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Research Article

The Effect of Planting Distance and Depth of Water Puddle to Damage Intensity by Rice Yellow Stem Borer (*Scirpophaga incertulas* Walker) (Lepidoptera: Crambidae) in Relation to Microclimate Change

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ABSTRACT

The rice yellow stemborer (*Scirpophaga incertulas*) is one of main pests on rice which may attack at all growth stages. The weather was considered one of influencing factors against its infestation. Therefore, this research was conducted to recognize microclimate factors affecting the infestation of *S. incertulas*. The experiment was carried out in Institute for Pest Forecasting, Jatisari Karawang from January–April 2017. The investigation was arranged in Factorial of Blocked Randomized Design with four repetitions and combinations of treatment factors, i.e. planting distance (conventional and *jajar legowo* 2 : 1) and depth of puddle (5 cm, 0 cm, and intermittent). The observation was performed from one to 12 weeks after planting. At the same time, three weather factors (temperature, relative humidity and rainfall) were observed in four West Java regencies i.e. in Bekasi, Karawang, Subang and Indramayu. The results showed that the conventional and the *jajar legowo* schemes are influenced by the micro air temperature. Both planting distance and depth of water puddle treatment were influenced by the micro air temperature. Microclimate factors which influenced the intensity of infestation were air temperature, humidity, water temperature, and light intensity. The weather factor showing effects in Bekasi, Karawang, and Indramayu was rainfall. However, the three weather factors did not affect on the acreage of pest infestation in Subang.

Keywords: microclimate, rice yellow stemborer, *Scirpophaga incertulas*

INTRODUCTION

The rice yellow stem borer (RYSB), *Scirpophaga incertulas* (Walker) (Lepidoptera: Crambidae), is an important pest of rice that causes severe damage to rice cultivation in Indonesia and several countries in Asia. This insect attacks all phases of rice growth from seedlings to near harvest. In the vegetative phase, larvae bore central of the tillers leads the shoots to wilt and eventually die, which is known as dead heart. When pest attacks in the generative phase, panicles turn white and hollow, which is known as white ears (BBPADI, 2015). YSB can lead to yield loss in both vegetative and generative phases. In 2003, YSB is a major pest infesting the nine popular rice varieties in the northern coastline with the damage intensity reached 37.9% in the initial season and increase 65% in the second season (Hendarsih & Usyati 2005). In 2011, the damage infestation area reached 146,315 ha, and 391 ha of which severed with yield failure. In 2012, the damage intensity area of YSB infestation in Indonesia decreased to 141,343 ha (103 ha severed by yield failure); 52,323 ha in 2013 planting season; 43,368 ha in 2013/2014 planting season; 43,312 ha in 2014 planting season, and 30,473 ha in 2014/2015 planting season (Ditlin TP, 2015).

One factor influences the dynamic of the insect population is a microclimate. The same with YSB activity influenced by temperature, humidity, light, and wind. Alteration in temperature can cause changes in pest status, distribution pattern, winter mortality, and phenological synchronization. Climate change is considered as the causal factor of YSB emergence (Estay *et al*., 2009). YSB is more adapt to the monsoon climate (Litsinger *et al*., 2006) which is a type of climate in the West Java region (Aldrian & Susanto, 2003). Species with tolerant ability tend to be more active and reproduce more rapid (Harrington *et al*., 2001). Previous studies stated that climate change can affect the distribution of phytophagous insects, especially Lepidoptera, the order of YSB (Cannon 1998; Parmesan *et al*., 1999; Batalden *et al*., 2007; Trnka *et al*., 2007). According to research conducted by Yang *et al* (2009), rice is the only host plant for YSB and its dynamic population driven by weather and conventional cropping pattern.

Planting distance and depth of puddle are considered to affect the state of microclimate around the plant. Therefore, a study on planting distance and depth of puddle were conducted to determine the effect of those to microclimate and the intensity of YSB infestation. Microclimate factors observed in this study were air temperature, humidity, water temperature, and light intensity. This study aimed to recognize the effect of planting distance and depth of puddle to microclimate, how significant it will increase the damage intensity of YSB, and analyze the relationship between weather factors with the acreage of YSB infestation in West Java.

MATERIALS AND METHODS

This study was conducted from January–April 2017 in the experimental field of the Institute for Pest Forecasting, Jatisari Karawang, West Java.

The Effect of Planting Distance and the Depth of Puddle to Microclimates and Intensity of YSB Infestation

An experiment was arranged in Factorial of Blocked Randomized Design (FBRD), with first factor (A) was planting distance using two treatments, i.e. conventional (25 cm×25 cm) and *jajar legowo* 2:1 (25×10×50 cm); and second factor (B) was the depth of puddle using three treatments, i.e. continuous inundation (5 cm), saturation (0 cm) and intermittent inundation (intermittent between inundation 5 cm and 0 cm alternately, the first week was 5 cm inundation, then the second week was 0 cm, and so on alternately every week until harvest time) (Kadja, 2015). By then, total six combination treatments were A1B1 (conventional planting distance, depth of puddle of 5 cm), A1B2 (conventional planting distance, depth of water of 0 cm), A1B3 (conventional planting distance, depth of puddle of intermittent), A2B1 (jajar legowo planting distance, depth of puddle of 5 cm), A2B2 (jajar legowo planting distance, depth of puddle of 0 cm), and A2B3 (jajar legowo planting distance, depth of puddle of intermittent). Each treatment was repeated 4 times.

Before conducting the experiment, the preparation of rice seedling and YSB egg masses were carried out first. Rice seeds were soaked in water for 24 hours to allow water to infiltrate the seeds easily and evenly (Vergara, 1995). Rice seeds were then drained, stored and covered with a white cloth for 24 hours or until the seeds germinated (roots emerged and grow buds). Seedlings were then spread on a 20×30 cm tray filled with soil. Seedlings were planted with the same planting distance as the treatment in 1 m × 1 m × 1 m containers made of cement contained with soil and compost. YSB egg masses were provided from collecting YSB adults from the field and then put in a pot containing rice plants covered by white cloth and then kept until the adult laid eggs. The eggs were then infested to the experimental field. The artificial infestation of YSB egg masses was conducted to ensure the existence of egg masses in the experimental field. Every container or trial repetition was inoculated with one YSB egg mass on the third week after planting. The effect of microclimates on YSB was observed after the eggs hatched.

The parameters observed were the number of tillers per clump, number of healthy tillers, number of tillers infested by YSB, the intensity of YSB infestation (calculated every week until harvest time). Temperature, humidity, light intensity, water temperature around the plant were observed every morning, afternoon and evening from the time of planting to harvest. The effect of planting distance and depth of puddle to microclimates and intensity of YSB infestation was analyzed using ANOVA and continued with the DMRT test (α = 0.05). Whereas the effect of weather factors on the intensity of YSB infestation was analyzed using linear regression by the SPSS.17 program.

Effect of Weather on the YSB Infestation Area in Four Regencies of West Java

The effect of weather on the YSB infestation in four regencies (Bekasi, Karawang, Subang, and Indramayu) of West Java was evaluated from the YSB infestation area and weather data during ten years (2006–2016). The acreage file of the YSB infestation was obtained from the Food Crop and Horticultural Protection Agency (BPTPH) of West Java Province. While climate data were obtained from Meteorological, Climatological, and Geophysical Agency of (BMKG) the Capital Special Region of

Jakarta. Data were then analyzed using multiple regression by the SPSS 17 program.

RESULTS AND DISCUSSION

The Effect of Planting Distance and Depth of Puddle to Microclimates and Intensity of YSB Infestation

Table 1 showed that planting distance and depth of puddle influenced the air temperature, but did not influence light intensity, humidity, water temperature, and intensity of YSB infestation. *Jajar legowo* and intermittent increased the temperatures around the crop. This result was similar to Sanjaya *et al.* (2014) reported that the cultivation techniques of SRI (System of Rice Intensification) and *jajar legowo* did not influence microclimates, yet generally affect production variables hence it could increase the rice production. The relationship between microclimates and the intensity of YSB infestation was analyzed using linear regression. The analysis was performed with a time lag based on the YSB life cycle (48–64 days) (Khan *et al*., 1991; Pathak & Khan, 1994). Analysis without taking into lag means that weather factors directly affect the infestation at that time. Analysis at one-week lag (lag 1) means that weather factors influence the intensity of YSB infestation in the next stage. The severe damage of YSB is in the larval stage. The longevity of YSB larvae is 28–35 days and molting of 5–7 times depending on weather conditions hence the longevity per instar is 5–6 days. Therefore, the analysis was carried out by lag 1 using the data that were transformed into logarithms (x + 1). Data transformation was performed to meet the classic assumption requirements for the linear regression equations.

Regression analysis showed that air temperature, humidity, water temperature, and light intensity negatively affected the intensity of the YSB infestation (F value was below $\alpha = 0.05$) (Table 2). This means that if the value of the four microclimates increases, the intensity of YRB infestation will decrease. The life cycle of YSB is influenced by temperature. In tropical regions, the rice is cultivated throughout the year, thus the YSB will reach 4–7 generations in one year (Hendarsih & Usyati, 2005; Pathak & Khan, 1994). Air temperature can directly affect insect reproduction. Insect requires optimum temperature for laying eggs, hatching, and larval stage growing into an adult. Eggs will still hatch at 13°C, with the optimum temperature of 24–29°C at 90–100% humidity. Humidity below 70% will reduce the hatching rate. The egg longevity will decrease if the temperature increases. S. *incertulas* larvae can grow and develop at a temperature of 17–35°C. Even though the larvae can still develop up to 35°C, eventually they will die (Pathak & Khan, 1994). Paddy water temperature above 35°C is considered to be the major factor of *Chilo suppressalis* population decline in July and August in Taiwan (Chang, 1968). According to Prasannakumar (2015), weather parameters i.e. minimum temperature, rainfall, and humidity in the morning affect the YSB population outbreak in India. The previous studies also reported that minimum temperature, rainfall, and relative humidity were important factors affecting the YSB population (Abraham, 1972; Bhatnagar & Saxena, 1999; Rehman, 2002).

Table 1. The response of weather factors and infestation intensity to planting distance and depth of puddle

Treatment	Air Temperature (ºC)	Humidity (%)	Water Temperature (ºC)	Light Intensity (lux)	Intensity of infestation (%)
Planting Distance (A)					
Conventional (A1)	28.18a	69.86a	25.26a	48044.47a	15.18a
Jajar legowo (A2)	28.08b	70.09a	25.19a	48044.44a	15.99a
Depth of puddle (B)					
5 cm (B1)	28.15a	69.99a	25.26a	48044.49a	16.15a
0 cm (B2)	28.12ab	69.92a	25.23a	48044.44a	15.27a
Intermitten (B3)	28.11b	70.01a	25.20a	48044.44a	15.34a
Interaction	(-)	(-)	(-)	(-)	(-)
Coefficient of variance	0.04	0.26	0.08	0.07	1.63

Remarks: (-) no interaction; A = planting distance (Factor 1), A1 = conventional (25×25 cm) and A2 = *jajar legowo* 2:1. B = depth of puddle (Factor 2), B1 = 5 cm, B2 = 0 cm, and B3 = Intermittent. Values followed by same letter in each column were not significantly different according to DMRT ($\alpha = 0.05$)

Effect of Weather on the YSB Infestation Area in Four Regencies of West Java

Bekasi, Karawang, Subang, and Indramayu Regencies were selected because those regions are the highest infestation of YSB and the center of rice production in West Java. Data were then analyzed by multiple regression using weather data (temperature, humidity, rainfall) from each regency to obtain the regression equation. Analysis of the relationship between weather and the intensity of the YSB infestation was conducted with a time lag based on the life cycle of YSB.

Bekasi Regency

The regression equation in Bekasi Regency was

Log (Y + 1) = 3.994 - 0.552*(logT + 1) - 0.184*(logRH + 1) - 0.267*(logCH + 1) (Table 3).

Y is the YSB infestation area. The three weather factors (temperature, humidity, and rainfall) contributed 5.2% to the YSB infestation area in Bekasi and 94.6% were influenced by other factors ($R^2 = 0.052$). A small coefficient of determination (R^2) indicated that the contribution of weather factors to the infestation area was also small. This is because the spreading of the infestation did not represent the YSB population in the field. The variable which significantly influenced the spreading of the YSB infestation was rainfall. The rainfall has a significant effect on the area of the YSB infestation (significance value of rainfall was 0.016, smaller than 0.05). Temperature and relative humidity have no significant effect on the spreading of the YSB infestation in Bekasi (variable of 0.869 and 0.572, respectively, greater than 0.05). The average monthly rainfall fluctuations in the Bekasi Regency area were quite high when compared to air temperature and humidity. The average monthly rainfall was 19.22–43.40 mm/month. These fluctuations may have a significant effect on the spreading of the YSB infestation. The regression coefficient of the rainfall variable was -0.267 that the rainfall has a negative effect on the area of infestation. If rainfall decreases by 1 mm, the infestation area will increase by 0.267 ha. Therefore, the infestation area of YSB will increase during the dry season where rainfall is lower than in the rainy season, thus it is necessitated to monitor the YSB infestation during the dry season.

Karawang Regency

The regression equation in Karawang Regency was

Log (Y + 1) = -8.230 + 1.670*(logT + 1) + 4.220*(logRH + 1) + 0.250*(logCH + 1)

Y is the YSB infestation area. The three weather factors (temperature, humidity, and rainfall) contributed 7.4% to the acreage of the YSB infestation in Karawang and 92.6% were influenced by other factors ($R^2 = 0.074$). A small coefficient of determination (R^2) indicated that the contribution of the weather element to the

Table 2. Regression analysis of the effect of weather factors on the intensity of yellow stem borer infestation

Climate factor	Regression equation	Coefficient of determination (R^2)	F statistic	Remark
Air temperature	Y = 7.185 - 3.998X	0.32	7.78E-06	*
Humidity	Y = 12.039 -5.969X	0.07	0.0179	*
Water temperature	Y = 4.719 - 2.395X	0.183	0.0012	*
Light intensity	Y = 9.479 - 1.276X	0.433	6.35E-08	*

Remarks: *significantly different, ns: not significantly different at (α = 0.05) according to ANOVA

Table 3. Multiple linear regression analysis between weather factors and the acreage of rice yellow stem borer (RYSB) infestation in Bekasi Regency

Variable	Coefficient of regression	Coefficient of determination (R^2)	Probability (F statistic)
Intercept	3.994ns	0.052	0.115
Temperature (T)	-0.552ns		
Humidity (RH)	-0.184ns		
Rainfall (CH)	-0.267*		

Remarks: *significantly different, ns: not significantly different at (α = 0.05) according to ANOVA infestation area was also small. This is because the spreading of the infestation did not represent the YSB population in the field. Table 4 showed that rainfall significantly influenced the YSB infestation area. Humidity significantly affected the infestation area as defined by the rainfall value of 0.05. Both temperature and humidity did not significantly affect the YSB infestation area in Karawang (significant value of 0.354 and 0.107, respectively, greater than 0.05). The rainfall regression coefficient was +0.250 that the rainfall has a positive effect on the infestation area. If rainfall increases by 1 mm, the infestation area will also increase by 0.250 ha.

Subang Regency

The regression equation in Subang Regency was Log (Y + 1) = -4,160+ 1,144*Log (T + 1) + 2,358* Log (RH + 1) + 0,143*Log (CH + 1).

Y is the YSB infestation area. The three weather factors (temperature, humidity, and rainfall) contributed 1.8% on YSB infestation in Subang and 98.2% were influenced by other factors (R^2 = 0.024). Table 5 revealed that the variables did not significantly influence the YSB infestation. Because there is no significant value of the variable is less than 0.05. The temperature and humidity did not significantly affect the YSB infestation area in Subang (significant value of 0.726 and 0.225, respectively, greater than 0.05).

Indramayu Regency

The regression equation in Indramayu Regency was Log (Y + 1) = 2,053 - 0,574*(logT + 1) + 0,344* (logRH + 1) + 0,328*(logCH + 1).

Y is the area of infestation. The three weather factors (temperature, humidity, and rainfall) have an influence of 4.3% on the acreage of the YSB infestation in Indramayu and 95.7% were influenced by other factors (R^2 = 0.043). Table 6 showed that rainfall was significantly influenced by the acreage of the YSB infestation, which defined by the significance value of rainfall was 0.045, smaller than 0.05. On the contrary, temperature and humidity with significant value 0.853 and 0.866, respectively, were higher than 0.05, that the two variables were not significantly influenced on the acreage of the YSB infestation in Indramayu.

Rainfall was the weather factor that influenced the acreage of the YSB infestation in the four regencies, except for Subang. Indonesia has three climate patterns, i.e. monsoon, equatorial, and local, thus it has a very different rainfall pattern from one region to another. Even one region has several different climate prediction zones (Sipayung, 2009). Regions that have different geographical areas will have different rainfall patterns and precipitation. The average amount of rainfall that falls in various parts

Table 4. Multiple linear regression analysis between weather factors and the acreage of rice yellow stem borer (RYSB) infestation in Karawang Regency

Variable	Coefficient of regression	Coefficient of determination (R^2)	Probability (F statistic)
Intercept	-8.230ns		
Temperature (T)	1.670ns	0.074	0.034
Humidity (RH)	4.220ns		
Rainfall (CH)	0.250*		

Remarks: *significantly different, ns: not significantly different at (α = 0.05) according to ANOVA

Table 5. Multiple linear regression analysis between weather factors and the acreage of rice yellow stem borer (RYSB) infestation in Subang Regency

Variable	Coefficient of regression	Coefficient of determination (R^2)	Probability (F statistic)
Intercept	-4.160ns		
Temperature (T)	1.144ns	0.024	0.445
Humidity (RH)	2.358ns		
Rainfall (CH)	0.143ns		

Remarks: *significantly different, ns: not significantly different at (α = 0.05) according to ANOVA

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Table 6. Multiple linear regression analysis between weather factors and the acreage of rice yellow stem borer (RYSB) infestation in Indramayu Regency

Variable	Coefficient of regression	Coefficient of determination (R^2)	Probability (F statistic)
Intercept	2.053ns	0.043	0.174
Temperature (T)	-0.574ns		
Humidity (RH)	0.344ns		
Rainfall (CH)	0.328*		

Remarks: *significantly different, ns: not significantly different at (α = 0.05) according to ANOVA

of Indonesia in a year is 500 mm to more than 5000 mm. Much or less rainfall is also influenced by the location and elevation. Areas located on the west or south coast experience great rainfall as a result of directly facing the west wind. Factors affecting rainfall are geographical location, altitude, site location radius from the sea, wind direction, mountain range, differences in land and sea temperatures, and land area (Tukidi, 2010).

Previous studies reported that one of the factors influence the diversity of rainfall in Indonesia is the phenomenon of ENSO (El Nino and The Southern Oscillation) (Haylock & Mc Bride, 2001; Aldrian & Susanto, 2003; Hendon, 2003). ENSO is a symptom of deviation in the sea condition characterized by rising sea surface temperature (Sea Surface Temperature-SST) in the Pacific Ocean around the equator (equatorial pacific) especially in the central and eastern regions (around the Peru coast). Because the ocean and the atmosphere are two interconnected systems, this deviation in the sea may cause deviation in the atmosphere which ultimately results in climate deviation (Supari, 2014). Rainfall also affects the diapause of white rice stem borer larvae. Larvae will stop diapause if they are exposed to low temperatures within a certain period. The minimum rainfall required by white rice stem borer larvae is 10 mm. Rainfall can form enough water vapor around the larvae so the temperature becomes low and stable at a certain period of time (Solikhin, 1999). The four regencies in this study are located in low-lying areas on the northern coast of West Java, which is the center of rice production. Considering the elevation of the four regencies, altitude carries no influence on the spread of *Scirpophaga* spp. (Hendarsih *et al.*, 2000).

CONCLUSION

Jajar legowo cultivation was considered to reduce micro temperatures around the plant. The depth of puddle of 5 cm and intermittent also influenced air temperature. There was no interaction between planting distance and depth of puddle to microclimate factors. Microclimate factors negatively influenced the intensity of yellow rice stem borer infestation. However, the four microclimate factors did not affect the chlorophyll content of paddy leaves, both in the vegetative and generative phases. Rainfall influenced the acreage of YSB infestation in Bekasi, Karawang, and Indramayu Regencies, whereas in Subang were not influenced by the weather factors.

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