation, reliance on climate information and forecasts, planting on the nursery, appropriate application of fertilizer, and effective use of pesticides (Onyeneke et al., 2021). Furthermore, some other climate-smart practices are improving irrigation facilities, and adjusting the timing of farm operations, as well as mitigation practices, such as zero tillage, soil testing and application of formulated fertilizer, and planting green manure (Liang et al., 2021).

Climate change strategies for rice farmers are developing rice growing techniques by using appropriate local rice varieties with higher yields under water shortage, improving soil fertility by using crop residues and green manure, reducing CO_2 emissions, operation and maintenance of irrigation systems for enough allocation of water demand in the dry season and water storage in the rainy season, and insure crop yield for small farmers (Kawasaki & Herath, 2011). The climate-smart technologies most preferred by farmers are water-smart, climate-smart technologies drip irrigation, drainage management, and weather-based rice agro advisories (Anugwa et al., 2022).

ADAPTATION OF CLIMATE-SMART PRACTICES IN RICE CULTIVATION

Crop management has offset the adverse effects of climate change on rice phenology in China (Chen et al., 2021). Thus, a dynamic cropping calendar, modernization of irrigation systems, and integrated plant nutrient management should be developed for farming practices to adapt to climate change (Ansari et al., 2021). The trend of a longer growth period and higher yield of rice reflects the ability of China's rice production system to adapt to climate change by adjusting planting regionalization and improving varieties and cultivation techniques (Saud et al., 2022). Rice productivity was found to be significantly higher among adopting farmers compared to non-adopting farmers (Khanal et al., 2019). Furthermore, climate change adaptation response, including climate-

smart agriculture participation, played a crucial role in improving the technical efficiency of rice production by 13%–14% compared to no adaptation response (Ho & Shimada, 2019).

Adopting both adaptive and mitigatory climate-smart practices increases rice yield and rice net income by 15.879% and 19.288%, respectively (Liang et al., 2021). Widespread adoption of climate-smart practices can increase the production of wheat, maize, and rice under future climatic conditions (De Pinto et al., 2020). The application of climate-smart agricultural technologies by smallholder farmers is vital for sustaining rice production (Anugwa et al., 2022). Technical training, cooperative membership, total owned land, and access to information services are important and influential determinants of adoption decisions (Liang et al., 2021).

CONCLUSION

Climate challenge factors negatively affected rice production around the world. Such as temperature affected rice growth stages and yield negatively. Recently, some practices have been conducted by rice farmers against climate change. For instance, the adaptation of climate-smart practices increased rice production by 13-14%. Moreover, adaptive and mitigatory climate-smart practices increased rice yield by 15.87%. Meanwhile, water-smart and climate-smart technologies are the most preferred by farmers. At the same time, the application of climate-smart agricultural technologies by farmers is vital to sustaining rice production under climate change. Thus, climate-smart practices in rice cultivation are a sustainable practical method to adapt by rice farmers in order to mitigate the negative effects of climate change factors on rice production, and increase rice production.

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