DOI: 10.55278/QLVU7706

Rice: A new host of fall armyworm *Spodoptera frugiperda* (J.E. Smith) and its strains in the Philippines

Evelyn M. Valdez[1], Ravindra C. Joshi[1,3,4], Genaro S. Rillon[1], Dindo King M. Donayre[1], Edwin C. Martin[1], Kennedy B. dela Cruz[1], Femia R. Sandoval[1], Eduardo Jimmy P. Quilang[1], Minda Flor Aquino[2], Jose Mariano, Jr.[2], Maria Katrina Pascual[2], Muhammad Faheem[3], and Sivapragasam Annamalai[3]

[1] Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija, 3119 Philippines[2] Department of Agriculture-Regional Crop Protection Center II, Ilagan, Isabela, 3300 Philippines [3] Centre for Agriculture and Biosciences International, PO Box 210, 43400 UPM Serdang, Selangor, Malaysia[4] SAFE Network, Andalas University, Limau Manis, Pauh, Padang City, West Sumatra 25175, Indonesia

Corresponding author**: **rc.joshi@mail.philrice.gov.ph

Considered now a global invasive pest of corn, the polyphagous fall armyworm (FAW), *Spodoptera frugiperda* J. E. Smith (Lepidoptera: Noctuidae), has spread rapidly across Africa, South and Southeast Asia and the Pacific since 2018 causing devastating impacts on corn-growing countries (Goergen et al., 2016; Hruska, 2019; Abro et al., 2021; FAO 2022). Regular updates of countries affected by FAW, and the global distribution, is available on CABI's FAW portal (www.cabi.org/ ISC/fall army worm) (CABI, 2019). In the Philippines, its first reported damage on corn was recorded in June 2019 in Piat, Cagayan Valley region (Navasero et al., 2019) and then it spread to all regions of the Philippines.

Rice has been reported as one of the key hosts of this pest in other countries e.g., the USA where it is a regular and serious pest mostly in the southeastern states (Pantoja et al., 1986). However, in the Philippines, the first reported FAW attack on rice was documented on May 17, 2021 on the rice seedbeds of Gonzaga, Cagayan. Thus, little is known on its spread and damage to rice and rice-based farming systems in the Philippines. Therefore, we monitored the presence of FAW in and around rice ecosystems, and identified areas where FAW was observed, so as to map the FAW invasion pathway in the Philippines. This information is crucial to come-up with adequate early preparedness and mitigation measures to counter any level of incursions of FAW invasions in rice – a staple crop in the Philippines and Asia.

Key rice production areas in the Philippines were monitored for the presence of FAW and its damage, in collaboration with the Department of Agriculture – Regional Field Offices (DA-RFOs) through the Regional Crop Protection Centers (RCPCs), and Municipal Local Government Unit (MLGUs) in different regions/provinces. Initially,

reports of occurrence was requested from the RCPCs and Bureau of Plant Industry (BPI). The sampling procedure for FAW occurrence and damage assessment used the visual observations or assessment method in scouting and collection of FAW in the rice fields, as well as in assessing the FAW damage. Prior to the visual observation inside the rice field, the field edges of the rice field were examined first for possible presence of FAW coming from the adjacent crops or grasses growing around the field. The non-rice vegetation, which could possibly serve as alternate hosts was noted. For observations in the seedbed, the data were taken inside a one m^2 quadrat with three replicates per seedbed. Monitoring was done on a monthly basis during the dry seasons and wet seasons of 2021 and 2022 in rice seedbeds, as well as in transplanted and direct-seeded rice fields.

Tracking the FAW Invasions in Rice

In the Philippines, during the first reported FAW damage on rice in seedbeds at Gonzaga, Cagayan in May 2021 there were three to 26 FAW larvae/ft^2 recorded during the validation and assessment (Fig. 1). FAW infestation was recorded in four provinces (Cagayan, Isabela, Nueva Vizcaya, and Quirino) in 14 municipalities from Region II with infestations in rice seedbeds and some in direct-seeded rice at seedling stage (Fig. 2).

A year after the FAW invasion in the rice seedbeds of Region 2, follow-up monitoring activities were conducted in the municipalities of Gonzaga, Santa Ana and Enrile in the Province of Cagayan. The re-invasion of FAW in the rice seedbeds was documented in the experimental field of Cagayan State University (CSU) in Barangay Flourishing, Gonzaga, Cagayan ($18^O15'7.7476"$ N, $121^O59'54.9823"$ E) in May 2022, a year after it was first recorded. Close monitoring of FAW population and damage in Cagayan revealed infestations in other barangays: Pateng (San Pedro and Paddek) ($18^O14'50.8200"$ N, $121^O58'29.2440"$ E); Ipil, Magrafil, Calayan, Tapel, Smart, Cabiraoan, Sitio Tabungao of Gonzaga and Barangay Rapuli of Santa Ana, Cagayan ($18^O22'36.3367"$ N, $122^O8'40.3710"$ E) (Figs. 2, 3 & 4). Most of the FAW-infested rice seedlings in the seedbeds were sown late compared to the neighboring fields which were established 2-3 weeks earlier. Also, it was observed that rice crops were established earlier in Gonzaga and Santa Ana, Cagayan by about a month or more compared to the other towns and provinces nearby. Rice varieties infested were both inbred (NSIC Rc 222, NSIC Rc 402) and hybrid (Pioneer, SL-8H, Syngenta NK S6003). The FAW population recorded was 19.33 larvae/m^2 (NSIC Rc222) and 3.33 larvae/m^2 (Pioneer hybrid variety) in CSU-Gonzaga campus experimental field; Brgy. Pateng, Gonzaga with 8.67 larvae/m^2 (Syngenta S6003 with 7.12% damage) and none in NSIC Rc 480; and Brgy Rapuli, Santa Ana, Cagayan with 20.8 larvae/m^2 (NSIC Rc 402 with 1.21% damage) and none in Pioneer PHB77 (NSIC Rc492H). During the Focus

Group Discussion (FGD), the farmers mentioned that they applied many kinds of insecticides to control FAW. However, the agricultural technicians from RCPC II provided farmers with Lufenorun (an insecticide from the "Benzoylurea" group which acts as a chitin synthesis inhibitor under IRAC 15) to apply in the seedbed. They also provided *Metarhizium* sp. to apply after transplanting, and sex pheromone traps to install in the FAW infested fields.

In addition, FAW and its damage on rice was also reported in Porais, San Jose City, Nueva Ecija (15° 44' 44.2860" N, 121° 2' 46.1508" E) last June 2022 by the local Government Unit-San Jose City through DA-RCPC III. Interview with the affected farmer said that it was the first time that his direct-seeded rice was infested with the FAW larvae. According to him, the common cropping pattern in the area is onion-rice. However, during the previous season, some neighboring fields were planted with white corn instead of onion.

FAW Strains in the Rice and Rice-Corn Cropping System

The field collected FAW larvae in the different monitoring sites were sent to CABI UK for FAW strain molecular characterization. The molecular analysis was performed by the Molecular Identification team of the Diagnostic and Advisory Service, CABI UK. Out of the 10 samples sent for strain identification, nine were successfully identified while no sequence was obtained in one sample (Table 1). Interestingly, one of the four samples collected from rice in CSU Gonzaga, Cagayan was corn strain while two of the five samples collected from corn in Tarlac and Pangasinan were rice strain. FAW rice strain has been reported from corn plants in Gonzaga, Cagayan (Navasero *et al*., 2019) and was also reported in Pakistan (Yousaf et al., 2022), and Australia (Piggott *et al*., 2021). However, to our knowledge this was the first report that a corn strain was collected attacking rice plant in the Philippines. Moreover, this was also the first report that a rice strain of FAW collected from corn plants is present in the provinces of Tarlac and Pangasinan. It is important to know the presence of both or either of the FAW strain for better management of the pest in relation to its host preference. Both FAW strains were collected in corn and rice plants and with the results of the molecular identification, the point is whether it is a C- or R-strain as both were observed attacking rice, and in almost equal proportions based on the samples used for identification (N=4 and 5 for corn strain and rice strain, respectively (Table 1). The possibility of the presence of FAW hybrids of the two strains in the monitoring areas needs also to be verified.

Fig. 1. Assessment of (A) FAW damage and collection of FAW larvae and pupa in rice seedbeds; and B) Rice seedlings with larva (yellow circle) and pupa (white circle) of FAW as well as the damage in leaves observed in Gonzaga, Cagayan on May 24, 2021.

(Photo credits: Dindo King Donayre).

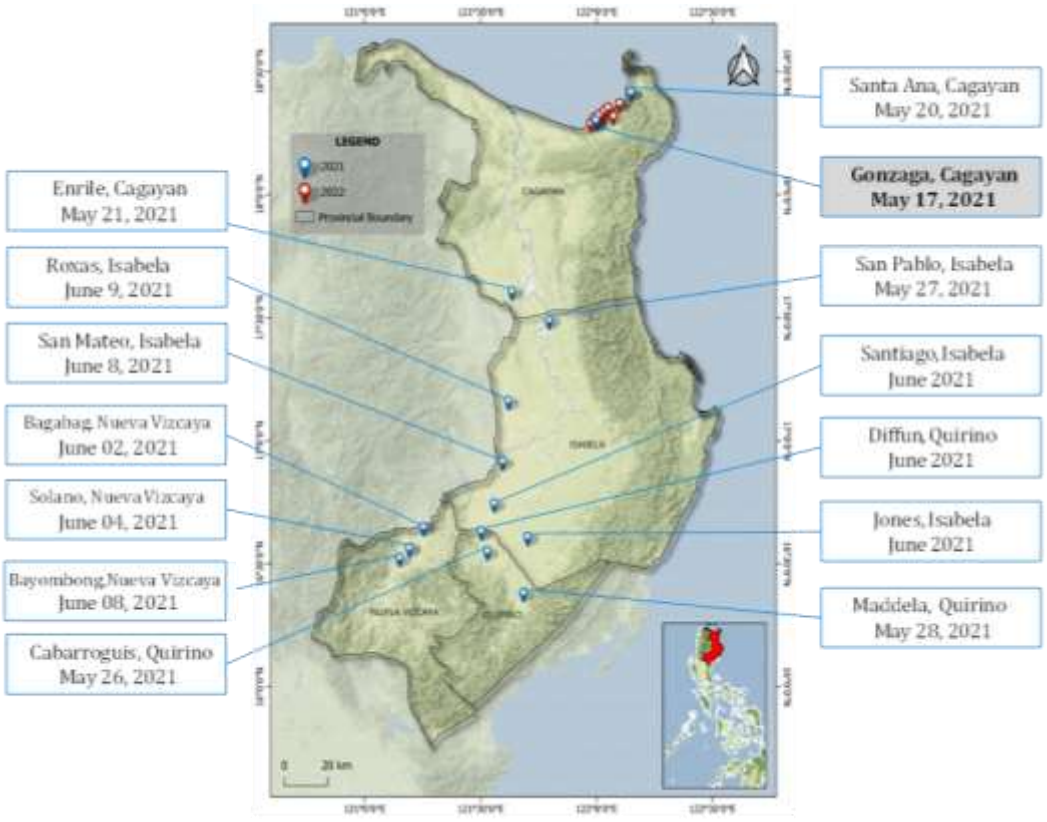

Fig. 2. Map of reported FAW infestation in Region II (Cagayan Valley), Philippines, during wet seasons (WS) of 2021. (Data source: 2021 WS DA-RCPC 2).

Fig. 3. FAW larvae collected and recorded in the rice seedbeds of the different infested barangays of Gonzaga and Santa Ana, Cagayan, 2022 wet season.

(Photo credits: Femia Sandoval).

Fig. 4. Re-invasion of FAW in rice seedbeds was recorded in Cagayan State University experimental field, Flourishing, Gonzaga, Cagayan and in other barangays of Gonzaga and Santa Ana on May 24 –27, 2022. (Data Source: 2022 WS – PhilRice and DA-RCPC 2).

Future Directions

In the Philippines, FAW is expanding its distribution to new rice areas, where it has never been reported earlier. Recurrent FAW invasions are a threat to the Philippine rice food security. Some possible reasons for future FAW invasions that need to be validated could be the (1) proximity of the rice to the corn cropping system; (2) mixed cropping of rice and corn; (3) changes in pesticide use or in the variety of corn planted near rice-growing areas. The impact of climate change drivers that favors FAW reproduction, growth and alters tri-trophic relationships needs special attention. In view of this, the Philippine Rice Research Institute has intensified its collaborative research efforts with CABI, and has also provided funds for the regular field monitoring, and research to elucidate its spread, damage and yield losses in rice, and consequently formulate strategies to manage FAW in rice should it become a challenge to rice production.

Table 1. Molecular identification of the collected fall armyworm (FAW) larvae from the different monitoring sites.

Sample Number	Collected from	Location	Date collected	FAW strain*
1	Rice	Callao, Gonzaga, Cagayan	May 24, 2021	sp. 1 rice strain
2	Rice	CSU campus Flourishing, Gonzaga, Cagayan	May 24, 2022	sp. 2 corn strain
3	Rice	Rapuli, Santa Ana, Cagayan	May 25, 2022	sp. 1 rice strain
4	Corn	Rapuli, Santa Ana, Cagayan	June 15, 2022	sp. 2 corn strain
5	Corn	Rizal, Rosales, Pangasinan	February 4, 2021	sp. 1 rice strain
6	Corn	Panalicsican, Concepcion, Tarlac	February 17, 2021	sp. 1 rice strain
7	Corn	Singat, Pura, Tarlac	March 2, 2021	sp. 2 corn strain
8	Rice	Pateng, Gonzaga, Cagayan	May 25, 2022	sp. 1 rice strain
9	Corn	Escaler, Magalang, Pampanga	February 18, 2021	No sequence obtained
10	Corn	PhilRice CES Maligaya, Science City of Muñoz, Nueva Ecija	June 28, 2022	sp. 2 corn strain

*Summary of sequencing results using The Barcode of Life Data System (BOLD) systems database.

References

Abro Z., Kimathi E., De Groote H., Tefera T., Sevgan. S and Niassy. S. 2021. Socioeconomic and health impacts of fall armyworm in Ethiopia. *PLoS ONE*. **16**(11): e0257736. https://doi.org/ 10.1371/journal.pone.0257736

CABI, 2019. Datasheet on *Spodoptera frugiperda* (fall armyworm), Ivan Rwomushana, CABI Africa, Canary Bird, 673 Limuru Road, Muthaiga, Nairobi, Kenya. https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.29810#tosummaryOfInvasiveness

FAO. 2022. Technical guidance on fall armyworm – Coordinated surveillance and an early warning system for the sustainable management of transboundary pests, with special reference to fall armyworm (*Spodoptera frugiperda* [J.E. Smith]) in South

and Southeast Asia. Bangkok. https://doi.org/10.4060/cc0227en ; https://www.fao.org/3/ cc0227en/cc0227en.pdf

Goergen G, Kumar, P. L, Sankung, S. B., Togola, A. and Tamò. M. 2016. First Report of Outbreaks of the Fall Armyworm *Spodoptera frugiperda* (J E Smith) (Lepidoptera, Noctuidae), a New Alien Invasive Pest in West and Central Africa. *PLoS ONE*, **11**(10): e0165632.doi:10.1371/ journal. pone.0165632

Hruska, A. J. 2019. Fall armyworm (*Spodoptera frugiperda*) management by small holders. CAB Reviews 14 No. 043.

Navasero, M. V, Navasero, M. M., Burgonio, G. A. S., Ardez, K. P., Ebuenga, M. D., Beltran M. J. B., Bato, M. B., Gonzales, P. G., Magsino, G. L., Caoili, B. L., Barrion-Dupo, A. L. A and Aquino, M. F. G. M., 2019. Detection of the fall armyworm, *Spodoptera frugiferda* (J.E. Smith) (Lepidoptera: Noctuidae) using larval morphological characters, and observations on its current local distribution in the Philippines. *Philipp Ent*. **33**(2):171-184.

Pantoja A, Smith, C. M. and Robinson, J. F. 1986. Effects of the fall armyworm (Lepidoptera: Noctuidae) on rice yields. *Journal of Economic Entomology*, **79** (5): 1324–1329. https://doi.org/10.1093/jee/79.5. 1324.

Piggott, M. P., Tadle, F. P. J., Patel Sgomz, K. C and Thistleton, B. 2021. Corn-strain or rice-strain? Detection of fall armyworm, *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae), in northern Australia. *Int J Trop Insect Sci*., **41**: 2607–2615. https://link.springer.com/article/ 10.1007/s42690-021-00441-7

Yousaf, S., Rehman, A., Masood, M., Ali, K. and Suleman, N. 2022. Occurrence and molecular identification of an invasive rice strain of fall armyworm *Spodoptera frugiferda* (Lepidoptera: Noctuidae) from Sindh, Pakistan, using mitochondrial cytochrome c oxidase I gene sequences. *Journal of Plant Diseases and Protection*, **129**:71-78. https://link.springer.com/article/ 10.1007/s41348-021-00548-6.

MS Received 25 March 2023
MS Accepted 15 June 2023