International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(1): 498-501
www.biochemjournal.com
Received: 16-10-2023
Accepted: 29-11-2023

Paramasiva I
Department of Entomology, Agricultural Research Station, Acharya N. G. Ranga Agricultural University, Nellore, Andhra Pradesh, India

Madhusudhan
Department of Plant Pathology, Agricultural Research Station, Acharya N. G. Ranga Agricultural University, Nellore, Andhra Pradesh, India

P Vineetha U
Department of Agronomy, Agricultural Research Station, Acharya N. G. Ranga Agricultural University, Nellore, Andhra Pradesh, India

Srilakshmi CH
Department of Plant Breeding, Agricultural Research Station, Acharya N. G. Ranga Agricultural University, Nellore, Andhra Pradesh, India

Corresponding Author:
Paramasiva I
Department of Entomology, Agricultural Research Station, Acharya N. G. Ranga Agricultural University, Nellore, Andhra Pradesh, India

Possible impact of climate change on incidence of insect pests of rice

Paramasiva I, Madhusudhan, P Vineetha U and Srilakshmi CH

DOI: https://doi.org/10.33545/26174693.2024.v8.i1g.425

Abstract
Extreme weather occurrences, variations in the pattern of rainfall, and an increase in the average world temperature were resulted to the existence of climate change. All living things, including plants, insects, and the relationships they have with the weather, herbivores, and other organisms, could be impacted by climate change. Such alterations in the weather and environment could have a significant impact on the dynamics of insect pest populations and crop conditions. These could result from indirect effects on the pest, host plants, rivals, and natural enemies in addition to direct effects on the distribution and quantity of pest populations.

Many researchers have proved through laboratory studies, elevated temperature and CO2 resulted in escalation of brown plant hopper, leaf folder and stem borer multiplication through increase in both fecundity and number of adults, thus inflicting higher yield loss in rice under elevated conditions. In contrast some studies proved that elevated conditions lowered female longevity, fecundity and egg survival rates, indicating that elevated conditions likely to limit population build up of rice pests. Furthermore, numerous studies have shown that while some insects cannot develop in high temperatures, others may adapt to the warmer weather through selection and evolution. The ability of brown planthoppers to withstand heat varies depending on their location. In some cases, if host plants are present, winter temperatures will become more favorable for pests as a result of global warming. For example, in the case of rice leaf folder and brown plant hopper, higher winter temperatures may not only reduce mortality but also speed up development, increasing the chance that the pest will accumulate and cause damage to crops in subsequent generations.

Global warming may increase the number of generations of rice insect pests and their potential to do harm, however this isn't always the case because the yield loss that these pests cause is the same in temperate, subtropical, and tropical locations. However, a detailed investigation reveals that both environmental conditions and human activity can have an impact on the occurrence and harm caused by rice pests. Global warming is undoubtedly a significant impact in the population rise, even though many other causes might also be involved. Long-term monitoring of the population dynamics of these insect pests is crucial for effective pest management in order to estimate potential changes in rice insect pests in the upcoming years.

Keywords: Climate change, Rice pests, stem borer, leaf folder, brown plant hopper

Introduction

By 2100, it is predicted that global temperatures would rise by 1.4 to 5.8 °C, along with increases in precipitation of 10% to 15% and an increased frequency of heat waves and cold snaps. Over the same time frame, carbon dioxide (CO_2) is predicted to rise from 540 to 970 ppm (IPCC, 2014) [12]. The average surface temperature of the world has risen by about 0.6 °C over the last century. Meantime, between 1901 and 2018, the average temperature in India increased by about 0.7 °C. The warming caused by GHGs is primarily to blame for this temperature increase. However, the anticipated amount of change in temperature and rainfall for India, among other places, is quite unknown.

The global distribution, abundance, and ecology of plants and animals will all be significantly impacted by these changes [Khadioli *et al*., 2014a; Khadioli *et al*., 2014b; Ntiri *et al*., 2016; Mutamiswa *et al*., 2018] [13-14, 22, 21]. Because they are ectothermic and precipitation-sensitive, insects are likely to be impacted by climate change (Bale *et al*., 2002) [3]. These impacts could be indirect, mediated by host plants, rivals, or natural enemies, or direct, caused by the impact of climate variables on the physiology and behavior of the insect (Bezemer *et al*., 1998; Thomson *et al*., 2010) [4, 30].

For about half of all people on Earth, rice is the primary basic diet. Over one hundred insect pest species consume rice. Twenty of these species are significant pests that seriously harm the economy. The brown planthopper, *Nilaparvata lugens* (Stal), rice yellow stem borer *Scirpophaga incertulas* (Walker), leaf folder, Napalocrocos medinalis (Linnaeus), gall midge (GM), *Orseolia oryzae* (Wood-Mason), panicle mite, and *Steneotarsonemus spinki* are the main insect pests of recent years that have regional significance.

In India, the frequency of stem borer was minimal until the 1970s, moderate until 1975, severe and widespread starting in 1980, and it continues to be a significant pest of rice. Not regarded as a nuisance until the 1970s, BPH became a major issue in the 1990s and has remained so to this day. Since 2000, there have been reports of a moderate occurrence of WBPH. In the upcoming ten years, the pest may become seriously prevalent, especially in irrigated ecologies. In recent decades, leaf folders, which were mild until the 1980s, have become a major nuisance. Gall midge is still in common use today, but the emergence of new biotypes could cause serious issues down the road. The occurrence of whorl maggots, panicle mites, Hispa, and caseworms has increased in localized places since 2000, and their shifting status in recent years has made them significant. With the exception of a few more pests of regional importance, the number of rice pests increased from three to fifteen between 1965 and 2009. Because of temperature increases and climatic shifts, mites such as leaf and panicle mites, which were not even regarded as minor pests in rice before the 1980s, have now become severe pests (Krishnaiah and Varma, 2011) [17].

Though there are several possible reasons for the abundance/shifts in insect pests *viz*., growing varieties lacking resistance to major pests, extensive cultivation of high yielding varieties, intensified rice cultivation throughout the year providing niches for pest multiplication, imbalance use of fertilizers and indiscriminate use of insecticides, harmful cultural practices, evolution of biotypes, changes in temperatures or rainfall patterns will have profound influence on pest scenario of rice crop.

Keeping these facts in view the topic on Possible impact of change in climate on rice pests is discussed here under.

Impact of climate change on rice pests

Because of their very sensitive physiology, insects typically double in metabolic rate for every 10 degrees Celsius increase in temperature. Elevated temperatures have the tendency to quicken the consumption, growth, and migration of insects. This can have an impact on population dynamics by affecting factors like fecundity, survival, generation time, and population size. According to Kun *et al*. (2014), the population size of brown plant hoppers may increase due to the combined effects of increasing temperature and CO2 levels.

In comparison to ambient CO2 and temperature (25.5 ± 2.1 hoppers/hill), enhanced temperature (≃3 °C higher than ambient) and elevated CO2 (570 ± 25 ppm) shown a beneficial effect on BPH multiplication, increasing its population (55.2 ± 5.7 hoppers/hill). According to Pandi *et al*. (2018) [6], increasing CO2 + temperature dramatically decreased adult longevity and nymphal length by 17.4% and 18.5%, respectively. However, elevated circumstances enhanced BPH fecundity by 29.5%.

Found that, in contrast to ambient CO2 and temperature, elevated temperature CO2 levels increased the BPH nymphal duration (14.2 days) and decreased female lifespan (9.6 days), fecundity (155.5 eggs/♀), and nymphal feeding rate (14.3 mm2). Between 25 and 35 °C, the adult survival of *Nilapavata lugens*, the brown plant hopper, was essentially unaffected; however, at 40 °C, it was significantly decreased. Female oviposition was comparatively higher at 35 and 40 °C than it was at 25 and 30 °C, but at 35 °C, egg survival was much lower. Pre-oviposition period lengths were also shortened at the higher temperatures. These results clearly show that Brown Plant Hopper [BPH] development is likely to be limited by temperatures above 35 °C (Heong *et al*., 1995) [9]. Certain insects cannot normally grow in high temperatures, whereas others may adjust to their surroundings (Hoffman and Blows, 1993) [10]. Certain species can flourish and proliferate quickly, whereas others cannot adapt and evolve to survive in warmer climates. Certain natural enemies can be negatively impacted by rising temperatures. For example, BPH is 17 times more tolerant of 40 °C than its predator Cyrtorrhinus lividipennis, which leads to an increase in BPH populations (Krishnaiah and Varma, 2011) [17].

Several investigations have revealed the genetic diversity of insects, some of which even possess the ability to endure extremely high or low temperatures (Huey *et al*. 1991, Quintana and Prevosti 1990) [11, 27]. In the Philippines, populations of brown planthoppers exhibit varying degrees of heat tolerance; for example, the LT50 of first- and third-instar nymphs from Khon Kaen, Thailand, is 57.2 and 144.6 hours, respectively, while it is only 23.4 and 22.8 hours, respectively, for the IRRI's strain (Heong and Domingo 1992) [8]. Brown planthoppers exhibit varying degrees of heat tolerance in different regions. Comparable outcomes were noted in a brown planthopper-predating mirid insect (*Cyrtorhinus lividipennis* Reuter). According to Heong and Domingo (1992) [8] and Peters (1991) [26], the Thai mirid strain has a heat tolerance that is roughly thirty times higher than the Philippine strain. These findings suggested that insects could adapt in the high temperature environment by selection and evolution.

Furthermore, as a result of global warming, winter temperatures will become more favorable for pests if host plants are present. For example, elevated winter temperatures may not only reduce mortality rates for rice leaf folder and brown plant hopper, but also speed up their development, increasing their potential to accumulate and harm crops in subsequent generations (Kirtani, 1999 & 2007) [15-16].

The rice leaffolder, *Cnaphalocrocis medinalis*, has been shown in several lab experiments to be affected by high temperatures in terms of growth rate, re-production rate, survival, adult longevity, population size, and sexual behavior (Liao *et al*., 2014; Park *et al*., 2010) [18, 23]. According to a 2019 study by Ali *et al*., during the 22-year model period, there was a large rise in leaf folder populations in November, which coincided with notable monthly temperature increases (but not rainfall). According to the model, more rainfall will reduce the abundance of leaf folders, while higher maximum temperatures will increase their population. This study indicates that recent leaffolder outbreaks in rice-growing nations may have been caused by warmer environments; so, rising temperatures increase the number of pests in the field, which raises rice output losses.

However, Heong *et al*. (1995) [9] found that at 35 °C, there was a significant reduction in the survival of the various stages of the rice leaffolder. When adults from pupae raised at 35 °C emerged, they were unable to lay eggs. This species' highest temperature threshold for survival seems to be between 30 and 35 °C. The rates at which pest and predator species emerge can be impacted differently by changes in the climate. Temperatures can also have an impact on predator search. When temperatures rose to 32 °C, the egg predator *Cyrtorhinus lividipennis* experienced a drop in handling times and an increase in instantaneous attack rates. The attack rate and handling time dropped significantly at 35 °C. This suggests that, up until a critical temperature of roughly 35 °C, predator activity is expected to rise with rising temperatures. Global warming has the potential to alter biological traits as well as temporal asynchrony amongst interacting populations. Temperature also considered to have the greatest influence on yellow stem borer, *Scirpophaga incertulas* abundance in rice. Climate change is expected to affect the behavior as well as distribution and abundance of YSB in southern Asia by increasing winter survival rates and the number of generations per year, as well as inducing an earlier appearance in the crops after winter (Patel *et al*., 2017) [24].
However, Ali *et al*., 2020 [2] found that the development rate of yellow stem borer was positively impacted by both rising temperatures and rainfall when taken separately. Nevertheless, there was a deleterious outcome when rainfall and high temperatures were coupled. Yellow stem borer abundance was positively impacted by temperature at intermediate to low rainfall levels, but negatively by high rainfall. When there is a lot of rainfall and a relatively low temperature, the yellow stem borer grows quickly. According to Haq *et al*. (2008) [7], there has been a decline in the number of S. incertulas during the past thirty years, which could be attributed to mortality brought on by increased rainfall and temperatures. According to Mohapatra *et al*. (2021) [20], under elevated conditions (i.e., 700 ppm and 550 ppm CO2 level), the incubation period and duration of adult (female and male) S. incertulas reduced while the total larval and pupal duration rose. Thus, increased CO2 has a major impact on S. incertulas' entire life cycle.
Global warming might theoretically lead to an increase in the number of generations of rice insect pests and their potential to do harm, although this isn't necessarily the case. Without chemical treatment, insect damage to sensitive rice varieties in Indonesia, the Philippines, and Japan resulted in yield losses of 48.3-58%, 50.4%, and 42–54 percent, respectively (Mochida *et al*. 1983) [19]. In Taiwan, insect pests resulted in yield losses of around 15% (878.2 kg ha^{-1}) and 30% (1427.8 kg ha^{-1}) for the first and second rice crops, respectively. A comparable yield loss of 20–25%, or 1,000 kg ha^{-1}, was documented in the Philippines (Pathak and Daliwal 1986) [25]. These results demonstrate that although temperate, subtropical, and tropical climates may differ slightly in temperature, humidity, and other climatic conditions, the yield loss caused by insect pests does not. For a higher yield, more fertilizers and insecticides are typically applied in agriculturally developing regions; nevertheless, this sometimes leads to the return or replacement of insect pests, which can cause more severe damage than in developed regions (Sogawa *et al*. 2003) [29]. These research make it abundantly evident that both climatic conditions and human activity can have an impact on the prevalence and harm caused by rice insect pests. Under the current trend of global warming, there will be little change in the incidence and harm caused by rice insect pests in the near future as long as cultural practices do not alter significantly (Cheng 1998) [5]. Global warming is undoubtedly a significant impact in the population rise, even though many other causes might also be involved. Long-term monitoring of the population dynamics of these insect pests is crucial for effective pest management in order to estimate potential changes in rice insect pests in the upcoming years.

Conclusions

Thus, different agro-ecosystems and ecological zones may experience different changes in the population dynamics of insect pests due to climate change, which calls for increased attention to comprehend and manage these challenges through additional research. However, little is known about the actual impact on the biological and ecological characteristics of insects. It is often known that the most significant element limiting an insect species' spread, rate of development, number of generations, and population abundance in a given area is the weather, especially the temperature. The intricate relationships that exist between host plants, insect pests, and environmental conditions are highly complex. Additionally, through evolution and selection, the majority of insect pests are able to adapt to a variety of environments. Consequently, extrapolating the potential effects of erratic climate change on insects solely from the findings of factor-limited research would be inaccurate. On the other hand, as a result of global warming, increasing temperatures will alter the agro environment in a given area as well as the cultural system and insect population. Therefore, keeping a close eye on the species and population fluctuations of insect pests should take precedence over all other considerations.

References

1. Ali MP, Mir MMK, Afrin S, Nowrin F, Haque SS, Haque MM, Hashem A, Tabassum B, Abd-Allah EF, Pittendrigh BR. Increased temperature induces leaffolder outbreak in rice field. J Appl Entomol. 2019;1–8.
2. Ali MP, Bari MN, Haque S, Kabir MMM, Choudhuri TR, Mankin RW, Ahmed N. Response of rice insect pest, *Scirpophaga incertulas* (Lepidoptera: Pyralidae) in warmer world. BMC Zoology. 2020;5:6.
3. Bale JS, Masters GJ, Hodkinson ID. Herbivory in global climate change research: direct effects of rising temperature on insect herbivores. Glob Chang Biol. 2002;8:1–16.
4. Bezemer TM, Jone TH, Knight KJ. Long-term effects of elevated CO2 and temperature on populations of the peach potato aphid Myzus persicae and its parasitoid Aphidius matricariae. Oecologia. 1998;116(1–2):128–35.
5. Cheng CH. Impact of global climate change on crop insect pests in relation to pest control strategies in Taiwan. In: Lin CY, Yang CM, editors. Proceedings of Symposium of Crop Production in Response to Global Climate Change. Taiwan Agricultural Research Institute Press; Taichung Hsien, Taiwan. 1998. p.74-85.

6. Pandi GGP, Chander S, Singh MP, Pathak H. Impact of Elevated CO2 and Temperature on Brown Planthopper Population in Rice Ecosystem. Proc. Natl. Acad. Sci. India Sect B Biol. Sci. 2018;88(1):57–64.
7. Haq M, Taher MA, Rabbi MF, Ali MA. Incidence and severity of rice diseases and insect pests in relation to climate change. International symposium on climate change and food security in South Asia, Dhaka, Bangladesh. 2008.
8. Heong KI, Domingo I. Shifts in predator-prey ranges in response to global warming. Intl Rice Res Inst Newsl. 1992;17:29-30.
9. Heong KL, Song YH, Pimsamarn S, Zhang J, Bae SD. Global Warming and Rice Arthropod Communities. In: Peng S, Ingram KT, Neue HU, Ziska LH, editors. Climate Change and Rice. Springer publications, Berlin. 1995. p. 327-335.
10. Hoffman AA, Blows MW. Evolutionary genetics and climate change: Will animals adapt to global warming. In: Kareiva PM, Kingsolver JG, Huey RB, editors. Biotic Interactions and Global Change. Sinauer, Sunderland, MA, USA. 1993. p. 165-178.
11. Huey RB, Partidge L, Fowler K. Thermal sensitivity of Drosophila melanogaster responses rapidly to laboratory natural selection. Evolution. 1991;45:751-756.
12. IPCC. Climate Change, Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Pachauri RK, Meyer LA, editors. Geneva. 2014. p. 151.
13. Khadioli N, Tonnang Z, Ongamo G, Achia T, Kipchirchir I, Kroschel J. Effect of temperature on the life history parameters of noctuid lepidopteran stem borers, Busseolafusca and Sesamiacalamistis. Ann Appl Biol. 2014a;165(3):373–86.
14. Khadioli N, Tonnang Z, Muchugu E, Ong'amo G, Achia T, Kipchirchir I. Effect of temperature on the phenology of *Chilo partellus* (Swinhoe) distribution of C. partellus in Africa under warmer temperatures through the development of life-table parameters. Bull Entomol Res. 2014b;104(06):809–22.
15. Kirtani K. Shift of IPM strategy for rice under global warming in temperate areas. In: Zhang R, Gu D, Zhang W, Zhou C, Pang Y, editors. Integrated pest management in Rice-based ecosystem. Zhongshan University Press, Guangzhou, PRC. 1999. p. 235-244.
16. Kirtani K. The impact of global warming and land use change on the pest status of rice and fruit bugs (Heteroptera) in Japan. Popul Ecol. 2007;48:5-12.
17. Krishnaiah K, Varma NRG. Changing pest scenario in the rice ecosystem – A National perspective. Rice knowledge management portal (RKMP). IIRR, Rajendra nagar, Hyderabad. 2011.
18. Liao HJ, Qian Q, Liu XD. Heat shock suppresses mating and sperm transfer in the rice leaf folder *Cnaphalocrocis medinalis*. Bull Entomol Res. 2014;104:383–392.
19. Mochida O, Heinrichs EA, Aquino V. Pest management systems on rice in the Pacific basin. Dunedin, New Zealand. 1983. 11pp.
20. Mohapatra M, Mohapatra SD, Patro B. Effect of increasing carbon dioxide on biology of a major rice pest yellow stem borer. The Pharma Innovation Journal. 2021;SP-10(9):545-547.
21. Mutamiswa R, Machekano H, Chidawanyika F, Nyamukondiwa C. Thermal resilience may shape population abundance of two sympatric congeneric Cotesia species (Hymenoptera: Braconidae). PLoS One. 2018;13(2):e0191840.
22. Ntiri ES, Calatayud PA, Van Den Berg J, Schulthess F, Le Ru BP. Influence of Temperature on Intra- And Interspecific Resource Utilization Within a Community of Lepidopteran Maize Stemborers. PLoS One. 2016;11(2):e0148735.
23. Park HH, Cho JR, Park CG, Kim KH, Goh HG, Lee SG. The occurrence of rice leaf-folder Cnaphalocrocis medinalis (Lepidoptera: Crambidae) in Suwon and its response to insecticides. Korean Journal of Applied Entomology. 2010;49:219–226.
24. Patel S, Singh CP. Seasonal incidence of rice stem borer, *Scirpophaga incertulas* (Walker) on different varieties of rice in relation to weather parameters. J Ent. Zoo Sudies. 2017;5(3):80-3.
25. Pathak MD, Dhaliwal GS. Insect control. In: Swaminathan MN, Sinha SK, editors. Global Aspects of Food Production. IRRI, Philippines; c1986. p. 357-386.
26. Peters RL. Consequences of global warming for biological diversity. In: Wyman RL, editor. Global Climate Change and Life on Earth. Chapman and Hall, London, UK. 1991. p. 99-118.
27. Quintana A, Prevosti A. Genetics and environmental factors in resistance of Drosophila subobscura adults to high-temperature shock. Theor Appl Genet. 1990;80:847-851.
28. SHI Bao-kun, HUANG Jian-li, HU Chao-xing, HOU Mao-lin. Interactive Effects of Elevated CO2 and Temperature on Rice Planthopper, *Nilaparvata lugens*. Journal of Integrative Agriculture. 2014;13(7):1520-1529.
29. Sogawa K, Lin GJ, Shen JH. A review on hyper-susceptibility of Chinese hybrid rice to insect pests. Chinese J Rice Sci. 2003;17(Supplement):23-30.
30. Thomson LJ, Macfadyen S, Hoffmann AA. Predicting the effects of climate change on natural enemies of agricultural pests. Biol Control. 2010;52:296-306.