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VALIDATION OF COUPLED BROWN PLANTHOPPER- INFOCROP RICE SIMULATION MODEL AND YIELD LOSS UNDER ELEVATED CO_2

G. Guru Pirasanna Pandi*, Subhash Chander, Soumia P. S. and Sujithra M.

Division of Entomology, ICAR- Indian Agricultural Research Institute, New Delhi 110012
*Current address- Division of Crop Protection, ICAR-National Rice Research Institute, Cuttack 753 006
* Email: guruagri@gmail.com (corresponding author)

ABSTRACT

Coupled brown planthopper (BPH)- ICAR-InfoCrop rice simulation model was validated with BPH population and crop yield under elevated CO_2 vis-à-vis ambient CO_2 experiments during 2013 and 2014. Under ambient CO_2, simulated BPH number varied from 13 to 118/ hill compared to observed population of 11 to 92/ hill; while in simulated varied from 19 to 177/ hill in comparison to the observed 16 to 168/ hill under elevated CO_2 during 2013. Likewise, during 2014 simulated BPH population ranged from 9 to 68/ hill compared to observed population of 10 to 65/ hill under ambient CO_2, whereas simulated one was found to be between 15 to 88 compared to 9 to 80/ hill observed under elevated CO_2. Simulated and observed BPH number were thus found to be proximal under elevated CO_2 ($R^2 = 0.96$; $p<0.0001$) and ambient CO_2 ($R^2 = 0.89$; $p<0.0001$) during the first year as well as during second year under elevated CO_2 ($R^2 = 0.93$; $p<0.0001$) and ambient CO_2 ($R^2 = 0.85$; $p<0.0001$), reflecting appropriate validation of the BPH population dynamics model. Simulated yield loss during 2013 was 19.6% compared to observed yield loss of 23.1% under ambient CO_2, with corresponding losses of 34.5 and 38.5% under elevated CO_2. In 2014, simulated yield loss was 11.7% in contrast to 14.4% observed under ambient CO_2, whereas simulated and observed yield loss was 25.2 and 29.91%, respectively under elevated CO_2. The modelling approach presented herein provides an outline for future risk of rice yield loss due to BPH in India under climate change scenarios.

Key words: Rice, brown planthopper, elevated CO_2, pest, food, insect, model, yield loss, model, coupling, simulation

Increase in atmospheric CO_2 will have a significant impact on plant growth and development primarily due to changes in photosynthetic carbon assimilation patterns (Reddy et al., 2010) and has been reported in many species including rice; while temperature rise has been found to have an adverse effect on C_3 plants (Pandi et al., 2016). However, actual effect on plant growth and yield would depend on interaction between CO_2 and temperature. In the context of climate change, temperature directly affects insects, while CO_2 affects them through host plants (Netherer and Schopf, 2010). Temperature is probably the single most important environmental factor influencing insect behaviour, distribution, development, survival and reproduction. It is believed that the effect of temperature on insects largely overwhelms the effects of other environmental factors (Bale et al., 2002). It has been estimated that with a 2°C temperature increase, insects might experience one to five additional life cycles per season (Yamamura and Kiritani 1998).

Changes in atmospheric CO_2 affect not only the plant quality but also the herbivore performance (Awmack et al., 2004). The C:N ratio of the plant foliage generally increases when plants are grown in elevated CO_2 than in ambient (Pandi et al., 2018). As a result, insect larvae increase leaf consumption and their sucking rates under elevated CO_2 to compensate for lower nitrogen in plant foliage (Rao et al., 2009; Pandi et al., 2018). Besides, size of plant canopy may also influence pest populations especially those of rice planthoppers through changes in micro-environment (Pandi et al., 2017).

Models are important analytical tools for evaluating, understanding and predicting the dynamics of insect populations in ecosystems under a variety of environmental conditions and management practices. Models provide overall good prediction of population growth potential for the wide range of climatic conditions under which the pests prevail. Simulation model have universal application as these are based on physiological and ecological process of insect and crop and thus prove to be better than empirical models, which are location specific in nature. Pest induced yield losses, a critical issue in the tropics, is not addressed in most models. However, InfoCrop, a generic dynamic crop