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缅甸稻飞虱的发生和防控情况（英文）

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摘要：稻飞虱是缅甸水稻种植区常见且分布广泛的一类害虫，可造成农作物不同程度的减产。稻飞虱的爆发与高产品种的大规模推广种植具有一致性，同时其种群变化也与天气条件有关。近年来，缅甸中部部分省份稻飞虱大量孳生，在一定程度上，这与氮肥施用水平有关。雨季稻飞虱种群增加，7 月和 8 月为高峰期。在缅甸，主要通过培育抗虫、抗旱、抗逆等水稻品种来防控稻飞虱。同时用诱虫灯进行早期入侵的虫源的监测，必要时，采用化学杀虫剂防治。缅甸部分农场还采用了病虫害综合管理系统（IPM），以建立健康、安全、可调节的水稻生态系统及可持续的病虫害管理。

关键词：稻飞虱；暴发；种群变化；防控策略；IPM
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Occurrence situation and control of rice planthoppers in Myanmar

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Abstract：Rice planthoppers are widely distributed pests in some rice growing areas of Myanmar. The yield reduction due to rice planthoppers became serious according to the degree of infestation. Outbreaks have coincided with the misuse of insecticides，the intensive uses of nitrogenous fertilizers and the extension of irrigation. Weather condition is also influenced on population fluctuation of rice planthopper. Recently，some provinces in middle regions of Myanmar were heavily infested with rice planthoppers and it was somehow correlated with the level of nitrogen fertilizer applied. During the rainy season，rice planthopper population was increased in rice paddy fields and the highest population was observed in July and August. For early warming and monitoring of the immigrated insect pests，light traps were used. As control strategy，pests，drought and stress tolerance resistant rice varieties were mainly cultivated in Myanmar. In order to get healthy，safe，and resilient rice ecosystem，Integrated Pest Management System（IPM）was also applied in some research farms in Myanmar.

Key words：Rice planthopper；outbreak；population fluctuation；control strategy；IPM

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Background

Myanmar is an agricultural country and agriculture sector is the backbone of its economy. Rice is the single most important crop not only as a staple, but also as a foreign exchange earner (Raitzer *et al.*, 2015). To meet the increasing demand for rice and to sustain export, rice production must be increased through area expansion, yield increases and crop intensification (Nguyen & Tran, 2002). As rice is an ideal host for many insect species and all its parts are vulnerable to insect-feeding from the time of sowing till harvest, insect pests become the major constraints for increasing rice production (Dale, 1994). Among these pests, rice planthoppers such as brown planthopper (*Nilaparvata lugens* Stål, BPH) and white backed planthopper (*Sogatella furcifera* Horváth, WBPH) are the most destructive pests to rice production (Mochida *et al.*, 1978). They infest the rice crops at all stages of plant growth. At early infestation, round yellow patches aree appeared which are soon turned into brownish due to the drying up to the plants (Kim & Sohn, 2005). These patches of infestation may spread out and cover the entire field (Chau *et al.*, 2003).

Rice planthoppers' infestation was first officially recorded in Bangladesh in 1969, but there were earlier records using synonyms of brown planthopper (*N. lugens*) in 1957 and in 1917 (Alam *et al.*, 1977). A serious outbreak of *S. furcifera* was reported in Pakistan in 1978, in the north-west of West Malaysia in May 1979, and in India in 1982 (Majid, 1979; Khan & Kushwaha, 1990; Ooijen & Maliepaard, 1996). In Myanmar, the first outbreak of rice planthopper was recorded in 1970 at the Kyaukse Central Farm (Mandalay Division) and in the upper Myanmar. In 1998, about 18 200 ha in Kha-yan and Thonge-khwa, Yangon Division of Myanmar were infested and this was also during the time of the rice planthopper outbreaks in Central Thailand in 1998 (Myint, 2010). In March 2009, about 8 100 ha of rice in Bogalay were heavily infested by rice planthoppers and a loss of 20 900 tons was estimated. In 2011, an area of about 10 ha was destroyed by rice planthopper (Win *et al.*, 2011). Nowadays, rice planthoppers caused a huge problem in the rice intensification programs of Myanmar.

Several factors have been attributed to planthopper outbreaks, but they may be different depending on countries. Climatic factors such as temperature, rainfall and relative humidity are also greatly influenced on rice insect population (Muhamad & Chung, 1993; Way & Heong, 1994; Heong *et al.*, 2007; Siswanto *et al.*, 2008). The factors such as extension of irrigation for double cropping of rice, the use of short duration photoperiod intensive rice varieties, intensive uses of nitrogenous fertilizers and insecticide are also influenced on rice planthoppers population and their outbreaks (Sogawa, 1971; Mochida *et al.*, 1978). The close spacing, the continuous submerged conditions in the fields, low populations of natural enemies due to indiscriminate use of insecticides and nitrogen fertilizers are the factors that contributed to the outbreak (Bhathal & Dhaliwal, 1991; Heinrichs & Mochida, 1984; Yein & Das, 1988).

1 Rice planthopper occurrence situation

Rice planthopper is common in rain-fed and irrigated wetland environments during the reproductive stage of the rice plant. The fluctuation of rice planthoppers was correlated with temperature and high rainfall patterns during the first cropping season (in July to November). In July to August with the highest rainfall, the rice planthoppers built up in the fields with maximum tillering stage of rice plants (Myint, 1975).

The population abundance of rice planthoppers in relation to plant density, average temperature, rainfall and relative humidity was recorded over rice growing seasons in Myanmar. During the rainy season, rice planthopper population built up with increase in plant tillers in the rice field and the highest peaks of rice planthopper population were noted in July and August (Win *et al.*, 2011). During dry season, the optimum population of rice planthoppers was recorded in

February, March and April. During the period of rice maturity and harvesting season, their population began to build up and peak. The dominant specie of WBPH immigrants was found in the early season < 60 Days After Transplanting (DAT), while BPH was more dominant in the late season > 60 DAT (Win *et al.*, 2011) (Fig. 1).

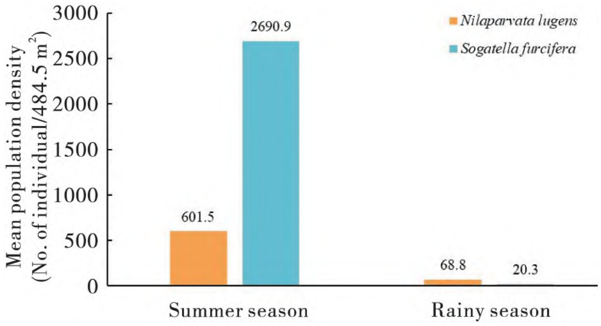

Fig. 1 Mean population of *Nilaparvata lugens* and *Sogatella furcifera* on rice in two different seasons (Mar, 2013)

In 2018, white-backed planthopper (WBPH) and brown plantopper (BPH) were collected from the paddy fields with the sweep net technique and its occurrence situation was observed in four Divisions of Myanmar. Rice planthoppers were sampled from 33 different locations (Supplement 1, 2) and estimated population fluctuation in these regions (Fig. 2). Heavy infestation of rice planthoppers, especially with BPH was occurred in Pyinmanar and Naypyitaw Region of Myanmar. Nearly 30% of the farms was heavily infested with 95% BPH and 5% WBPH. Farmers overused nitrogen fertilizer to get high yield per year. In some parts of Sagaing Division, heavy infestation of both WBPH and BPH was also observed. It may be due to the heavy usage of fertilizers and double-cropping of rice per year. All these data were recorded during sample collection and field surveillance with farmers (data not published).

In Magway Division, some rice-growing areas were heavily infested with 90% WBPH and 10% BPH. The farmers in these regions were also cultivated short intensive rice varieties and double-cropped the rice. Moreover, intensive uses of nitrogen fertilizers and chemical pesticides were also the reasons that caused heavy infestation of WPH. In Mandalay Division, there was no hopper-burn condition and light infestation with WBPH and BPH was occurred with some farms. In Mandalay Division, most farms were cultivated the rice once per year and used the recommended amount of fertilizers. The population of rice planthoppers and their natural enemies was balanced in most farms of Mandalay region. In Yangon and Ayarwaddy Divisions, rice planthopper condition was not serious and the condition is normal. Other than rice hoppers, the farmers were facing the problem with small snails (data not published). All these data were recorded during sample collection and field surveillance with farmers (data not published).

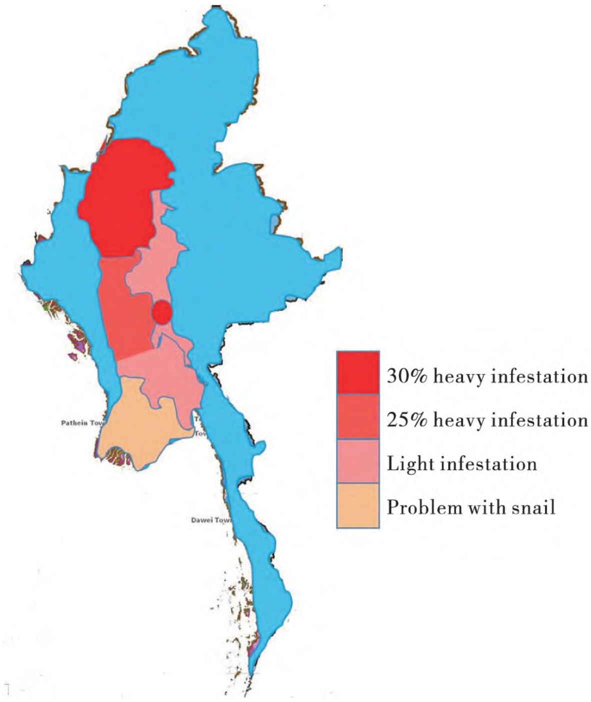

Fig. 2 Rice planthopper occurrence situation in Myanmar in 2018

2 Distribution and their migration

As rice planthoppers are long ranged migrants, they make wind-assisted migratory fights each year to colonize the summer rice growing areas of China. These insects were found to migrate 200 to 300 km in mainland China (Tu *et al.*, 1988). They were distributed in Asia, Australia, and the Pacific Islands. In Asia, they were found in Bangladesh, Brunei, Myanmar, China, India, Indonesia, Japan, Cambodia, Korea, Laos, Malaysia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, and Vietnam. In Australia and the Pacific Islands, they were found on the Caroline Islands, Fiji, Mariana Islands, Papua New Guinea, and Solomon Islands (Reissig *et al.*, 1986). They were also found in the area extended from Pakistan to Japan, and many islands in Southeast Asia, Micronesia, and Melanesia. Mainly on rice, they were found throughout the year, except in Japan and Korea where adult pests migrated into the country each summer (Dyck & Thomas, 1979). The hoppers were carried to Korea and Japan by prevailing winds from permanent breeding grounds in southern China.

Influxes of planthopper were occurred from late June to mid-July every year coinciding with the arrival of low-pressure fronts from the south. In the tropics, migrations were also occurred. Hopper adults collected from two successive inter-island voyages were indicated that migrant planthoppers were reaching the Philippine Archipelago from certain rice growing areas lying to the southwest of the Philippines in the Indian Ocean (Saxena, 1986). The inflowing warm and humid air currents facilitated this migration. Observations were indicated that the brown planthoppers took off at dusk and some were capable of continuously flying up to 26 h if the temperature was more than 17℃ (Rosenberg & Magor, 1983). Rice planthopper movements were governed by synoptic weather patterns, which, together with the flight duration of the insect and temperature thresholds of flight were determined the speed, direction, and extent of insect displacement. Migration studies at the Natural Resources Institute had concentrated on using trajectory analysis to model possible movements between rice growing areas in temperate and tropical areas and radar to observe migration directly (Pender, 1994). Light intensity and air temperature were the parameters that determined take-off behavior and height of flight of migrating brown planthopper (Chen *et al.*, 1980; Jiang *et al.*, 1982; Chen *et al.*, 1984).

3 Strategies for rice planthopper control

3.1 Early warming and monitoring of immigrated insect pests

If the presence of pests cannot be early detected, they will develop unnoticed and will cause damage and difficult to control. Several nonchemical approaches for controlling rice diseases, insect pests, and weeds have been studied and applied, specifically using yellow sticky board, sex pheromone trap and light trap. To determine and control the presence of insect pests in rice crops, light traps have been widely used in some developing countries such as China (Ma & Ma, 2012), Japan (Endo *et al.*, 2014), also in Brazil (Oliveira *et al.*, 2008). Light trap is very important to monitor pest immigrants that is first arrived at the nursery or rice plants (Baehaki, 2013).

As light trap attracts the pests at night by the light it emits, the pests catch in the light trap at any time and its data can be used as a data of dispersal, distribution of pests and anticipation of pest outbreak either at country or beyond countries (Shimoda & Honda, 2013). In Myanmar, light trap are used for early warning and monitoring of pest immigrants which came into rice crops (Mu, 2016).

In 2016, monitoring of rice planthoppers using light traps and field scouting were carried out in four regions in Myanmar (Fig. 3). First was in Pangon Research Farm in Sagaing District. Second was in Naypyitaw Agricultural Research Farm in Naypyitaw District. Third was in Let pa Dan Research Farm in Bago District. The last was in Myaung Mya Research Farm in Ayeyarwaddy District. Moreover, yellow sticky traps, aerial sticky trap and white cloth were also set up in these four regions and monitored the rice pest situation (Mu, 2016).

According to the light trap catching rice pests Data, in Myanmar, 46 families from 10 Orders of insect species were observed from two different seasons. Species diversity was higher in rainy season than in summer season. It may be due to the higher number of rice plantations in rainy season. The species diversity of natural enemy species was higher in

Fig. 3 Light trap setting regions for monitoring pest immigrants in Myanmar

summer seasons than in rainy season. However, population of insect pest species was higher in rainy season than in summer (Mar, 2013).

3.2 Cultivation of resistance rice varieties

The cultivation of resistant varieties is the most effective and economical method to control rice planthoppers in rice growing areas. In Myanmar, rice is grown during the monsoon and summer seasons in four growing zones: the delta, dry zone, coastal zone, and mountainous areas. About 80% of the annual production is harvested during the monsoon season and the remaining 20% during the summer season. About 50% of the total production comes from the delta comprised of the Ayeyarwaddy, Bago and Yangon regions. About 25% is produced in the dry zone, including Mandalay, Sagaing, and Magway regions. The rest is produced from the coastal and mountainous areas (Raitzer *et al.*, 2015).

All farmers grow the resistant rice varieties recommended by Agriculture and Irrigation. Myanmar has been collaborated with IRRI for 30 years. About 70 high-yielding varieties (HYVs) had been developed by Myanmar rice breeders in collaboration with International Rice Research Institute (IRRI) (Myint, 2013). Twenty-eight of these HYVs are widely grown by farmers and used in more than 40% of the 8 M ha rice area in the country. The top five varieties grown in 2011 – 2012 were Manawthukha (Mahsuri mutant), Sin Thwe Latt (IR 53936-90-3-2-1), Shwe War Thun (IR 5 mutant), Aye Yar Min (Maclardo), and Thee Dat Yin (IR 13240-3-2-1). However, other HYVs varieties were still needed to be accessible by farmers and enable to meet quality requirements in international rice trade.

Even though rice breeding had been strong, research and development of appropriate pre-harvest and post-harvest crop management options have been lagging. The few recommendations for rice were adapted from other countries brought by IRRI to Myanmar through the Irrigated Rice Research Consortium (IRRC) and the Consortium for Unfavorable Rice Environments (CURE). As such, there were limited defined management recommendations for varieties in different growing environments in the country (Myint, 2013).

3.3 Application of selective insecticide

The common method of controlling rice planthoppers in Myanmar is the application of synthetic insecticide. Most of insecticides are effective at one day after treatment, but at 7 days their effectiveness begins to drop, indicating short residual activity, even in the greenhouse. In Myanmar, in previous years, the usage of chemical pesticides was increasing because of limited knowledge on integrated pest management and the proper use of pesticides by farmers (Peeters *et al.*, 2012). The implementation of pesticide regulations was likewise weak, and this had resulted in the entry of unregistered and/or banned products. The lack of policy regarding pesticide use, weak regulation, and monitoring of pesticide entry in the market, and farmers' lack of knowledge of proper pest management was likely resulted in pesticide misuse and the eventual occurrence of pest problems and loss of biodiversity in the rice ecosystem (Peeters *et al.*, 2012).

Nowadays, results of insecticide evaluation programs have been used as a guide for planthopper control in Myanmar. At least 31 different recommended insecticides had been applied throughout Asia, not only because of their effectiveness but also because of their commercial availability and safety (Heinrichs, 1979). Insecticides such as Zolar 25 EC, cover 25 SC, Cupromax 85WP, Cymoz 72WP, Dizi 32.5 SC and Pyricide 40 SC are commonly used in rice growing areas in Myanmar. As pesticide application leads health risks to farmers and consumers, and may cause resistance build-up in pests and resurgence of secondary pest, pesticides are sprayed when only necessary. If the population of rice planthopper does not reach the economic threshold level, pesticides do not apply. When the number of rice hoppers is reached about 100 nymphs per rice hill, recommended insecticides are sprayed (Mu, 2016).

3.4 Cultural practices

Cultural practices such as good land preparation (plowing and harrowing), removal of weeds inside the rice field, synchronous planting and fallow periods, fertilizer management, water management and planting of resistant varieties are very important to make the environment less favorable for pest invasion, reproduction, survival, and dispersal. Its aim is to achieve reductions in pest numbers (Zahirul, 2001).

Different tillage operations such as plowing and harrowing are affected on various stages of white grubs. Plowing in 3 ~ 4 weeks intervals during off-season exposes the grubs to harsh weather and predators. Management of post-harvest crop residues is mainly directed toward the control of stem borers, ear-cutting caterpillars, disease pathogens, and weed management (Litsinger, 1994; Zahirul, 2001). Traditionally, burning straw and stubble is a common practice to control stem borers, armyworms, plant hoppers, and leaffolders. The threshing process and sun drying are very effective in killing the larvae and pupae of stem borers and eggs of leafhoppers and planthoppers in the straw.

As insects readily disperse from field to field and can maintain high population levels, staggered planting ensures the greater survival of rice pests throughout the year by extending the temporal availability of the host plant. Synchronous planting and the creation of a rice-free period of at least one month between successive rice crops can greatly reduce pest abundance. It is advocated for management of planthoppers, leafhoppers, stem borers, and so on (Zahirul, 2001).

As some rice insect pests develop on common rice field weeds, mostly on grasses, weed hosts act as a bridge between rice crops or preferred stages of rice crops to sustain pest populations. Weed control is suggested to control leaf-folders, leaf-hoppers, planthoppers, seed bugs, leaf beetles, black bug, mealy bug, armyworms, caseworms, root aphids, root bugs, root weevils, leaf miners, and seedling maggot. Cutting weeds from areas bordering paddies and removing weeds from rice fields can reduce potential nesting sites and shelter for rats and alternate hosts of insects (Zahirul, 2001). Herbicides such as D-min 60 EC and Quinfuron 40WP ware normally sprayed for three times since planting until harvest in rice growing fields of Myanmar (according to data surveillance with farmer).

Even though high rates of nitrogen fertilizer provide more nutrition to plants and result in higher yield, it can increase weed populations in the current and subsequent crops, increase the incidence of fungal and bacterial diseases by increasing tissue susceptibility and tiller density, and encourage the multiplication of planthoppers, leaffolders, stem borers, leafhoppers, gall midge, armyworm, root weevil and leaf beetles (Reissig *et al.*, 1986). Under high nitrogen fertilizer conditions, insects generally grow larger, cause more damage, produce more offspring, grow faster, and complete more generations per crop (Zahirul, 2001). Therefore, nowadays, recommended rate of N fertilizers such as Moe Pearl is mostly applied in Myanmar (according to data surveillance with farmer).

Water management system is also important for pest control. The draining of fields is a common practice to suppress planthoppers and armyworms. Alternate flooding and draining, if it is carried out for 5 ~ 7 days, can minimize some semi-aquatic insect pests such as black bugs, planthoppers, gall midge, hispa, and most stem borers. Draining rice fields can reduce the threat of hopper-burn. Draining stimulates calcium uptake, which hardens plant tissues and makes them more resistant to pests. However, draining may also stimulate weed growth. Frequency of action was important because alternative flooding and draining can cause high losses of nitrogen (Zahirul, 2001).

Host plant resistance have been proposed to reduce both direct mechanical damage and viral transmission. Since the early 1970s, breeding for resistance against the pest such as BPH and WBPH had been a priority at IRRI (Heinrichs *et al.*, 1986) and other National Agricultural Research and Extension Services (NARES) throughout South, South-East and East Asia. Breeding resistant rice varieties was a viable, ecologically acceptable approach for management of rice planthopper (Teng, 1994). Moreover, planting resistance rice varieties was environment-friendly, inexpensive, and compatible with other methods of control under integrated pest management (IPM) system.

3.5 Promoting natural enemies

Areas of land contain hundreds or thousands of species which tend to form a balance in ecosystem and each of them depends on some of the others. Any specie is less likely to build up a large population if its natural enemies which feed on it are also present. Hence, the natural enemies of plant pests are considered as farmers' friends (Verkerk, 2001). Various beneficial organisms can help the farmer to control pests and some diseases. If large outbreaks of rice pests do sometimes occur in natural systems, it is necessary to promote the beneficial insects that eat or parasitize on target pests. If natural enemies of rice pests become established in ecosystem, the pests become less populated. Then, no pest outbreak occurs and ecosystem will be balanced.

Farmers can help to keep the ecosystem balance by trying not to harm natural enemies such as ladybirds, marid and spiders which feed on rice pests (Chandra, 2017). Flowering Plants such as fennel and thistles provide nectar and pollen to natural enemies. Growing flowering plants can give shelter and refuge to them by having living fences (hedges) around rice crops. In this way, population density of natural enemies is encouraged. Live fences such as trees and hedges act as windbreaks and provide shelters for natural enemies. Mixed cropping systems also provide food and shelter and attract a wider range of natural enemies. Mulches around plants provide attractive environments for ground-living predators such as beetles and spiders. Natural enemies are more susceptible to pesticides than the pest itself and are thus harmed or killed while the pest is not much affected (Verkerk, 2001). That is why, at last, only when necessary, specific selective pesticides, not broad spectrum one, is applied.

3.6 Vegetable-based ecological engineering

Ecological engineering has recently emerged as a model for pest management approaches. Using cultural techniques to effect habitat manipulation and enhancing biological control is the attitude of ecological engineering (Gurr *et al.*, 2004). The aim of ecological engineering in agriculture ecosystem is to integrate soil and pest management strategies with regular practices of farmers for the benefit of environment and farming community. It will not only suppress the pest population but also enhance the soil micro flora and enrich the soil with organic matter (Sree & Jesu, 2018). It also protects the crops from economic damage by strategic use of plant biodiversity to enhance the effciency of natural enemies for suppressing pests (Gurr *et al.*, 2004; Cullen & Jesu, 2008).

In ecological engineering, growing flowering plants is the key component to provide resources such as nectar and pollen to natural enemies for promoting biological control (Wackers, 2007). It includes attractant plants to attract the natural enemies, repellent plants to repel the pests, trap plants to attract and trap the crop pests, barrier or guard plants to prevent the entry of pests. As ecological infrastructure in Myanmar, vegetable crops such as Okra, Sunflower and Sesame are grown around rice crops. For the successful implementation of this technology, the farmers need to follow the eco-friendly approaches on community basis and avoid the use of insecticides during the first 40 days age of the crop growth for building up of the beneficial insects for effective pest management (Litsinger *et al.*, 2009).

4 Current progress of Integrated Pest Management (IPM) system

Integrated Pest Management (IPM) system is an effective, broad-based, and environmentally sensitive approach to pest management. The goals of IPM in Myanmar are to get healthy, safe, and resilient rice ecosystem and obtain sustainable insect pest management. Frameworks of IPM are carried out with four actions: using cultural practices that prevent economically-damaging populations of rice insect pests, promoting natural enemy through conservation biological control, using augmentative biocontrol, and applying selective insecticides. In Myanmar, *Trichogramma* is released into rice fields by small cards on which about 1 000 parasitized eggs are clued. 100 cards are placed at regular intervals (about 10 × 10 m) per ha of rice, resulting in 100, 100 wasps per ha (Mu, 2016). Moreover, yellow sticky traps, aerial sticky trap, white cloth and light traps are also set up in some regions and monitored the rice pest situation. Project staffs are carried out on rice planthopper identification, field surveys and data management. Then, annual AFICI-IMP project evaluation and expert workshops are attained at home and aboard (Mu, 2016).

5 Achievements

As the usage of chemical pesticides is the traditional control method of rice planthoppers in Myanmar, the Law is implemented to regulate registration and entry of chemical pesticide products into the market and to ensure that quality standards are met by pesticide companies. Department of Agricultural Research (DAR) is one of the Government organization in Myanmar and established with 168 Divisions. It is situated in Napyitaw, Capital city of Myanmar and mainly carried on increasing per capital income and standard living of rural populace relying on Agriculture Sector. It is collaborated with national and international agricultural projects and try to develop agricultural human resources. Regeneration of new hybrid strains have been researched by inbreeding resistance varieties and high-quality traditional varieties and trying to offer to farmers.

To be able to control rice planthopper outbreak in time, pest monitoring and forecasting are regularly carried out using light traps. In each district, around 50 farmers and 20 staffs under Department of Agricultural Research (DAR) are trained on rice planthopper identification, field surveys and data management. Farmers are advised to manage rice planthopper based on ETL and rice crop stage. As expected outcomes, it will be helpful in prediction of outbreaks of rice pests. Specific diversity are identified and farmers are known earlier before the incidence of rice planthopper outbreak (Mu, 2016). Nowadays, Myanmar is an active member of the Greater Mekong Sub-region and the Association of South East Asian Nations (ASEAN). In future, these partnerships will be strengthened and sustained to share knowledge, technologies, facilities, and information systems on pest management system.

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