EFFECT OF TEMPERATURE ON GROWTH, QUALITY, YIELD ATTRIBUTING CHARACTERS AND YIELD OF RICE – A REVIEW.

ABSTRACT

Rice (Oryza sativa L.) is the second most important food in the world after wheat. Most rice is now grown in areas where the temperature is higher than the optimum growing temperature (28/22°C); therefore, a further increase in average temperature or high temperature occurring in the sensitive phase of the crop can affect growth and yield. Clutter. For every 1°C increase in daytime maximum/night minimum temperature from 28°C/21°C to 34°C/27°C, rice yield decreases by 7% to 8%. Additionally, the benefits that crops derive from high atmospheric carbon dioxide concentrations must be lost due to warming. The thermal stability of cell membranes is thought to correlate well with yield performance. Temperature is important in photosynthesis, but too hot can cause reduced photosynthesis of leaves and reduced distribution of dry matter to shoots and roots. The disadvantage of temperature is not limited to the above-ground rice. The underground area is affected, if not more, by the flood, and the temperature of the soil changes due to the heat. Future increases in global temperatures threaten people worldwide who depend on crops for their health and food security. In the past, the stress of the crisis on rice production focused on the rice crop. This review highlights the importance of rice in the world, the effect of high temperature on the growth, quality, yield and properties of rice, and the need for future research.

Keywords: Rice, Temperature, Global warming, CO_2

INTRODUCTION

Rice is the most important and important energy product in the world, providing the staple food of more than 60% of the world's population. Rice is produced and consumed in Asia in a major places. India is the country with the largest cultivated area in the world and its productivity is second only to China. Rice covers about 24% of the country's total cultivated area and accounts for 42% of the country's total crop.

Regarding cultivation and growth, temperature is the most important. There is now clear evidence of a noticeable increase in global average temperatures that have altered precipitation since the 20th century. In general, the rise of temperature will be higher in winter (rabi) than in the rainy season (kharif). It is estimated that India will experience a 10-12% increase in precipitation and a 3-5°C increase in average annual temperature by the end of the 21st century. Warming has been reported across the region, with the greatest extent in northern India. Now the question is: Is it possible to produce more rice to meet the rice demand? Keling et al. (1989) show that the concentration of carbon dioxide (CO2) in the earth's atmosphere is now increasing at an increasing rate. Due to the increase in CO2 and other "greenhouse gases", Hansen et al. (1988) reported that several general cycles predict global temperatures. While most of the published studies on the effects of CO2 and temperature on plants have mainly concerned climate crops, tropical plants have received less attention. Because both carbon dioxide and temperature affect crops, it is important to measure the impact of climate change on food crops such as rice.

Climate and atmospheric scientists generally agree that by the end of the 21st century, atmospheric CO2 concentrations could range from 510 to 760 µL and temperatures could be 1.5 - 4.5 ºC warmer than today and extreme weather events such as heat and drought occur more frequently, as suggested by Wigley and Raper (1992). This is both good and bad news for growers because high levels of carbon dioxide can increase productivity and reduce soil water use, but high soil and water temperature temporarily reduces yield and quality. Average global temperatures can make farming difficult. International and regional studies have varied in India; however, wheat and rice yields are expected to decline overall. Changes in atmospheric temperature at different growth stages have different effects on growth and production. The effects of the temperature evaluated by the researchers on the products are summarized herewith.

For C3 crops such as rice and wheat, foliar CO2 assimilation is expected to be the basis for crop production under high CO2 conditions. Water relationships, hormone levels and activity, and changes in food and carbon distribution can also contribute. Physiological and biochemical changes not only affect production, but also change growth and affect product quality. Rawson (1992) reported that climate change, like widespread warming and the occurrence of high temperatures over time, can affect growth and development, reducing food and possibly good. Rawson (1992) also reported that a temperature increase of 2°C seems insignificant compared to an increase of up to 30°C in one day, and results are equally likely to affect results. Therefore, this temperature can be considered as the emergency temperature if the product drops. Crops that are already grown in environments with seldom high temperatures, such as Australia and the United States, will be affected by climate change. However, some effects of water temperature may be offset by physical and biochemical changes due to higher CO2 levels.

The physiological response of plants to temperature may be (i) tolerance resulting from mechanisms that maintain high metabolic activity under mild stress and reduce work under severe stress, and (ii) avoidance associated with reduction in metabolic rate. A condition subjected to severe stress that leads to drowsiness. The latter has nothing to do with rice production. The critical temperature defines the environment in which the life cycle can be completed. In general, rice is adversely affected by temperature in hot and cold regions in low and temperate regions. Rice has different sensitivity to temperature at different stages of its life cycle. Therefore, the critical temperature (usually below 20°C and above 30°C) varies with the growth stage. This article focuses on the effects of high CO2 and temperature on rice growth, development and yield, although reference is made to the response of other species. Apart from the work of Baker and Allen (1993) and Rawson (1992), few long-term CO2 studies have investigated the interaction between CO2 concentration and temperature. Therefore, much of the discussion about the combination of CO2 and temperature is predictable. Hence, with which we have tried to review the effect of temperature on various qualitative and quantitative parameters of rice.

1. Climate requirement

Nagoto and Kobayashi (1957) reported that the required temperature for flowering is between 26.5°C and 29.5°C, and below 20°C may cause poor seed quality. Ebata and Nagata (1967) found that the optimum night-time temperature required for maturation is 23°C. The optimum temperature range for initiation of flowering is 25° to 30°C during the day and 20° to 25°C at night for successful anthesis, optimum temperature is being reported 30°C by Owen (2011).

Depending on the variety, the crop needs an average temperature not above 20°C and not below 15°C during the growing season. Angus and Robertson (1976) also found optimum temperatures of 25°C for plant height and 30°C for leaf emergence. Yoshida (1981) recommends 25°C to 31°C for tillering, 30°C to 33°C for flowering and 20°C to 25°C for ripening. Jing et al., (2007) found out that the optimum diurnal air temperature for high seed setting rate, grain weight and for the good qualities of rice were 35°C and 30°C at the filling stage for two different varieties.

2. Germination

Rice is most sensitive to high temperature at heading followed by at about 9 days before heading; Yoshida (1981). It has been reported that when the daytime temperatures exceed 33°C and reach zero at a maximum of 40°C, the pollen number and grain yield begin to decrease, and it has a significant effect on germination. As early as 1933 Livingston and Haasis found that 6 days of incubation at 25°C is required for 90% germination, 2 days at 31-36°C and longer incubation at 0 to 5°C. At low temperatures, germination proceeds very slowly and may take a month or longer. Takahashi (1961) studied the effect of temperature on the germination of Ou-no 200 rice variety by three factors: temperature, time and germination rate. Germination reaches approximately 90-97% in 2 days under 27ºC - 37ºC incubation conditions. But the germination rate drops below or above that. For a germination rate of 90% or higher, the incubation period is about 6 days at a temperature between 15°C and 37°C. No germination occurs at 8°C and 45°C.

The suppression of germination at supra optimal temperatures is called thermo-inhibition. The germinating seeds may experience a 25 °C fluctuation in temperature throughout the course of a day, from a minimum of 22 °C to a maximum of 47 °C over a 12 hour period, under upland (aerobic) conditions. Under irrigated conditions, this fluctuation in temperature in a day will be less. If seeds germinate erratically over a long time, seedling growth will not be uniform and plants will mature over a wider period. The freshly harvested seed of rice can have low germination caused by post-harvest dormancy, which is referred to as exhibiting "nondeep physiological dormancy" (Hartmann et al., 1997).

3. Seedling growth

A temperature of 22°C or less is considered unfavorable for seedling growth. Seedlings can grow well below 35°C and growth can drop significantly above that. Seedlings can die above 40°C. Nishiyama (1977) reported that the minimum temperature for shoot elongation is 7°C to 16°C and root elongation is 12°C to 16°C. The critical minimum for elongation of both shoot and root is, hence, about 10°C.

4. Plant height

According to studies reported by Singh (2000), temperature during the day and night increases cell elongation in the internodal region, promoting plant growth and internodal elongation of stems. Osada et al., (1973) and Oh-e et al., (2007) also reported that rice plant height increased with temperature of 30°C to 35°C. Kondo and Okamura (1931) stated that the optimum temperature for dry matter products is equal to or lower than the stem elongation. In a recent study, Oh-e et al. (2007) reported that plant height increased faster at higher temperatures than at lower temperatures.

5. Leaf area and development

Sharma and Singh (1999) showed that an increase in leaf size can lead to an increase in the total number of leaves per shoot and per plant. The increase in total leaf area per plant is due solely to the size of consecutive leaves. Hong et al. (1999) found that plants grown at high temperatures had more green leaves. Increased leaf number and tiller number in plants exposed to night-time temperatures were reported by Kanno et al. (2009)

Yin et al., (1996) were able to predict correct leaf appearance for four temperature treatments based on relationships for each crop. This indicates that, in contrast to the phenological development of flowering, diurnal temperature has no particular effect on leaves in rice. The optimum temperature for leaf growth was found to be higher than the optimum temperature from growth to flowering. The final number of main stem leaves varies with daily temperature. When daily heat delays flowering, it also increases the number of leaves. This might explain why day and night had a different effect on development to flowering but not on leaf development. The largest decrease in amylose content in polished rice (from 21.6% to 15.5%) is due to the increase in daytime temperature. In starch, this equates to a reduction of the amylose content from 24.9% to 18.4%. Gao et al. (1992) reported that moderate temperature causes rapid leaf emergence and temperature is an important determinant of leaf development in rice. The phyllochron concept, which is defined as the time interval between the appearances of successive leaf tips by Klepper et al., (1982), is used to predict the appearance of individual leaves, expressed in thermal time, with units of degree days. Yin et al. (1996) reported that rice plants are grown at a constant temperature, leaf appearance rate (LAR) does not change over time indicating age. Leaf appearance rate increases with temperature from a T base of 8 °C, until the leaves reached 36°C - 40°C, the survival temperature (Baker et al., 1995) and biomass increased to 33°C (Matsushima et al., 1964).

6. Biomass

Kima et al., (2011) reported that, high temperature increased the rate of grain filling and leaf senescence while it reduced the duration of them. However, grain filling was terminated earlier than complete leaf senescence, the time gap being greater at higher temperature. In addition, the fraction of dry matter partitioning to the leaf sheath + culm resumed to increase following the termination of grain filling under high temperature.

7. Tillers and panicles

Lalitha et al. (1999) reported that increasing the temperature in tillering stage from 24.1ºC to 27.4°C increased the tiller production from 453 to 689 tiller m^2. Yoshida (1973) found that when the temperature was increased from 22ºC to 31ºC, the temperature increase affected the early growth stages and showed that the growth was over time. Tillers are stronger at high temperatures than at low temperatures. Sato (1972) reported that the optimum temperature for tillering is 25°C during the day and 20°C at night. Tillers increased with increasing temperature in the range of 15°C to 33°C. Chaudhary and Ghildyal (1970) found that temperatures above 33°C damaged tillering. Oh-e et al., (2007) observed that the number of tillers per square meter during the early growth period was generally larger under high temperature and the maximum tillering stage was earlier than under normal temperature conditions Panicle differentiation occurs generally at temperatures between 18 and 30 °C. During tillering stage, the number of panicles will increase if the air temperature is lower than

20 °C; Yamamoto et al., (1985). After the active-tillering stage, high temperatures decrease the number of panicles, especially at maturity.

8. Spiklet sterility

Bhattacharya (1970) found that high temperature at ripening resulted in precocity, mainly due to the inability of the spikelet to serve as a sink, as the spikelet aperture was already closed. Yoshida and Parao (1976) reported that high temperature causes sterility as severe as 40ºC, leading to complete crop failure. The result presented by Satake and Yoshida (1978) was that flowering spikes were exposed to temperatures above 35°C for 5 days during flowering, resulting in sterile and non-seeded spikes. Fu et al. (1999) reported that spikelet sterility was positively correlated with mean daily temperature and maximum daily temperature with coefficients of 0.8604 and 0.9850 ($P < 0.05$), respectively, indicating damage during seed set. and the injury in seed setting was found with high average daily temperature during the grain filling stage. Chakrabarti et al. (2010) reported that exposure of crops to high temperature during anthesis (the most sensitive stage) in rice can reduce flower fertility. When the temperature during anthesis exceeds 33°C, pollen sterility gradually increases and the germination of pollen grains on the stigma decreases, which in turn affects pollen germination and seed formation, limiting rice yield. The increase in spikelet sterility under high night temperature was associated with a decrease in pollen germination (36%), an increase in respiration rate (28%) and relative membrane damage (86%). Mohammad and Tarpeli (2009 and 2010) reported that it is not related to photosynthesis. (Production).

9. Grain filling

As reported by Tian et al., (2007) and Xie et al., (2009), high temperature during flowering and seed filling can cause spikelet sterility and reduced yield by shortening seed filling time. Yoshida and Hara (1977) and Oh et al. (2007) observed that at high temperature, the grain growth rate is faster and the grain filling period is shorter. It was suggested by Osada et al., (1973) that temperatures above 30°C are generally unfavourable for ripening. Morita *et al.*, (2005) reported that high night temperatures (22ºC / 34 °C, day / night) were more harmful to grain weight in rice than high day temperatures (34ºC / 22 °C) and control conditions (22ºC / 22 °C) at optimum temperature. The results of Song et al., (2013) showed that high temperatures at night had a clear effect on the amount of granulation from 1 to 10 days after flowering and it was between 9.89 and 40.45% and reduced the accumulation of granulated materials. You have poor appearance and poor milled quality (e.g. brown rice percentage, milled rice percentage, milled rice percentage, incomplete rice percentage, chalky and chalky rice percentage). Above 22°C, an increase in mean temperature corresponds to an increase in protein content. Therefore, the temperature during ripening is also considered as another factor influencing the protein content. This indicates that protein accumulation is less affected by temperature than total dry matter accumulation. Therefore, temperature affects the accumulation of non-protein components, especially starch, more than the accumulation of protein.

10. Chalkiness

Chalkiness is one of the key factors in determining the quality and price of rice. Yoshioka et al., (2007) found that in Japan, chalk grains are commonly classified into different categories such as milk white rice, white kernel rice, white belly rice, white base rice and white back rice. Wakamatsu et al., (2007) observed that the incidence of white back and white based kernel was high when the average temperature during the 20-day period after heading was 27°C or higher. Below this temperature, no such occurrence was apparent. Yamakawa et al., (2007) reported that exposure of mature grains to high temperature results in decreased amylose content and increased long-chain amylopectin. Highly chalky grain contained amylopectin enriched mainly in long chains compared to mildly chalky grains, suggesting that such changes in amylopectin structure may be involved in grain chalkiness. Cooper et al., (2008) reported that rice head yield, grain size and amylase content decreased and the number of chalky grains found increased with increasing night temperature, while brown rice total, lipid and protein content did not change. She et al., (2010) observed that the seeds developed under high temperature conditions and had chalky or white cored endosperm. According to Lanning et al., (2011) increased night air temperature contributed to higher chalk formation and reduced rice milling quality. Yonemaru and Morita (2012) found that high temperature during rice ripening caused "unripe thin grain" and "chalky grain" states and subsequently reduced yield and reduced milling quality. Das et al., (2010) reported that high temperature of 30 - 36 °C during grain filling resulted in significant increase in chalk percentage and decrease in percentage of head rice regeneration and amylase accumulation in almost all varieties.

11. Heat tolerance

Matsui and Omasa (2002) reported a relationship between anther morphological characteristics and fertility in japonica rice cultivars exposed to high temperature (37.5 and 26 °C day and night); the percentage of fertility was negatively correlated with the number of cell layers that separated the anther from the lacuna that formed between the septum and the stomium. They concluded that the tight closure of the locule by opening the locule of cell layers and reducing fertility at high temperature. Prasad et al., (2006) evaluated fourteen rice cultivars of different species (*Oryza sativa and Oryza glaberrima*) and ecotypes (*indica and japonica*) exposed to ambient and high temperature (ambient +50 C) in Gainesville, Florida. High temperature significantly reduced spikelet fertility in all cultivars. Chakrabarti et al., (2010) studied "the effect of high temperature on pollen and spikelet sterility in Basmati and Non-Basmati rice. The increase in temperature increased pollen sterility and reduced the germination of pollen grains on the stigma". The variety Pusa Sugandh 2 (Basmati) recorded 17% pollen sterility and 26% reduction in pollen germination at 35.5°C. Increased temperature during the grain filling period also increased ear sterility in the rice variety. Non-Basmati rice varieties were less affected by increased temperature than Basmati types. Shah et al., (2011) studied the effect of high temperature stress on rice plant and its tolerance related traits. The shoot and flower stages were most sensitive to high temperatures leading to complete sterility. Significant variation in response to heat stress was found among rice germplasm. Flowering in cooler days, greater pollen viability, larger anthers, longer basal dehiscence, and the presence of long basal pores are some of the phenotypic markers for high temperature tolerance. Jagdish et al., (2011) studied that rice crops will often be subjected to water deficit and heat stress at the most sensitive stage of flowering, causing spike sterility and yield losses. Water deficit alone and in combination with heat stress significantly reduced petiole elongation, capturing 32% and 55% of spikelets in the leaf sheath, respectively. Trapped spikelets had lower spikelet fecundity (66% of control) than those occurring normally (> 93%). Weighted average fruiting of emerged spikelets was fair with head stress

(35%) but higher with combined stress (44%), indicating acquired heat tolerance when water deficit stress preceded. Pale et al., (2012) evaluated a total of 600 rice germplasm from the north-eastern hills of India for their high temperature tolerance. A total of 78 genotypes showed more than 80% germination at 40 °C, while only 27 genotypes showed 60% or more germination at 45 °C. At the seedling stage, 18 genotypes successfully recovered from the 40°C treatment, while only 9 recovered from the 45°C exposure. These 9 genotypes were found to contain 30–60% relative water content after 22 days of drought stress. Jagadish et al., (2012) reported that high temperature stress negatively affects rice production, especially in vulnerable areas of South and Southeast Asia. Hemantaranjan et al., (2014) reported that high temperature during seed germination can delay or completely inhibit germination depending on plant species and stress intensity. At a later stage, high temperature can adversely affect vital physiological processes such as photosynthesis, respiration, water relations and membrane stability, as well as modulate the levels of hormones and primary and secondary metabolites. Kumar et al., (1999) recorded significant differences in plant height, number of tillers per plant, flag leaf area, number of panicles per plant, number of spikelets per plant, yield per plant and test weight. Foolad (2005) reported that growth chamber and greenhouse studies indicate that high temperature is most damaging when flowers are first visible and sensitivity lasts 10-15 days. The reproductive stages most sensitive to high temperature are gametogenesis (8-9 days before anthesis) and fertilization (1-3 days after anthesis) in various plants. The main influence of temperature is the acceleration of development. In both rice and wheat, the rate of leaf appearance is faster and the time to flowering is shortened with increasing temperature. It is shown that low temperature had a significant effect at the one percent level on all characters such as panicle number, panicle length and number of full, empty and total grains; as a result, the yield caused a significant reduction. Low temperature in the range of 15℃ to 19°C during the reproductive phase impairs microspore development and causes the production of sterile pollen grains, resulting in poor grain filling and high spikelet sterility and reduced spikelet fertility and affecting grain quality.

12. Crop duration

Swaminathan (1984) reported that high temperature increases the rate of plant growth and shortens the vegetative period, possibly resulting in a reduction of the grain filling period from 25 days in tropical to 35 days in temperate. Sinha and Swaminathan (1991) suggested that a 0.5℃ increase in winter temperature shortened the harvest period by 7 days and reduced yield by 0.45 t/ha. Ziska et al. (1997) found that a 4°C increase in temperature during the growing season accelerated crop maturity by 5 and 6 days in the wet and dry seasons, respectively. Lalita et al. (1999) stated that average daily temperature above 26℃ limits tillering period to 5 weeks after planting. Venkatramanan and Singh (2009) found that the number of days from flowering to maturity was reduced in plants grown at high day and night temperatures. The harvesting period was shortened at high temperature. The duration of treatment at 4°C was 96 days (12 days earlier than ambient temperature) and 102 days (6 days earlier than ambient temperature) at 2°C compared to 102 days (6 days earlier than ambient temperature). Days. Rani and Maragatham (2013) in Khalif 2012 reported that temperature increased from ambient levels (2°C and 4°C) during the crop growing season under a temperature-controlled room. The results showed that the number of days to maturity was shorter at temperatures above 4°C (96 days) and 2°C (102 days) than at ambient temperature (108 days). Cumulative growth degree days at high temperature of 4°C were higher and closer than ambient values at 2°C, i.e. 1641 and 1583 days, respectively.

13. Grain quality

"High temperatures during the ripening period resulted in abnormal grain quality, abnormal morphology and color in rice, probably due to enzymatic activity related to grain filling, respiratory consumption of assimilation products, and decreased sink activity" as reported by Inaba and Sato (1976) and Tsukaguchi. and Iida (2008). Xun et al., (2005) observed that "high temperature at the grain filling stage increased the protein content, and decreased the amylose content and rice taste meter value, the grain quality being low. Varieties showed greater magnitude of increase or decrease than superior varieties".

14. Yield and its components

Yoshida (1983) found out that "the number of panicles is closely associated with grain yield, but there is often a negative correlation between the number of panicles per unit land area and spikelets per panicle and between spikelets per unit land area and filled grain percentage or 1000 grain weight. It is seen that high temperature (40 / 33 / 37°C, daytime dry bulb air temperature / night-time dry bulb air temperature / paddy water temperatures) during stem elongation led to death of rice plants while CO2 enrichment (660 mmol CO^2 mol^1 air) helped plants to survive, but with sterile panicles. As a result of high temperature, the extent of sterility can vary from a few empty glumes to the entire panicle having unfilled grains. Temperatures below 20 °C or above 35 °C and radiation lower than 200 cal cm2 day1 at anthesis can result in up to 40–60% sterility". Lin et al., (1997) reported that "seed set and panicle weight of rice plants grown at higher temperatures (ambient 4 °C) are significantly reduced while green leaf area increased, relative to those plants grown at ambient temperatures. Generally, the rice cultivars with high yield potential have grain weights in the range of 20–30 g and grain weight generally follows the order of maturity within a panicle, the first maturing grain being the heaviest". "High temperature can increase the grain growth rate, but decrease the grain-filling period" was found out by Akita (1989). The rice yield in the temperate or high altitude subtropical or tropical environments shows plasticity in the yield components and there are strong compensation mechanisms, particularly, for panicle and spikelet number in crops under tropical conditions. In subtropical rice - growing regions, occurrence of seasonal high night temperature (HNT) during the critical stages of development reduced rice yield and its quality. High night temperatures decreased the yield by 90 per cent, spikelet sterility with 61 per cent and grain length of 2 per cent, width 2 per cent and weight. High night temperature increased grain nitrogen concentration (44%), which was inversely related to grain weight. The average milling recovery decreased from 67.88 per cent in crop plants exposed to 30°C (minimum temperature) to 56.49 per cent in plants that experienced 36°C (maximum temperature). The HRR per cent was drastically reduced from 55.08 per cent at 30°C to 30.79 per cent at 36°C. The amylose content also got varied with lowest (24.33%) at 36°C and highest (28.80%) at 30°C. High temperature resulted in increased gelatinization temperature values. The average protein content found decreased from 9.12 per cent at 30°C to 7. 38 per cent at 36°C. Islam (2011) studied the impact of high temperature of 34°C at booting stage and at the grain filling stage and found that photosynthetic rate, grain yield and harvest index did decrease, but leaf conductance and transpiration rate got increased. Total dry matter per plant was the lowest with the temperature of 34°C at booting stage, but plant height and number of panicles/plant was not affected by the temperature stress. Basak et al., (2014) studied that “the impact of climate change on rice yields depend on actual patterns of climatic factors change in rice growing regions. Both higher maximum and minimum temperature reduce rice yields due to spikelet sterility and higher respiration losses. At the same time, rice production may be threatened in vulnerable regions. Overall, much uncertainty still exists about the true direction of the impacts of CO_2 and temperature”.

15. Yield

The optimum temperature for grain yield is usually 5 to 10 °C lower than that for photosynthesis. Increasing temperature treatments above 28°/21°/25°C decreased grain yield mainly due to reduced number of filled grain panicles. Various phenological stages such as active tillering, panicle initiation, 50 percent flowering and harvest were found to be lower for crops grown under elevated temperatures (4°C and 2°C) than at ambient temperatures. Under elevated temperatures of 4°C and 2°C, grain yield was 23 and 13.3 percent less than the ambient. The highest grain yield was 5.3 t ha-1 under 2°C level and 4.7 t ha-1 under 4°C level from treatment with 6.2 t ha-1 at ambient temperature. Higher temperatures reduce yields due to sterile flowers and shorter cropping periods. Matsui et al., (2000) reported that “the average optimum temperature for japonica rice crop in Japan was about 20-22 °C. Although temperature during harvest affects weight per grain, the 1000-grain weight of a particular cultivar is considered nearly constant under different climates and cultural practices”. However, Murata (1976) observed that “the 1000-grain weight of the same variety varied from about 24 g at an average temperature of 22 °C over a 3-week period to 21 g at an average temperature of 28 °C. Kyushu, southern Japan”. Peng et al., (2004) reported a 10 percent decrease in grain yield for each 1°C increase in dry season minimum growing season temperature, while the effect of maximum temperature on crop yield was negligible. This report provides direct evidence of reduced rice yields due to increased night-time temperatures associated with global warming. Whereas, Baker and Allen (1993) and Peng et al., (2004) found that grain yield of rice increased approximately 1°C above 25°C until reaching zero yield at an average temperature of 35–36°C. 10% decrease. , using a 7 °C day and night temperature difference. “However, the optimum temperature for grain formation and yield is low (25°C)” (Baker et al., 1995).

Conclusion

This review emphasizes the global importance of rice, the impact of high temperatures on rice growth, quality, yield, and characteristics, and the need for future research. High temperatures during the ripening period resulted in abnormal grain quality, abnormal morphology and color in rice, probably due to enzymatic activity related to grain filling, respiratory consumption of assimilation products, and decreased sink activity.

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