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## FALL ARMYWORM (FAW) EPIDEMIC IN SRI LANKA: RATNAPURA DISTRICT PERSPECTIVES

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### ABSTRACT

A recent outbreak of FAW (*Spodoptera frugiperda*) caused a substantial yield loss in corn was recorded in Sri Lanka especially from Uva, Eastern and North Central provinces. This was first reported in Sri Lanka in August 2018 and over the last six months, the livelihood of the majority of small-scale farming families was greatly affected. National mobilization of resources, agriculture related institutions together with university academia actively participated with the government campaign of combating the pest and improving the livelihood of affected people all over the country. The effort of this short communication is to describe the magnitude of FAW infestation, its implications in Ratnapura District, Sri Lanka and the contribution of the inter-institutional support towards the sustainable management of the Fall ArmyWorm epidemic in Sri Lanka. Amount of land extent used for corn cultivation in Ratnapura district was estimated as 292.65ha, while 32.95 ha were infected with the pest (11.3%). Highest provincial land extent use for corn in Sri Lanka was Uva province where considerable pest damage has been reported. In Uva, total 42436.7 ha were cultivated in maha season where 30998.3 ha has infected and destroyed (73%). Even though corn was cultivated in lower land extent in Ratnapura, effective and organized disaster management response in Ratnapura was able to minimize the pest impact to 11.3% from total losses.

**Keywords:** *Spodoptera frugiperda*, Ratnapura, Corn, Yield loss, Sabaragamuwa University, Sustainable Management.

### INTRODUCTION

Transboundary crop pests affect food production, instigating substantial losses to farmers and threatening food security. The spread of transboundary crop pests has increased intensely after the introduction of industrial farming technology. Globalization, trade and climate change, as well as reduced resilience in production systems due to decades of industrial farming, have all played a big role. Transboundary plant pests can easily spread across the world and reach epidemic proportions. Epidemics and expansions can cause massive losses to crop, threatening the livings of poor farmers. Fall Armyworm, fruit flies, locusts etc. are among the most destructive transboundary crop pests. They spread in three principal ways: international trade, human migration, environmental forces (e.g. weather and windborne) (Pantoja-Lopez, 1985). Fall Armyworm

(*Spodoptera frugiperda*; Noctuidae) (FAW) outbreak, the first emergence of the pest in Sri Lanka in August 2018, has so far caused massive damage on large-scale corn monocropping systems.

In Sri Lanka, corn is cultivated mainly in two cropping seasons of the year namely *Maha* and *Yala*. During the *Maha* season, the estimated corn growing extent is about 82,539 ha and about 9,000-10,000 ha during the *Yala* season. During the *Maha* season (2018/2019), over 50 % of the cultivation (54,416 hectares) has been infested by the pest (DOA statistics, 2019). Based on information from the FAO, it appears that a number of countries in the South Asian region have already been invaded by the FAW. Moreover, corn is considered to be the second most important food crop grown in Sri Lanka next to the staple diet rice in terms of extent cultivated, foreign exchange involved in imports and agro-industrial utilization. It is

widely used in both the food and feed industries. Among the major annual upland crops grown by small-scale farmers, maize has received increased attention in recent years due to increased local demand with the expansion of animal feed industry as fodder, silage and grains for manufacturing livestock feed. Corn and Sugar maize have been playing a vital role during total mixed ration (TMR) feeding methods for high yielding cattle. Therefore sustainable crop management against this nature of alien worms must properly be addressed (Mudugamuwa, 2019). FAW is an alien pest to Sri Lanka, whose presence on Sri Lankan soil was first reported in August 2018, in Ampara district of Eastern province. This is the first scientific report come out from present outbreak of FAW infestation in Sri Lanka, as per available literature. The pest is known to cause extensive crop losses of up to 80% depending on existing conditions and is difficult to control with a single type of pesticide, especially when it has reached an advanced larval development stage. In the absence of natural control or good management, the FAW can cause substantial damage to maize and many other crops including rice. Once established in a new area, FAW cannot be practically eradicated by quick-fix remedies. It has already become a horrible pest that farmers need to learn about and management strategies to overcome the problem. There's disagreement among Sri Lankan scientists about how the FAW invaded the country. One suggested avenue is that it arrived on foodstuffs and plant materials imported from the foreign countries which were feasible as insects can readily cross the borders with infested plant materials while other suggested, they cross border flying of moth. The species has been intercepted on shipments destined for Europe on several occasions. It's also possible that the FAW arrived over the Indian Ocean through wind currents, FAW also reported in India in May 2018 (Mudugamuwa, 2019; Pantoja-Lopez, 1985; Chormule *et al.*, 2019). This is because wind-borne adult insects can move over vast distances. Whichever way the FAW arrived, its rapid spread across the country confirms to its high dispersal ability. As strong flyers, adult moth crosses borders with ease.

Biotic pollutions like these threaten biodiversity, the functioning of natural and agricultural ecosystems, and ultimately food security in the country. South Asian region is considered to be particularly vulnerable to invasive pests due to its high dependence on agriculture. Understanding how armyworms breed, travel and feed is critical to

managing the devastation they can cause. They have a number of characteristics that make them particularly hard to control. This includes the fact that the moths are strong flyers, the fact that they breed at an astonishingly high rate and that their larvae can feed on a particularly wide range of host plant (Pantoja-Lopez, 1985). They tend to develop resistance to pesticides and therefore, finding solutions through pesticides appears to be futile and will create other problems such as destruction of natural pest predators that remain active in the country. Given the severe economic threat that the FAW poses, the government should put in place emergency plans. These include monitoring with pheromone traps to determine the spread of the FAW, roadshows to increase public awareness, a temporary ban on crops such as corn, restrictions on transportations of plant materials etc. Control of the pest will be best achieved through switching from industrial-type monocropping to ecological agriculture technologies with the promotion of natural predators and parasitoids (Hailu *et al.*, 2018).

#### **Taxonomy of the pest**

Domain: Eukaryota  
 Kingdom: Animalia  
 Phylum: Arthropoda  
 Class: Insecta  
 Order: Lepidoptera  
 Family: Noctuidae  
 Genus: Spodoptera  
 Species: *Spodoptera frugiperda*

**Biology of the pest:** Biology and the behaviour of the pest are greatly affected by the existing environmental factors especially the tropical climate in Sri Lanka. It is a well-known fact that the FAW represents complete metamorphosis and all four stages in the life cycle namely eggs, larva, pupa and adult are characteristically different from each other (Figure 1). Spherical shaped eggs are approximately 0.75 mm diameter and just after oviposition they are yellowish green in colour and with maturity, the colour turns darker and in the verge of hatching resemble in light brown (Figure 2). Egg masses collected from the field represented approximately 60-200 number of eggs in each which were laid in several layers normally ranges from 2-4. Exceptionally egg masses laid as a row in single layer also found with samples. Usually, egg masses are covered with grey coloured setae/scales by the moth during oviposition for protection. Rarely egg masses without the protected covering are also reported (Pantoja-Lopez, 1985).

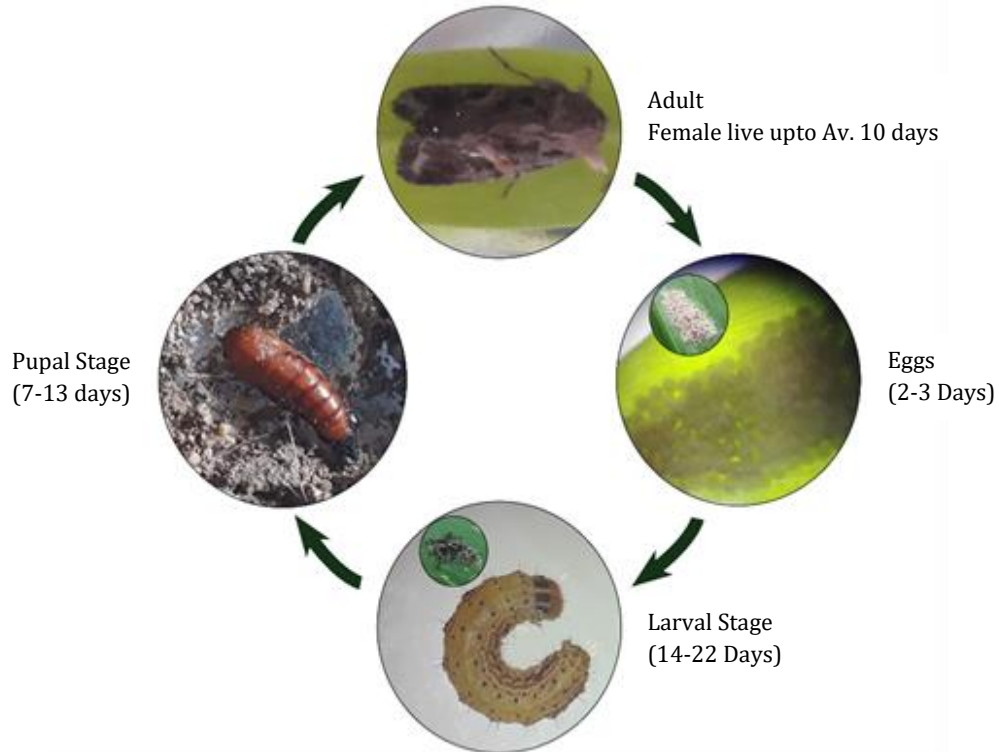


Figure 1. Life cycle ranges from 24-40 days.



Figure 2. Newly hatched (L1 Larva).



Figure 3. Mature (L6 Larva).

Usually, consecutive six larval stages are there during completing the life cycle. Eruciform Larvae have four pairs of fleshy abdominal pro-legs in addition to the pair at the end of the body which are clearly visible with maturity towards latter stages in the larval development. On hatching, they are green with black lines and spots, and as they grow commonly, they become brownish and have black dorsal and spiracular lines (Figure 3). Further, there is a wider dark stripe and a wavy yellowish band on each side. Inverted Y-shape in white-yellow on the head and four black spots arranged in a square on the last abdominal segment are the most common characteristic features of identification in latter

stage larva. Fully grown larvae range from 3-4 cm in length (Pantoja-Lopez, 1985). From L1-L6 all larval stages are feeding on the host plant gregariously while causing tremendous losses in the crop. Comparatively latter stage larval instars are ingesting a greater amount of food than the initial larval instars. Young FAW larvae can spread in the field by the wind on hanging silken threads. Due to hiding of larva inside leaf whorls of corn enable them to protect from predators (Hailu *et al.*, 2018). Cannibalistic behaviour of larger larvae results in one or two larvae per whorl. Larval stages are characterized by prominent active feeding period and the inactive period prior to each molt.



Figure 4. Pupa



Figure 5. Male Moth



Figure 6. Female moth

Pupation takes place in the soil inside a loose cocoon or rarely between leaves of the host plant. Pupae with the incidence of no substrate they pupate on the surface. Pupae are shorter than the mature larvae and are shiny brown in colour. Slight colour variations were observed ranging from light brown to dark brown. The female pupa is slightly longer than the male (Figure 4). Adult moths are nocturnal and Female moths are slightly bigger than males (Figure 6).

Characteristics in forewings can be utilized in the separation of sexes. Both males and females are having mottled brown-grey coloured forewings and dirty white-straw coloured hind wings. Fore wings of males are having more characteristic markings with white colour patches in distal ends of the wing (Figure 5) (Passoa, 1991).

**Nature of the Damage:** Damage can be seen in almost all growth stages including early vegetative up to reproductive stages. Since the larvae burrow into the leaf whorl, it is very difficult to detect early infestations. Newly hatched larvae initially feed on one side and it causes to remain the other epidermis layer intact. Later, holes in leaves and even cutting the stem also observed in young plants. Feeding the growing point of young plants leads to no cob formation. Larval feeding is characterized by large accumulations of wet fecal matter (Passoa, 1991). Based on field observations of site visits in selected areas of the Ratnapura District, plants with 2-3 leaf whorls to tasselling are the most preferable stages for the pest. If plants mature with cobs, larvae can enter into the cob directly and burrow while creating huge economic losses (Figure 7).



Figure 7. (a) (b) (c): Damaged corn plants in different stages.

#### MATERIAL AND METHODS

The survey was conducted during the period of January-March 2019 in Corn growing areas in the Ratnapura district to evaluate the abundance and severity of FAW infestation collaboration with the Provincial Department of Agriculture, Ratnapura, Sri Lanka. Audio, video and printed materials were used to improve the public awareness of the FAW damage, their life cycle and improve proper identification of *Spodoptera frugiperda*.

**Contribution of the Sabaragamuwa University of Sri Lanka in FAW control:** Close collaboration was

established with the Dean, Faculty of Agricultural Sciences, panel of Academic experts and students with the Governor and his office, Provincial Department of Agriculture, Provincial Department of health, DIG Sabaragamuwa province and many activities were implemented to combat the pest. Field, fair inspection programs, farmer awareness, pest identification and control programs, GIS mapping of infested areas and initiation of long term research are some of the activities which are already implemented by the Faculty of Agricultural Sciences (Figure 8).





Figure 8. (a) (b) (c): Some field inspection and farmer awareness activities.

**Weekly fair inspection program:** Routine fair inspection programs at Pambahinna and Balangoda areas were launched during January 2019 to March 2019 period to aware farmers, sellers and the general public on the issue. This programme was successfully completed and effective training for the general public in the area was achieved especially relating to minimizing the dispersal of the pest and breaking the completion of the pest's life cycle.

**GIS mapping:** GIS data were recorded in each point of infestation together with related other information as land extent, host plant and characteristics, cropping system etc. These data are very important in forecasting the pest occurrence in forthcoming *Yala* season.

**Establishment of research:** Throughout the series of field visits in Ratnapura district including Weligepola, Balangoda and Udawalawa areas, many aspects for productive research were identified. With the objective of continuing long term research project, samples were collected from different fields and subjected to different studies in faculty laboratories in a very protective manner. At the preliminary stage, studies relevant to biology and the behaviour of the pest was started to experiment and this study will be expanded in future towards the investigation of commercialized biocontrol tool to manage the pest sustainably.

**Government strategies towards the alleviation of the pest:** Following strategies were implemented by the Department of Agriculture with the collaboration of several other institutions to alleviate this epidemic and provide sustainable solutions to safeguard growers. These strategies were divided broadly into three categories as short term/ immediate, medium term and long term strategies.

**Short term/ immediate strategies:** As the initial immediate step towards the campaign, appointing Committees Island wide by the president and aggregating task forces comprised with officials in different institutions representing Department of Agriculture, Universities, Mahaweli Authority and some

other government and non-governmental organizations was done. Numbers of activities were implemented with the assistance of the special task force representing the whole country. Farmer awareness on prevention, suppression and eradication of the pest, importance of avoiding late planting, safe disposal of crop residues and measures avoiding the spread of the pest were the main aspects which was considered mainly during farmer training. With the involvement of the government, actions were taken to destroy abandon cultivations with residues to avoid spreading of the pest. Added to this, Preparation of guidelines to control FAW according to the 1999 no.35 Plant Protection Act, monitoring pest populations, estimation of the damage, yield and yield losses, provision of 50% subsidy for chemicals to control the pest, provision of the ceiling of Rs. 40,000/- per acre for farmers to compensate the loss were some other immediate strategies taken by the government.

**Medium term strategies:** Awareness programs were conducted for dealers of corn for animal feed and immature fresh cobs to prevent dispersal of the pest through marketing channels. Establishment of demonstration pest controlled plots to increase the awareness for the public, farmers and interested parties. Government is already planned to take assistance from other countries which are experienced the pest epidemic and from international organizations such as FAO to manage the issue.

Evaluation of possible biocontrol agents, introducing biocontrol strategies (Microbial Pesticides virus; i.e. sfNPV), testing local, natural pesticides to control the pest (at the moment 8 are testing), forecasting the damage by using pheromones and novel technologies, identify highest damage areas, the host range of the pest were initiated.

**Long term strategies:** Based on the plant protection act of the Sri Lankan government, empowering the district, village and administrative officer level pest control committees with legal authority to take actions in

control was established. Further, the investigation of locally available biocontrol agents against the pest, identifying pesticides to destroy eggs, investigation of effective, novel techniques to apply pesticides in large scale fields, possible changes in pest lifecycle and damages due to climatic differences, introduction of effective para-pheromones to attract and destroy adult insects, development of resistant varieties were the main focused long term aspects to be followed.

**Long term initiatives in progress:** Government of Sri Lanka with the collaboration of United Nations Food and Agriculture Organization (FAO) many activities were initiated with the objectives of protecting livelihoods and food security of the farming community of the FAW affected areas. Capacity improving programs for main stakeholders, the awareness, surveillance, monitoring and integrated management of the FAW was amongst. This was initiated since 18<sup>th</sup> March 2019 under the title of “Emergency response to enhance technical capacity for early warning, monitoring and management of FAW in Sri Lanka”. This FAO funded project plans to be implemented with three concepts as early warning, extension and awareness and identification of biocontrol agents. Introduction of a mobile app (FAMEWS: Fall Armyworm Monitoring and Early Warning System) is in the process and may serve as a

global platform in sustainable control of FAW in Sri Lanka.

## RESULTS AND DISCUSSION

Based on the collected data during field surveys and statistics of the Department of agriculture, Detrimental infestation was recorded in corn and then it was reported in sugarcane and some vegetable crops including tomato, cabbage and knol-kol. There is a possibility and growing concern that the pest can be devastating to other major crops including paddy in future. Based on the field surveys conducted by the Faculty of Agricultural Sciences, the Sabaragamuwa University of Sri Lanka during the months of January and February 2019 with the collaboration of Agrarian Services Centre, Weligepola, Sabaragamuwa Province, there was no any evidence reported the pest occurrence in other crops than corn. Moreover, even in mixed cropping systems with a little number of corn plants, the heavy infestation was recorded only in corn and not in paddy, banana, tomato, chillies, brinjal, okra, leafy vegetables or any other crop in visited fields (Figure 9). However, based on statistics of the Department of Agriculture, there were approximately five acres from total vegetable lands were infested and the majority was reported in Nuwara Eliya, Matale and Northern Province.

Table 1. Distribution of FAW in Ratnapura District.

Agricultural Zone	AI Division	Affected Area				Total %
		>75%	75%	50%	25%	
Embilipitiya	Kolonna	-	0.1	-	1.75	1.85
	Embilipitiya	1.75	-	-	3.05	4.8
	Thimbolketiya	1.8	-	-	2.05	3.85
	Pallebadda	-	0.1	-	1.1	1.2
	Godakawela	-	-	-	0.2	0.2
	Panamura	-	-	-	1.25	1.25
	Kahawatta	-	-	-	0.35	0.35
Balangoda	Opanayaka	0.2	-	0.2	0.4	0.8
	Ratmalawinna	0.05	-	-	1.44	1.49
	Dhamana	-	-	0.2	2.75	2.95
	Kaltota	1.5	-	-	3.5	5
	Weligepola	0.05	-	-	2.6	2.65
	Ambawila	1	-	-	3.5	4.5
Total		6.35	0.2	0.4	23.94	30.89

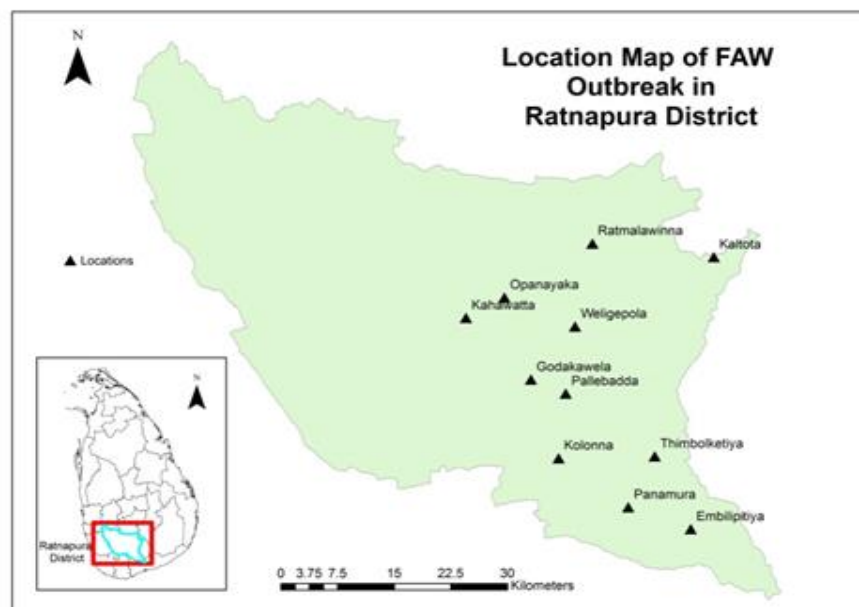


Figure 9. Location map of FAW outbreak in Ratnapura District. Majority of lands in Ratnapura District were recorded less damages (25% level of infestation in 23.9% of lands). Thimbolketiya, Embilipitiya and Kattota were the AI (Agriculture Instructor) Divisions with more than 75% level of infestation.

**Estimation of National yield loss:** Yield estimates were collected from the data available at the Ministry of Agriculture, Sri Lanka. Further island wide data was verified through The Special Committee appointed by President for fact finding and monitoring of FAW infestation Sri Lanka with comprised of Provincial Directors of Agriculture, University Academia and other

related parties. Cultivated extents of corn and infested extents by the pest were presented in detail. Based on the given data it was reported that, even with the damage, majority of farmers had a considerable yield from their cultivations (Table 2 & Figure 10), but the damage may not be considered as negligible at any capacity.

Table 2. Provincial extents of FAW infestation in corn.

Province	Total cultivated extent of corn (Ha)	Total Infested extent (Ha)	% Infested
Sabaragamuwa	292.65	32.95	11.3
Uva	42436.7	30998.3	73
North Central	18012	10504	58.3
Southern	319	13.9	4.4
North Western	1115	310.6	27.9
Eastern	14805.	12080.5	81.6
Northern	614	106.5	17.3
Western	7	2.9	41.4
Central	6661	115.45	1.7

When compared to the total cultivated land extents, the highest percentage of heavily infested lands were recorded in Uva, Eastern and North central provinces (Figure 10). These three areas first infected with FAW and people were unable to manage due to lack of proper

awareness programmes. By the time FAW reach to Sabaragamuwa, Department of Agriculture, SUSL activities and government strategies were greatly contributed to control the issue with minimum crop damage (Table 1).

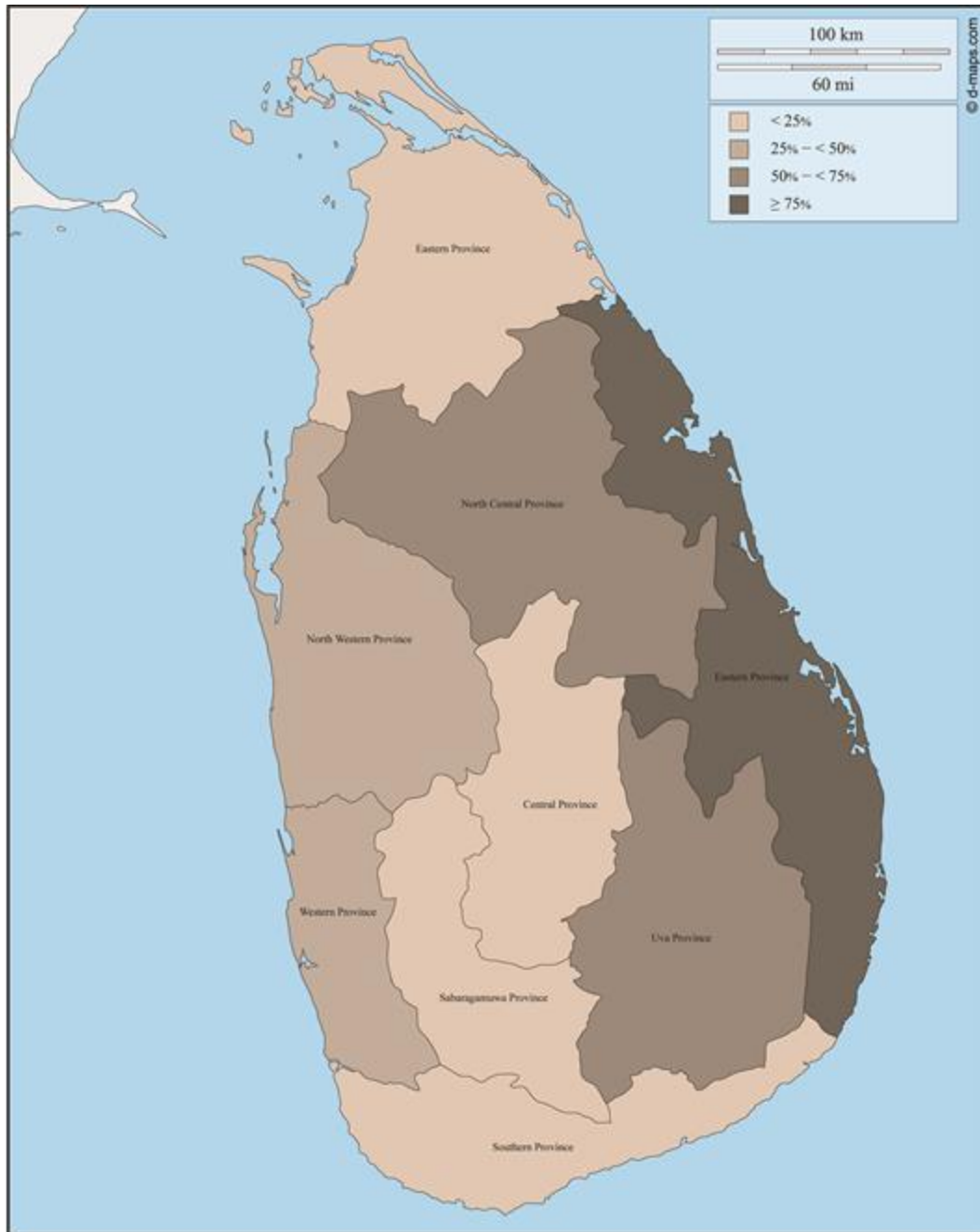


Figure 10. Provincial distribution of FAW infestation in corn in Sri Lanka during Maha season of 2018- 2019. The estimated highest yield loss was reported in Eastern province (Dark brown) and subsequent losses of different provinces indicated in a different colour intensities where highest colour intensity denotes high distribution (Dark brown) while lower intensities denote the lower distribution of FAW and low yield impact Source: Department of Agriculture, Sri Lanka, 2019.

Sri Lanka as a mainly agricultural country, the initial report of FAW infestation has become both social and political turmoil apart from economic catastrophe in the island nation. Even though few reports were coming out from neighbouring countries, the appearance of similar

conditions thereof, local authorities have not made any significant attention over these reports. The country which is surrounded by huge sea belt that assuming the inability of wind route spread of moth nevertheless has not tightened the regular quarantine activities in



harbours or airports as well.

**Sustainable Management of FAW in Sri Lanka:** The initial establishment of the infestation since 2018, farmers started the use of chemical insecticides extensively as a remedy for the control of FAW infestation. Department of Agriculture recommended a few insecticides to control the pest. Most of these contact poisoning insecticides never reach the pest because of their hiding behaviour. Therefore, chemical insecticides became as an ineffective tool. Even though the use of wood ash was effective to destroy the larvae but the practical difficulty for using them as large scale has become a leading constraint. Many botanical pesticides are under investigation in different research institutions to find out an environmentally sound solution for pest control. At present, series of programmes are arranged by the Ministry of Agriculture, Sri Lanka under the guidance of FAO instructions with the title of “Emergency response to enhance technical capacity for early warning, monitoring and management of FAW in Sri Lanka”. Continuous support from the university community is expected by the Ministry of Agriculture, together with other agriculture related institutions. According to the latest guidelines by the Department of Agriculture, Sri Lanka for the control of FAW, the following practices should have followed from the beginning of the *Yala* season 2019.

**Before the establishment of the crop in *Yala* season:** Prior to the establishment of the crop in *Yala* season 2019, consideration on planting dates and time of planting plays an important role. It is strongly recommended that completion of the crop establishment by 15<sup>th</sup> of May, 2019 with altogether is beneficial to break the pest development into an epidemic level. Further, deep ploughing and destroying inactive pupal stages from the soil, application of organic manure/fertilizer to the field to improve the vigour of plants, the establishment of pheromone traps to attract male moths and reduce mating and population build-up are recommended as immediate control strategies.

**At the time of the establishment:** At the time of field establishment, special attention should be given about the nutritional status of the soil. Care should be given to avoid the use of excessive dosages of N fertilizer (75 kg of urea/ha in basal dressing is recommended) to retard the succulent growth of plants which attracts pests easily. Further, seed treatments at the establishment

ensure healthy planting material for the cultivation. Followings are the new recommended spacing which facilitates for effective application of control strategies. A distance of 30 x 45cm within rows and in between rows was recommended respectively. One seed at a place and while keeping 120 cm distance after every 4 rows is also recommended.

**After the establishment of seeds:** Frequent field monitoring to check the occurrence of the pest is essential to ensure early detection of the pest. Especially egg masses could be observed on immature leaves. It is necessary to remove and destroy egg masses from the field to bring down the pest population. Also, the application of wood ash to the growing point at the initial stage is beneficial. If an infestation has occurred, the application of recommended insecticide is advisable, and the chemical should be changed in 7-10 intervals to prevent resistance buildup. Chemical application is beneficial during evening hours since the adult moth is active during the night. Moreover, maintenance of *Sesbania*, *Moringa* like plants in the vicinity of the field serves as good habitats for natural enemies of FAW.

**After harvesting:** Care should be given during transportation of crop residues as animal feed. Large crop residues should cut into small pieces and transportation should be practiced in a closed manner to avoid dispersal of the pest within the country.

#### CONCLUSION

Considering the pest development status in the global context, there is no country which could eradicate the pest completely. Among the major contributory factors that becoming FAW as a difficult pest to control are feeding behaviour of the larva, strong flying power of the moth, high egg laying capacity and tendency to develop resistance for insecticides. Cold temperature negatively effects on completing the life cycle of the pest and in tropical countries such as Sri Lanka provides a suitable condition to breed and proliferate faster than their temperate counterparts. Based on the field observations in the selected locations in the Ratnapura district, the following observations were found. The late planted and hybrid corn cultivars were reported to have heavy infestations. Integrated pest management (IPM) tool become important for the sustainable management of the pest. Further, the practices come under the IPM includes cultural, physical, biological, chemical and host plant resistance strategies in combination. The success of the

Sabaragamuwa province in managing FAW outbreak during 2018/19 *Maha* season was mainly achieved by the implementation of combined control strategies such as knowledge dissemination programs for farmers and the general public, regular inspection and tracking of pest, application of suitable IPM practices with timely collaborative efforts.

#### CONFLICT OF INTEREST

There is no conflict of interest to disclose under this project.

#### ACKNOWLEDGEMENT

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