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Effect of increasing carbon dioxide on biology of a major rice pest yellow stem borer

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Abstract
The experiment was conducted at National Rice Research Institute (NRRI), Cuttack, Odisha under two elevated carbon dioxide concentration i.e. 550ppm & 700ppmCO_2 against ambient condition i.e. 410ppm CO_2. The study revealed lowest incubation period (5.65±0.22 and 5.80±0.20 days) and adult longevity (2.24±0.17 and 2.30±0.11 days in female, 2.25±0.35 and 2.20±0.20 days in male), highest larval duration (32.25±0.39 and 32.90±0.37 days), pupal duration (7.80±0.27 and 7.95±0.11 days) and total life cycle (48.05±0.67 and 48.95±0.54 days in female, 47.95±0.77 and 48.85±0.57 days in male) were under 700ppm CO_2 level against ambient CO_2 in atmosphere i.e. highest incubation period (6.50±0.30 and 6.70±0.20 days) and adult longevity (2.80±0.20 and 2.90±0.13 days in female, 2.75±0.30 and 2.65±0.22 days in male), lowest larval duration (26.05±0.48 and 26.15±0.48 days), pupal duration (7.20±0.32 and 7.30±0.11days) and total life cycle (42.55±0.44 and 43.05±0.69 days in female, 42.50±0.55 and 42.80±0.83 days in male) during the *RABI* 2017-18 and 2018-19 respectively. Similarly the intermediate incubation period, total larval duration, pupal period, adult longevity and total life cycle of *S. incertulas* were completed in 6.20±0.11 and 6.35±0.13, 28.90±1.06 and 29.15±0.54, 7.65±0.28 and 7.80±0.20, 2.45±0.41 and 2.55±0.11 in case of female, 2.40±0.13 and 2.35±0.13 in case of male, 45.20±1.30 and 45.85±0.51 of female, 45.15±1.16 and 45.65±0.62 days of male under 550ppm CO_2 level during *RABI* 2017-18 and 2018-19 respectively.

Keywords: rice, *Scirpophaga incertulas*, biology, elevated carbon dioxide

Introduction
Rice, *Oryza sativa* L. is most important staple food crop occupying area (43.78mha), production (118.43 mi tone), productivity (2705 kg/ha) in India. The global atmospheric CO_2 concentration
has increased from 280 ppm in pre-industrial times to 410 ppm at present and will reach upto 550 ppm by 2050 and 730–1020 ppm by 2100 (IPCC, 2014) [6]. A comprehensive review of rice arthropod communities under global warming showed that arthropods can evolve in diverse ways to adapt to the climate changes (Heong *et al*., 1965) [5]. In the context of climate change, temperature affects insects directly and CO_2 affects them indirectly through host plants (Netherer and Schopf, 2010). Insect pests are major constraints for increasing the productivity in all the ecosystems of rice in the tropics. In India, approximately 100 insect species feed on rice and 20 of these are considered to be major pests, causing 30% yield loss. (Cramer, 1967; Pathak and Dhaliwal,1981) [4, 8]. Yellow stem borer (YSB) is one of the major pest in rice and its incidence varies between fields, locations, seasons and period. At various conditions it causes 30 to 70 percent yield loss (Chakraborty, 2011) [2]. Its damage causes dead heart and white ear head in the crop during vegetative and reproductive stages, respectively. The unique character i.e. monophagous by nature makes the pest more devastative on rice plant. Being an internal feeder, information on biology of *S. incertulas* under climate change is not available until now. In this perspective, effort was given to assess the effect of rising CO_2 on the biology of yellow stem borer.

Material and Methods
Location and Climate
The comparative biology of Yellow Stem Borer, *Scirpophaga incertulas* was studied under elevated carbon dioxide on in open top chamber (OTC) during the *RABI* (April-June) 2017-18 and 2018-19 at the ICAR- National Rice Research Institute, Cuttack, Odisha (20^0 N latitude, 86^0 E longitude and is at an elevation of 23.5 m above the mean sea level).

Plant Material

The comparative biology of *S. incertulas* was studied on susceptible rice variety Taichung Native 1 (TN_1) (90 days) under ambient (410ppm CO_2) and two under elevated (550ppm & 700ppm CO_2) condition.

Methodology

To carryout experiment, the nursery was raised in plastic tray inside each OTC and the fifteen days old rice plant were transplanted in plastic pots with recommended package of practices. The potted rice seedlings were covered with mylar cages in order to prevent the infestation of other inset pests. One pair of adult was released in each pot when crop was 45 days old under each treatment. One day after release, the egg-masses were collected from plant by cutting the leaf section and kept on moist filter paper in petridishes within plastic tray.

In order to study the biology under OTC, the larvae of *S. incertulas* was reared as per lab procedure. After hatching the 1st instar onwards were reared in a glass beaker lined with filter paper kept on plastic tray. Each instar of larvae was provided with fresh cut stems (8-10cm) of plant grown in the OTC. The young stem (without internode) of plant were fed to the larvae of 1st to 3rd instar whereas from 3rd onwards the larvae were provided with stems having internode. When the last instar larvae covered the upper portion of stem with white silken thread, it was splited in order to collect the pupa. The collected pupa were kept inside glass-vial properly for emergence of the adult. Simultaneously, the first instar larvae was also released on plant inside mylar cage to get the adult moths. The observations on duration of each and every stage of life cycle i.e egg, larvae, pupae and adult (male & female) were recorded inside the OTCs. The experiment was replicated five times in a Complete Randomized Design (C.R.D.)

Results and Discussion

Egg period

The mean incubation period ($F_{2,12}$= 17.84 and 29.06, p<0.05) 5.65±0.22 and 6.20±0.11 days, 5.80±0.20 and 6.35±0.13 days differed significantly with elevated CO_2 concentrations than ambient CO_2 (6.50±0.30 and 6.70±0.20 days) during 2017-18 and 2018-19 respectively (Table 1 &2). Similar observation was reported by Viswajyothi *et al.* (2020) [15] in life cycle of pink stem borer on maize under elevated CO_2 level.

Larval period

The mean total larval duration ($F_{2,12}$= 94.34 and 251.83, p<0.05) 32.25±0.39 and 32.90±0.37 days were highest significantly under700ppm followed by 28.90±1.06 and 29.15±0.54 days at 550ppm CO_2 against ambient condition i.e. 26.05±0.48 and 26.15±0.48 days during 2017-18 and 2018-19 respectively.

Pupal duration

The mean pupal duration of *S. incertulas* were also higher under 550ppm and 700 ppm CO_2 level than ambient (410ppm) during 2017-18 and 2018-19.

Similar observations on longer larval and pupal duration of *S. incertulas* was reported on other lepidopteran pests like *S. litura* feeding on castor (Rao *et al*. 2009) [9] and peanut (Rao *et al*. 2014 and Sreenivas *et al*. 2018) [10, 11] and *H. armigera* (Yin *et al*. 2010, Khadar *et al*. 2014 and Singh *et al*. 2017) [14, 7, 12], Asian corn borer, *Ostrinia furnacalis* (Xie *et al*. 2015) [13].

Adult longevity

The mean duration of adult longevity i.e female and male was minimum under 550ppm and 700 ppm CO_2 level than ambient 410ppm during 2017-18 and 2018-19 respectively.

The adult longevity of *Sesamia inferens* on maize was not so much influenced by elevated CO_2 found by Viswajyothi *et al*. (2020) [15]. Similar observation on decreased adult longevity was reported in *H. armigera* on wheat by Chen *et al*. (2005) [3].

Total Life cycle (Egg to adult emergence)

The mean total life cycle of adult ($F_{2,12}$ = 48.29 and 125.17, p<0.05) 45.20±1.30 and 45.85±0.51 days, 48.05±0.67 and 48.95±0.54 days of female and ($F_{2,12}$= 48.84 and 96.43, p<0.05) 45.15±1.16 and 45.65±0.62, 47.95±0.77 and 48.85±0.57 days of male differed significantly with elevated CO_2 concentrations than ambient CO_2 (42.55±0.44 and 43.05±0.69, 42.50±0.55 and 42.80±0.83) concentration during 2017-18 and 2018-19 respectively.

Table 1: Duration (in days) (Mean*±SD) of different stages (egg to adult) of Yellow stem borer, *Scirpophaga incertulas* under elevated carbon dioxide

2017-18

Parameters	410 ppm CO_2	550 ppm CO_2	700 ppm CO_2	F(2,12)
Incubation period	6.50±0.30	6.20±0.11	5.65±0.22	17.84
Larval period	26.05±0.48	28.90±1.06	32.25±0.39	94.34
Pupa period	7.20±0.32	7.65±0.28	7.80±0.27	5.57
Adult (Female)	2.80±0.20	2.45±0.41	2.24±0.17	4.92
Adult (Male)	2.75±0.30	2.40±0.13	2.25±0.35	4.16
Total Life cycle (Female)	42.55±0.44	45.20±1.30	48.05±0.67	48.29
Total Life cycle (Male)	42.50±0.55	45.15±1.16	47.95±0.77	48.84
P<0.05 is significant				

2018-19

Parameters	410 ppm CO_2	550 ppm CO_2	700 ppm CO_2	F(2,12)
Egg period	6.70±0.20	6.35±0.13	5.80±0.20	29.06
Larval period	26.15±0.48	29.15±0.54	32.90±0.37	251.83
Pupa period	7.30±0.11	7.80±0.20	7.95±0.11	25.27
Adult (Female)	2.90±0.13	2.55±0.11	2.30±0.11	31.14
Adult (Male)	2.65±0.22	2.35±0.13	2.20±0.20	7.00
Total Life cycle (Female)	43.05±0.69	45.85±0.51	48.95±0.54	125.17

Total Life cycle (Male)	42.80±0.83	45.65±0.62	48.85±0.57	96.43
P<0.05 is significant				

*Means are based on five replications

Conclusion

Here the above results showed that the incubation period and duration of adult (female and male) *S. incertulas* was decreased whereas the total larval and pupal duration increased under elevated condition i.e 700ppm and 550ppm CO_2 level. Hence elevated CO_2 significantly affect the total life cycle period of *S. incertulas*.

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