Journal of Engineering and Applied Sciences

MEDWELL PUBLICATIONS SINCE 2000

# Preliminary Application Environment Results from Regional Weather Prediction (WRF Model) for Rice Blast Disease Model

Pramet Kaewmesri and Usa Humphries
*Department of Mathematics, Faculty of Science, King Mongkut's University of Technology Thonburi (KMUTT), 126 Pracha-Uthit Road, Bang mod, Thung 10140, Khru, Thailand, Bangkok*

**Key words:** WRF model, environment factor, rice blast disease, graph, line

**Corresponding Author:**
Usa Humphries
*Department of Mathematics, Faculty of Science, King Mongkut's University of Technology Thonburi (KMUTT), 126 Pracha-Uthit Road, Bang mod, 10140, Thung Khru, Thailand, Bangkok*

Page No.: 2075-2082
Volume: 15, Issue 9, 2020
ISSN: 1816-949x
Journal of Engineering and Applied Sciences


**Abstract:** Rice is very important and the main food in Thailand. Because it's a main economic-financial export product. One disease of rice in Thailand is rice blast disease. The *Pyricularia oryzae* is a fungus that makes rice blast disease occurrence. This fungus prefers to grow on the susceptible rice cultivar. Furthermore, the spore can survive and germinate, under the favorite environment condition. The environmental factors are included in relative humidity, soil temperature, temperature and rainfall. The good estimations of the environment are crucial to helping the risk management of rice blast disasters occurrence. The aim of this study to simulate the environment factors using the WRF model which occurred rice blast experiment and the results of the simulations are compared with the amount of the environmental factors from Prachinburi rice research Center data. The results from the WRF model were shown good trend and estimated value nearly with Prachinburi Rice Research Center data in the line graph. The correlation coefficient statistical method confirms the result from the WRF model that shows high accuracy, especially at 06:00 p.m. So, this study supported the environment factor from the WRF Model that can be used in the simulation of the severity of rice blast disease.

## INTRODUCTION

Why was rice very important in Thailand? Thailand is still an agricultural country and the first reason. Because rice is the main food of Thai people. In another condition, rice was an important economic-financial and main export product of Thailand.

In Fig. 1, the data were shown the principal rice exporting countries worldwide in 2016/2017, measured in 1,000 metric tons as of February, 2017. The most 5 country most rice exporting are India (10.3 million metric tons), Thailand (10 million metric tons), Vietnam (5.8 million metric tons), Pakistan (4.2 million metric tons) and United States (3.5 million metric tons). This information was supported that rice was very important in Thailand. Sometimes, the rice disease occurred on rice paddy that effects the rice production in the future. The result of the rice disease occurrence impacted the farmer, rice products, prices of rice and especially, rice exporting. Therefore, the warning of rice disease occurrence was

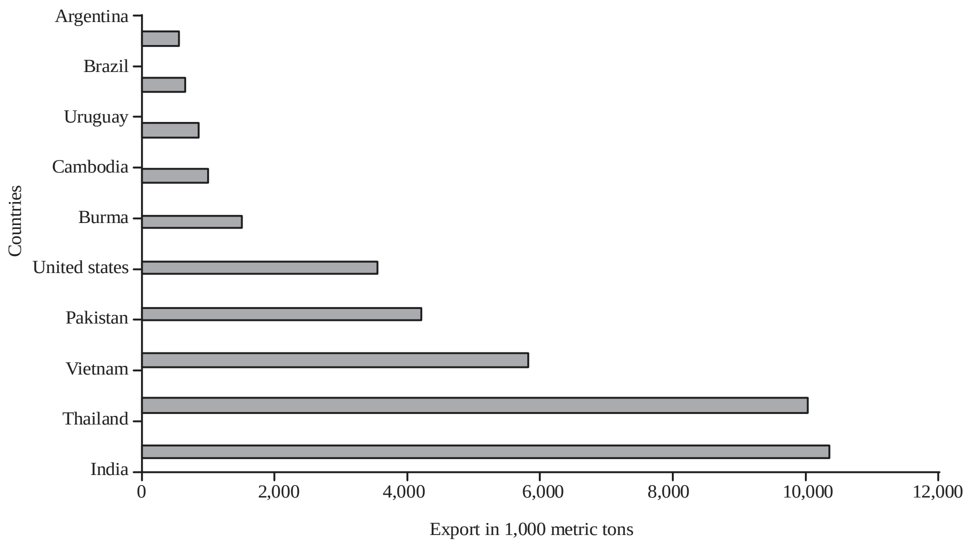


Fig. 1: The principal rice exporting countries worldwide in 2016/2017 (1,000 metric tons) (https://www.statista.com/statistics/255947/top-rice-exporting-countries-worldwide-2011/)

very important. One of the rice diseases in Thailand was the rice blast disease. Following[1], they have studied the simulation of the severity of rice blast disease in Thailand. Furthermore, they were found the rice blast disease that is more effective in rice of Thailand, especially over Prachin Buri province. Because the Prachin Buri is one of the provinces that have been affected by rice blast disease. The most rice blast disease causes serious damage to rice paddy in Thailand that cause of disease occurs from *Pyricularia oryzae*. It is an important fungus disease of rice to occur in most rice-producing areas of the world and including Thailand [1-4]. Rice blast disease can strike all aerial parts of the plant. Most infections occur on the leaves, causing diamond-shaped lesions with a grey or white center to appear or on the panicles which turn white and die before being filled with grain[4]. The condition factor of *Pyricularia oryzae* was summary by[1]. This fungus prefers to grow on the susceptible rice cultivar. Furthermore, the spore can survive and germinate, under the favorite environment conditions. The environment factors are included temperature, soil temperature, rainfall and relative humidity. These are crucial conditions for the expansion of filaments and the sporulation of the fungus. Hence, the environmental conditions were very important in the simulation of the severity of rice blast disease in many places. Therefore, the improvement in environmental prediction will be the main factor in helping to manage the simulation severity of rice blast disease. It will help the researcher and farmers to minimize damage by warning in advance of rice blast disease events. Good estimations of the environment are crucial to helping the risk management of rice blast disasters in addition to improve rice management. The aim of this study can summaries as follows:

- To simulate the environment factors (relative humidity, soil temperature, temperature and rainfall) which occurred rice blast experiment at Prachinburi rice research center
- The results of the simulations are compared with the environmental factors amount from Prachinburi rice research center data

## MATERIALS AND METHODS

**Model description:** The Weather Research Forecast (WRF) model is a numerical weather prediction and atmosphere simulation system model developed by the National Center for Atmospheric Research (NCAR). It is capable of creating a simulation using real-time data or idealized atmospheric simulations. The model contains with a terrain-following sigma coordinate is used in the vertical coordinate, Arakawa C-grid staggering for the horizontal grid, initial conditions, boundary condition, multiple-nested domain, mapping to the sphere, and a full set of physical parameterization options. The dynamics solver integrates the compressible, non-hydrostatic, Euler equations. Please find more detail in[5-7].

**Domain and physics configuration:** The multi-nested domain experiments included three domains as shown in Fig. 2. The resolution of the horizontal of the outer domain was 36 km$^2$ and located between longitudes 78.00 and 124.30°E and latitudes -7.12 and 32.58°N. The sub-domain resolution was 12 km$^2$ and located between longitudes 88.55 and 113.75°E and latitudes 0.07 and 26.30°N. The innermost domain resolution was 4 km$^2$.

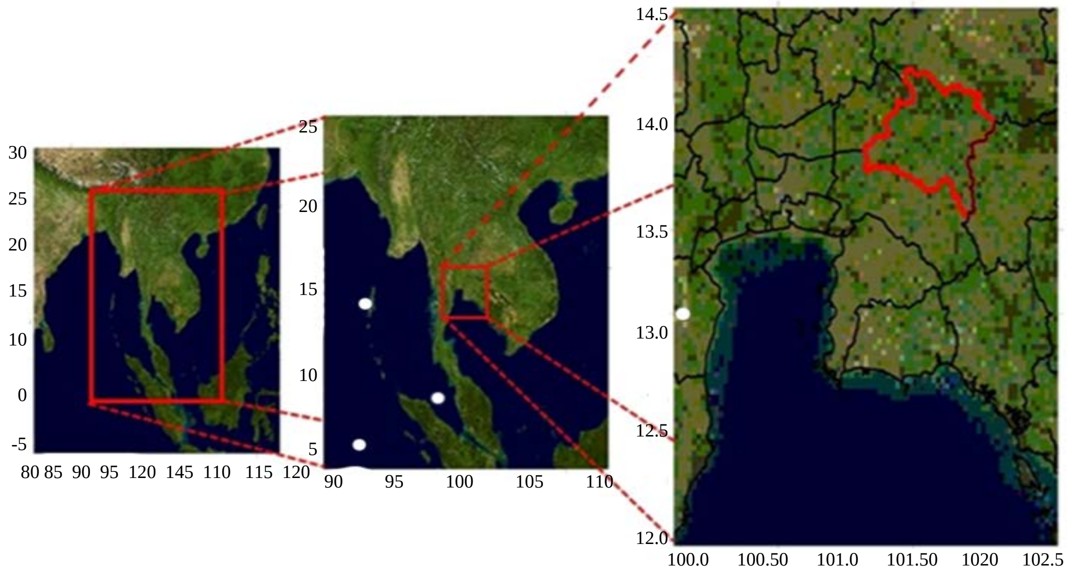


Fig. 2: The domain option in outer domain grid resolution (36 km), subdomain grid resolution (12 km) and inner domain grid resolution (4 km)

This domain was located between longitudes 99.73 and 102.58°E and latitudes 11.62-14.82°N with 27 layers in the vertical direction with a maximum of 50 hPa. The physics options used in this study consisted the Yonsei University planetary boundary layer (YSU) scheme for the Planetary Boundary Layer (PBL)[8], the Rapid Radiative Transfer Model (RRTM) scheme for the longwave radiation[9], the Dudhia scheme for the shortwave radiation[10], the Kain Frisch scheme for the cumulus parameterization scheme[11], the WSM6 scheme for the microphysics parameterization scheme[12] and the Noah Land-Surface model for the land surface scheme[13].

**Data sources and experiment configuration:** The initial and boundary conditions were used for the and 6-hourly intervals from National Center for Environment Prediction Final Operational Global Analysis (FNL). The FNL product is from the Global Data Assimilation System (GDAS). The period of data during 18 UTC 30 July, 1999 to present and the analyses available on the surface covered longitude 180-180°W and latitude 90-90°N.

The environment factor observation was recorded by Prachinburi Rice Research Center. The data included temperature, soil temperature, rainfall and relative humidity from December, 23, 2015-March, 31, 2016 (Total 14 weeks for simulation). The environment factor included relative humidity, soil temperature and temperature were recorded twice per day, at 06:00 a.m. and 06:00 p.m. Figure 3 was shown relative humidity (%), soil temperature (°C) and temperature (°C)) at 06:00 a.m. and 06:00 p.m. The rate severity of rice blast disease was presented in Fig. 3. It can separate the rated severity of rice blast disease into 5 periods that have 1, 5, 25, 50 and 90% of rate severity of rice blast disease over Prachinburi Rice Research Center.

## RESULTS AND DISCUSSION

In this study, the spatial pattern results were collected from four environmental factors (relative humidity, soil temperature, temperature and rainfall) at 06:00 a.m. and at 06:00 p.m. For example, the spatial pattern of relative humidity from the model at 06:00 a.m. (Fig. 3 and 4a) and 06:00 p.m. (Fig. 4b). However, this study was focused on comparison environment factors between results from the WRF model with Prachinburi Rice Research Center data. The Prachin buri Rice Research Center location was used for extraction data at 14.01 and 101.22°E as shown in Fig. 5.

In case of relative humidity at 6:00 a.m. (Fig. 6), the results of WRF Model can capture a good trend of simulation with Prachinburi Rice Research Center data on 1% (week 1), 5% (week 2), 25% (week 3), 50% (4-5, 7-9 and week 11-12) and 90% (week 13-14). Over the point of minimum during week 6-7 and week 10, the Prachinburi Rice Research Center data can record the value over 37 and 43%. On the other hand, the WRF Model can record value over 48 and 49%. In case of relative humidity at 06:00 p.m. (Fig. 7), the results of

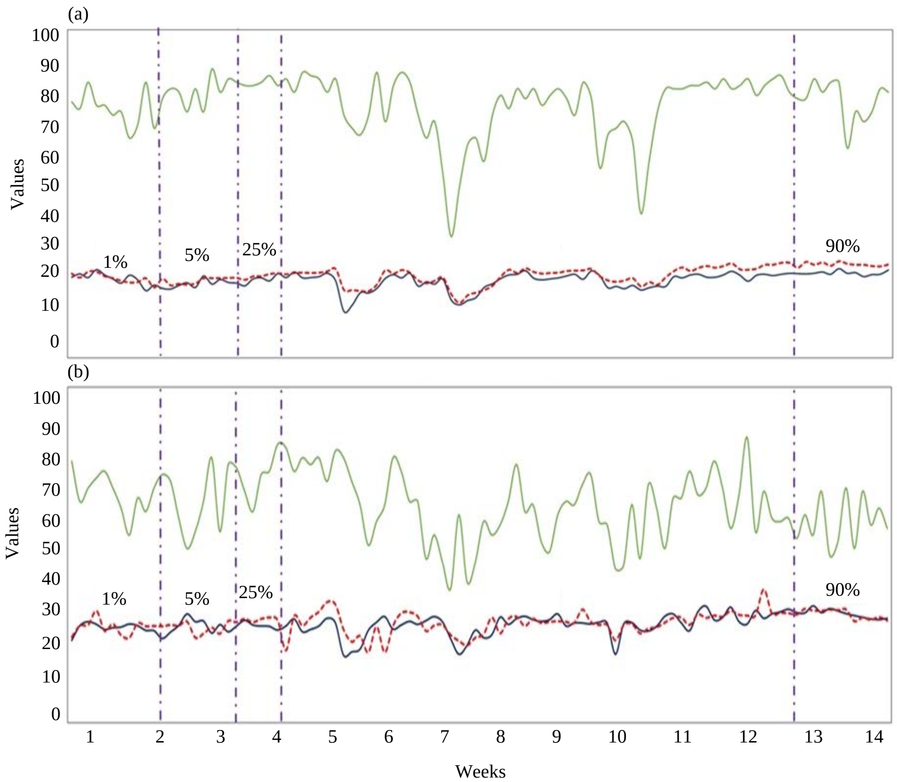


Fig. 3: The environment factor observation included relative humidity (Unit: %) (Green line), soil temperature (Unit: Degree Celsius) (Red dash line) and temperature (Unit: Degree Celsius) (Blue line) from December 23, 2015 to March, 31, 2016 (14 weeks for simulating); (a) Relative humidity, soil temperature and temperature at 6 a.m. and (b) Relative humidity, soil temperature and temperature at 18.00 p.m.

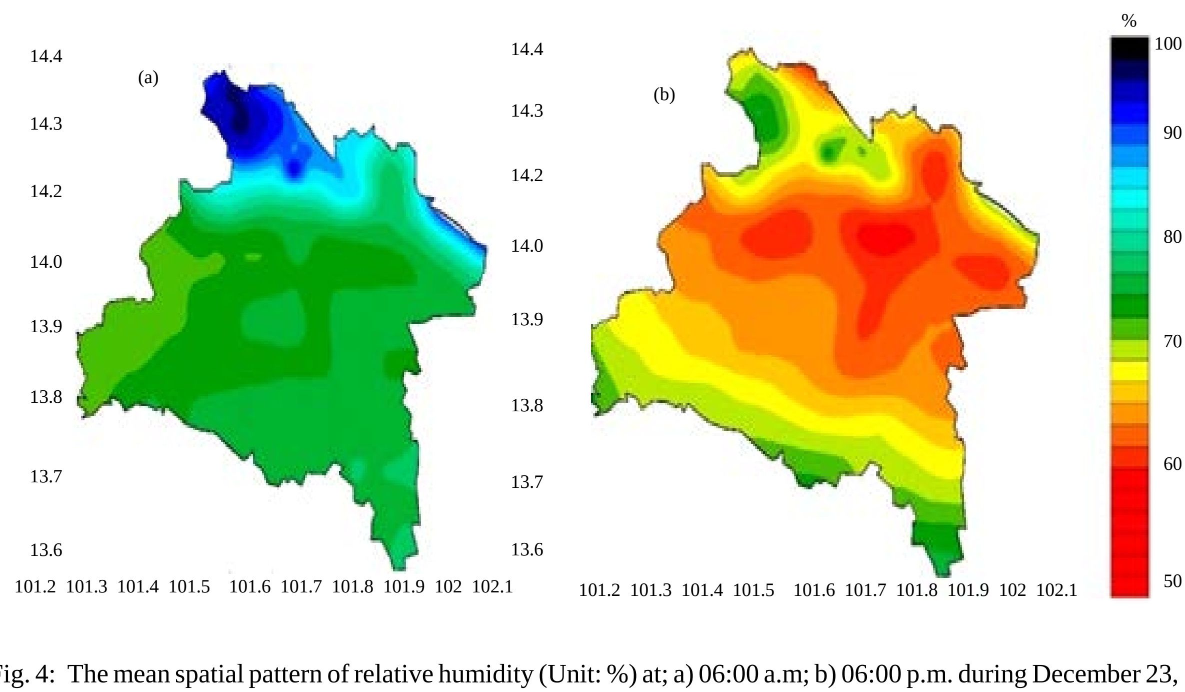


Fig. 4: The mean spatial pattern of relative humidity (Unit: %) at; a) 06:00 a.m; b) 06:00 p.m. during December 23, 2015 to March, 31, 2016 over Prachinburi Province

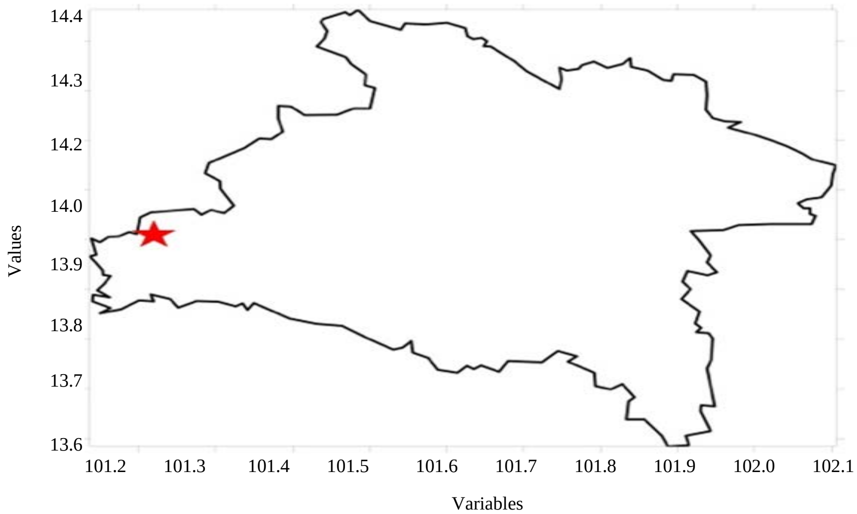


Fig. 5: The station location of Prachinburi Rice Research Center lies in the red star

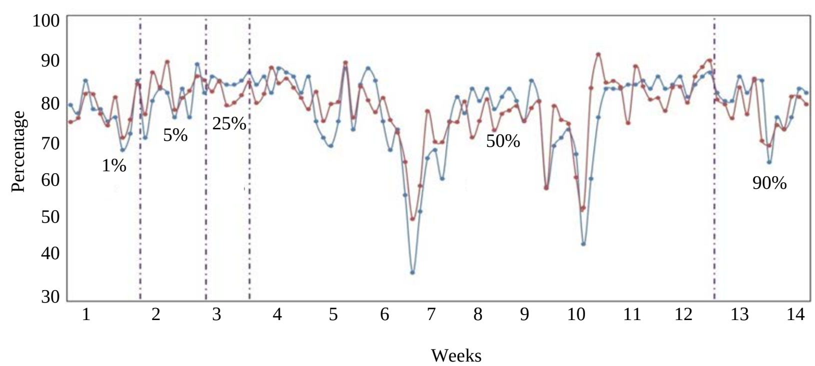


Fig. 6: The comparison of the relative humidity (Unit: %) between Prachinburi Rice Research Center data (Blue line) and WRF (Red line) model at 06:00 a.m. from December, 23, 2015 to March, 31, 2016.

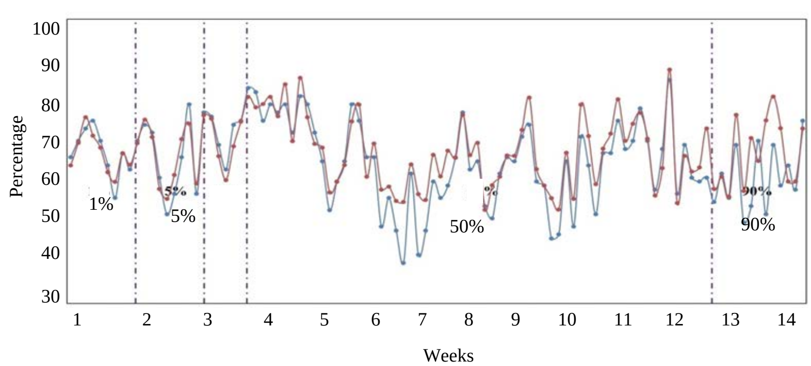


Fig. 7: The comparison of the relative humidity (Unit: %) between Prachinburi Rice Research Center data (Blue line) and WRF (Red line) model at 06:00 p.m. from December, 23, 2015 to March, 31, 2016

WRF Model can capture a good trend of simulation with Prachinburi Rice Research Center data in 1% (week 1), 50% (4-6, 8-9 and week 11-12).

In the case of the soil temperature at 6:00 a.m. (Fig. 8), the results of the WRF model have overestimated simulation comparing with Prachinburi Rice Research

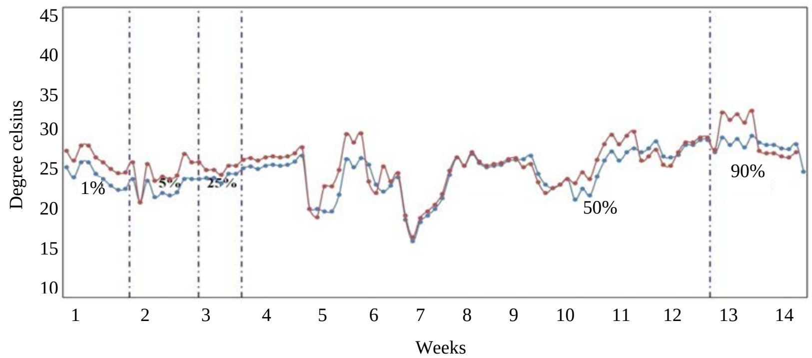


Fig. 8: The comparison of soil temperature (Unit: Degree Celsius) between Prachinburi Rice Research Center data (Blue line) and WRF (Red line) model at 06:00 a.m. during December, 23, 2015 to March, 31, 2016

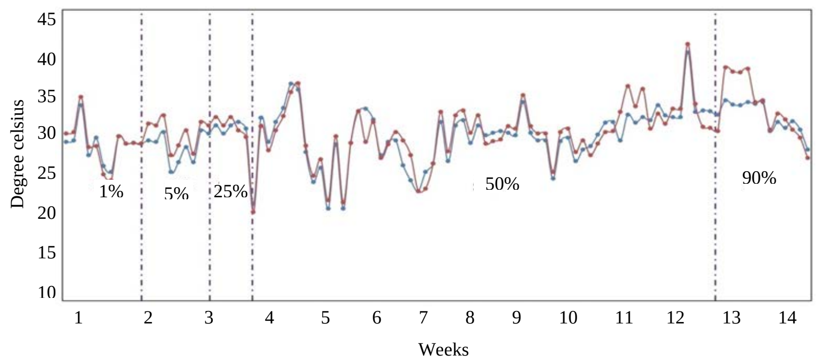


Fig. 9: The comparison of soil temperature (Unit: Degree Celsius) between Prachinburi Rice Research Center data (Blue line) and WRF (Red line) model at 06:00 p.m. during December, 23, 2015 to March, 31, 2016.

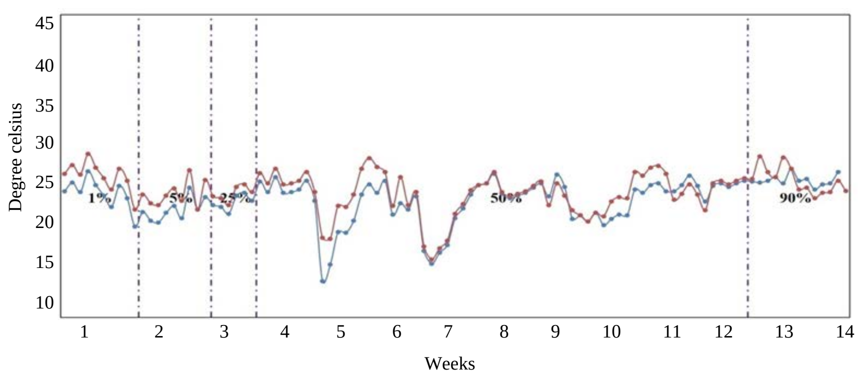


Fig. 10: The comparison of temperature (Unit: Degree Celsius) between Prachinburi Rice Research Center data (Blue line) and WRF (Red line) model at 06:00 a.m. during December, 23, 2015 to March, 31, 2016

Center data. However, the WRF Model was shown a good trend with the Prachinburi Rice Research Center data. In the case of the soil temperature at 06:00 p.m. (Fig. 9), the result of the WRF Model was a good trend comparing with Prachinburi Rice Research Center data. But the WRF model was shown overestimate over week 13-14.

In case of temperature at 6:00 a.m. (Fig. 10), the results of the WRF Model have overestimated simulation comparing with Prachinburi Rice Research Center data over 1, 5, 25, 50 and 90%. By the way, the WRF Model was underestimated over 50 and 90%. Over the point of minimum during week 5 and week 7, the Prachinburi Rice

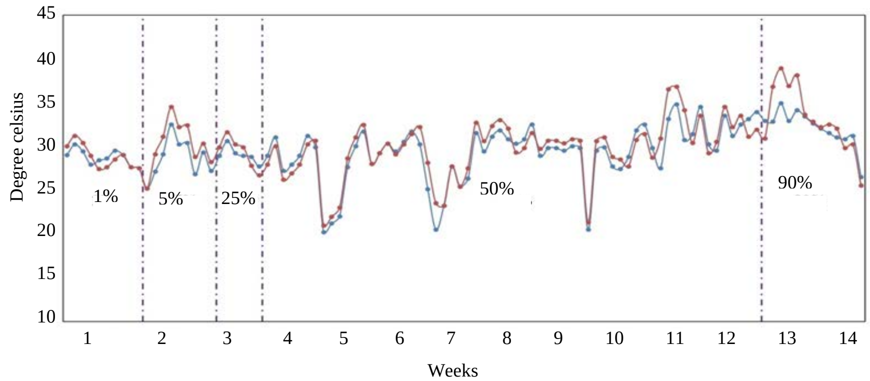


Fig. 11: The comparison of temperature (Unit: Degree Celsius) between Prachinburi Rice Research Center data (Blue line) and WRF (Red line) model at 06:00 p.m. during December, 23, 2015 to March, 31, 2016

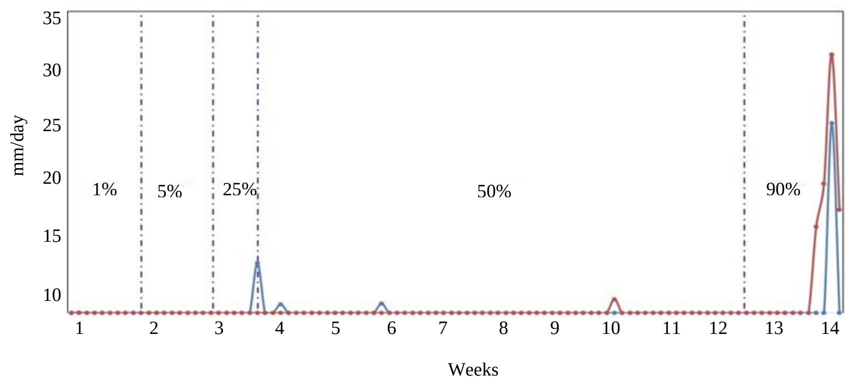


Fig. 12: The comparison of rainfall (mm/day) between Prachinburi Rice Research Center data (Blue line) and WRF (Red line) model during December 23, 2015 to March, 31, 2016

Table 1: The Correlation Coefficient between WRF Model and Prachinburi Rice Research Center

| Parameters | 06:00 a.m. | 06:00 p.m. | Average |
|---|---|---|---|
| Relative humidity | 0.605 | 0.722 | 0.567 |
| Temperature | 0.777 | 0.816 | 0.794 |
| Soil temperature | 0.750 | 0.818 | 0.731 |
| Accumulate Rainfall | N/A | N/A | 0.604 |

Research Center data can record value over 14 and 16°C. On the other hand, the result of the WRF Model shown value over 18 and 16°C. However, the WRF Model was shown a good trend of over 50% (weeks 4-12). In the case of temperature at 06:00 p.m. (Fig. 11), the result of the WRF Model was a good trend comparing with Prachinburi Rice Research Center data. But the WRF Model was shown overestimate over week 13-14 similarly soil temperature.

In the case of rainfall (Fig. 12), the result of the WRF Model was a good trend with Prachinburi Rice Research Center data. But the WRF model was more overestimate on 25% (week 4) and 90% (week 13). The WRF can record value at 5 and 29 mm day$^{-1}$. But the Prachinburi Rice Research Center data can record value at 0 and 23 mm day$^{-1}$.

The ability of WRF results to produce environment factor at Prachinburi Rice Research Center, Correlation Coefficient is presented in Table 1. The WRF Model was estimated good Correlation Coefficient (>0.50). The highest value of relative humidity, soil temperature and temperature was shown good Correlation Coefficient at 06:00 p.m. and value at 0.722, 0.816 and 0.818 respectively. The accumulate rainfall was shown good Correlation Coefficient (> 0.50) at 0.604 similarly another environmental factor.

## CONCLUSION

A summary condition factor of *Pyricularia oryzae*, this fungus prefers to grow on the susceptible rice cultivar. Furthermore, the spore can survive and germinate, under the favorite environment conditions. The environmental factors are included relative humidity, soil temperature, temperature and rainfall. So, this study investigated the WRF model simulation the environment factors (relative humidity, soil temperature, temperature, and rainfall) event which occurred rice blast experiment and compared with environment factors amount from

Prachinburi Rice Research Center data. The results from the WRF Model (relative humidity, soil temperature, temperature and rainfall) were shown good trend and estimated value nearly with Prachinburi Rice Research Center data in the line graph. The Correlation Coefficient statistical method supported the result from the WRF model that shows high accuracy, especially at 18:00 p.m. The highest value of relative humidity, soil temperature, temperature and rainfall were shown a good correlation coefficient at 0.722, 0.816, 0.818 and 0.604 at 18:00 p.m. respectively. The results from this study supported the WRF model that can be used to simulate the environment factors and apply the results with the severity of rice blast disease in Prachinburi Rice Research Center data.

## ACKNOWLEDGMENTS

The researchers would like to thank the Prachin Buri Rice Research Center for historical incidence data of rice blast disease. The authors acknowledge King Mongkut's University of Technology Thonburi for funding Postdoctoral Fellowship to Dr.Pramet Kaewmesri. The authors are very grateful to the Department of Mathematics, Faculty of Science for all support.

## REFERENCES

01. Bunsri, T., 2017. Simulation of severity of rice blast disease in Prachin Buri using plant disease epidemiological model: Simulation of rice blast disease. Proceedings of the 22nd Annual Meeting in Mathematics (AMM 2017), June 2-4, 2017, At Lotus Hotel, Pang Suan Kaew, Chiang Mai, pp: 1-11.
02. Rossman, A.Y., R.J. Howard and B. Valent, 1990. Pyricularia grisea, the correct name for the rice blast disease fungus. Mycologia, 82: 509-512.
03. Hosseyni-Moghaddam, M. and J. Soltani, 2013. An investigation on the effects of photoperiod, aging and culture media onvegetative growth and sporulation of rice blast pathogen Pyricularia oryzae. Progress Biol. Sci., 3: 135-143.
04. Srivastava, D., M.D. Shamim, D. Kumar, P. Pandey, N.A. Khan and K.N. Singh, 2014. Morphological and molecular characterization of Pyricularia oryzae causing blast disease in rice (Oryza sativa) from North India. Int. J. Sci. Res. Publ., 4: 2250-3153.
05. Skamarock, W.C., J.B. Klemp, J. Dudhia, D.O. Gill, D.M. Barker, W. Wang and J.G. Powers, 2008. A description of the Advanced Research WRF Version 3. NCAR Technical Note-475+ STR, National Center for Atmospheric Research, Boulder, Colorado.
06. Kaewmesri, P., U. Humphries, A. Wangwongchai, P. Wongwises, B. Archevarapuprok and S. Sooktawee, 2017. The simulation of heavy rainfall events over Thailand using microphysics schemes in Weather Research and Forecasting (WRF) model. World Applied Sci. J., 35: 310-315.
07. Kaewmesri, P., U. Humphries and S. Sooktawee, 2017. Simulation of high-resolution WRF model for an extreme rainfall event over the southern part of Thailand. Int. J. Adv. Applied Sci., 4: 26-34.
08. Hong, S.Y. and Y. Noh, 2006. A new vertical diffusion package with an explicit treatment of entrainment processes. Monthly Weather Rev., 134: 2318-2341.
09. Mlawer, E.J., S.J. Taubman, P.D. Brown, M.J. Iacono and S.A. Clough, 1997. Radiative transfer for inhomogeneous atmospheres: RRTM, a validated correlated-k model for the longwave. J. Geophys. Res. Atmos., 102: 16663-16682.
10. Dudhia, J., 1989. Numerical study of convection observed during the winter monsoon experiment using a mesoscale two-dimensional model. J. Atmos. Sci., 46: 3077-3107.
11. Janjic, Z.I., 1994. The step-mountain eta coordinate model: further developments of the convection, viscous sublayer and turbulence closure schemes. Mon. Weather Rev., 122: 927-945.
12. Hong, S.Y. and J.O.J. Lim, 2006. The WRF single-moment 6-class microphysics scheme (WSM6). Asia-Pac. J. Atmos. Sci., 42: 129-151.
13. Tewari, M., F. Chen, W. Wang, J. Dudhia and M.A. LeMone et al., 2004. Implementation and verification of the unified NOAH land surface model in the WRF model. Proceedings of the Joint 20th and 16th Conference on Weather Analysis and Forecasting and Numerical Weather Prediction, Vol. 1115, January 14, 2004, American Meteorological Society, Seattle, Washington, pp: 2165-2170.