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INSECTICIDAL ACTIVITIES OF RAKTA KOMOL *ADENANTHERA PAVONINA* (l.) PLANT EXTRACT AGAINST PULSE BEETLE *CALLOSOBRUCHUS CHINENSIS* (L.) ADULTS

Abdul Matin[1], Omar Ali Mondal[1*], Wehedul Islam[1], Farjana Binta Omar[1] and Ataur Rahman Khan[3]
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PREVENTION OF DENGUE THROUGH SAVING SKIN FROM MOSQUITO BITE

Md. Abdul Hamid Miah[1]

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Received: 27 September 2024; Accepted: 18 October 2024

Dengue in Bangladesh has been a nagging problem for the past few years with varying intensity over months. But sustainable control is yet far away. Rigorous attempts to control dengue have been limited to clean water hyacinths in ditches and ponds, stagnant water from flower pots, coconut shells, drains, tyres, etc. which are accumulated and encourage mosquito breeding.

It is an established fact that vector-borne diseases are better controlled by killing vectors. It is not known whether any research conducted to control mosquitoes in ponds, ditches, small or big water bodies, derelict ponds and changes in population density of mosquitoes in those areas. Obviously, population density will be more in ponds and other small or big water bodies than in flower pots on roof tops, tyres etc. Even if water hyacinth is cleaned, the larvae remain quite homely there.

Chemicals that kill larvae are called larvicides. Media reports say larvicide does not work. But the scientific reasons for failure have not been unearthed. The scientific reasons for failures have been discussed in two publications (Miah 2023, Miah 2024). According to WHO protocol, mosquito larvae are released in containers having different concentrations of larvicides. The larvae are surrounded by larvicides, and obviously they will die. These larvicides, when sprayed on larvae living above the ground, will be contaminated leading to mortality. But the biology of mosquitoes is different. They breed in water and larvae and pupae live under water, only they move to the water surface for breathing.

One aspect has been overlooked all the time because of the knowledge gap. Standing water in irrigated Boro rice field, which is clear, is a safe place for breeding of mosquitoes. Large scale adoption of the technique of Alternate

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Wetting and Drying (AWD) developed by International Rice Research Institute in water management is good enough to tackle this. The Department of Agricultural Extension under the Ministry of Agriculture is quite familiar with this technique.

The larvicide sprayed on water bodies cannot reach mosquito larvae living under water. The above two publications are based on 100 years old publication of works where soybean oil thinly poured in water created a thin oily film on water surface and caused suffocation to mosquito larvae and pupae. To implement that finding, simply soak sand or soil in soybean oil and throw those at random as sand balls over the whole water body. Larvae and pupae of mosquitoes, when coming up to water surface for oxygen uptake through their spiracles located at the tip of abdomen, cannot pierce through the oily film to inhale oxygen. As a result they die of asphyxiation (suffocation). Since oily film will disrupt surface tension of water, adult mosquitoes trying to land on water surface will have their legs dipped in water and be stuck to die (Miah 2023, Miah 2024).

Since available larvicides are ineffective, there is dire necessity to look for alternative larvicides. News media publicize prevalence and apprehend cause of mosquito population. But there is hardly any research or message on killing mosquitoes and protection of skin from mosquito bites under Bangladesh environment .In the prevailing circumstances, in addition to treatment in the hospital, a concerted effort is warranted at national level, community level in urban, periurban and rural level to control mosquito as well as to save skin from mosquito bite as preventive measures. These deserve a top priority attention to put dengue at bay. Simply hospitalization is not a sustainable strategy at all to get rid of dengue in the country.

This article elaborates different mechanisms to save skin from mosquito bite, for practicing at home and at community levels in urban, peri urban and rural areas which can be coordinated at national level.

A. Mosquito Magnet R, maker of CO2 recommended 30 ideas (Mosquito Magnet**)** to eliminate mosquitoes through various ways: a) Personal protection, b) Pet protection, c) Home protection, d) Yard protection, e) Community protection. Some of these relevant to Bangladesh socio-ecosystem are mentioned here.

Personal protection: 1) Use repellents- Mosquito repellent tablets like DEET is one option. In addition, several plants grown in Bangladesh work as good repellents,

like marigold, lavender, Tulsi, Mint, etc. The age-old system, now almost forgotten, is incense (dhup) smoke. Smoke of camphor is also a good repellent when used in the houses in the evening, keeping doors shut for some time. 2) Make simple diet changes, like eating more whole grain, fruits. Vegetables will make human being less attractive to mosquitoes. 3) Use mosquito repelling clothing- Special clothing may be made available which contain permethrin. This chemical is literally built in the fabric which repels mosquitoes. 4) Wear light coloured clothing which is less noticeable to mosquitoes. This also encourages less sweating and less smell. Sweat and smell are good attractants of mosquitoes. 5) Use extra mosquito protection like long sleeved shirts, full length pants and heavy weaved fabrics. With less exposed flesh, one will experience less bites.

Pet protection: Domestic animals are also good sources of blood for sucking specifically by female mosquitoes. So protect their skin using soybean oil smeared thinly over their body at regular interval. Camphor mixed with water if kept in animal sheds will repel mosquitoes.

Home protection: 1) Keep doors and windows closed particularly in the evening and morning when mosquitoes move to take shelter at day or night and stay longer. Using incense smoke in the evening will ensure better protection. 2) Run fans: Breeze from a fan can keep mosquitoes at bay. Oscillating fans can provide extra degree of difficulty to mosquito maneuverability. 3) Keep indoor humidity low. Air cooler is perfect for this. Moreover, it removes body odour and dries them out if they stay inside for too long.

Yard protection: Yard may inadvertently be a heaven for mosquitoes. Limit the number of breeding sites and protective cover that mosquitoes rely on, such as bush, jungles, and pits. Remove any water retaining material. 1) Invest in the mosquito traps as described later in this paper. 2) Eliminate standing water in containers where mosquitoes breed. It also includes puddles and ruts (a furrow or track in the ground) in the yard. 3) Put screens over rain barrels. Mosquitoes may also breed inside that barrel if not properly covered. A screen fastened over the rain barrel will block their access while serving as a debris filter. 4) Trim all grasses in the yard. Tall grass and thick vegetation provide protective cover and shades for mosquitoes during heat and light of the day. By eliminating these mosquito-friendly plants from the yard and premises, mosquitoes will keep away from the vicinity of dwelling houses. 5) Add

mosquito repelling plants in the yard like basil, mint, and lavender. Extracts of their leaves, if sprinkled inside the house will generate a type of pleasing smell which will also repel mosquitoes. Cracks in sanitary tanks also encourage mosquito breeding and spread in the vicinity.

Community protection: Mosquito is a menace, not for any individual, but for all members of the community as well. So involving the entire community is vital to address any common problem, communicate with all community members, neighbors, local organizations, municipality, mosques, local offices etc. 1) If standing water is noticed in the community, inform the appropriate authority to eliminate stagnant water or put soybean oil to create an oily film , which will kill larvae through suffocation. 2) Plant right trees around the shallow and stagnant water bodies which will absorb water in excess quantity, such as Eucalyptus, Avocado etc. 3) Support mosquito control efforts taken by public and private sectors. The Ministry of Health and Ministry of Local Government, Rural Development and Cooperatives may publicize mosquito control strategies in different areas. This simple communication can have a huge impact on future budgetary plans for mosquito control. Television channels can play a vital role through publicizing mosquito killing and skin protection strategies.

Protect domestic animals: Domestic animals like cows, goat sheep, and dogs are good hosts of mosquitoes for blood sucking. Smear light quantities of soybean oil or extracts of repellent plants over their bodies discussed above. Camphor can also be used.

Protect wild life: Protect wildlife that eat mosquitoes like frogs, birds, spiders, predatory insects, fish in ditches, ponds and other water bodies. Spraying larvicide leads to killing of many beneficial fauna like frogs, insects and spiders. Spraying larvicides will rather encourage mosquito population build up through killing their natural enemies. Share any mosquito control technique among people so that they know and can practice those wherever possible

B. Killing mosquito eggs, larva, pupa and adults with soybean oil: Soak sand or sandy soil in Soybean oil in a container. Scoop out this wet sand by hand and throw over the stagnant water, ponds, derelict pond, ditch etc. after cleaning those from water hyacinth and other floating weeds and debris. Oils from these sand or soil

will come out to spread over the water surface and will make an oily film to restrict access of oxygen to larvae and pupae to initiate asphyxiation (suffocation).

Mosquitoes lay eggs on substratum close to the water surface. Because of the process of adsorption, the imbibants (substratum) will allow imbibe (oil+water) to move upwards upto certain height of imbibants. So eggs will be in touch with oil, and egg chorion will be dissolved leading to failure of hatching. Thus the process will kill mosquitoes at all life stages.This phenomenon is similar to killing four birds with one stone.

Spray oil on the rooftop flower pots, coconut shells etc. and other junk areas where water may be accumulated and stored for mosquito breeding. Spraying on running water will be of no use.

C. Killing adults: A lesson can be learnt from Malaria Eradication Program implemented in fifties of last century, where mosquito, the vector was targeted using DDT in houses. DDT is no longer allowed for use; instead a long persisting insecticide needs to be developed for spraying in the houses. This approach is for killing adults. Adults can also be killed by sticky traps described later.

D. Protection of skin from mosquito bites: The traditional system of using mosquito nets while sleeping is one way of protecting skin from mosquito bite.But skin is exposed to mosquitoes for the rest of day and night outside the mosquito curtain. That time is enough for mosquito bites and disease transmission. Unless people are cautious, simply treating patients in the hospital, cleaning some water hyacinth, in water bodies, standing water of flower pots and air cooler, freezer etc. will never control dengue sustainably. However, few Do It Yourself (DIY) systems are suggested here.

E. Individual cum home approach: Apart from the community approach, some personal approaches are essential at individual level at home, both in towns and villages. The approaches are application of traps and repellents.

Traps: Trap is a known word for catching birds, rats, fish and other beneficial or harmful animals. Mosquito trap may seem to be unknown to many, because people are familiar with mosquito killing with pesticide, including mosquito coils and mosquito curtain for comfortable sleeping. Few trapping techniques are mentioned here as stated by Hensley (2023), Stewart (2024a, b).

Straw water technique

Materials needed and process: Bucket, water, straw, resin, castor oil. Place one handful of straw in a bucket and put water at the ratio 1:4. Allow this organic matter or straw for 3-4 days when the materials will be fermented producing a smell of carbon dioxide. This will work as attractants. Drain out this water after about a week. Larvae will die due to lack of water. While the fermented hay is at the bottom with water, the sides of the containers also need to be used as adult traps. Smear the sides with sticky glue which can also be made at home. Put 5 parts of resin into 8 parts of boiling castor oil and stir thoroughly. The glue will be ready.

When the attractant will invite adult mosquitoes they will land on the surface of the container also and will be stuck in the glue and die. Glycerin may also be used as another sticky material. These traps made in small containers should be placed in a few locations near and outside the windows and doors of the dwelling houses. The trap will remain effective for a month. It is better to replace the materials occasionally so that eggs laid there do not have time to hatch to perpetuate breeding.

Yeast and sugar technique: Making a combination of sugar, yeast and water is an effective way to trap mosquitoes in and around houses.After a few hours, the yeast starts releasing a steady stream of carbon dioxide, which mosquitoes are highly attracted to.

Materials needed and process: Empty plastic bottle, White sugar, yeast, water, black cloth or handkerchief. Cut off the top of an empty plastic bottle, cutting right below the neck. In the bottom of the bottle, mix together a sugar and yeast solution (if using a 2 liter bottle, mix 1 cup of warm water, 4 tablespoons (tbsp) of sugar, and 1/3 teaspoon of yeast; for a smaller bottle, use the same ratio and adjust the amount accordingly. Flip the top part of the bottle over so that it's pointed downwards and forms a funnel. Place it on top of the bottom part of the bottle. Use tape or glue to hold the funnel in place, making sure that any gaps or openings around the edges are sealed. Wrap the bottle in something black (leaving the top uncovered for mosquitoes to fly in) so that both the inside and outside are dark. Refill the trap with fresh yeast and sugar every few days. Place the device outside the houses in the afternoon.

Stagnant water technique: Mosquitoes are attracted to stagnant water if used correctly. Soaps and detergents are surfactants, which reduces the surface tension

of the water. When mosquitoes try to land on the surface of the water to lay their eggs, they won't be able to stay afloat and end up drowning. This is suitable for small areas around houses.

Keep in mind that this only works for certain mosquitoes. Only female mosquitoes that have already fed on blood will actively look for stagnant water to lay their eggs in. Make sure that stagnant water around the houses is eliminated. If it is to be installed inside the houses, kill the indoor mosquitoes or drive out with smoke or other repellents to be free from bite, because they will bite first before going into a trap.

Materials needed and process: Bucket or bowl, water and dish washing soap or liquid detergent. Fill a bowl or bucket with water.Add a few drops of soap or liquid detergent and mix gently, without making it too bubbly.

Sticky trap technique: During the day time, mosquitoes rest in the dark places of houses. This sticky trap does not attract mosquitoes *per se* rather arrests movement when they sit on the device. The device is a kind of sticky material which can be made at home. Take 8 parts of castor oil and boil. Put 5 parts of resin into the boiling oil and stir to make the sticky gum **(**Miah *et al*. 1984**)**. This gum is to be smeared on both sides of suitable size of cardboard/hard board/strong paper and hung in dark solitary places in the house. Glycerin can also serve as the sticky material. Mosquitoes resting on these sticky surfaces will not be able to escape.

Repellents: Repellents can function in two different ways: a) preventing mosquitoes from entering into the houses and b) preventing mosquitoes from coming in contact with the skin. Both ways will ensure skin safety from mosquito bites.

Homemade mosquito repellents rely on (Stewart 2024c) combination of essential oils mixed with a base of vinegar, witch hazel, coconut oil or isopropyl alcohol. One or several of the top 10 mosquito-repelling essential oils for maximum effect include: Eucalyptus, lavender, cinnamon, thyme, tea tree oil, rosemary, chamomile, peppermint, cedarwood and Citronella. These essential oils are found to be a mask for the odors that female mosquitoes are attuned to when searching for a blood meal. Sweat, body odor, CO2 and sometimes even blood type can emit smells that attract these blood suckers. Three Do It Yourself (DIY) mosquito repellent recipes are mentioned here.

1. Coconut Peppermint Mosquito Repellent: Materials needed and process: Coconut oil, Peppermint, Essential oil. To make it, mix 1/3 cup coconut oil and 15 drops of peppermint essential oil in a jar. At room temperature, the substance will be a liquid, but if it is stored in the refrigerator, it will solidify. It can be applied on the body with fingers on a hot day for a refreshing way to keep mosquitoes at bay.

2. Rosemary Mosquito Repellent: Materials needed and process: Rosemary oil, Apple cider, Vinegar, Water. Combine 1/4 cup apple cider vinegar, 1/4 cup water and 40 drops of rosemary oil in a spray bottle and shake well. If rosemary is not liked, lavender may be tried.

3. Eucalyptus Mosquito Repellent: Materials needed and process: Witch hazel, Eucalyptus oil, Water. For a "foolproof recipe" that banishes mosquitoes, combine 1/3 cup witch hazel and 1/3 cup water with 40 drops of eucalyptus essential oil. Mosquitoes detest the strong aroma of eucalyptus. On its own, witch hazel doesn't really have a scent, but lemongrass, citronella, or tea tree oil will work if eucalyptus is not preferred. Once the fragrance is gone, the repellency is gone.

Abrams (2023) suggested that 7 homemade repellents some of which are mentioned here.

1. Garlic water: Garlic is also a known mosquito repellent. Try whipping up a DIY spray by adding a few cloves of fresh, minced garlic to a tablespoon of mineral oil, then allowing it to sit and infuse for a day. Strain out the garlic, and then add it to a spray bottle of water. Spraying the garlic water mixture near all outdoor light sources will create a barrier that mosquitoes will not want to cross.

2. Coffee grounds: The internet recently discovered that mosquitoes hate the smell of coffee, so people have been sprinkling it all over their gardens and patios, or even burning it in a cup to see how well it works. The caffeinated beverage actually repels multiple types of insects, making it an ideal choice for outdoor parties of any size.

3. Incense: Burning certain types of incense or candles can also help repel mosquitoes. Citronella and lemongrass are both known for their insect-repelling properties. Burn them in and around home to create a natural barrier against mosquitoes. Some plant derivatives known as incense in Bangladesh were used in dwelling houses in the past. This also works when applied in the evening.

4. Essential oils: Adding a few drops of pungent oils like thyme, lavender or peppermint to a spray bottle filled with water, then spraying it around kitchen and mosquito-ridden outdoor spaces to repel mosquitoes.

Process of making some homemade mosquito repellents (Kinney 2024) out of 17 are described here-

1. Lemon Eucalyptus Oil: Lemon eucalyptus essential oil is derived from a plant that contains citronella oil and p-mnthane 3,8-diol. The property which makes this chemical compound effective is the p-methane, which is very useful as a DIY mosquito repellent.

Materials needed and process: 2 teaspoons lemon eucalyptus oil, 3 ounces of witch hazel, Spray bottle.

Add witch hazel and lemon eucalyptus oil to the spray bottle and combine. Store this spray in a dark and dry place. Typically, this mixture lasts a few weeks. Apply the solution as needed directly onto the skin. However, do a test patch first.

2. Cinnamon Oil Recipe: Cinnamon is a powerful herb that is extracted from cinnamon bark. It has been known to be effective in repelling mosquitoes and similar insects.

Materials needed and process: 2 teaspoons cinnamon extract, 2 ounces of water, Spray bottle. Pour water in the spray bottle. Add cinnamon extract. Shake the bottle a few times until the mixture is thoroughly combined. Spray the solution onto your body before leaving the house and reapply as needed.

3. Lemongrass and Rosemary oil: Limonene and citronella are components that are found within lemongrass and are used to repel mosquitoes. Rosemary essential oil has strong properties of eucalyptol as well, making it useful repellent.

Materials Needed and process: 10 drops rosemary oil, 10 drops lemongrass oil,4 ounces jojoba oil,Spray bottle. Pour rosemary and lemongrass oil into a squeeze bottle. Add the jojoba oil and mix until all three oils are combined. Shake the bottle multiple times before applying it to the skin.

4. Tea tree oil: Tea tree oil has numerous benefits and is best known for being anti-microbial. Typically, it is used as a topical, but others use it as an antiseptic or anti-

inflammatory remedy. These properties enable it to soothe and repair itchy bumps while also preventing insects from biting.

Materials needed and process: 8 drops tea tree oil, 4 ounces coconut oil or olive oil, squeeze bottle .Combine tea tree oil and coconut oil or olive oil. Mix them until they are combined and then apply this multiple times throughout the day.

5. Lavender oil, Vanilla and Lemon insect repellent: Lavender oil, vanilla and lemon each has properties that repel mosquitoes. Limonene, eucalyptol and camphor can all be found in lavender oil and are effective at keeping bugs away. The citrus in lemon also has a high acid content, which prevents them from biting skin.

Materials needed and process: 10 drops of lavender essential oil, 3 tbsp. vanilla extract, 3 tbsp. fresh lemon juice,1 cup of water and Spray bottle. Mix lavender oil with vanilla extract in a spray bottle. Add in the freshly squeezed lemon juice before finally adding water. Shake the bottle continuously until the ingredients are combined. This can be sprayed on the skin two to three times a day.

6. Neem and Coconut oil: A small amount of neem oil is an effective mosquito repellent that can be used in multiple ways. Mixing neem oil with coconut oil will help ensure that it doesn't damage the skin and prevents further mosquito bites. Furthermore, neem oil ensures that no toxic chemical is put onto the body that may damage skin. Neem oil makes a great DIY mosquito repellent spray for the yard. These materials are easily available in Bangladesh.

Materials needed and process: 20 drops neem oil, 2 ounces of coconut oil, spray bottle. Place neem oil into a squeeze bottle. Mix it well with coconut oil before applying it to the skin.

7. Apple Cider Vinegar: Apple cider vinegar itself is not a repellent, but mixing it with essential oils can help. Combine with peppermint, lavender or cinnamon oil for a homemade insect repellent. The apple cider vinegar will raise the pH levels of skin, causing mosquitoes to fly in the other direction.

Materials needed and process: 2 ounces apple cider vinegar, 1/2 cup of water,10 drops peppermint oil and a bottle with pump. Pour apple cider vinegar into a bottle. Add water before adding peppermint oil. Once all these three are combined, shake

the solution until it's mixed. Shake it every time before using it as the oil may separate from the other ingredients. Apply it to the skin before leaving the house.

Onion cup method (Google/Facebook): This is a simple homemade repellent made of materials easily available in markets and villages.

Materials needed and process: Onion, Naphthalene, mustard oil, leaves of neem and mint, tissue paper. Take a big onion. Cut the top and bottom slightly to give it a shape of a cup by scooping the flesh from one side. Put ground naphthalene in the cup and pour mustard oil in the cup. Then take a piece of tissue paper and put neem and mint leaves on it and make a roll, put two ends of the roll in such a manner that the two tips will form a wick. Insert this roll in the onion cup with the wick on top. Drench the tissue paper roll thoroughly with mustard oil. Set fire on the wick. The combined smell of neem, naphthalene, mint and mustard oil will drive out mosquitoes. Keep it burned for a few minutes every day in the evening. After fire is put off, the smoke generated will further work for some time as repellent.

CONCLUSION

In view of failure to control dengue, it is now the time to think of an integrated approach to control dengue, not just providing medical services in hospitals. There are four components of integrated approach: a) Treatment of patients in hospitals after infection, b) Killing of mosquitoes at their different life stages, c) Saving skin from mosquito bites since one mosquito is enough for transmission d) Prevent breeding in stagnant water in irrigated Boro rice field. Therefore, it is necessary to launch a nation-wide "Dengue Eradication Program" for which a strategic plan needs to be formulated. Few technical committees to handle above a,b,c and d components of integration will need to be formed with relevant experienced scientists. The functions indicated as "a" will be handled by Hospitals and the Ministry of Health. Components "b" will be operated by City Corporations "c" will be handled by the Ministry of Local Government Rural Development & Cooperatives, "d" will be coordinated by Department of Agricultural Extension under Ministry of Agriculture.

City Corporation will administer soybean oil over all areas having stagnant water. Participation of local people will have to be ensured. There will be some selected people to administer crude soybean oil. Refined and consumable oil may

be pilferage which can be stopped by putting a few drops of kerosene oil in soybean oil before delivery to the end point. They will be supplied with crude soybean oil, sand, pieces of cloth or unusable tissue paper or newspaper. Sand will have to be soaked in soybean oil. Then scoop out sand with hand which has to be thrown at random at different places of water bodies. Sand may also be wrapped with tissue paper for throwing to a long distance .The selected people may be paid some service charge as honorarium and City Corporation will monitor the performance. For rural areas, Union Parishad can be assigned with the tasks of soybean oil application and training on homemade mosquito traps and repellents. Upazila Health workers may be assigned for monitoring the efforts.

Electronic and print media will need to publicize the techniques regularly as part of Dengue Eradication Program. Additionally plenty of leaflets containing the process of making traps and repellents at home will be distributed by Sub-Assistant Agriculture Officers (SAAO) of Department Agricultural Extension who are working in village level.

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SURVEY AND ASSESSMENT OF POLLINATION SERVICE OF HONEY BEE FOR IMPROVEMENT OF MUSTARD PRODUCTION IN HAKALUKI HAOR: WETLAND ECOSYSTEM, AN ECOLOGICALLY CRITICAL AREA OF BANGLADESH

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ABSTRACT

Hakaluki haor is the largest haor (wetland ecosystem, north eastern part of Bangladesh) consisting of fresh water swamp forest which has been declared as Ecologically Critical Area (ECA) of Bangladesh. Mustard is one of the most promising short duration crops in this ecosystem to escape from the pre-monsoon flood. However, mustard yield was decreasing day by day due to the reduction of natural honey bee population. To develop a baseline information regarding the potentiality of apiculture practices, a survey of the local farmers and an experiment was conducted to assess the pollination services of honey bee in mustard field. It was found that about 62% of the farmers had positive perception about honey bee and 72% of the farmers were interested in apiculture. Around 73.3% of the farmers noticed the reduction of native honey bee population and 50% of the farmers considered reduction of natural honey bee being responsible for lower yield of mustard. About 77.3% of the farmers used different groups of pesticides viz. organophosphorous, pyrethroid, carbamate, triazoles, dicarboximide, and neonicotinoid in their mustard fields to manage different pests and diseases. In field experiment, open pollination with artificial beehive significantly increased the number of silique per plant, seed per silique, weight of 1000 seeds and yield per plant. This study highlighted the scope of increasing pollination services through adopting intensive apiculture practices in the surveyed area for the sustainable livelihood.

Keywords: Pollination service, Mustard, Farmers' Perception, Pesticides, Protected wetland, honey bee conservation

INTRODUCTION

Wetlands of Bangladesh encompass haors, baors (a dead section of a river created when the river changed course), beels (a lake-like wetland with static water), ponds, flooded rice lands and floodplains, natural lakes, man-made reservoirs, and coastal

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and marine areas. The total area of wetlands in Bangladesh is about 7–8 million ha, which constitutes about 50% of the land surface of the country (Islam *et al.* 2018, Haroon and Kibria 2017, Khan *et al.* 1994). Haor is a bowl-shaped large tectonic depression that is flooded every year during monsoon. Hakaluki haor is the largest natural inland freshwater wetland ecosystem located in Sylhet and Moulvibazar districts of Bangladesh as well as one of Asia's larger marsh wetland ecosystem (Ahmed *et al.* 2008). This haor also contains fresh water swamp forest. According to the Bangladesh Environment Conservation Act 1995 (BECA), it was announced as an "Ecologically Critical Area" (ECA) in 1999 by the Government of Bangladesh to conserve from extensive exploitation and deforestation (CNRS 2002). More than 190,000 people live around the haor and all of them are more or less dependent on the resources of the haor for their livelihoods (IUCN 2006, Islam *et al.* 2011). Most of the people depend on agricultural crop production for their livelihood. The farmers of Hakaluki haor area cultivate different crops only from November to April (Rabi season) (Kamruzzaman and Shaw 2018, Baishakhy *et al.* 2020, Mohsenipour *et al.* 2018). This haor is flooded with pre-monsoon rain till mid-May which causes serious damage to Rabi crops (Suman and Bhattacharaya 2015). To overcome this critical problem, mustard is cultivated at Hakaluki haor areas as a suitable short-duration crop during the Rabi season (Helal *et al*. 2016).

Mustard production is very crucial for the livelihood of the farmers of Hakaluki haor area. It is a cross pollinated crop. The contribution of pollinators during crop production is termed as pollination service. Pollination service is an unavoidable natural phenomenon in mustard crop. Several researchers have conducted researches on pollination service contributing to the yield of mustard in different countries of the world (Mandal *et al.* 2018, Atmowidi *et al.* 2007, Patidar *et al.* 2017, Devkota *et al.* 2021). Assessment of insect-mediated pollination service is essential to ensure sustainable use of biodiversity resources as they highlight the different aspects of land uses (Pascual *et al.* 2017). The annual worth of global pollination services was assessed as high as USD 600 billion (IPBES 2016). However, limited number of researches were conducted to evaluate the pollination service in local area and in locations with insufficient or low-quality data (Pandeya *et al.* 2016).

Approximately 78% of the flowering plants directly or indirectly depend on pollinators for their reproduction and survival (Klein *et al.* 2007, James *et al.*

2008, Ollerton *et al.* 2011) and it is directly related to the food security of human populations. Pollinators, mostly honey bees, contribute to 35% of the world's food production (FAO 2015). Due to their economic and ecological importance in agriculture sector, a variety of methods have been used to evaluate the pollination services of pollinators (Gallai and Vaissiere 2009, Breeze *et al.* 2016, Klein *et al.* 2007, 2018, Lautenbach *et al.* 2012, Losey and Vaughan 2006, Breeze *et al.* 2011, Calderone 2012, Giannini *et al.* 2015). Along with pollination service, honey bees provide different products like honey, royal jelly, beeswax, pollen and venom (Rabie *et al.* 2018, Kolayli and Keskin 2020). Apiculture practice can be a source of income for the economically vulnerable people of Hakaluki haor area (Ibrahim *et al.* 2021). In the fiscal year of 2018-19, Bangladesh produced around 1805.68 MT honey and earned foreign currency by exporting honey to different countries of the world (BSCIC 2019).

According to the farmers' of Hakaluki haor area, the yield of the mustard is reducing day by day due to a decline in honey bee population. Reduction in mustard yield often occurs due to inadequate pollination from lower abundance of pollinators, especially honey bees (Abrol 2007). To assess the congeniality of apiculture, local farmers' perception and scientific evidence are prerequisite. Therefore, it was aimed to evaluate the farmers' perception regarding the pollinators and pollination service and to assess pollination service at the mustard field in Hakaluki haor area.

MATERIALS AND METHODS

Two consecutive experiments were conducted in Hakaluki haor area of Bangladesh. In the first experiment a survey was conducted on farmers' perception about the pollinators and pollination services and in the second experiment, pollination service was assessed in the field of Hakaluki haor.

Experiment 1: Farmers' perception about pollinators and pollination services in the Hakaluki haor areas

Study Site: The study area lies between 24° 35′ N and 24° 44′ N latitude and between 92°00' E and 92°08′E longitude (Choudhury and Nishat 2005). It includes three upazilas (Sub district) (*viz.,* Baralekha, Juri, Kulaura) of Moulvibazar district and two upazilas (*viz.,* Golapganj and Fenchuganj) of Sylhet district in the North-Eastern part of Bangladesh (Fig. 1).

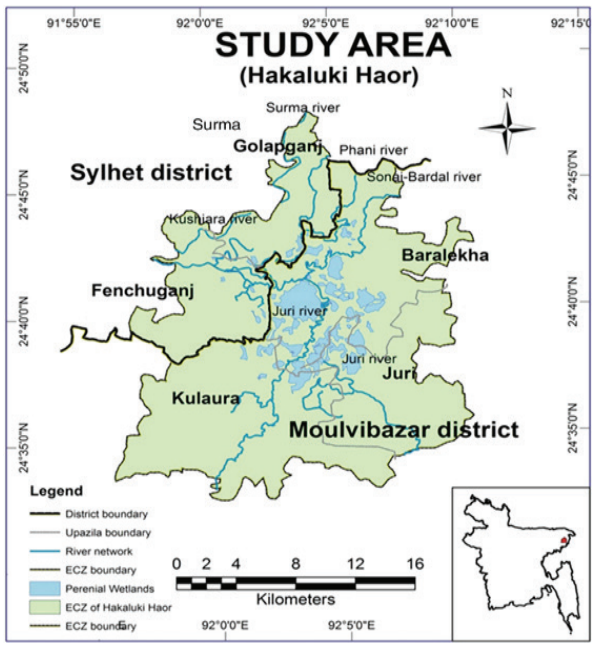


Fig. 1. The study area of Hakaluki haor in Bangladesh (Islam *et al.* 2018)

Questionnaire preparation and Survey: Conducted a comprehensive survey among the farmers of Hakaluki haor area of Bangladesh during November 2019 to February 2020 using a semi-structured and standardized questionnaire. The questionnaire was designed based on pre-survey and previous literature (Chanthayod *et al.* 2017, Bhattacharyya *et al.* 2017). The questionnaire consisted of 25 open and closed-ended questions. The questionnaire was divided into three parts. The first part of the questionnaire focused on collecting socio-economic characteristics about the farmers. This part aimed to collect information on various factors related to farmers' age, education, family size, land area, land ownership, participation in training programs etc. The second part included questions related to the farmers knowledge on apiculture, source of knowledge, interest of apiculture, ability to differentiate different honey bee species, their thinking about apiculture (i.e., beneficial, harmful, or neutral) and so on. The third part of the questionnaire was designed to collect information about management practiced by the mustard farmers.

To ensure the validity, clarity, relevance, and internal consistency of the questionnaire items, the questionnaire was thoroughly reviewed by experts in

the fields of agriculture and pest management. Based on the suggestions of the experts, the irrelevant questions of the questionnaire or the options in the closed-ended questions were removed from the final questionnaire format. Prior to data collection, each enumerator provided a brief overview of the questionnaire and the objectives of the study. They also received training on data collection methods prior to conducting the survey.

The representative respondents (farmers) were determined according to Tuan *et al.* (2014) and Singh and Masuku (2014) as:

$$n = \frac{z^2 * p * q}{e^2}$$

Where,

- n= the sample size,
- z = 1.96 for the desired confidence level of 95%,
- p = population proportion= 11% = 0.11,
- q= 1-p
- e = desired level of precision (0.05)

Conducted face-to-face interviews with randomly chosen 150 farmers of five upazilas (30 farmers from each upazila) from Moulvibazar and Sylhet districts (Table 1). These farmers were chosen through random sampling by consulting with the local officials of Department of Agriculture Extension, Ministry of Agriculture, Bangladesh to eliminate the negative effect of bias on the quality of the collected data (Jabed *et al.* 2020).

Table 1. Distribution of farmers in surveyed areas

Name of District	Name of Upazila	Number of blocks per upazila	Number of growers per block	Number of total growers per district
Moulvibazar	Baralekha	3	10	30
	Juri	3	10	30
	Kulaura	3	10	30
Sylhet	Fenchuganj	3	10	30
	Golapganj	3	10	30

Experiment 2: Assessment of honey bee pollination service in the Hakaluki haor areas

Study site: This field experiment was conducted at Barni village of Baralekha upazila during November 2020 to March 2021. We selected two fields to measure the pollination service with a minimum distance between these fields according to Garibaldi *et al.* (2011) and Hülsmann *et al.* (2015). The soil and weather parameter were more or less similar of these two fields as these fields belonged to the same Agro-Ecological Zone (Eastern Shurma Kushiyara Floodplain) and same haor area (BAMIS 2021).

Land preparation, Seed sowing and Intercultural operations: The experimental plot was prepared properly to obtain a good tilt. Mustard seeds (Tori-7) were sown in broadcasting method with a seed rate of 8 kg ha^{-1} (Biswas 2017). Intercultural operations *viz.* weeding, thinning, irrigation was done and nutrient elements through Urea, TSP, MoP, Gypsum, Magnesium sulphate, Zinc sulphate and borax were applied at the proper time as per recommended dose (Ahmmed *et al.* 2018, Chowdhury and Hassan 2013).

Experimental Design: This research was conducted by following Randomized Complete Block Design (RCBD). Study was set up in experimental plots in two different locations with two treatments, open pollination (OP) as control and open pollination with beehive (OPB) as the experimental treatment. In OPB, a wooden bee box with nine frames was set up to supply the additional honey bee to the mustard field. Honey bees of *Apis mellifera* species were used in the artificial wooden beehive. Each treatment was replicated five times in randomly selected plots with an area of 9m² (3m x 3m). In OP, only natural pollinators were allowed to pollinate the mustard flowers. On the other hand, both the natural pollinators and artificially provided honey bees were allowed to pollinate the mustard flowers in OPB as suggested by Hudewenz *et al.* (2014) and Hossain *et al.* (2018).

Harvesting: Mustard plants were harvested manually at maturity (after 90 days of seed sowing) from each plot. The harvested mustard plants were bundled and tagged properly. The tagged bundles of mustard plants were sun dried for proper drying. Threshing and cleaning were done separately with proper care. Then the mustard seeds were weighted and packed for storing.

Data collection: Yield contributing parameters of mustard such as number of siliques per plant, length of silique, number of seed per silique, weight of 1000 seeds and yield per plant were recorded. The number of siliques was counted at mature stage of the mustard crop before harvesting. All other parameters were recorded after harvesting the crop. Representative six plants from each replication were selected to record the silique length, seed number per silique, 1000 seed weight and yield per plant.

Data analysis: Survey data were analyzed by IBM® SPSS 26 software. Statistical differences in farmers' socio-economic characteristics (e.g., age, education, land ownership, total land area, participation in training programs, etc.) among surveyed areas were estimated using the Chi-square test. The Chi-square test was also used to assess the relationships of farmers' knowledge of apiculture with their socio-economic characteristics, such as their age, educational status, land area, and participation in training programs. Relationships of farmers' interest of apiculture with their knowledge of apiculture and participation in training programs was also analyzed using the chi-square test. On the other hand, field experiment data were used to perform independent t-test to analyze the significance of OP and OPB by using the same statistical software. Each time the level of significance was set at 0.05.

RESULTS

Farmers' perception on pollinators and pollination services at Hakaluki haor: The survey represented the socio-economic conditions of the farmers from Hakaluki haor areas of Bangladesh, which is situated in Baralekha, Juri, Kulaura, Golapganj and Fenchuganj upazila of Moulvibazar and Sylhet district, respectively. Farmers' ages and education level across the survey areas did not show any significant difference (Table 2). The result showed that the respondent's age ranged from 20 years to 75 years where 33.3% of the farmers were from 46 to 60 years. Among the respondents, 28.6% of farmers did not receive any formal education and 9.3% of farmers were unable to write their own names. Result showed that family size varied significantly across the survey areas. More than half (57.3%) of the farmers had medium family with 6-9 members followed by 26.7% and 16% of the farmers had small (up to five members) and large family (10 and above members), respectively.

It was revealed that the land ownership and land areas for mustard cultivation by the farmers of Hakaluki Haor has significant variation among the survey areas. Around 59.3% of the farmers had their own lands for crop cultivation. However, 44.8% were tenant farmers and 12.9% of the farmers took lease of land for crop cultivation. On an average 47% farmers cultivated mustard in less than 1 acre of land followed by 15.3% and 10.7% of the farmers cultivated mustard in 1.01 to 2 and more than 2 acres of land respectively. It was also found that only 10.7% of the farmers of Hakaluki haor area received training on apiculture (Table 2).

Table 2. Socio demography of the farmers of Hakaluki haor area of Bangladesh on 2019-20

Variables	Survey areas (% of farmers)						Chi-square test	
	Fenchuganj	Golapganj	Kulaura	Juri	Borolekha	Total	DF	X^2 value
Age								
Up to 35	23.3	23.3	43.3	23.3	30.0	28.7	12	8.9ns
36-45	30.0	23.3	26.7	33.3	20.0	26.7		
46-60	33.3	43.3	26.7	26.7	36.7	33.3		
Above 60	13.3	10.0	3.3	16.7	13.3	11.3		
Education								
Illiterate	6.7	10.0	6.7	10.0	13.3	9.3	16	18.7ns
Only Signature	23.3	20.0	13.3	20.0	20.0	19.3		
[1]PSC	23.3	46.7	30.0	26.7	53.3	36.0		
[2]JSC	20.0	16.7	26.7	26.7	10.0	20.0		
[3]SSC and above	26.7	6.7	23.3	16.7	3.3	15.4		
Family size								
Small (up to 5)	33.3	40.0	16.7	36.7	6.7	26.7	8	23.2*
Medium (6-9)	63.3	53.3	66.7	46.7	56.7	57.3		
Large (10 and above)	3.3	6.7	16.7	16.7	36.7	16.0		
Land ownership								
Own	56.7	53.3	76.7	80.0	30.0	59.3	12	50.7***
Lease	20.0	10.0	20.0	3.3	36.7	18.0		
Tenant (Borga)	63.3	73.3	40.0	50.0	86.7	62.7		

Land area								
Less than 0.5 acre	50.0	46.7	83.3	46.7	10.0	47.3	12	67.8***
0.51-1.00 acre	30.0	43.3	10.0	36.7	13.3	26.7		
1.01-2.00 acre	10.0	3.3	3.3	16.7	43.3	15.3		
More than 2.00 acre	10.0	6.7	3.3	0.0	33.3	10.7		
Participation in training								
Yes	20.0	16.7	0.0	6.7	10.0	10.7	4	7.9ns
No	80.0	83.3	100.0	93.3	90.0	89.3		

Note: 1= Primary School Certificate; 2 = Junior School Certificate; 3 = Secondary School Certificate; Statistically significant at *p < 0.05, **p < 0.01, ***p < 0.001, ns = not significant, DF = Degree of freedom, X2 = Chi-square co-efficient

Farmers usually cultivated oil seed crops *viz.,* mustard, sesame, sunflower, niger, flax, soybean, and groundnut; cereal crops *viz.,* rice, wheat, maize; vegetables *viz.,* pumpkin, cucumber, bottle gourd, bitter gourd, tomato, red amaranth, French bean, brinjal, potato, country bean, carrot, radish; and spices *viz.,* coriander, chili, onion; in their fields (Table 3).

Table 3. Crops cultivated by the farmers of Hakaluki haor area of Bangladesh on 2019-20

Name of the crops			
Oil crops	Cereal crops	Vegetables	Spices
Mustard (*Brassica* sp.) (Varieties: Tori-7, BARI Mustard-14, BARI Mustard-17)	Rice (*Oryza sativa*)	Pumpkin (*Cucurbita maxima*)	
Sesame (*Sesamum indicum*)	Wheat (*Triticum aestivum*)	Cucumber (*Cucumis sativus*)	
Sunflower (*Helianthus annuus*)	Maize (*Zea mays*)	Bottle gourd (*Lagenaria siceraria*)	
Niger (*Guizotia abyssinica*)		Bitter gourd (*Momordica charantia*)	
Flax (*Linum usitatissimum*)		Tomato (*Solanum lycopersicum*)	
Soybean (*Glycine max*)		Red amaranth (*Amaranthus cruentus*)	
Ground nut (*Arachis hypogaea*)		French bean (*Phaseolus vulgaris*)	
		Brinjal (*Solanum melongena*)	
		Potato (*Solanum tuberosum*)	
		Country bean (*Lablab purpureus*)	
		Carrot (*Daucus carota* subsp. *sativus*)	
		Radish (*Raphanus sativus*)	

About 77.3% of the farmers had knowledge about apiculture in mustard field and the main sources of this knowledge were local farmers (73.3%) and government organizations (22.4%) (Table 4). A large number of farmers (72%) were interested in apiculture. Most of the farmers (87.3%) were able to identify honey bee in their fields. Among the farmers, 62% considered honey bee as beneficial insect. However, 15.3% considered as harmful insect and rest of the farmers (22.7%) had no idea about the interaction of honey bee. Majority of the respondents (86.7%) agreed to allow bee hives in their mustard fields. Main causes were benevolence (41.5%) and from the belief that their crop production would be increased (38.5%) as well as 9.2% of the farmers believed that honey bee could reduce the abundance of harmful pests like aphid in the mustard field (Table 4).

Table 4. Farmers' perception on apiculture at mustard field in Hakaluki haor area of Bangladesh on 2019-20

Particulates	Responses	Frequency	Percentage (%)
Knowledge about apiculture	Yes	116	77.3
	No	34	22.7
Sources of knowledge on apiculture (N=116)	TV & Radio	3	2.6
	Local farmers	85	73.3
	Govt. organization	26	22.4
	Others	2	1.7
Interested in apiculture	Yes	108	72.0
	No	42	28.0
Identify honey bee	Yes	131	87.3
	No	19	12.7
Consider honey bee as	Beneficial insect	93	62.0
	Harmful insect	23	15.3
	No idea	34	22.7
Allowing apiculture near mustard field	Yes	130	86.7
	No	20	13.3
Causes of allowing apiculture (N=130)	Social welfare	54	41.5
	To increase crop production	50	38.5
	To get free honey	11	8.5
	To learn apiculture	3	2.3
	To reduce pest	12	9.2

Farmers' age and education level did not influence their knowledge of apiculture; however, their knowledge of apiculture was significantly influenced by the total land area they owned and their participation in training programs. On the other hand, both farmers' knowledge of apiculture and participation in training programs were significantly associated with their interest in apiculture (Table 5).

Table 5. Relationship between farmers' knowledge and interest of apiculture with their socio-economic characteristics

Characteristics	knowledge of apiculture	
	DF	X^2 value
Age	3	1.05ns
Education	4	2.1ns
Land area	3	11.4*
Participation in training	1	5.3*
	Interest of apiculture	
	DF	X^2 value
Knowledge of apiculture	1	29.4***
Participation in training	1	6.9**

Note: Statistically significant at *p < 0.05, **p < 0.01, ***p < 0.001, ns = not significant, DF = Degree of freedom, X2 = Chi-square co-efficient

About 77.3% of the farmers used pesticides in their mustard field (Fig. 2a). Moreover, around 38% of the farmers applied pesticides for two times in their mustard fields (Fig. 2b). The farmers of Hakaluki haor usually applied pesticides at noon to their crops (Fig. 2c). Farmers used pesticides from different groups like Organophosphorous, Synthetic Pyrethroid, Carbamate, Triazoles, Dicarboximide, Neonicotinoid and as a mixer of two groups like Organophosphorous + Synthetic Pyrethroid, Carbamate + Acylalanine, Neonicotinoid + Organochlorinated (Table 6).

It was found that 73.3% of the farmers noticed the decreasing population of honey bee in Hakaluki haor area while 20% of the farmers did not notice the population reduction of honey bee (Fig. 3a). Half of the farmers (50%) believed that crop yield was reducing due to less honey bee population and 23.3% of the farmers had no idea whether the honey bee population affects the crop yield or not (Fig. 3b).

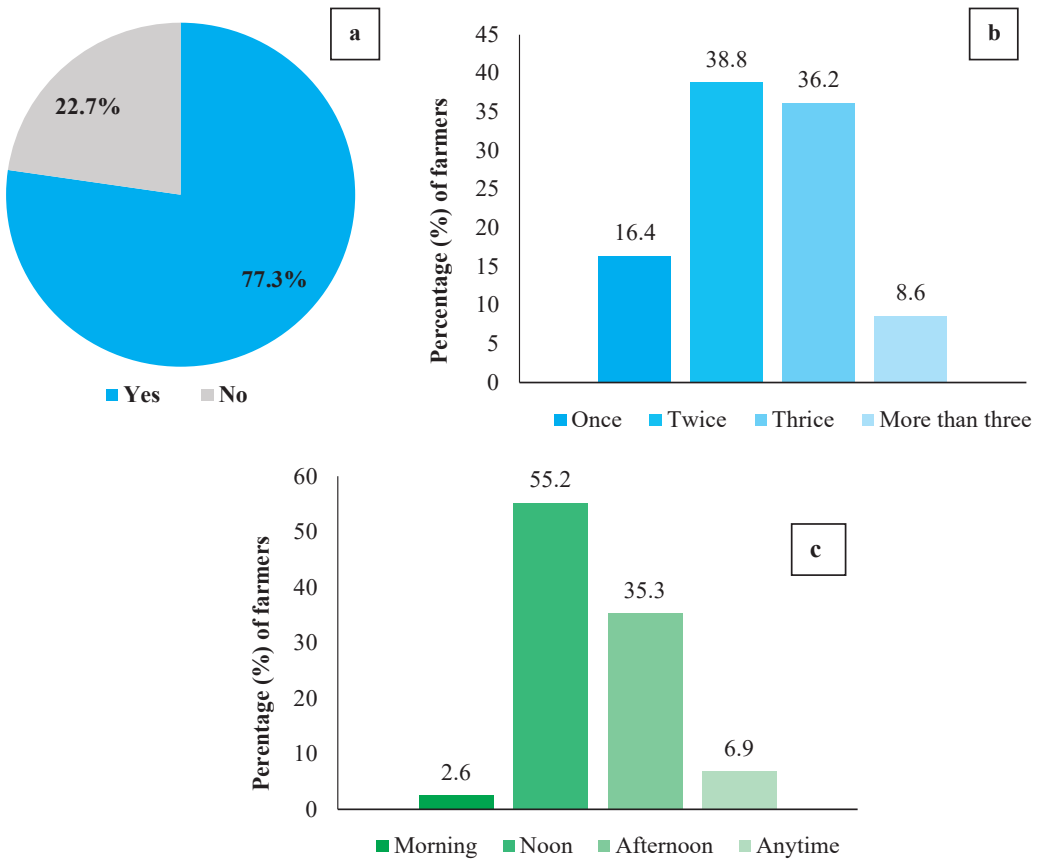


Fig. 2a. Percentage of farmers applying pesticides b) Frequency of pesticide application per season by the farmers (N=116) c) Time of applying pesticides by the farmers (N=116) on their mustard field in Hakaluki haor area of Bangladesh on 2019-20

Table 6. Pesticides applied by the mustard farmers of Hakaluki haor area of Bangladesh on 2019-20

Pesticide group	Common name of Pesticide	Pesticide types	WHO Class (GHS)
Carbamate	Carbosulfan	Insecticide	II (3)
	Cartap	Insecticide	II (4)
	Mancozeb	Fungicide	U (5)
Avermectin	Emamectin Benzoate	Insecticide	II (3)
Carbamate + Acylalanine	Mancozeb (64%) + Metalaxyl (8%)	Fungicide	U (5), II (4)
Dicarboximide	Iprodione (50%)	Fungicide	III (5)
Neonicotinoid	Imidacloprid	Insecticide	II (4)
	Thiamethoxam (25%)	Insecticide	II (4)
Neonicotinoid + Organochlorinated	Thiamethoxam(20%)+ Chlorantraniliprole (20%)	Insecticide	II (4), U (5)
Organophosphorous	Dimethoate	Insecticide	II (3)
	Fenitrothion	Insecticide	II (4)
	Malathion	Insecticide	III (5)
	Acephate	Insecticide	II (4)
Organophosphorous + Synthetic Pyrethroid	Chlorpyrifos (50%) + Cypermethrin (5%)	Insecticide	II (3), II (3)
	Profenofos (40%) + Cypermethrin (2.5%)	Insecticide	II (4), II (3)
	Chlorpyrifos (50%) + Cypermethrin (5%)	Insecticide	II (3), II (3)
	Profenofos (40%) + Cypermthrin (2.5%)	Insecticide	II (4), II (3)
Synthetic Pyrethroid	Cypermethrin	Insecticide	II (3)
	Lambda Cyhalothrin	Insecticide	II (3)
	Lambda Cyhalothrin	Insecticide	II (3)
	Cypermethrin	Insecticide	II (3)
	Cypermethrin	Insecticide	II (3)
Triazoles	Difenoconazole (25%)	Insecticide	II (4)

Note: WHO = World Health Organization, GHS = Globally Harmonized System of Classification and Labelling of Chemicals, II = Moderately Hazardous, III = Slightly Hazardous, U = Unlikely to present acute hazard

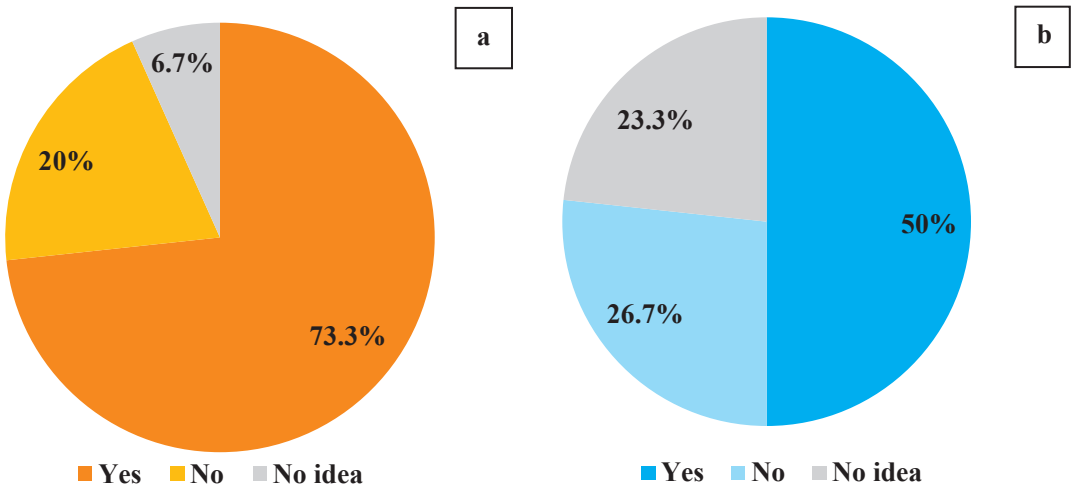


Fig. 3a. Percentage (%) of farmer noticed declining honey bee population b) Farmers' perception percentage (%) on reduced honey bee population responsible for low yield in Hakaluki haor area of Bangladesh on 2019-20

Evaluation of pollination service at Hakaluki hoar area of Bangladesh: The pollination treatments were found to be responsible for the variation in yield contributing parameters. Compared to the open pollination (OP), open pollination with beehive (OPB) had statistically significant contribution to the number of siliques per plant ($p<0.01$), number of seed per silique ($p<0.05$), however, the length of siliqua did not show any significant differences among the treatments (Fig. 4a, 4b, 4c). In open pollination, the number of siliques per plant, length of silique, number of seed per silique were 50.17±1.76, 3.87±0.2 cm, and 15.55±0.51 while in open pollination with beehive, those were 90.47±4.26, 3.83±0.23 cm, and 17.03±0.18, respectively. Eventually, weight of 1000 seeds ($p<0.01$) and yield per plant ($p<0.01$) also showed the significant difference among the treatments (Fig. 4d, 4e). In open pollination, the weight of 1000 seeds and yield per plant were 1.89±0.03 g and 1.47±0.07 g whereas in open pollination with beehive, it was 2.35±0.08 g and 3.6±0.12 g, respectively.

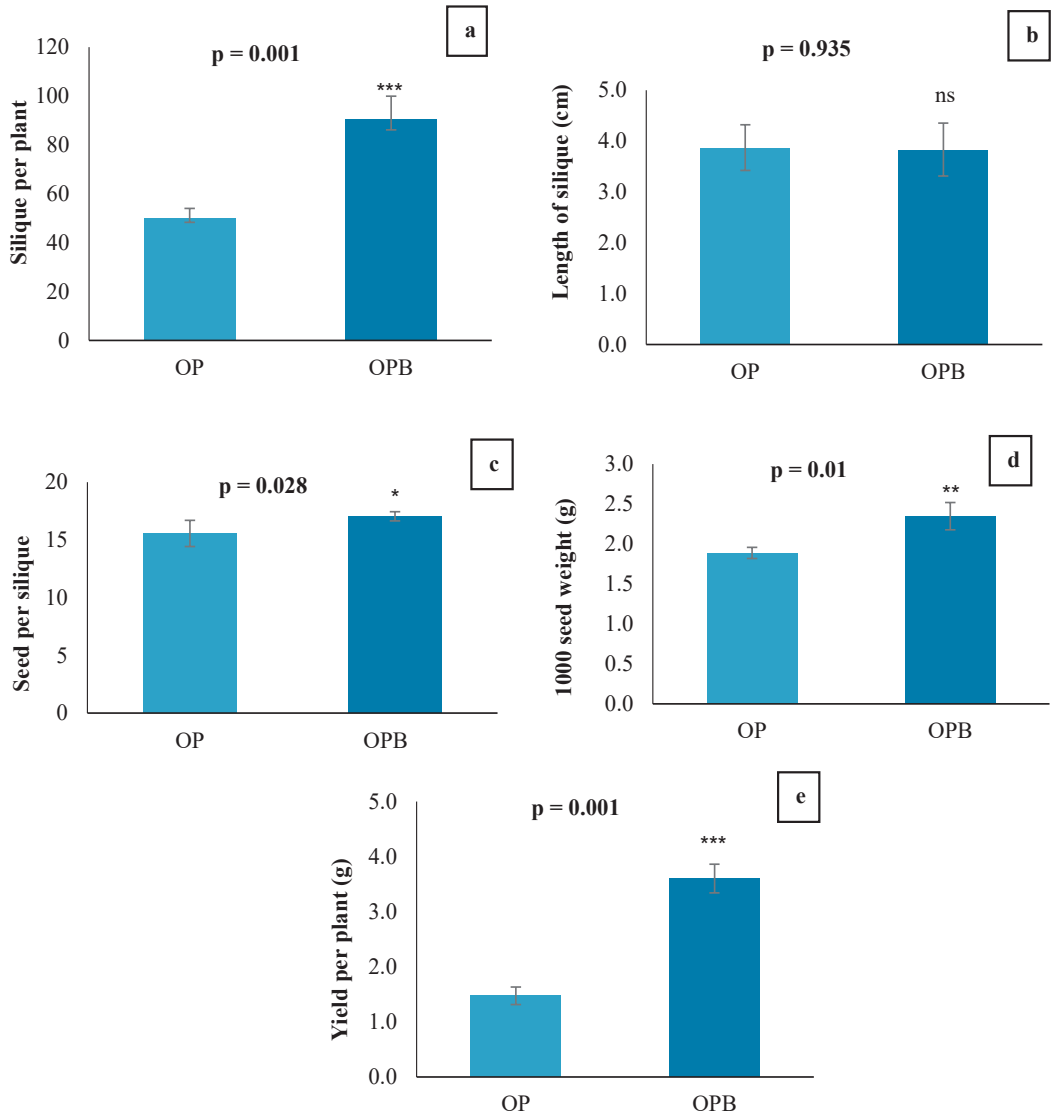


Fig. 4a. Mean number of silique per mustard plant b) Mean length (cm) of silique c) Mean number of seed per silique d) Mean of 1000 seed weight (g) of mustard e) Mean yield (g) of mustard per plant in different pollination treatments in Hakaluki haor area of Bangladesh on 2020-21.

OP= Open Pollination; OPB= Open Pollination with Beehive, ns = non-significant; * = significant at 5% level of significance; ** = significant at 1% level of significance; *** = significant at 0.1% level of significance.

DISCUSSION

Apiculture is a promising practice in mustard field. Day by day the farmers are being cognizant of apiculture in mustard field. Majority of the farmers of Hakaluki haor area were found to have knowledge about apiculture. In haor area, their main source of knowledge were local farmers and government organizations. Ayansola (2012) reported that, 65.3% of the respondents gained knowledge from their friends and acquaintances as well as some respondents gained knowledge on apiculture by attending seminars or workshops in southwestern Nigeria. Kasina *et al.* (2009) documented in Kenya that the regions where honey bees exist naturally in the surrounding areas, the farmers are well known to honey bees. As most of them have knowledge about apiculture, more than half of the farmers considered honey bee as beneficial insect. However, some considered honey bee as harmful insect. Moniruzzaman and Rahman (2009) also found similar kind of perception among the farmers in Bangladesh. From this belief, sometimes farmers did not allow the beekeepers to set up their hives in mustard field. As the farmers of this haor area had an overall positive perception about honey bee, they agreed to allow bee hive in their mustard field. In haor area, one third of the farmers were found to be conscious about pollination service in the mustard field. Ali *et al.* (2020) found that 64% the respondents were not sure about the pollination service in crop field of Punjab, Pakistan. Small portion of the farmers in haor area believed honey bee could reduce aphid. Morandin *et al.* (2016) reported that field edge habitat was able to increase the population of native honey bee along with natural enemies (beneficial insects) and this reduced the aphid population. Despite being very interested, only a limited number of farmers received training on apiculture due to the scarcity of training facilities. According to the annual report of Bangladesh Small and Cottage Industries Corporation (BSCIC 2019), only 270 members received training on apiculture during the fiscal year 2018-19. This number is too low to meet the national demand of Bangladesh. Moniruzzaman and Rahman (2009) reported that training facilities should be increased.

Insects and diseases cause damage to the mustard (Udin *et al.* 2019, Gupta *et al.* 2020). To manage these insects and diseases, the farmers injudiciously applied a large number of pesticides in their mustard fields. Biswas (2013) and Mandal (2020) reported that malathion, chlorpyriphos, cypermethrin were used to manage the pests

of mustard crop. When they face any problem in their fields, they prefer to go to the pesticide dealers and apply pesticides in their field without any consultation with experts or government officials. Sometimes they are deceived by the pesticides dealers and apply pesticides of one crop to another crop irrationally. Rashid *et al.* (2003) and Yadav (2020) found that many farmers of Bangladesh and India use pesticides irrationally in their crop fields. It was found that farmers usually apply pesticides to manage aphid in mustard field. When the infestation is low, they apply only once. In case of higher infestation, they increased the use of pesticides. They usually preferred noon for pesticide application as they used to do other works in the morning and spent leisure period in the evening as well as they could take a bath after the pesticide application.

According to the farmers' perception, honey bee population was declining day by day. Land cover change or deforestation in the haor area (Ferreira *et al.* 2020, Dar *et al.* 2021) and the increasing use of pesticides in mustard field (Stanley *et al.* 2015, Challa *et al.* 2019) could be responsible for negatively affecting the honey bee population. Half of the farmers believed that the lower abundance of honey bee was responsible for low yield of mustard in hoar area. Researchers also showed that honey bee plays an important role in yield enhancement of mustard (Devkota *et al.* 2021, Hossain *et al.* 2020).

In the field experiment, mustard yield was significantly higher in open pollination with beehive. This indicates that more pollination is positively related to mustard yield. Adequate pollination could be the cause of increased number of siliques per plant as well as it also increased the number of seed per silique (Shakeel and Inayatullah 2013, Tara and Sharma 2010). Sufficient pollination might be the reason of higher average weight of seed (Stanley *et al.* 2013, Bommarco *et al.* 2012, Hudewenz *et al.* 2014). Plants with incompletely pollinated flowers have fewer seeds and reduced fitness, and they produce inferior fruit (Kasina *et al.* 2009, Ricketts *et al.* 2004). But the average length of silique did not differ significantly. Hossain *et al.* (2020) reported that silique length was statistically same in open and netted with bee treatment. However, it was found that pollination treatments could influence the length of the silique (Ali *et al.* 2011, Sekhon *et al.* 2020). The results of this field experiment indicated the pollination crisis due to reduction of native honey bee in Hakaluki haor area which aligned with the local farmers' belief. Kremen *et*

al. (2002) described that natural honey bee reduction resulted in a decline of natural honey bee pollination service in California, USA.

CONCLUSIONS

Mustard yield is affected due to lack of pollinators in Hakaluki haor area of Bangladesh. Farmers of this area used pesticides in their mustard fields to manage harmful pests to recover their yield. The present research revealed that farmers of Hakaluki haor, carried a positive perception about the contribution of pollinators in the mustard field. Additionally, the field experiment at Hakaluki haor area highlighted the contribution of apiculture practices to maximize the yield of mustard crop. Henceforth, the information from this study shed light upon the importance of apiculture practice by the farmers in the mustard field of haor areas. The results of the study will use to aware the farmers on the value of pollination services of honey bees. These results also might be supportive to develop the farmers training manual on mustard production in Haor areas of Bangladesh by practicing apiculture. In addition, the findings of the study quantified the pollination services which might be emphasized further research for the improvement of mustard production.

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VARIETIES AND WEATHER PARAMETERS AFFECTING THE INCIDENCE AND INFESTATION OF THRIPS ON MUNG BEAN

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ABSTRACT

Evaluation of mung bean varieties was carried out against thrips under natural field condition to find out tolerant or least susceptible variety during January to April, 2016. Ten varieties were used as study materials. Results revealed that no variety was free from the attack of thrips. The number of thrips in each flower varied significantly among the flowering stages. The lowest thrips population was found in variety BU mung 1 and IPSA mung 5 showed less susceptible to thrips. BARI Mung- 6, BARI Mung -5 and GK Mung- 27 had highest population of thrips which indicated that these varieties were highly susceptible to thrips while IPSA Mung- 5 and BU Mung- 1 had the lowest population indicating less susceptible to thrips. The percent damaged flower plant^{-1} varied significantly among the flowering stages. The lowest per cent flower damage was in variety BU mung 1 (11.33%) at 50% flowering stage and in BARI mung 2 (20.00%) at 100% flowering stage. BARI Mung- 6, BARI Mung- 5 and GK Mung- 27 had highest number of damaged flower which indicated that these varieties were highly susceptible to thrips. BU Mung- 1 and IPSA Mung- 5 showed comparatively better resistance against thrips. The number of thrips was higher during high temperature and relative humidity. With the increase of flower infestation there was progressive fall in the yield. BU mung 1 and IPSA mung 5 were comparatively less susceptible varieties to thrips among tested varieties.

Keywords: Mung bean, variety, incidence, infestation, thrips

INTRODUCTION

Mung bean (*Vigna radiate* L. Wilezek) is one of the most important pulses crop belonging to the family Leguminosae grown in tropical and sub-tropical regions. Mung bean is an important source of protein and several essential micronutrients for both human and domestic animals. It contains 24.5% protein and 59.9%

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carbohydrate. It also contains 75 mg calcium; 8.5 mg iron and 49 mg β–carotene per 100 g of split dual (Bakr *et al*. 2004). The foliage and stem are also a good source of fodder for livestock as well as a green manure. Mung bean is cultivated with minimum land preparation and without fertilizer application even without insect, diseases or weed control. All these factors are responsible for low yield of mung bean. Despite its importance, mung bean yields are greatly reduced by a complex of biotic and abiotic factors of which insect pests are the most important. Approximately 64 insect species have been reported to attack mung bean in the field and thrips is one of the most devastating sucking pests which include thrips, jassids and whiteflies (Khattak *et al*. 2004). Among them thrips (*Megalurothrips distalis* Karny, *Megalurothrips usitatus* Bangall and *Caliothrips indicus* Bangall) are associated mostly with the damage of tender buds and flowers of mung bean. Thrips cause substantial damage during the vegetative and reproductive stages of the crop (Hossain *et al*. 2004, Rahman *et al*. 2000). The most common symptom of thrips infestation on mung bean is silver scarring on the leaf, which happens when thrips remove the cell content of leaf tissue (Duff 2012). *M. usitatus* was identified as one of the most economically devastating pests of the crop (Duraimu-rugan and Tyagi 2014). During the vegetative stage, *M. usitatus* prefers to suck plant juice from terminal buds and rasps the top unopened trifoliate leaves, which can quickly migrate to flowers, once formed during the flowering stage (Gitonga 1999). In the early stages of blossoming, male and female thrips are distributed at random in the flowers (Chang 1992). Both nymphs and adults feed on pollen and rasp flower parts and also suck the plant fluid leaking from the wounded plant parts (Hossain *et al*. 2004). The *M. usitatus* induces necrosis and early shed-ding of flower buds and blooms as a result of oviposition and feeding, which inhibits pod development, lowers the market value of the crop, and reduces yield output (Fan *et al*. 2013). *M. usitatus* causes mung bean production reduction ranging from 13 to 64% (Farajallah 2013). Some thrips species feed on the pollen and nectar produced by the flower, rather than attacking growing pods.

Different chemical pesticides are extensively used for controlling thrips of mungbean in recent years (Broughton and Herron 2009). Due to indiscriminate and frequent application of chemical pesticides resulted undesirable side effects including environmental pollution, pest resurgence, upset, resistance to pesticide, and develops high pesticide residues in food and other products (Ansari *et al*. 2014).

On the other hand, non-chemical control plays an important role in evolving an ecologically sound and environmentally acceptable method but not cost effective. Among the insect control options, host plant resistance by the use of resistant varieties is an effective and safe strategy in pest management with no additional cost to the growers by the plantation of resistant cultivars. However, investigation on the screening of the high-yielding varieties for insect pest resistance or tolerance is insufficient. The varieties of mung bean (*Vigna radiata* L. Wilczek) developed in Bangladesh also lack proper screening which can aid in insect pest management and increase the productivity of the crop. Insect pest is a major biotic barrier in mung bean production and accounts for 42 and 58% losses at the vegetative and reproductive stages, respectively (Malik 1992). Utilization of resistant host is one of the valuable management options for insect pest management. Under these circumstances, it becomes necessary to find out the most tolerant/ resistant variety/ varieties of mung bean against thrips.

MATERIALS AND METHODS

Field experiment was carried out at farmer's field in Sonakhali, Barguna sadar, Barguna to evaluate the resistance sources(s) among different verities of mung bean against thrips during the period from January to April 2016. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total number of plots was 30 and the size of the individual plot was 3.0m x 2.0m. The distance between unit plots was 0.75m and between blocks was 1.0m. Ten varieties viz., BARI Mung- 2, BARI Mung- 5, BARI Mung- 6, BU Mung- 1, BU Mung- 2, IPSA Mung- 5, IPSA Mung- 12, GK Mung- 27, BINA Mung- 2 and local Mung were included in the study. All the seeds were subjected to germination test before sowing. In all cases, the rate of germination was more than 90%. The seeds were sown on 1 February 2016 at the rate of 20 kg ha^{-1}. The seeds were placed in the line continuously at a depth of 4-5cm and covered by loose soil by hand. The spacing was 15 cm between rows and 10 cm between plants. At first trifoliate stage seedling was carefully thinned to retain one seedling $hill^{-1}$. Seed germination occurred from 10^{th} day after sowing. Intercultural operations were done as and when necessary to ensure normal growth and development of crops. Irrigation was applied as and when needed. Proper drainage system was also developed for draining out excess water. First weeding was done at 30 DAS followed by once a week to keep

the plots free from weeds and to keep the soil loose and aerated for the whole period of the crop growth. Weekly data were collected and recorded by direct counting early in the afternoon (4.0 – 6.0 pm). The number of plants per m^2 was selected randomly from each plot. For taking the data on the number of thrips were recorded from infested flowers at three stages like at 50% flowering stage, at 100% flowering stage and at pod initiation stage, respectively. Thrips population was assessed from 20 opened flowers, which were randomly collected from two rows of each side of the plot avoiding border rows and the selected 1 m^2 area of the center of each unit plot. The collected flowers were immediately opened on the white paper board and counted the number of thrips. The selected 1 m^2 area of the centre of each unit plot was kept undisturbed for recording yield data. The percentage of thrips infested flowers was calculated from the number of infested and total flowers collected from 10 randomly selected inflorescences from each m^2 plot $^{-1}$ using the formula:

$$\% \text{ flower infestation} = \frac{\text{Total number of infested flowers}}{\text{Total number of flowers}} \times 100$$

Mung bean was harvested thrice at 65-72 DAS. First only ripen pods were harvested at 65 DAS (4th April 2016) when about 80% of the pods became black in color. After first picking, flowering appeared and pod formation occurred second time. These pods were harvested at 72 DAS (second time on 11th April 2016) after ripening. The harvested crop of 1 m^2 area from each unit plot was bundled separately. Grains were recorded from 1 m^2 area per plot and the yields were expressed in kilogram (kg) and per hectare.

Data on temperature and relative humidity were collected from Weather Observatory, Meteorological Department, Kalapara, Patuakhali. Data were analyzed following the analysis of variance (ANOVA) using WASP program and the mean differences were adjudged by CD (critical difference) values.

RESULTS AND DISCUSSION

Population of thrips on different varieties of mung bean: Number of thrips per flower was recorded at different stages of different mung bean varieties and is presented in Table 1. At 50% flowering stage, significantly the highest population

of thrips (7.0) was recorded in the variety BARI Mung- 6. The second highest number was recorded in BARI Mung- 2 (6.33) followed by GK Mung- 27 (6.00), BU Mung- 2 (5.67), BARI Mung- 5 (5.00) and BINA Mung- 2 (4.67). BARI Mung- 5 (5.67), BARI Mung- 2 (2.41) was statistically identical with GK Mung- 27 (5.67). However, the lowest number of thrips was found in the variety of IPSA Mung- 12 (4.0) which was statistically similar with BU Mung 1 (4.0) followed by local Mung (4.33) and IPSA Mung- 5 (4.33). Local Mung (4.33) was statistically identical with IPSA Mung- 5 (4.33).

At 100% flowering stage, the highest number of thrips was observed in the variety BARI Mung- 6 (5.0). The second highest number was recorded in BARI Mung- 2 (4.33) followed by BINA Mung- 2 (4.0), BARI Mung- 5 (4.0), BU Mung- 1 (4.0), IPSA Mung- 12 (3.67) and GK Mung 27 (3.67). BARI Mung 5 was statistically identical with BINA Mung 2. However, the lowest number of thrips was observed in the variety IPSA Mung 5 (2.67) followed by BU Mung 2 (3.0) and local Mung (3.33).

At pod initiation stage, significantly the highest number of thrips was observed in the variety BARI Mung 6 (4.0). The second highest number was recorded in BARIi Mung- 5 (3.0) which was statistically similar with GK Mung- 27 (3.00) followed by local Mung 2 (2.67), BINA Mung- 2 (2.333) and IPSA Mung- 5 (2.33). IPSA Mung- 5 was statistically identical with BINA Mung- 2. However, the lowest number of thrips was observed in the variety of IPSA Mung- 5 (1.0) which was statistically similar with BU Mung- 1 (1.0) followed by BARI Mung- 2 (2.0) and BU Mung- 2 (2.0).

The number of thrips in each flower varied significantly among the flowering stages (Table 1). From above results it was indicated that the thrips population varied in different varieties at different stages. All the varieties in respect of thrips population was evident and the BARI Mung- 6, BARI Mung -5 and GK Mung- 27 had the highest population level which indicated that these varieties were highly susceptible to thrips. Among all the tested varieties, none showed complete resistance against thrips however, IPSA Mung- 5 and BU Mung- 1 showed comparatively better resistance against thrips.

Table 1. Number of thrips at flowering and pod initiation stages of different varieties of mungbean

Varieties name	Number of thrips/flower			Mean
	At 50% flowering stage	At 100% flowering stage	At pod initiation stage	
BARI Mung - 2	6.33 ab	4.33	2.00 bc	4.22 b
GK Mung - 27	6.00 abc	3.67	3.00 ab	4.22 b
BINA Mung - 2	4.67 cde	4.00	2.33 bc	3.67 bcd
IPSA Mung - 5	4.33 de	2.67	1.00 c	2.67 d
IPSA Mung - 12	4.00 e	3.67	2.33 bc	3.33 bcd
BU Mung - 1	4.00 e	4.00	1.00 c	3.00 cd
BU Mung - 2	5.67 abcd	3.00	2.00 bc	3.56 bcd
BARI Mung - 5	5.00 bcde	4.00	3.00 ab	4.00 bc
Local Mung	4.333 de	3.33	2.67 ab	3.44 bcd
BARI Mung - 6	7.00a	5.00	4.00 a	5.33 a
Level of significance	**	NS	**	**
CV (%)	18.06	22.09	33.70	15.96

** Significant at 1 % level, NS- Non significant. Means within column followed by the same letter are not significantly different from one another by CD (critical difference) values. Values are average of three replications.

Flower infestation inflorescence^{-1} by thrips: Percent flower infestation by thrips at different stages of mungbean varieties varied significantly (Table 2). At 50% flowering stage, the highest percent damaged flower (23.67%) was recorded in the variety of BARI Mung- 6. The second highest percent damaged flower was recorded in BARI Mung- 5 (22.33%) followed by IPSA Mung- 12 (20.0%), BINA Mung- 2 (19.67%), BU Mung- 2 (19.67%), GK Mung- 27 (18.33%) and local Mung (16.67%). BINA Mung- 2 was statistically identical with BU Mung- 2 (19.67%). However, the lowest percent damaged flower was found in the variety of BU Mung- 1 (11.33%) followed by BARI Mung- 2 (13.33%) and IPSA Mung- 5 (14.0%).

At 100% flowering stage, the highest percent of damaged flower (32.33%) was recorded in the variety of BARI Mung- 6. The second highest percent damaged flower was recorded in BARI Mung- 5 (31.0%) followed by BINA Mung- 12 (32.67%), GK Mung- 27 (30.0%), IPSA Mung- 12 (24.33%), local Mung (23.67%) and BU Mung- 2 (22.67%). BINA Mung- 2 was statistically identical with BU Mung- 2 (19.67%). However, the lowest percent damaged flower was found in the

variety of BARI Mung- 2 (20.0%) followed by BARI Mung- 5 (20.33%) and BU Mung- 1 (21.0%).

At pod initiation stage, significantly the highest percent damaged flower (40.67%) was recorded in the variety of BARI Mung- 6. The second highest percent damaged flower was recorded in BARI Mung- 5 (38.33%) followed by GK Mung- 27 (36.67%). No significant differences was observed among the varieties BINA Mung- 2 (35.0%) and IPSA Mung- 12 (34.0%) followed by local Mung (32.33%), BU Mung- 2 (32.0%). However, the lowest number of damaged flower was found in the variety of BU Mung- 2 (24.33%) followed by IPSA Mung- 5 (27.33%) and BARI Mung- 2 (29.67%).

The percent damaged flower plant^{-1} varied significantly and differed among the flowering stages (Table 2). From above results, it was indicated that the number of damage flower varied in different varieties at different stages. All the varieties in respect of number of damage flower were evident and the BARI Mung- 6, BARI Mung- 5 and GK Mung- 27 had highest number of damage flower, which indicated that these varieties were highly susceptible to thrips. Among all tested varieties, none showed complete resistance against thrips. However, BU Mung- 1 and IPSA Mung- 5 showed comparatively better resistance against thrips.

Table 2. Percentage of flower infestation by thrips at flowering and pod initiation stages of mungbean

Varieties name	% Flower infestation/inflorescence		
	At 50% flowering stage	At 100% flowering stage	At pod initiation stage
BARI Mung - 2	13.33	20.00	29.67 cde
GK Mung - 27	18.33	30.00	36.67 abc
BINA Mung - 2	19.67	30.67	35.00 abcd
IPSA Mung - 5	14.00	31.00	27.33 de
IPSA Mung - 12	20.00	24.33	34.0 abcd
BU Mung - 1	11.33	21.00	24.33 e
BU Mung - 2	19.67	22.67	32.00 bcde
BARI Mung - 5	22.33	20.33	38.33 ab
Local Mung	16.67	23.67	32.33 bcde
BARI Mung - 6	23.67	32.33	40.67 a
Level of significance	NS	NS	**
CV (%)	31.87	23.17	14.59

** Significant at 1 % level, NS- Non significant. Means within column followed by the same letter are not significantly different from one another by CD (critical difference) values. Values are average of three replications.

Population fluctuation of thrips relation to temperature and relative humidity: The seasonal abundance of thrips per square meter plant is shown in the month of March (Fig. 1). It is revealed from the figure that thrips was the maximum as noticed on 6th March, 2016 and the prevalence was continued up to the 20th March, 2016. At the beginning of the season, a maximum thrips was found and then declined up to to the 20th March. After that time abundance of thrips was slightly decreased up to the 20th March. The prevailing temperature and relative humidity were 33-34^{0}C and 96-98% at the peak period, respectively. It was revealed that number of thrips was higher during high temperature and relative humidity.

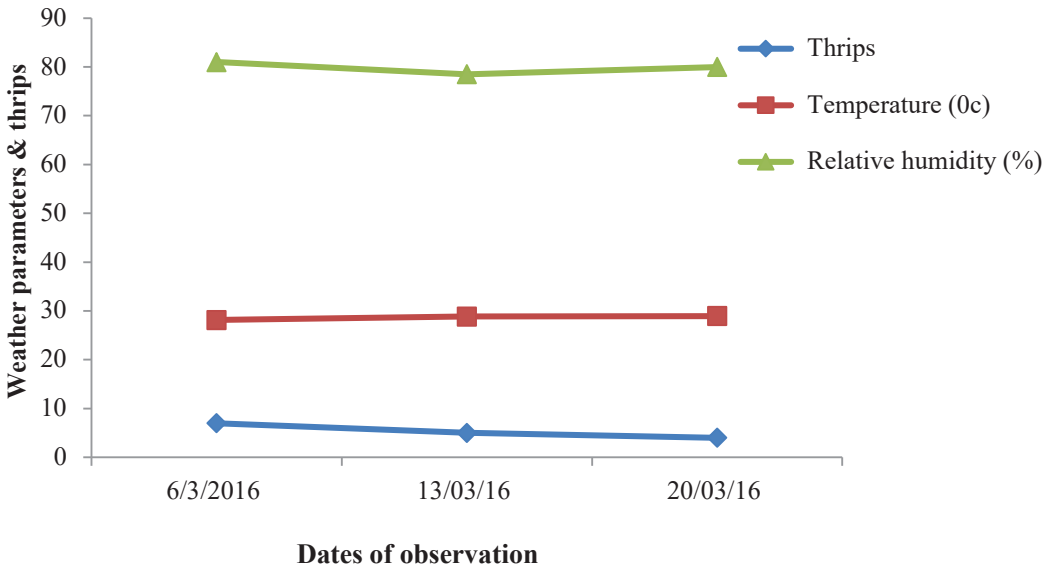


Fig. 1. Trend in population fluctuation of thrips with mean temperature (°C) & mean relative humidity (%) on highly susceptible variety of BARI Mung- 6.

Relationship between flower infestation and yield: A strong negative relationship between percent flower infestation and total yield was found in different varieties, which indicated that where the increase of flower infestation there was progressive fall in the yield. A linear regression was fitted between thrips infestation and total yield (Fig. 2). The correlation coefficient (r) was 0.95 and the contribution of the regression (R^2 = 0.9065, when Y = - 11.771x + 1006) was 90.65%.

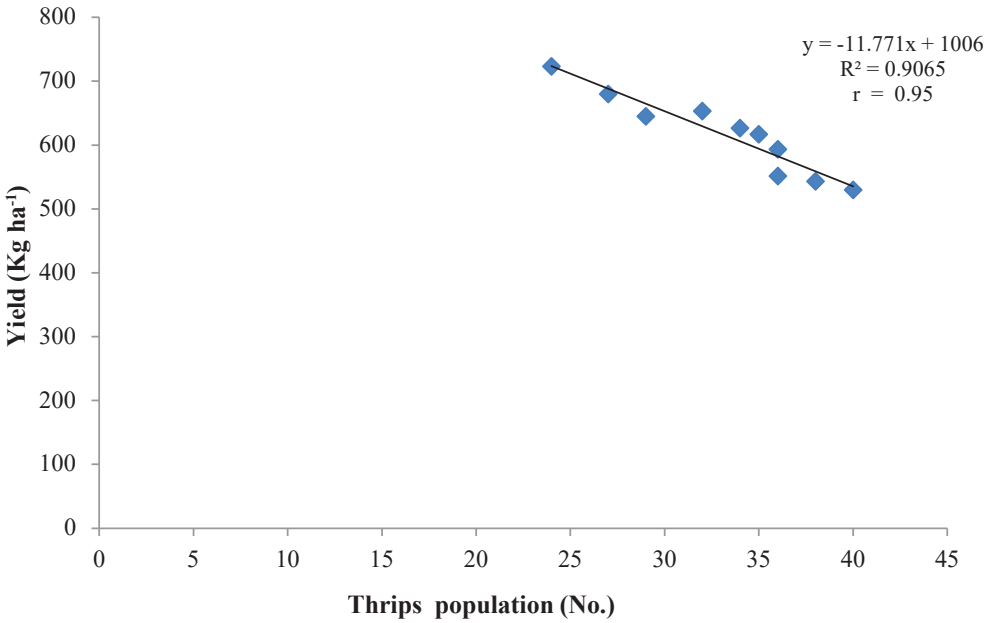


Fig. 2. Relationship between flower infestation and yield of different mung bean varieties.

Diverse biophysical and biochemical properties enhance the resistance in plants, but exceptions can happen depending on the type of crop and environment (Kosini *et al*. 2017). Plant biochemicals provide both direct and indirect defense function against insect pests (Roda and Baldwin 2003). Significant variations were detected in damaging the flower bud, flower infestation, and shedding by thrips which affected the yield of mung bean. Negative responses of thrips to the increasing trichomes, moisture, chlorophyll, phenol, and potassium in mung bean suggest the significance of these properties to develop resistant varieties against thrips (Yasmin *et al*. 2022). Nadeem *et al*. (2014) studied eight advanced mung bean genotypes in comparison with two check varieties against sucking pests under natural conditions. Findings showed that none of the tested genotypes have complete resistance against sucking pests like thrips, jassids and whiteflies. Previous researchers like Sahoo and Hota (1991), Chhabra and Kooner (1993) and Chhabara and Kooner (1994) evaluated mung bean cultivars against their resistance to insect pests and screened out a large number of mung bean genotypes for resistance/susceptibility against sucking pests. Naqvi *et al*. (1995) tested 10 genotypes of mung bean against

insects and found only two cultivars, M-8-20 and M-1030 resistant against insects compared to others. Khattak *et al*. (2004) screened five mungbean varieties *viz*., NM 92, NM- 98, NM-121-125, M-1 and NCM-2009 against sucking pests like whiteflies, jassid and thrips and observed that whitefly, jassid and thrips population was comparatively lower on NM-92 and NM-98, which enabled to get higher yield compared to other tested varieties. The results of the present study are supported by Khan *et al.* (2011) who recorded thrips populations from flowering to pod filling stage and found positive relationship of thrips population with prevailing weather conditions of temperature and relative humidity which are comparable with our results but Sedaratian *et al*. (2010) found negative correlation of rainfall, temperature and relative humidity with the thrips population. Khan *et al.* (2008) also found that abiotic factors have significant effects on the population of thrips which are comparable with the present findings.

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SCREENING OF TROPICAL SUGAR BEET VARIETIES AGAINST SUGAR BEET CATERPILLAR (*SPODOPTERA LITURA)* IN BANGLADESH

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ABSTRACT

Screening of tropical sugar beet varieties against the sugar beet caterpillar, *Spodoptera litura*, is important for understanding how different varieties respond to caterpillar pressure and developing pest-resistant cultivars, and increasing sugar beet crop productivity in Bangladesh. A study was carried out to identify the most tolerant sugar beet cultivars against *Spodoptera litura* attack as well as the extent of infestations by this insect pest. Results revealed that Cauvery was the best-suited cultivar, whereas PAC-60008 was the most susceptible to *S. litura*. The PAC-60008 variety had the highest (7.73) number of bores plant^{-1} and caterpillar (14.66), whereas the Cauvery variety had the lowest (2.20) number of bore plant^{-1} and the fewest (2.00) caterpillar. Sugar beet yield and its associated attributes were higher in Cauvery variety but lower in PAC-60008 variety. Cauvery had the highest yield (89.96 t ha^{-1}), while the PAC-60008 variety had the lowest (76.06 t ha^{-1}). Cauvery exhibited the highest Brix (18.23%) and Pol (13.45%), whereas PAC-60008 showed the lowest Brix (14.70%) and Pol (11.18%). Cauvery variety was more tolerant to *Spodoptera litura*, and further study may be undertaken in multiple locations to get more information on the causes of lower pest infestation and production increase before providing recommendation for commercial cultivation of Cauvery variety.

Keywords: *Spodoptera litura*, Sugar Beet, Variety, Tolerant variety, Cauvery, PAC-60008, Brix, Pol

INTRODUCTION

Tropical sugar beet, scientifically known as *Beta vulgaris* L., is a temperate crop that produces 35–40% of the world's sugar annually. It is the second most significant sugar crop in the world, after sugarcane (Amr and Gaffer 2010, Wu *et al.*

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2016). According to Chen *et al.* (2008), sugar beet has lately become a major biofuel alternative to energy produced by fossil fuels. Asadi (2007) states that sugar beet can be processed from 270 to 300 days in a year. India, Pakistan, and Bangladesh are among the tropical and subtropical nations that are now cultivating sugar beet with great success. The vast range of agroclimatic conditions in Bangladesh makes it an ideal location for growing sugar beets, even in coastal regions (Tayyab *et al.* 2023). Sugarcane takes 12–16 months to harvest, while sugar beet need only 4-6 months, resulting 2-3 times greater sugar yields per hectare (Baloach *et al.* 2002). Cultivation of sugar beet might alleviate the sugar/goor shortage, meet demand, and improve country's economic condition. There has to be extensive study into all facets of effectively producing the crop in order to fulfill the growing demand for sugar, and this research is happening quickly in every country where sugarcane is grown. There is a great deal of untapped potential for sugar beet farming in Bangladesh, which may lead to more than enough sugar output.

The high prevalence of insect pests and diseases are of the many challenges associated with growing sugar beets, a relatively young crop (Patil *et al.* 2007). A production loss of 18 t ha^{-1} is possible due to sugar beet insect infestations. One of the major issues with sugar beet farming is the presence of insect pests. Aphids, webworms, cutworms, red mites, grasshoppers, hairy caterpillars, flea beetles, and fleas are different insect pests that have been recorded (Zhang *et al*. 2008). Among sugar beet insect pests, the *Spodoptera litura* caterpillar is the most damaging (Mehta *et al*. 2022). This caterpillar has been shown to feed on a wide variety of plants and crops, including cotton, legumes, oil seeds, vegetables, ornamental plants, and even certain weeds (Zhou *et al*. 2010, Navasero 2011). Many commercially significant crops may be defoliated by the caterpillar of the *Spodoptera litura*, classified it as a very dangerous pest. Sugar beet infestations by the *Spodoptera litura* begin in March and reach its peak in late March and early April (Chatterjee and Nayak 1987, Iqbal *et al.* 2015). Leaf skeletonization and feeding holes in roots caused by severe infestations and made the crop unfit for marketing. Particularly hard-hit crops are harvested later in the season; in the worst instances, damage to all of the roots which may reduce yields by as much as 100% (Baitha *et al*. 2022). So far, several approaches of pest management have been suggested for suppressing sugar beet caterpillars, including using of resistant cultivars, cultural practices,

mechanical control, biological and chemical treatments, and so on. No effective method of varietal screening against this invasive pest has been implemented yet in Bangladesh. Therefore, the present study was aimed to find out the more tolerant sugar beet variety (ies) against *Spodoptera litura.*

MATERIALS AND METHODS

Twelve tropical sugar beet varieties viz., SV-35, SV-887, SV-889, SV-891, SV-892, SV-893, SV-894, PAC-60008, Danicia, Serenada, BSRI Sugar beet-1 (Shubhra), BSRI Sugar beet-2 (Cauvery) were grown from seed in the research field. The varieties were collected from the Bangladesh Sugarcrop Research Institute (BSRI). The field of the Experimental Farm of SAU was used for the study, which followed the Randomized Complete Block Design (RCBD) with three replications. The whole field was 0.055 hectares and divided into three blocks. Each block included twelve plots, each measuring 3.0 m x 2.0 m. There was a two-meter gap between the blocks, and a one-meter gap between the plots. So, in all, thirty-six plots were included. In accordance with the experimental design, treatments were distributed to each block. The seeds were planted at SAU Experimental Farm using ridge techniques with a spacing of 50 cm. x 20 cm, where seed to seed and row to row distances were 50 cm. and 20 cm, respectively. There were four lines in each plot, and fourteen seeds at each line. The first watering was done two days after the seeds sowing. The plant was irrigated second time after one month and third irrigation after two months avoiding water stagnation in the field. After the second and third irrigations, urea was applied as top dressing. Each trench was sown with two seeds. After two weeks, the remaining seedlings were thinned and one healthy seedling was retained for the study. The soil crust was broken and the plots were kept free of weeds by weeding as needed. After 20 days of sowing, the first weeding was done, and further weeding was done after 25 days interval to maintain a weed-free plot. To ensure that every plant had an adequate quantity of soil at its base, earthing up was done in every row. Prior to irrigation, this was done on 30 and 60 days after seeding.

Data recorded: Data was collected from seedlings after one month of age and contained upto the last harvest. Data were gathered in various conditions. The leaf area index (LAI), dry matter, number of bores, number of larvae, beet weight (g), beet diameter (cm), beet length (cm), yield, brix %, and pol % were recorded.

Germination Percentage: An indicator of a seed's potential for sprouting is its germination percent which was determined by using the following formula:

$$\text{Germination Percentage (GP)} = \frac{\text{No. of germinated seeds}}{\text{Total no. of seeds}} \times 100$$

Leaf area index (LAI): A dimensionless metric that describes plant canopy is the leaf area index (LAI). In broadleaf canopies, it is the ratio of the area of the green side of the leaves to determine the area of the ground is expressed as:

$$\text{LAI} = \frac{\text{Leaf coverage area plant}^{-1}}{\text{Soil covered area plant}^{-1}}$$

An indication of a plant's growth rate, the leaf area index (LAI) measures the area of a plant's leaves relative to its stem or ground surface.

Brix percentage: Brix is the refractometer-measured concentration of soluble solids in the plant's first-stage juice processing. By monitoring the light's refraction as it passes through a liquid sample, a refractometer may ascertain the degree of Brix. Sugary liquids have a higher index of refraction because they are denser than water. The device then calculates the Brix value by comparing it to the rate at which light refracts through water.

Determination of Sucrose (Pol) percentage of beet: The polarimeter can only measure the sucrose concentration in the juice as a percentage, either as Pol or sucrose. Atago Co., Ltd. of Japan provided the automated polarimeter (Model AP-300) that was used to measure the pol percent juice. A 200 mm polarimeter tube was filled with the transparent liquid. After the tube was filled with clarified juice, great care was taken to ensure that no air bubbles would be seen within. As the image's location was altered, the polarimeter/saccharimeter was fine-tuned and focused clearly. After making the necessary adjustments, the scale gave the direct pol and the two parts of the field of vision seemed equally bright. Using Schmittz's Table for sucrose (pol) for use in Horne's Dry Lead technique with an undiluted solution, the pol was adjusted against brix.

Data analysis: Proper form was used to combine and tabulate the data acquired for growth, phonology, yield, and yield contributing characteristics for statistical

analysis. Computer software called "Statistix 10" was used for statistical analysis of the obtained data and compared the means of the treatments using the Least Significant Difference (LSD) method, which was described by Gomez and Gomez in 1984. The significance threshold was set at 5%.

RESULTS AND DISCUSSION

The impact of sugar beet genotypes on the *Spodoptera litura* caterpillar: Germination percentage: Table 1 displays the germination % of the sugar beet varieties those were investigated. Around fifteen days after seed planting, germination took place. At a depth ranging from three-quarters to 3.81 cm, the seeds were sown into somewhat damp soil. Although sugar beets thrived in a wide range of soil types, the ideal growing conditions included well-drained soil devoid of roots and big stones, which may stunt root development. Soil pH between 6.0 and 6.5 is ideal for sugar beets. The proportion of sugar beet seeds that germinated seed showed statistically significant variation. The percentage of germination has a substantial impact on sugar beet production. The Cauvery variety had the best germination rate of 94.87%, which was statistically close to Shubhra (93.59%). Among the tested varieties, PAC-60008 had the poorest germination rate (84.62%). Nevertheless, the variety PAC-60008 had the greatest germination rate of 93.14%, followed by Cauvery (92.85%), and Shubhra (81.52%), as reported by Islam *et al.* (2014).

Leaf area index (LAI): Leaf area index (LAI), a crucial metric in plant ecology. It served as a proxy for the photosynthetic active area and the area transpired as it revealed the amount of vegetation present. It is also the place where air contaminants first make contact. The quantity of leaf material in a canopy may be measured using the leaf area index (LAI). It is defined as the ratio of the area of the one-sided leaf to the area of the ground. The smallest leaf area index (LAI) reported was 6.75 m^2 for the Serenada variety, while the highest was 9.37 m^2 for the Cauvery variety. With 8.64 m^2, the Shubhra variety has the second-highest LAI. The variety SV892 has the greatest LAI (3.05), as reported by Islam *et al.* (2015). While the treatments' effects were noticeable in later stages and they were inconsistent at early stages

when it came to leaf area. At the 5% level of significance or above, the variety had a significant influence on the leaf area index in this study (Table 1).

Dry matter (DM): When water is removed from feed, grain, and fresh or dried forages, what's left is the dry matter. The dry matter percentage of fresh pasture is lower than that of hay or grain of the same weight because of the pasture's high-water content. One measure of a feed's nutritional availability is its dry matter content. From the time of seeding until the plant reached maturity, the dry weight per plant grew steadily. As shown in Table 1, the percentage of dry matter found in the sugar beet varieties. The findings showed that the variations were significantly different from one another. The sugar beet variety SV-887 had the greatest percentage of dry matter (14.34%), while the sugar beet variety SV-35 had the lowest percent (9.73%). The SV-889 variety had the second highest % DM of 14.20 (Table 1).

Number of *S. litura* larvae plant^{-1}: There are five stages of larval life cycle, with the last two stages reaching a weight of 800 mg. The fresh weight of one larva was taken after they were feed to four to eight grams of sugar beet leaves. But at the end of the process, eighty percent of the food is gone. The number of larvae per plant changed with each stage of development, which in turn indicates the plant's resistance to *Spodoptera litura* (Table 1). There was a minimum of 2.00 larvae per plant in the Cauvery variety and a maximum of 14.66 in the PAC-60008 were recorded. At Shubhra variety, the second-lowest number of larvae (7.33) was recorded. The number of larvae per plant was significantly affected by the variety in this study (5% level of significance). The effects of the sugar beet variety were shown in this study (Table 1).

Number of bore beet^{-1}: The number of bores per Sugar beet varies with the phases of development and showed how much resistant the plant is to a particular kind of pest. Bores per Sugar beet ranged from 2.20 in the Cauvery variety to 2.26 in the Shubhra variety, with 7.73 in the PAC-60008 variety being the highest. There were notable variations in the number of bore per plant across the sugar beet varieties (Table 1).

Beet weight: Worthiness of sugar beet varieties is determined by the weight of beet at harvest. Under ideal conditions, high-quality sugar beets may have higher beet weight compared to other varieties. The Cauvery beet variety had the highest

Table 1. Germination %, Leaf area index, Dry matter, larvae per plant and number of bore beet^{-1} observed in twelve sugar beet varieties

Variety	Germination (%)	Leaf area index (m^2)	Dry matter (%)	Number of larvae plant^{-1}	Number of bore beet^{-1}
SV-35	85.90^{de}	6.87^{c}	9.73^{b}	13.33^{a}	5.86^{abc}
SV-887	88.46^{cde}	7.23^{bc}	14.34^{a}	10.66^{ab}	4.80^{abcd}
SV-889	89.74^{bcd}	7.57^{bc}	14.20^{a}	8.66^{ab}	3.60^{bcd}
SV-891	89.10^{bcde}	7.35^{bc}	11.76^{ab}	9.33^{ab}	3.80^{bcd}
SV-892	90.38^{abcd}	7.66^{bc}	10.61^{b}	8.00^{ab}	3.86^{bcd}
SV-893	86.54^{de}	8.00^{abc}	12.54^{ab}	11.33^{ab}	6.13^{ab}
SV-894	91.67^{abc}	8.06^{abc}	10.42^{ab}	8.66^{ab}	2.93^{bcd}
PAC-60008	84.62^{e}	6.77^{c}	11.14^{ab}	14.66^{a}	7.73^{a}
Danicia	87.18^{cde}	7.07^{c}	11.37^{ab}	10.00^{ab}	5.13^{abcd}
Serenada	89.74^{bcd}	6.75^{c}	11.06^{ab}	11.00^{ab}	5.66^{abcd}
Shubhra	93.59^{ab}	8.64^{ab}	12.07^{ab}	7.33^{ab}	2.26^{cd}
Cauvery	94.87^{a}	9.37^{a}	10.49^{b}	2.00^{b}	2.20^{d}
CV	3.30	11.34	17.05	66.62	47.49
LSD (0.05)	2.59	1.46	3.36	10.81	3.61

[At $p<0.05$, there is a significant difference between the means in the same column that are followed by different letters]

weight of 851.67 g, followed by Shubhra variety (813.33 g), and the PAC-60008 variety (693.67 g) (Table 2). The variety influenced beet weight significantly in this study (5% level of significance). In the current study, beet weight is somewhat lower than that of the Cauvery variety (995.70 g) and the Shubhra variety (835.95 g), as reported by Islam *et al.* (2014). Soil and climatic variations could be the reason.

Beet girth: Beet girth at harvest might affect the varietal quality of Sugar beet. Table 2 showed that the SV-35 variety had the lower beet girth of 24.67 cm, while the Cauvery and Shubhra varieties had 31.33 and 31.00 cm respectively. The SV-887 cultivar had the second-highest beet girth of 29.33 cm. Significant girth variations among the sugar beet cultivars were shown. Islam *et al.* (2014) reported that the Aranka variety of beets had the widest girth of 34.46 cm.

Beet length: The quality of a sugar beet variety was also determined by its length. Table 2 showed that the highest length of 31.67 cm was found in the Cauvary variety,

and the shortest length was (26.33 cm) obtained in the SV-35 variety. The Shubrha variety had the second-longest length of 29.66 cm, while SV-894 had 28.66 cm length. The present findings are in agreement with those of Islam *et al.* (2014), who also measured beet length and reported that variety Cauvery had the longest (31.24 cm). There were significant variations among the tested varieties.

Yield (t ha^{-1}): Sugar beet yields have been steadily rising globally over the last few decades. Developing better breeding methods is crucial for maximizing the crop's output potential. The change occurred when the plants assimilate partitioning shifted toward store carbohydrates (sucrose) while structural carbohydrates (leaves, cell wall components) dropped inadvertently. Table 2 shows that the yield ranged from 76.06 t ha^{-1} for the PAC-60008 variety to an impressive 89.96 t ha^{-1} for the Cauvary variety followed by Shubrha with 87.86 t ha^{-1}, while the SV-894 variety had the third-highest beet yield with 87.15 t ha^{-1}. Islam *et al.* (2014) reported that among the varieties tested, Aranka had the highest yield (98.80 t ha^{-1}) and Shubrha the lowest (59.90 t ha^{-1}). At the 5% level of significance, the varieties were shown to have a significant influence on yield in this study.

Table 2. The parameters that contribute in yield of sugar beet varieties

Variety	Yield contributing attributes of sugar beet			Yield (t ha^{-1})
	Beet weight (g)	Girth of beet (cm)	Length of beet (cm)	
SV-35	711.67^{f}	24.67^{e}	26.33^{e}	76.88^{e}
SV-887	740.67^{ef}	26.67^{cde}	27.67^{cd}	84.44^{abcd}
SV-889	765.00^{cd}	27.33^{cde}	28.33^{c}	84.73^{abcd}
SV-891	753.00^{de}	27.00^{cde}	27.67^{cd}	86.20^{abc}
SV-892	798.00^{bc}	28.33^{bcd}	28.33^{c}	85.65^{abc}
SV-893	710.00^{f}	25.67^{de}	26.83^{de}	79.34^{de}
SV-894	808.00^{b}	28.67^{abc}	28.67^{bc}	87.15^{ab}
PAC-60008	693.67^{g}	27.67^{cd}	26.67^{de}	76.06^{e}
Danicia	731.67^{def}	26.33^{cde}	27.00^{de}	83.17^{bcd}
Serenada	718.33^{ef}	26.00^{cde}	26.67^{de}	80.94^{cde}
Shubhra	813.33^{b}	30.67^{ab}	29.67^{b}	87.86^{ab}
Cauvery	851.67^{a}	31.33^{a}	31.67^{a}	89.96^{a}
CV	3.13	5.96	2.78	4.29
LSD (0.05)	37.14	2.77	1.31	6.07

[At $p<0.05$, there is a significant difference between the means in the same column that are followed by different letters].

Brix Percentage: An aqueous solution's sugar concentration is represented by its Brix percentage. As a percentage of mass, the solution's strength is represented by its Brix, which is 1 g of sucrose in 100 g of solution. Twelve different sugar beet varieties were tested, and the brix ranged from 14.70% to 18.23%. Cauvery had the greatest brix percent (18.23%), which was statistically similar with that of Shubhra (18.13%), SV-894 (17.80%), SV-892 at (17.76%), and SV-889 (17.73%). Figure 1 showed its comparable brix of SV-35 (15.40%), Serenada (15.50%), and SV-887 (15.83%), but the lowest brix was in PAC-60008 (14.70%) and (15.06%) in SV-893. Islam *et al.* (2014) reported that varieties HI-0044 had the lowest brix percentage of 17.39% and varieties Shubhra, Cauvery, and Aranka had the highest, ranging from 18.48% to 18.87%.

Pol Percentage: In Figure 1, the varieties with the greatest Pol percentage were 13.45% in Cauvary and 13.36% in Shubrha and PAC-60008 had 11.18% pol. In a study conducted by Islam *et al.* (2014), the pol percentage was determined to be 10.08 % in the Aranka variety. When comparing the Pol percentages of several sugar beet varieties, it was found some notable variation. According to the results, the sugar beet variety Cauvary performed best in this study. In comparison to other varieties, this one had a high germination percentage, Leaf Area Index (LAI), and Dry Matter (DM). There was a favorable correlation between yield and other yield-related characteristics of the Cauvery variety. Among these varieties, Shubhra was ranked the second.

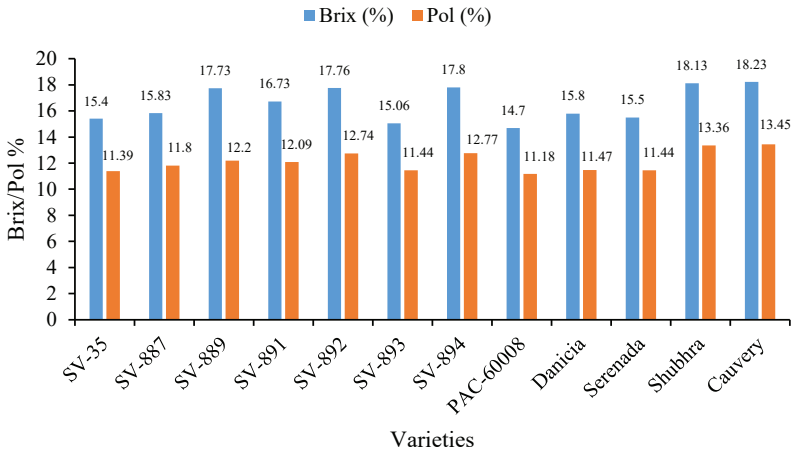


Fig. 1. Brix (%) and Pol (%) of the studied sugar beet varieties

CONCLUSION

The Cauvery variety exhibited the highest germination rate, LAI, and yield, along with the highest a brix and pol percentage, indicating its superior performer. Additionally, the number of caterpillar per plant and the number of bores per beet were significantly influenced by the sugar beet genotype, with the PAC-60008 variety showing the highest infestation rates with the lowest brix and pol percentage, indicating its inferior performer. This research can inform future breeding programs aimed at improving sugar beet yield and pest resistance.

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ABUNDANCE AND DIVERSITY OF INSECT PESTS ATTACKING MAIZE (*ZEA MAYS*) IN SYLHET DISTRICT OF BANGLADESH

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ABSTRACT

Maize (*Zea mays*), a globally significant crop, is increasingly cultivated in Sylhet district of Bangladesh, but faces challenges due to various insect pests. This study aimed to record the abundance and diversity of insect pests of maize field in Sylhet district. Field studies were conducted at Jalalabad Union of Sylhet Sadar Upazila under Sylhet district, from January to May 2022. Results revealed that various insect pests and natural enemies were found in the maize field viz., cutworm, fall armyworm, tachinid fly, non-biting midge, ladybird beetle, honey bee, and grasshopper. Among these insect pests, non-biting midge (*Chironomus* sp.) (51%) and fall armyworm (*Spodoptera frugiperda*) (16%) were identified as the most prevalent. Insect pests and natural enemies varied by functional diversity with 51% categorized as neutral, 30% as pests, 10% as predators, 5% as parasitoids and 4% as pollinators. The abundance and diversity of insect pests belongs to five different orders which include Diptera (56%), Lepidoptera (24%), Coleoptera (10%), Orthoptera (6%), and Hymenoptera (4%). The Shannon-Wiener Diversity Index was 1.74, indicating a stable community structure, and Pielou's Evenness Index was 0.275, suggesting moderate species distribution uniformity. Insect abundance differed across maize growth stages, with certain pests prevalent in specific stages: cutworm was found during the seedling stage; non-biting midge and ladybird beetle were observed from seedling to harvest; fall armyworm, tachinid fly, and grasshopper were present in both vegetative and reproductive stages; and honey bee appeared during the reproductive stage. Temperature and relative humidity were found to have distinct effects on insect populations, with correlations varying among different species. Temperature was positively correlated with non-biting midge (r = 0.86), fall armyworm (r = 0.54), and tachinid fly (r = 0.39), while negative correlations were observed with ladybird beetle (r = -0.05) and grasshopper (r = -0.31). In terms of relative humidity, positive correlations were identified for fall armyworm (r = 0.14), ladybird beetle (r = 0.31), grasshopper (r = 0.64), and tachinid fly (r = 0.07), whereas non-biting midge showed a negative correlation (r = -0.12). These findings would be helpful for implementing IPM program to manage these pests effectively and ensure sustainable maize cultivation.

Keywords: Maize insects, insect diversity, abundance, IPM, Sylhet, Correlation, Temperature, Humidity

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INTRODUCTION

Maize (*Zea mays*), belongs to the Poaceae family, and is the third most important staple food all over the world followed after wheat and rice (Singh and Jaglan 2018). Among the top three cereals, maize is capable of producing the highest grain yield per unit area, and considered the highest human consumption food all over the world (Wotia and Omukunda 2021). About 200 million people in underdeveloped nations directly consume maize as a primary food (Nuss and Tanumihardjo 2010). In terms of caloric and protein intake, this grain is the staple diet in underdeveloped nations, accounting for 61% of consumption in Mesoamerica, 45% in Eastern and Southern Africa, 29% in the Andean region, and 25% in West and Central Africa (Shiferaw *et al.* 2011). In the warmer parts of the world, maize is typically grown for grain, whereas in the cooler regions, it is grown for silage (Millner *et al.* 2005). Due to its higher genetic output potential and wider range of adaptability among cereal crops, it is referred to as the "Queen of Cereals" in popular culture (Chloupek and Hrstkova 2005). Maize has huge demand in international market for its nutritional values like carbohydrate, protein, fat (oil) and it is also used for beverage, animal feed, poultry feed (Arifie *et al.* 2019). The primary way that maize is eaten in developed nations as second-cycle food, such as meat, eggs, and dairy products (Sofi *et al.* 2009).

In Bangladesh, maize is considered as cash crop and the third grain crop followed after rice and wheat (Biswas *et al.* 2022). The major maize producing districts of Bangladesh are Dinajpur, Chuadanga, Thakurgaon, Lalmonirhat, Rajshahi, Kushtia, Rangpur and Bogura (Biswas *et al.* 2022). At present total cultivated land areas of maize is about 398,309.66 hectares and total annual production is about 3713793.1 MT (BBS 2023). Compared to the production area of maize, yield is not being obtained as expected (Ayalew and Sekar 2016). To overcome the yield loss farmers are using the hybrid varieties. However, it has been claimed that hybrid maize is extremely vulnerable to insect pest

attacks, both in the field and during storage (Almekinders *et al.* 2021). Maize crop is infested by numerous insect-pests in its different growth stages (Tefera *et al.* 2016). Paini *et al.* (2016) reported more than 1300 species of insect-pest and pathogens in maize crop. The major insect-pests of maize at emergence stage are: cutworm (*Agrotis* spp.), maize stem borer (*Chilo partellus*), pink stem borer (*Sesamia inferens*), cotton bollworm (*Helicoverpa armigera*) etc. At tasseling stage: white grub beetle (*Holotrichia longipennis*), miaze leafhopper (*Dalbulus maidis*) etc, at reproductive stage: grass hopper (*Oxya japonica*), Flea beetle (*Chaetocnema pulicaria*), wireworm (*Agriotes* spp.) (Arifie *et al.* 2019). The fall armyworm (S*podoptera frugiperda*) which is native to the tropical and subtropical region of America has recently become major and serious pest in maize all over the world (Sisay *et al.* 2018). Recently it has spread even in Bangladesh, causing major loss to economically cultivated maize crop (Early *et al.* 2018).

Sylhet, the north-eastern district of Bangladesh, is very new in maize cultivation. The department of Agricultural Extension under Ministry of Agriculture is supporting the farmers of Sylhet district to grow maize crop in winter as most of the land of Sylhet district remain fallow during the winter season. Accordingly, farmers have started to grow maize as a new crop in this region. However, various insect pest infestation in different growth stages of maize made them reluctant to grow this crop in this region. Farmers of this area are not familiar with the insect pest of maize. For the sustainable cultivation of maize crop in Sylhet integrated pest management (IPM) of maize crop is necessary. For establishing IPM, pest list with their abundance is prerequisite (Deguine *et al.* 2021). As the maize farmers of Sylhet district are not acquainted with the insect pest of maize and their abundance in maize field, this research was aimed to enlist the available insect pests and natural enemies of maize with their abundance in relation to maize crop growth stages.

MATERIALS AND METHODS

The field experiment was conducted on abundance of insect pests in maize (*Zea mays*) at Palpur village, Jalalabad Union, Sylhet district, during the period from January to May 2022. Geographically, the study area is situated between 24°53' and 25°01' north latitude and between 91°42' and 91°52' east longitude (Banglapedia 2021) (Fig. 1).

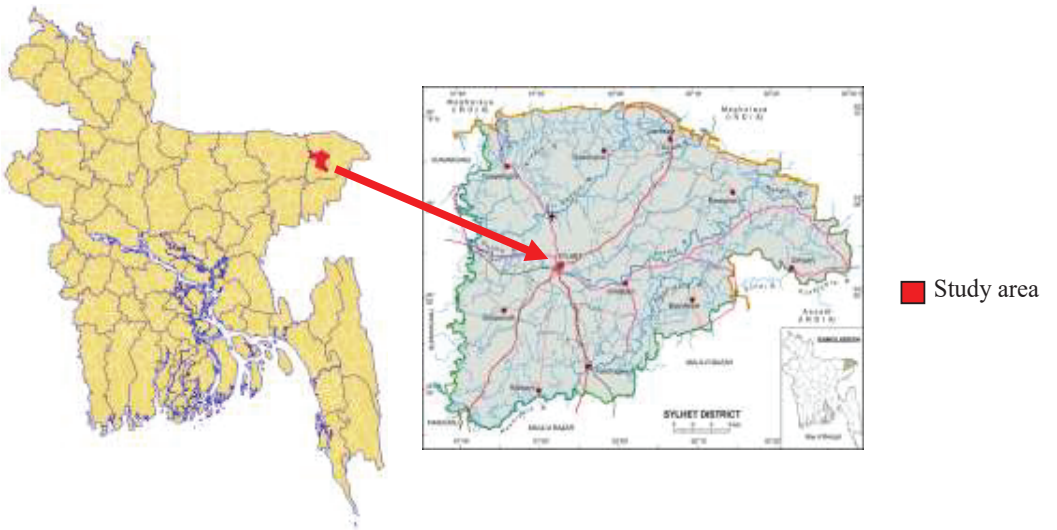


Fig. 1. Map showing the experimental site at Jalalabad Union of Sylhet District.

The experimental site was selected near the Surma riverside. The site has a tropical monsoon climate with the extreme unsteady rainfall condition. But during the experimental period of January to April, 2022, scanty rainfall prevailed during cropping season. The temperature ranged from 12°C to 34.4°C and the relative humidity ranged from 55% to 89% during the period. The plot was thoroughly prepared through multiple plowings using a power tiller to ensure well-tilled soil. After tilling, the field was left undisturbed for 3 days. Weeds and unwanted stubbles were carefully removed manually.

Different kinds of fertilizer and manure: Urea (360 kg ha-1), TSP (150 kg ha-1), MoP (250 kg ha-1), and cow-dung (10 tons ha-1), were applied by broadcasting method to the experimental site. Half of the urea as well as other fertilizers and cow dung were applied in the time of the final land preparation, and the rest of

the urea was used after 28 days of seed sowing. The experiment was arranged in a randomized complete block design (RCBD) with eight replications. Each treated plot measured 6m × 5m and there were total 8 plots. The distance between plots was 1 meter, with a row spacing of 75-90 cm. Each subplot contained 9 rows, with 13 plants per row. The maize Supershine F1 variety was collected from the local market of Sylhet and sown for this study. The seeds were soaked for 3 hours prior to planting. The germination rate was 85-90%. Germination occurred within 5 to 7 days under optimal conditions. The dribbling method was used for planting, where seeds were manually sown to a uniform depth 6 cm.

After seedling establishment, several intercultural operations were performed, including irrigation, weeding, and gap filling, to promote better growth and development. Watering was carried out three times, with the timing and amount carefully adjusted to support seedling growth and maintain soil moisture. During gap filling, damaged seedlings were replaced with healthy ones, and surplus seedlings were transplanted along the borders. Weeding was done 2 times during the growing season, with the first weeding done 15–20 days after planting and the second around 30–40 days after planting, before the silking stage. Finally, spading was conducted to keep the land weed-free.

Data collection: Data collection began on February 11, 2022, after 15 days of sowing and continued until harvest. Data was recorded six times from 9 randomly selected plants per plot across eight plots, with observations taken at intervals of 14 days between 10 am and 12 pm. The purpose of the study was to understand the abundance, and diversity of insect pests and natural enemies throughout the maize crop's lifecycle. The insects were collected using handpicking and net sweeping methods to capture individuals across different growth stages i.e., seedling, vegetative, and reproductive.

The seedling stage was defined as the period from emergence to 4 weeks of plant growth, followed by the vegetative stage, which ended with the appearance of silking, and finally the reproductive stage, which lasted until harvest. During each growth stage, data was recorded to identify the diversity and abundance of insect's

present, as well as their functional roles (e.g., pests, predators, pollinators, or neutral). Diversity indices such as the Shannon-Wiener diversity index (H) and Pielou's evenness index (J) were used to analyze species diversity and distribution patterns in the community. Abiotic factors, specifically relative humidity and temperature, were also recorded at each data collection interval with the help of digital hygrometer that was placed in the field, as these factors significantly influence insect populations. Relationships between these abiotic parameters and the abundance of different insect species were explored to determine their effects.

Data analysis: Statistical analysis was performed to evaluate the relative abundance, Shannon-Wiener diversity index (H), and Pielou's evenness index (J) of insect species. The Shannon-Wiener diversity index and Pielou's evenness index results were described in the paragraphs, providing a comparative view of species richness and distribution uniformity across different plots. Insect composition was visually represented using a pie chart, depicting the relative abundance of each insect category, enhancing understanding of the predominant species within the study area. The relationship between temperature, humidity, and their combined impact on insect abundance was analyzed using correlation and regression techniques. Microsoft Excel 2007 was used for all other calculations.

Relative Abundance (%): The relative abundance of insect species was alculated to show the distribution of insects across different genera, families, and orders. It was computed using the formula:

Relative abundance (%) = (n/N) * 100

Where,

n= Number of each individual
N= Total number of individuals

This formula provided insights into the proportional representation of each species relative to the total insect population.

Shannon-Wiener Diversity Index (H): The Shannon-Wiener diversity index (H) was used to quantify species diversity, taking into account both species richness and

the evenness of species distribution. It was calculated using the following formula:

$$H' = -\sum(Pi \times InPi)$$

Where:

- Pi = Proportion of individuals of the ith species, Pi=ni/Pi
- ni = Number of individuals of the ith species
- N = Total number of individuals
- ln = Natural logarithm
- ∑ = Summation across all species

This index provided an understanding of both the richness and evenness of species present in the ecosystem.

After calculating the diversity index, it was matched with the general interpretation of the diversity index (Reflinaldon and Hamid 2023) (Table 1).

Table 1. General interpretation of Shannon Diversity Index values (Reflinaldon and Hamid 2023)

Diversity Index	Community Structure Condition	Category
H' ≥ 2.41	Very Stable	Excellent
1.8 ≤ H' < 2.41	More Stable	Good
1.21 ≤ H' < 1.8	Stable	Medium
0.61 ≤ H' < 1.21	Stable Enough	Bad
H' < 0.6	Unstable	Very Bad

Pielou's Evenness Index (J): Pielou's evenness index (J) was used to measure how evenly individuals are distributed across different species in the community. It was calculated using the following formula:

$$J = \frac{H}{Hmax}$$

Where:

- H = Shannon-Wiener diversity index
- Hmax=ln(n), with n being the total number of species

Pielou's index indicated the uniformity in the species distribution, with values closer to 1 representing more even distributions across species. These diversity metrics, combined with relative abundance data, allowed for a comprehensive analysis of insect community structure and ecological dynamics within the study area.

RESULTS

The study identified a variety of insect species of maize in Sylhet, Bangladesh, including both insect pests and beneficial insects. Insect pests like cutworms (*Agrotis* spp.), fall armyworms (*Spodoptera frugiperda*), and grasshoppers (*Tettigonia viridissima*) were found. Conversely, beneficial insects such as tachinid flies (*Lixophaga* sp.), ladybird beetles (*Coccinella* spp.) contribute to natural pest control. Honeybees (*Apis mellifera*) help in pollination. These insects' pests are from five different orders *viz*., Lepidoptera, Diptera, Coleoptera, Hymenoptera, and Orthoptera (Table 2).

Table 2. Biodiversity of insect species of maize in Sylhet district, Bangladesh

Sl No.	Common name	Scientific name	Family	Order
1	Cutworm	*Agrotis* spp.	Noctuidae	Lepidoptera
2	Fall armyworm	*Spodoptera frugiperda*	Noctuidae	Lepidoptera
3	Tachinid fly	*Lixophaga* sp.	Tachinidae	Diptera
4	Non-biting midge	*Chironomus* sp.	Chironomidae	Diptera
5	Ladybird beetle	*Coccinella* spp.	Coccinellidae	Coleoptera
6	Honeybee	*Apis mellifera*	Apidae	Hymenoptera
7	Grasshopper	*Tettigonia viridissima*	Tettigoniidae	Orthoptera

The relative abundance of various insect species found in the study area. The data reveals that non-biting midge were the most dominant species, making up 51% of the total insect population of maize. Fall armyworms were the second most abundant species, accounting for 16%, followed by cutworms and ladybird beetles, both at 9%. Grasshoppers contributed 6% of the population. Among natural enemies, ladybird beetles were the most prevalent (9%), whereas tachinid fly and honey bee represented 5% and 4%, respectively (Table 3).

Table 3. Relative abundance of insect species of maize in Sylhet, Bangladesh

Sl. No.	Species	Relative abundance
1	Cutworm	9%
2	Fall armyworm	16%
3	Tachinid fly	5%
4	Non-biting midge	51%
5	Grasshopper	6%
6	Ladybird beetle	9%
7	Honey bee	4%

The higher the value of H', the more the diversity of species in the community and vice-versa. The Shanon-wiener diversity index (H') was calculated 1.74 indicating that community structure was stable and moderately diversified by different species in the community (Table 1). Pielou's index indicated the uniformity in the species distribution, with values closer to 1 representing more even distributions across species. The estimated value of J was 0.275 delineating that there was a moderate degree of evenness of species found in study area. Nearly half (51%) of the total insect population was categorized as neutral, largely due to the substantial presence of non-biting midge. Pollinator i.e., honey bee contributed 4% to maize crop pollination. Pests like Cutworm, Fall armyworm, and Grasshopper made up a significant portion, at 30%, causing considerable damage to maize plants, while predator i.e. Ladybird beetle represented 10%, and parasitoid, Tachinid fly presenting 5% having a relatively minor role as beneficial insects (Fig. 2).

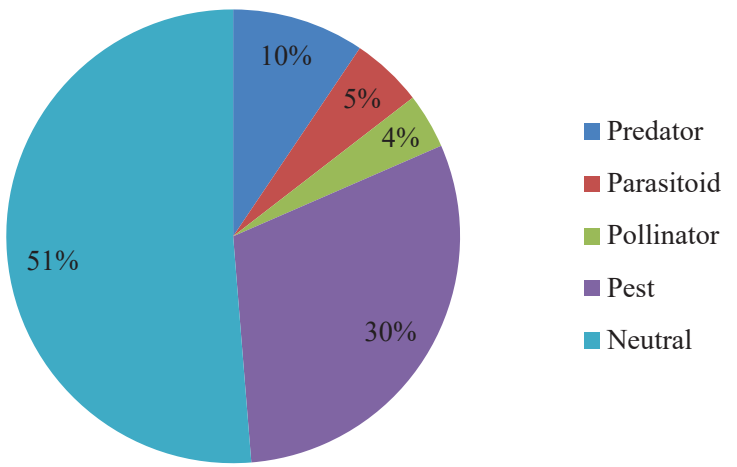


Fig. 2. Functional diversity of maize insect species in Sylhet

The dipteran insects were widely distributed throughout the maize field, comprising more than half (56%) of the total insect population. Lepidoptera and Coleoptera were also significant, constituting 24% and 10%, respectively. The remaining orders; Orthoptera, and Hymenoptera collectively accounted for 10%, with less significance compared to the abundance of other orders (Fig. 3).

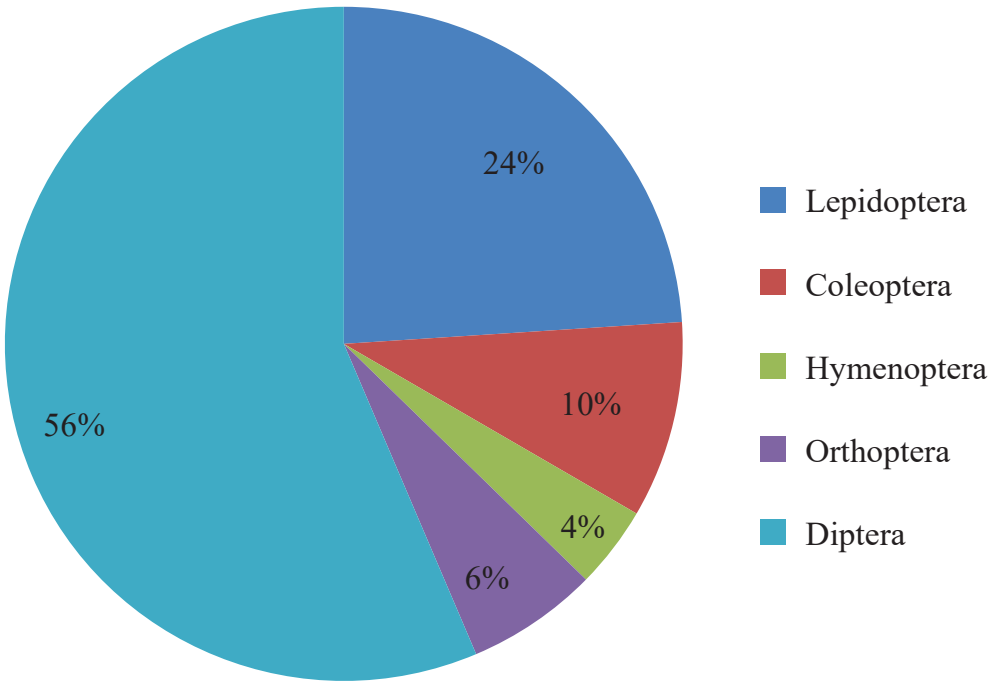


Fig. 3. Order wise distribution of maize insect species in Sylhet

Insect populations of maize crop varied with maize growth stages. Cutworm and non-biting midge were most abundant in the vegetative stage, with cutworm decreasing at the reproductive stage. Ladybird beetles and fall armyworms showed higher numbers at the vegetative stage. Tachinid flies, grasshoppers, and honeybees had low numbers, with slight increases in the reproductive stage (Fig. 4).

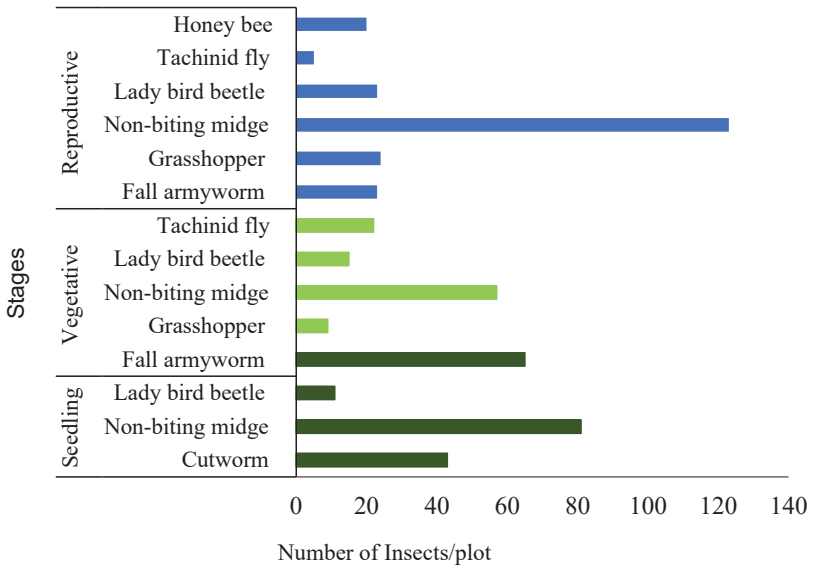


Fig. 4. Prevalence of insect species at different stages of maize

Temperature has a positive correlation with non-biting midge (r=0.86) and fall armyworm (r= 0.54), respectively. In contrast, temperature has a negative correlation with grasshopper (-0.31) (Fig. 5). This graph suggests that non-biting midge and fall armyworm population increase with the increase of temperature. Whereas, grasshopper population decreases with increasing temperature.

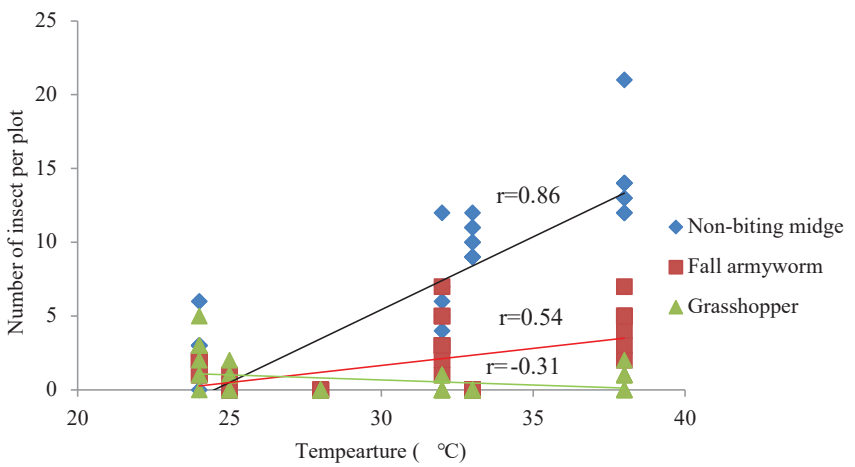


Fig. 5. Effect of temperature on pest population (Non-biting midge, Fall armyworm, Grasshopper) of maize in Sylhet

In case of natural enemies, temperature showed a positive correlation with the tachinid fly (r = 0.39), exhibiting that its population increases considerably with rising temperatures. In contrast, the lady bird beetle had a very weak negative correlation (r = -0.05), suggesting that its population rarely depends upon temperature (Fig. 6).

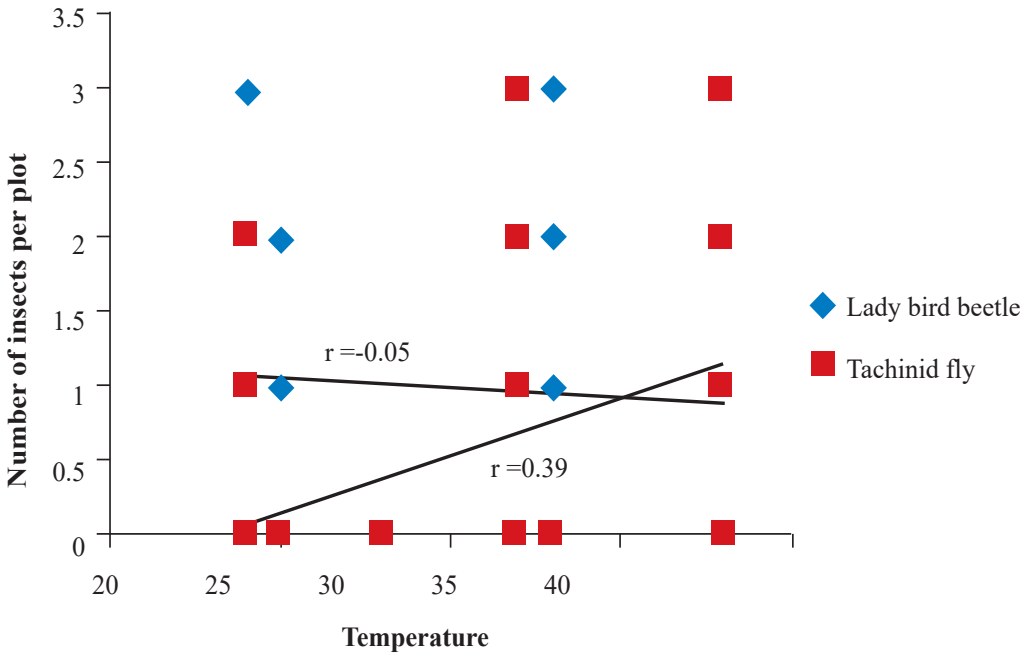


Fig. 6. Effect of temperature on natural enemies' population (Ladybird beetle, Tachinid fly) of maize in Sylhet

The correlation between grasshoppers and relative humidity was found strong (r= 0.64), indicating that relative humidity has a significant effect on increasing grasshopper populations. The fall armyworm had a weak positive correlation with relative humidity (r= 0.14), suggesting that their numbers are not affected much with higher humidity levels. In contrast, non-biting midge exhibited a negative correlation with relative humidity (r = -0.12), indicating it doesn't affect much in their population as humidity increases or decreases (Fig. 7).

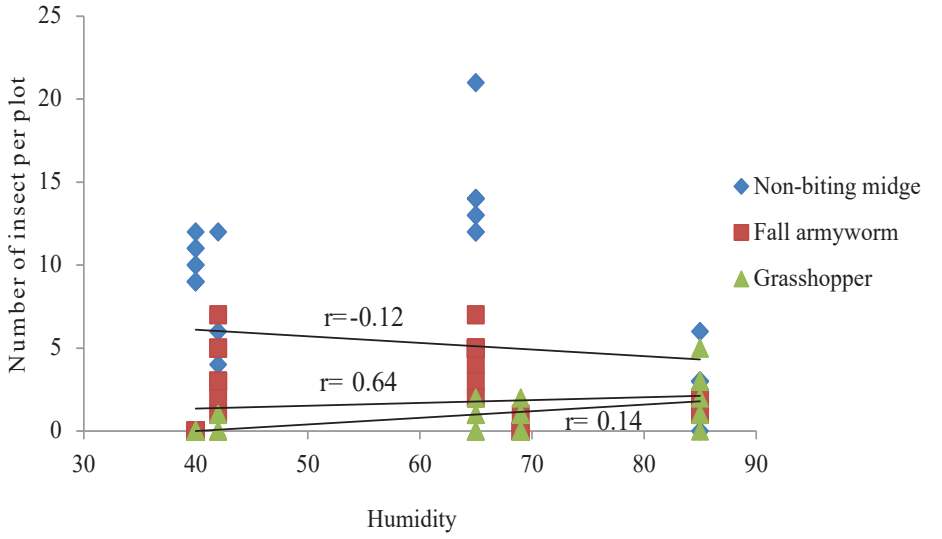


Fig. 7. Effect of relative humidity on the pests population of maize in Sylhet

The relation of relative humidity with both lady bird beetles and tachinid flies has a positive slope (r = 0.31), (r= 0.07), respectively. These results signify that lady bird beetle has a stronger relation with relative humidity than tachinid fly (Fig. 8).

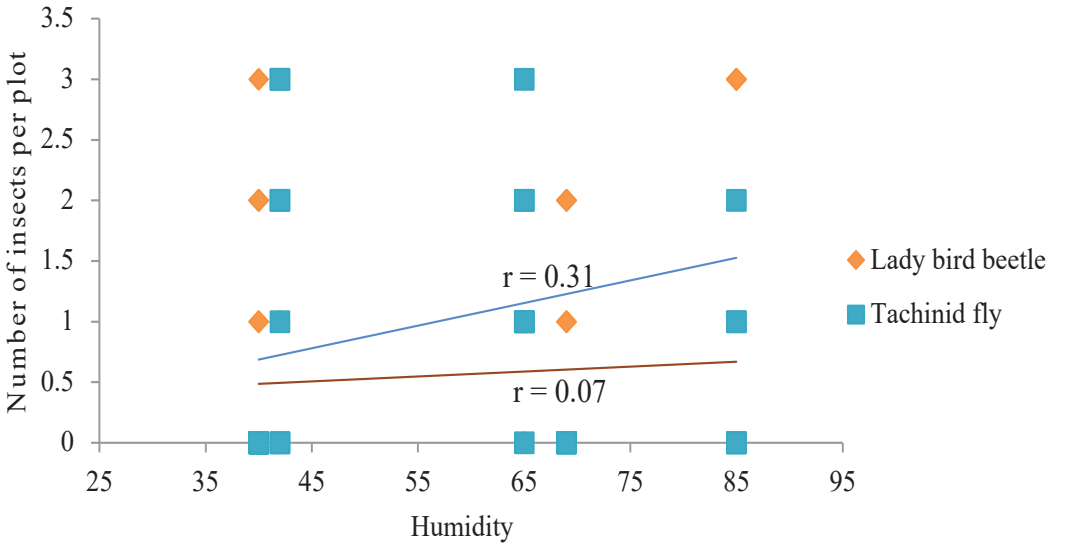


Fig. 8. Effect of relative humidity on natural enemies' populations of maize crop in Sylhet

DISCUSSION

Our study revealed the presence of seven insect species which belong to six different orders. Among the species, non-biting midge were the most dominant species followed by fall armyworm, cutworm, ladybird beetle, grasshopper, tachinid fly and spider. Dhillon *et al.* (2013) mentioned armyworms, cutworms, earworms, grain moths and borers as the most devastating pest of maize. Non-biting midges are not major arthropod associated with maize plant. The high abundance of midges in our experimental area could be due to their preference for aquatic habitats, as our site was located near a riverside (Naser and Roy 2012).

Our results also signified that 51% of the arthropods found in the maize field did not show any significant impact and acted as neutral species whether 30% of the arthropods exhibited as pest, 10% was predator, 5% was parasitoid, and 4% was pollinator. Among these, diptera was the most abundant insect order followed by lepidoptera, coleoptera, orthoptera, hymenoptera, and hemiptera. Kane *et al.* (2023) checked insect pest of maize where heteroptera was dominant order followed by coleoptera and orthoptera. The variation in insect order abundance could be attributed to factors such as genetic variation of crop, habitat complexity, crop diversification, and agricultural practices (Meena *et al.* 2023, He *et al.* 2019).

The present study exhibited that cutworms were observed only at seedling stage. Cutworm larvae cut the stem of maize seedlings near soil surface. A sixth-instar-cutworm larva cause significant damage to seedlings (Devi 2020). In contrast of cutworms, honeybees were prevailed at reproductive stage. In male flowers of maize, 97.13% of the flower visitors were honeybees (Abrol 2012). Though maize is wind-pollinated crop, but the presence of honeybee significantly enhances number of seed set (Alemberhe and Gebremeskel 2016). Fall armyworm, grasshopper, tachinid fly, and spider were observed in both vegetative and reproductive stage. Fall armyworms are one of the most severe pests of maize responsible for 60% of yield loss in maize by feeding the plant's young tissues (Hernández-Trejo *et al.* 2018). Grasshoppers cause minimal damage to corn during their immature stages; however, once they reach adulthood, they migrate to the field edges, feeding on leaves, the tips of the ears, and sometimes chewing on the stalks. In cases of severe infestation, they can completely strip the plants, leading to the destruction of most of the field (Hernández-Zul *et al.* 2012). Tachinid flies are parasitoid that can be

used to reduce the population of fall armyworms in maize fields (Hernández-García *et al.* 2021). Non-biting midge and ladybird beetle were recorded throughout the growing season of maize. Ladybird beetles are effective to control pest population in maize field (Nyukuri *et al.* 2012). The study also checked the correlation among the environmental factors (temperature, humidity) with pests and natural enemies. Preference of temperature and humidity varies from species to species. Non-biting midge, fall armyworm, and tachinid fly showed a positive correlation with temperature while grasshopper and ladybird beetle showed a negative correlation with temperature. Additionally, fall armyworm, grasshopper, ladybird beetle, and tachinid fly represent a positive correlation with relative humidity while non- biting midge showed a negative correlation. Temperature and humidity showed a great impact on population dynamics, developmental and survival responses (Régnière *et al.* 2012, Khan *et al.* 2018).

CONCLUSIONS

Maize (*Zea mays*), is a very new crop in Sylhet district of Bangladesh. This is the first report where the abundance and diversity of insect pests of maize in Sylhet were documented. The study categorized the pests and beneficial arthropods and also documented the presence of insect pests at different growth stages of the maize, providing a comprehensive understanding of insect pests dynamics of maize in Sylhet. This research provides a foundation for developing effective integrated pest management (IPM) strategies. The successful documentation of pest diversity and abundance will aid in the implementation of targeted pest management in different stages of maize, conserving natural enemies, ultimately supporting sustainable maize cultivation and improving its yield in Sylhet.

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EFFICACY OF BIOPESTICIDES AND INSECTICIDES AGAINST FALL ARMYWORM, *SPODOPTERA FRUGIPERDA* (LEPIDOPTERA: NOCTUIDAE) ON MAIZE

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ABSTRACT

The fall armyworm (FAW), *Spodoptera frugiperda* was first recoded in Bangladesh on November 18, 2018, FAW had posed a major threat to maize production. To assess the effectiveness of different biopesticides and insecticides against FAW, a field study was conducted at the Bangladesh Wheat and Maize Research Institute (BWMRI) in 6 February 2020. The study tested virus-based bio-pesticides and newly formulated organic insecticides. Results showed that chemical insecticides were generally more effective than bio-pesticides in reducing infestation during the vegetative stage. However, during the reproductive stage, both chemical and bio-pesticide treatments significantly reduced cob infestation compared to untreated control plots. Among the tested insecticides, Spinosad 45SC (Tracer) provided effective control of small fresh windowpane (SFW) symptoms, maintaining low infestation levels throughout the growing stages, peaking 46% at six leaf stage (V6) and then reducing 0% at the tasseling stage. Incidence of infested whorl (IW), was minimal, with only minor occurrence at tasseling stage (10%). In contrast, *Spodoptera Nuclear Polyhedrosis Virus* (Spodo-NPV) was less effective at the early stages, showing high infestation levels of FAW symptoms at V6 (68%) and IW symptoms beginning at seven leaf stage (V7) (26%) and peaking at eight leaf stage (V8) (38%). However, SNPV proved effective in reducing both SFW and IW symptoms at the tasseling stage. *Spodoptera frugiperda MNPV* 32% (Fawligen) showed moderate control over immature larvae, with infestation levels decreasing from V6 (44%) at tasseling (0%). However, IW-type damages were more persistent, peaking at V8 (86%) and remaining at a significant level (10%) even at tasseling stage. In terms of yield, maize grain production was highest in plots treated with bio-pesticides. Fawligen-treated plots produced the highest yield (4594 ± 84 kg/ha), followed closely by Spodo-NPV (4522 ± 128 kgha^{-1}) and Spinosad 2.5% SC (Success) (4286 ± 285 kgha^{-1}). Based on these findings, Spodo-NPV and Fawligen are recommended for FAW control infesting maize crops, as they are both effective and safe for human health and environment.

Keywords: Fall Armyworm, Maize yield, Spinosad, *Spodoptera NPV Polyhedrosis Virus*, *Spodoptera frugiperda* MNPV, Chlorantraniliprole

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INTRODUCTION

Maize is the second most widely grown cereal crop in Bangladesh in terms of acreage and production. Its value has been rising steadily in recent years due to high demand from the poultry, dairy and fish farming industries. With its low production costs, higher profitability, strong demand in the poultry sector and resilience compared to other crops, many farmers have shifted from rice and wheat to maize cultivation (Kausar and Alam 2016). In addition to its use in animal feed, maize is also increasingly consumed by people in forms such as popcorn, baby corn and sweet corn. During the 2020-21 and 2021-22 *Rabi* and *Kharif* seasons, approximately 480,000 and 398,400 hectares of land were cultivated for maize, producing roughly 4.2618 and 4.1164 million metric tons of grain, respectively (BBS 2022). According to the 2023 report by the Department of Agricultural Extension (DAE), maize production reached 6.4220 million metric tons, covering an area of 496,882.34 hectares.

The intensification of maize cultivation, coupled with climate change, evolving resistance in plant pathogens, the introduction of invasive pests and indiscriminate pesticide use, has disrupted agro-ecosystem balance, highlighting the need for strategic management approaches in food production (Del 2017). Maize yields in Bangladesh are relatively low compared to other countries, primarily due to infestations by insect pests and diseases. Various pests attack maize at different growth stages, from planting to harvest. These include *Spodoptera* species, maize borers, jassids, and shoot flies. Among these, fall armyworm (*Spodoptera frugiperda* Smith) has gained particular attention for its potential to cause significant crop losses (Gondal *et al*. 2022). Growing crops with different growth cycles like summer-planted corn, cotton and millet during off-season periods creates conditions that allow *Spodoptera frugiperda* to move between plant species (Nagoshi 2009). This movement may explain why this pest has become more prevalent in crops where it was previously considered occasional or secondary insect pest (Barros *et al*. 2010).

The fall armyworm (*S. frugiperda*) is an invasive and highly destructive insect pest that originated in the America but has since spread globally. It was first reported in African regions such as Benin, Togo, and Nigeria (Nagoshi *et al*. 2019)

before reaching various states in India and subsequently spreading throughout Asia. Recently, the fall armyworm has also been detected in Bangladesh (Alam *et al*. 2018). In maize crops, the FAW causes substantial production losses due to the voracious feeding behavior of its larvae and its presence throughout the crop cycle. Yield losses can range from 34% to 40%, depending on the plant's developmental stage (Cruz 2002). The last three larval stages of the fall armyworm are especially damaging, consuming up to 98% of the maize crop. The larvae tend to feed on nearly all parts of the plant, showing a strong preference for reproductive components, particularly in the final instar stage. During the maize whorl stage, larvae reside inside the whorl, feeding on leaves and stems. This feeding behavior can suppress proper tassel formation or induce it prematurely. Larval injury to the cob silk reduces the chances of pollination and lowers the number of kernels per ear. FAW larvae also damage the cob directly by tunneling and feeding on kernels, which weakens the attachment at the ear base. After feeding, leaves display irregular white markings and a mesh-like appearance due to the larvae's chewing mouthparts, which promotes fungal growth (Acharya *et al*. 2020).

This species poses a serious threat to food security in Bangladesh, highlighting the urgent need for an effective and comprehensive management strategy to control this destructive pest. It is essential to conduct studies evaluating the effectiveness of chemical insecticides on target pests, as the adaptability of a population can vary with different developmental stages (Cruz 2002). Research on *Helicoverpa armigera* (Lepidoptera: Noctuidae) has shown that young caterpillars are highly susceptible to insecticides, whereas control efficacy declines significantly when insects reach more advanced stages. Additionally, in field conditions, insect generations are often asynchronous, with individuals at various developmental stages coexisting in the same area (Lucchini 1977). Managing this pest has required frequent insecticide applications, leading to the development of resistance in *S. frugiperda* populations to various products (Wang *et al.* 2018). This increased reliance on chemical control has also raised environmental concerns (Michelotto *et al*. 2017).

These studies are essential insights for managing pest species effectively (Sosa-Gómez and Omoto 2012). Given the significant threat posed by the Fall Armyworm (FAW) caterpillar and the limited research on chemical control efficacy

in maize production, this study aimed to assess the performance of some selected biopesticides and newly formulated chemical insecticides in controlling *S. frugiperda* under field conditions.

MATERIALS AND METHODS

This study was carried out at the research field of Bangladesh Wheat and Maize Research Institute (BWMRI) in 6 February 2020. The variety, Khoi Bhutta (popcorn) was used for this study. Insecticides used in this study are biopesticides and new molecule synthetic compounds with high LD_{50} values which signify decreased toxicity.

Maize field: A power-operated tractor was used to prepare the land, making sure that the tilling was deep enough, loose, and fine enough to promote healthy seed germination. The spacing between maize seeds was 25 cm and 60 cm from row to row. The rate of fertilizers was applied for one hectare of land as 260 kg of urea, 180 kg of TSP, 180 kg of MoP, 150 kg of gypsum, 10 kg of zinc sulfate, 8 kg of boric acid, and 100 kg of magnesium sulfate. One-third of urea along with all other fertilizers were applied during final land preparation prior to sowing. Half of the remaining urea is applied 30 days after planting (at the stage of 6 leaves), and the other half is applied 60 days after sowing, when the male flowers (tassels) appear. Weeding and irrigation were carried out as needed. The size of the experimental plot was 10m by 10m.

Treatments: The treatments, including biopesticides and synthetic new molecule insecticides were used in this study viz., Spodo-NPV (*Spodoptera Nuclear Polyhedrosis Virus*) @ 0.2g/ L water, Fawligen (*Spodoptera frugiperda* MNPV32%) @0.3ml/L water, Tracer 45SC (Spinosad 45%) @ 0.4ml/L water, Coragen 18.5% SC (Chlorantraniliprole) @0.5ml/ L water, Success 2.5%SC (Spinosad) @ 1.3ml/L water and Untreated control (Table 1). Four times spraying was planned to begin at 30 days after sowing and continued 7 days after that. Secondly, at 60 days after sowing and spraying was continued 7 days after that.

Leaf infestation: Leaf infestation data was collected in situ condition after the incidence of fall armyworm infestation. Data was collected from five spots of each

plot as maintained "W" pattern method. Ten plants per plot were examined, and the number of FAW-infested plants-either Small Fresh Windowpane (SFW) or Infested Whorl (IW)-was noted. Attach on that the top three leaves were considered as new infestation.

Cob infestation: Cob samples were taken from 2m by 3 rows (2 m × 1.8 m = 3.6 m^2) of maize plants in the field once the cobs had matured. A 3.6 m^2 unit area was used to record the number of plants, cobs, percentage of infested cobs, intesity of cob infestation and yield data. From one plot, three samples were taken. For every treatment, nine samples (3 samples x 3 replications) were created. A visual scale was used to collect data on the percentage of cob infestations and the scales were then converted to percentage damage (Williams *et al*. 2006). Percent cob infestation was calculated using following formula:

$$\text{Percent cob infestation} = \frac{\text{Number of infested cobs}}{\text{Total number of cobs}} \times 100$$

The percentage intensity of the infestation was determined by the area of a cob that was infested. Data on grain yield were taken into account with a moisture content of 14% and expressed as kilogram per hectare.

Table 1. Bio pesticides and insecticides applied against Fall Armyworm in maize production.

Treatments (Trade name)	Active ingredient	Manufacturer	Doses (ml/l water)	Group	WHO hazard category
Spodo-NPV	Spodoptera Nuclear Polyhedrosis Virus	Ispahani Agro Ltd, BD	0.2g/ l	Microbial pesticide	III
Fawligen	Occlusion bodies of *Spodoptera frugiperda* MNPV-3AP2: 32%; Other ingredients: 68%	AgBiTech LLC, TX 76155, USA	0.3ml/ l	Microbial pesticide	III
Tracer	Spinosad 45%	Auto crop care Ltd, BD	0.4ml/l	Newer	III
Coragen	Chlorantraniliprole 18.5%	Petrochem Agro-Industries Ltd, BD	0.5ml/ l	Newer	U
Success	Spinosad 2.5%	Auto crop care Ltd, BD	1.3ml/l	Newer	III
Untreated control	Water	-	-	-	-

III= slightly hazardous, U= unlikely to present acute hazard

Data analysis: Three replications were considered as part of the Randomized Complete Block Design (RCBD) design used in this study. CropStat 7.2 was used to analyze the data using balanced analysis of variance. Five spots in each plot, each with ten plants in compliance, were used to calculate the mean data of leaf infestation. Each figure represents a single treatment and three replications of each treatment were used. After being converted into square root values, the data on the percentage of leaf infestation was examined. Three locations from each plot were used to collect data for the yield and yield contributing attributes; each spot was kept at a size of 2 m × 1.8 m (3 rows) = 3.6 m^2 unit area. ANOVA was used to analyze the percentage data at the 5% level of significance.

RESULTS AND DISCUSSION

Effect of bio pesticides and insecticides on Fall armyworm infestation in maize: The Table 2 illustrated the efficacy of different treatments (Spodo-NPV, Fawligen, Tracer, Coragen, Success, and a Control) on FAW infestation at various maize plant growth stages: four leaf stage (V4), six leaf stage (V6), seven leaf stage (V7), eight leaf stage (V8) and tasseling stage. For each stage and treatment, percent infestation values were recorded with significance levels indicated. In the maize growth stages, mainly focused on two specific symptoms: Small Fresh Windowpane (SFW) like damage caused by immature FAW larvae and Infested Whorl (IW) like damage caused by mature FAW larvae. The significance of differences was assessed with Least Significant Difference (LSD) values and P-values, with significant differences denoted at a 1% level (**).

After application of pesticides, *Spodoptera Nuclear Polyhedrosis Virus* (SNPV) was not so effective at initial stages SFW infestation begins at 4% in the V4 stage, peaks at 68% in the V6 stage and reduces significantly, reaching 0% by the tasseling stage. In the IW symptoms there was no infestation at V4 and V6 stages, started at the V7 stage (26%) and infestation rise sharply to 38% by V8 before dropping to 6% by the tasseling stage. But effective in reducing both SFW and IW symptoms at the tasseling stage. Total infestations were low, with a notable peak of 68% at the V6 stage. This suggests that while SNPV offers some control, it might not prevent early infestations effectively. SNPV showed mixed effectiveness, reducing infestation at tasseling stage but with higher levels at earlier stages. This aligns with

findings on biopesticides, which often need repeated applications to maintain low pest levels (Geisler *et al*. 2024).

Spodoptera frugiperda MNPV32% (Fawligen) showed a moderate control over immature larvae starts with 8% infestation at V4, with a peak of 44% at V6 before falling to 0% at the tasseling stage. But IW type damages were more persistent, infestation were absent in early stages, but rises to 86% at V8 before reducing to 10% at tasseling stage. Total incidence showed high infestation at V8 with 90%, indicating substantial efficacy at early stages but less control at V8. Fawligen's high infestation levels during V6 and V8 stages suggest its limited efficacy in controlling mid-stage infestations, though it provided eventual control. Studies have shown that Fawligen can be effective under specific conditions but may require supplementary treatments at high-pressure pest environments (Prasanna *et al.* 2018).

On the other hand, chemical pesticides provided strong control over both SFW and IW symptoms. Tracer effectively controlled SFW symptoms with low levels of infestation throughout the stages, begins with no infestation at V4, spikes at 46% at V6, and remains low afterward, reaching 0% by the tasseling stage. IW symptoms were negligible; there is no infestation at early stages, with a peak only at the tasseling stage (10%). Total infestations showed generally low infestation, with a slight peak in V6 and minimal infestation afterward, showing effective control overall. Tracer's low infestation rates and maintained control through tasseling stage reflect its effectiveness, especially as a spinosad-based pesticide known for rapid pest control with minimal environmental impact (Wang *et al.* 2021).

Chlorantraniliprole (Coragen 18.5% SC) maintained good control SFW symptoms showed a low initial infestation, peaking at 44% in the V6 stage before declining to 0% at tasseling stage and IW symptoms was minimal, with a small peak at V8 (4%) and 8% at tasseling stage. Total infestations remains low, suggesting effective control. Coragen's consistent pest suppression aligns with prior studies highlighting chlorantraniliprole's efficacy in targeting FAW without harming beneficial insects (Huang *et al.* 2020). Its extended control through multiple growth stages emphasizes its reliability.

Success 18.5% SC also provided consistent control showed a reduction in SFW symptoms started with 6% infestation, peaks at 52% at V6 and remains low

afterward and IW Infestation is minimal, with minor peaks in later stages but reaches 0% at the tasseling stage. Total infestations showed moderate control with a lower infestation profile than untreated Control. Success effectively reduced infestation at tasseling stage, though it had slightly higher peaks than other chemical treatments. This indicated that might be beneficial as part of an integrated pest management (IPM) approach (Mendesil *et al*. 2024).

Finally, the control group experienced the highest levels of both SFW and IW Infestation begins low but reaches the highest levels by V8 (94%) and remains high at the tasseling stage (46%). Total infestations remained high throughout the stages, highlighting the need for effective control measures. Lack of treatment in the control plot resulted in severe infestation indicating the importance of applying pesticides.

Overall, SNPV and Fawligen had showed less capability to control both immature and mature larvae of FAW. That might be high temperature in that period (month of April 2020) where virus based bio-pesticides did not function effectively. The results show that Tracer and Coragen treatments were most effective in reducing FAW infestation across growth stages, with low infestation levels observed throughout. SNPV and Fawligen also provide control but have higher infestation peaks during the V6 and V8 stages. The Control group shows persistently high infestation, underscoring the necessity of treatments to manage FAW effectively.

These results demonstrate that Coragen and Tracer provided the most consistent control across different growth stages, effectively reducing infestation at tasseling stage. The biocontrol agents SNPV and Fawligen also contributed to pest suppression but showed fluctuating efficacy, especially at the V6 and V8 stages, which aligns with challenges in achieving full pest control with biopesticides at high-pest-pressure environments (Lacey *et al*. 2015). The untreated Control group experienced consistently high infestation, emphasizing the necessity of pest management strategies. Without intervention, FAW causes significant yield and quality losses, and integrated approaches combining chemical and biocontrol methods may optimize pest management effectiveness (De Groote *et al*. 2020).

Effect of bio pesticides and insecticides on plant growth, yield contributing characters and cob infestation in maize: Table 3 summarized the detailed analysis

of the data on plant population, cob count, cob infestation, and infestation intensity in maize after applying various treatments. This information provides insight into how different treatments affect plant productivity and pest infestation levels.

Plant number/3.6 m²: Across all treatments, the number of plants per 3.6 m² was fairly consistent, ranging from 24.8 (Fawligen) to 26.4 (Coragen). The untreated Control had 25.2 plants, indicating that treatment applications did not significantly show the impact on plant population density.

Cob number/3.6 m²: Cob number varied slightly, with Success produced the highest average number of cobs (27.6 per 3.6 m²) followed by Fawligen (27.0) and Coragen (27.0), while the Control had the lowest (23.6). Treated plots showed an increase in cob number compared to the control. Success treated plot had the highest cob number increase over control at 16.95%, followed closely by Coragen and Fawligen (both at 14.41%). The increase in cob count suggests that insecticide applications potentially reduced pest pressure, allowing plants to allocate more resources toward reproductive growth, resulting in higher cob counts. The increase in cob count suggests that insecticide applications potentially reduced pest pressure, allowing plants to allocate more resources toward reproductive growth, resulting in higher cob counts.

Table 2. Mean percent infestation of FAW observed at different stages of plant growth after treatments application

Treatments	Infestation types	Percent infestation				
		V4 (26.3.2020)	V6 (5.4.2020)	V7 (12.4.2020)	V8 (20.4.2020)	Tasseling (4.5.2020)
SNPV	SFW	4.0 (1.5)	68.0 (8.2)	6.0 (1.9)	4.0 (1.5)	0.0 (0.7)
	IW	0.0 (0.7)	0.0 (0.7)	26.0 (4.9)	38.0 (6.1)	6.0 (2.2)
	Total	4.0 (1.5)	68.0 (8.2)	32.0 (5.5)	42.0 (6.4)	6.0 (2.2)
Fawligen	SFW	8.0 (2.5)	44.0 (6.6)	22.0 (4.7)	4.0 (1.5)	0.0 (0.7)
	IW	0.0 (0.7)	0.00 (0.7)	36.0 (6.0)	86.0 (9.3)	10.0 (2.7)
	Total	8.0 (2.5)	44.0 (6.6)	58.0 (7.6)	90.0 (9.5)	10.0 (2.7)

Treatments	Infestation types	Percent infestation				
		V4 (26.3.2020)	V6 (5.4.2020)	V7 (12.4.2020)	V8 (20.4.2020)	Tasseling (4.5.2020)
Tracer	SFW	0.0 (0.7)	46.0 (6.5)	2.0 (1.2)	2.0 (1.2)	0.0 (0.7)
	IW	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	10.0 (2.7)
	Total	0.0 (0.7)	46.0 (6.5)	2.0 (1.2)	2.0 (1.2)	10.0 (2.7)
Coragen	SFW	2.0 (1.2)	44.0 (6.6)	6.0 (1.9)	0.0 (0.7)	0.0 (0.7)
	IW	0.0 (0.7)	0.0 (0.7)	2.0 (1.2)	4.0 (1.5)	8.0 (2.5)
	Total	2.0 (1.2)	44.0 (6.6)	8.0 (2.5)	4.0 (1.5)	8.0 (2.5)
Success	SFW	6.0 (1.9)	52.0 (7.2)	12.0 (2.8)	2.0 (1.2)	0.0 (0.7)
	IW	0.0 (0.7)	0.0 (0.7)	4.0 (1.5)	6.0 (1.9)	0.0 (0.7)
	Total	6.0 (1.9)	52.0 (7.2)	16.0 (3.6)	8.0 (2.2)	0.0 (0.7)
Control	SFW	54.0 (7.3)	80.0 (8.9)	10.0 (2.7)	2.0 (1.2)	0.0 (0.7)
	IW	0.0 (0.7)	0.0 (0.7)	58.0 (7.5)	94.0 (9.7)	46.0 (6.6)
	Total	54.0 (7.3)	80.0 (8.9)	68.0 (8.1)	96.0 (9.8)	46.0 (6.6)
LSD at 5%	SFW	1.79	1.93	2.27	1.65	0.00
	IW	0.00	0.00	1.60	1.69	1.87
	Total	1.79	1.93	2.15	1.85	1.87
P	SFW	**	ns	Ns	ns	Ns
	IW	ns	ns	**	**	**
	Total	**	ns	**	**	**

Values in the parentheses were transformed into square root, ** = significant at 1% level, ns = non-significant. SFW = Small Fresh Windowpane, IW denoted as Infested Whorl, V4 =four leaf stage, V6=Six leaf stage, V7=Seven leaf stage, V8= Eight leaf stage and Tasseling= Tasseling stage

Cob infestation (%) and percentage decrease in infested cobs over control: Rate of cob infestation ranged from a low of 12.2% in the Coragen treatment to a high of 22.9% in the untreated control. Notably, Coragen had the most effective in reducing infested cobs, indicating strong efficacy in limiting pest impact on cobs. The Control group had the highest infestation rate, suggesting that pest control measures significantly showed impact on cob quality. In terms of percentage decrease in infested cobs over control, Coragen treatment achieved the highest reduction (46.72%), indicating strong efficacy against pests. Fawligen and SNPV also showed substantial decreases (28.82% and 33.62%, respectively). This suggests that Coragen may have superior effectiveness in reducing cob infestation in maize.

Infestation intensity: Infestation intensity was markedly higher in the untreated control plot, with an average of 14.6%, compared to treated plots, which ranged between 3.4% (Fawligen) and 4.6% (Success). Coragen and Tracer also exhibited reduced infestation intensity, aligning with their lower cob infestation rates. The reduction in intensity suggests that treatments, particularly Fawligen, are effective not only lowering infestation rates but also reducing the severity of pest damage to the maize cobs.

The results demonstrate that Coragen was the most effective treatment in reducing cob infestation (12.2%) and keeping infestation intensity low (4.2%). This aligns with studies showing that Coragen, an insecticide with chlorantraniliprole as the active ingredient, provides potent, targeted action against fall armyworm (FAW) and minimizes crop damage in maize, effectively protecting yield and quality (Wang *et al*. 2023).

Fawligen, a bio-pesticide based on entomopathogenic viruses, also performed well, with the lowest infestation intensity (3.4%). Biopesticides like Fawligen effectively target pests without harming beneficial organisms or the environment. They are increasingly being adopted for sustainable agriculture due to their targeted pest control and minimal environmental impact (Lacey *et al*. 2015). While Tracer and Success showed reasonable control of cob infestation and reduce intensity, Success treated plot had slightly higher infestation (17.4%) than other treatments. However, it resulted the highest cob production (27.6 cobs per unit area). The higher cob number may reflect improved plant health due to treatment application but could also be due to environmental conditions favoring cob formation in the particular

plot. In contrast, the untreated control had the highest levels of cob infestation (22.9%) and intensity (14.6%). These results highlight the necessity of pest control measures against FAW, as untreated plots not only have higher pest damage but may also experience yield losses. Studies corroborate that untreated maize plots can experience substantial yield loss due to FAW, with reductions in cob quality and size directly reduce marketability (De Groote *et al.* 2020).

Overall, these findings suggest that Coragen and Fawligen are effective in managing FAW infestation while promoting sustainable crop health. The non-significant results for plant number and cob count indicate that treatment effects on FAW were more directly associated with reduced infestation intensity rather than plant or cob density.

Table 3. Effect of insecticides on growth, yield contributing characters and cob infestation in maize crop

Treatments	Plant number/ 3.6m²	Cob number/ 3.6m²	Cob number increased over control (%)	Infested cob (%)	Infested cob decreased over control (%)	Intensity (%)	Intensity decreased over control (%)
SNPV	25.8 ± 0.2	26.8 ± 0.9	13.56	15.2 ± 4.4	33.62	4.2 ± 1.5	64.38
Fawligen	24.8 ± 0.4	27.0 ± 0.7	14.41	16.3 ± 1.4	28.82	3.4 ± 0.5	76.71
Tracer	25.2 ± 0.5	26.8 ± 0.2	13.56	16.4 ± 3.0	27.95	4.2 ± 0.9	71.23
Coragen	26.4 ± 0.2	27.0 ± 0.8	14.41	12.2 ± 3.3	46.72	4.2 ± 0.6	71.23
Success	25.8 ± 0.7	27.6 ± 1.7	16.95	17.4 ± 1.4	24.02	4.6 ± 0.4	68.49
Control	25.2 ± 0.4	23.6 ± 0.7	-	22.9 ± 0.7	-	14.6 ± 3.5	-
LSD at 5%	1.28	2.58		6.87		4.79	
P	ns	ns		ns		**	

** denoted as significant at 1% level; ns for non-significant

Effect of various insecticides applied against Fall Armyworm in Maize: The Figure 1 illustrated the yield of maize crops (measured in kg/ha) following the application of different treatments aimed to controlling fall armyworm (FAW) infestations. The results were evaluated for statistical significance with an LSD at 5% and the significance level is denoted at 1% (**), indicating meaningful differences among the treatments.

Fawligen (a Biocontrol Agent) treatment achieved the highest yield in the study, 4594 ± 84 kg/ha. This yield indicated strong efficacy in pest suppression by

Fawligen, possibly due to its compatibility with the FAW lifecycle and ability to manage infestations with minimal crop damage.

Yield with SNPV treatment reached 4522 ± 128 kg ha^{-1}, indicating that SNPV provided effective pest suppression, supporting a high yield comparable to other biocontrol agents. This suggests that SNPV is a viable option for integrated pest management (IPM) as it successfully minimized yield losses due to FAW attack without the use of chemical pesticides. Tracer treatment resulted in a comparatively lower yield of 4183 ± 55 kg ha^{-1}. While Tracer effectively suppressed infestation in earlier growth stages, this lower yield suggested that it may not provide extended protection throughout the season. The data shows that Fawligen and SNPV were the most effective treatments in terms of yield, with 4594 ± 84 kg/ha and 4522 ± 128 kg ha^{-1}, respectively, demonstrating the effectiveness of biocontrol agents in managing FAW without sacrificing crop productivity. This aligns with findings from other studies that show biocontrol agents can sustain high yields while maintaining environmental sustainability (Prasanna *et al*. 2018). The success of these biocontrol treatments supports their integration into IPM programs, particularly in regions where FAW is prevalent.

Coragen (Chlorantraniliprole-based Insecticide) treatment resulted in a yield of 4153 ± 238 kg ha^{-1}, which is moderate but effective in reducing FAW damage to a significant extent. Chlorantraniliprole's targeted mode of action against borer insects like FAW likely contributed to a more stable yield compared to Tracer. Success (Spinosad-based Insecticide) treatment resulted in a yield of 4286 ± 285 kg ha^{-1}, which is close to Coragen's yield and suggests a moderate level of pest control. Spinosad has shown efficacy in controlling FAW, likely contributing to reduced crop damage and resulting higher yield.

Coragen and Success (yielding 4153 ± 238 kg ha^{-1} and 4286 ± 285 kg ha^{-1}, respectively) were effective at moderating FAW infestation and maintained yields above the untreated control plot. These insecticides are known for their targeted modes of action and are highly effective in protecting maize crops from FAW without causing significant harm to beneficial insects. This is especially valuable in IPM frameworks, where selective control agents like Coragen and Success can reduce environmental impact while effectively managing the pests (Huang *et al.* 2020).

Tracer (Spinosad-based Insecticide) resulted moderate yield (4183 ± 55 kg ha^{-1}), despite of its efficacy in suppressing infestation. Tracer's performance aligns with research indicating that while spinosad is effective against FAW at early stages, it may not provide sufficient season-long control, especially when pest pressure is high (Hertlein *et al*. 2011).

The untreated control plot had the lowest yield of 3692 ± 184 kg ha^{-1}, demonstrating the severe impact of FAW infestations on crop productivity. This highlights the necessity of implementing pest management strategies to avoid substantial yield losses in FAW-prone areas. The untreated control yielding 3692 ± 184 kg ha^{-1}, showed the highest crop losses. This highlights the importance of active FAW management to prevent economic losses, as untreated crops face significant reductions in yield due to uncontrolled infestations. Research has established that FAW infestations can cause yield reductions of up to 40% if left untreated, underscoring the need for effective pest management strategies (Day *et al*. 2017).

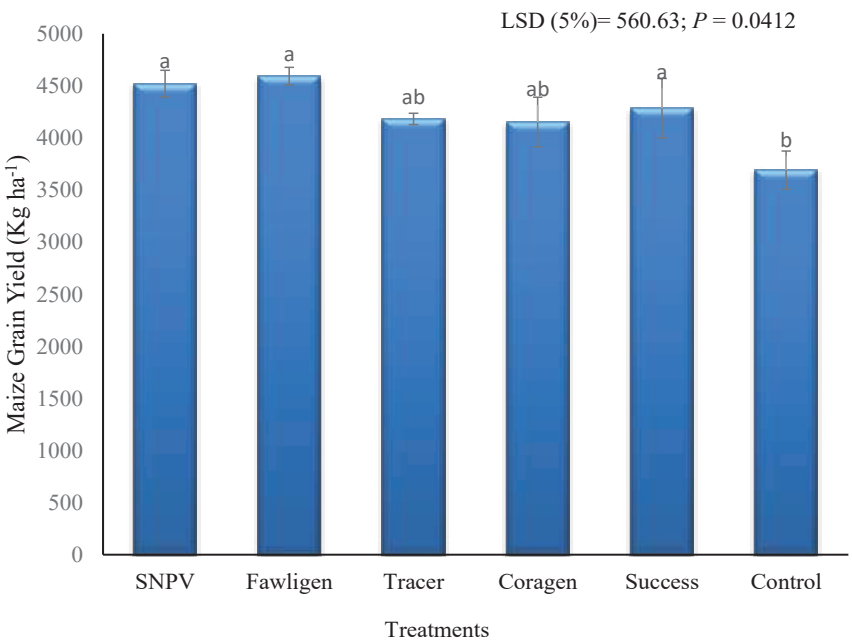


Fig. 1. Maize grain yield differed for using bio pesticides and insecticides applied for the management of Fall Armyworm.

Relationship between cob infestation (%)/3.6 m² and yield (kgha⁻¹) of maize: The data from Fig. 2 illustrated a linear relationship between the cob infestation (%)/3.6 m² and their yield per hectare (measured in kg). A negative correlation was evident between the cob infestation (%) and their yield. Specifically, for every one percent infestation increase in cob infestation (%)/3.6 m², the yield of maize per hectare decreases by 117.83 kg. A regression line was constructed to represent this association, formulated as y = -145.83x + 4748.7, where 'y' represented yield (kg ha⁻¹) and 'x' represented cob infestation (%)/3.6 m². The coefficient of determination, $R^2 = 0.7184$, indicated that 71.84% of the variability in maize yield per hectare was attributed to the variation in cob infestation (%)/3.6 m².

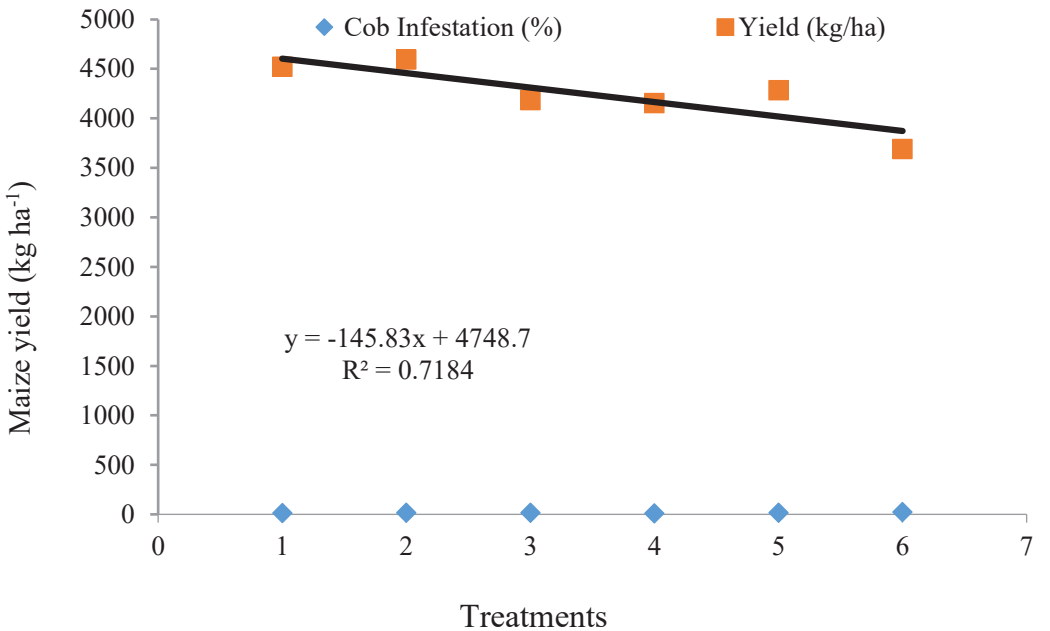


Fig. 2. Relationship between cob infestation (%)/3.6 m² and yield (kg ha⁻¹) of maize. Where, 'y' represented yield (kg ha⁻¹) and 'x' represented cob infestation (%)/3.6 m²

Relationship between total FAW infestation (%) and yield (kgha⁻¹) of maize: The relationship between the total FAW infestation (%) and yield per hectare (measured in kilogram) in the field was found to be linear (Fig. 3). There's a negative correlation between the width of total FAW infestation (%) and yield. Specifically, for every one percent increase in total FAW infestation (%), the yield of maize

per hectare decreases by 117.83 kg. A regression line was fitted to represent this relationship, expressed as y =-145.83x + 4748.7, where 'y' represented yield (kg ha^{-1}) and 'x' represented FAW infestation (%). The coefficient of determination, $R^2 = 0.7184$, indicated that 71.84% of the variability in maize yield per hectare was explained by the variation in FAW infestation.

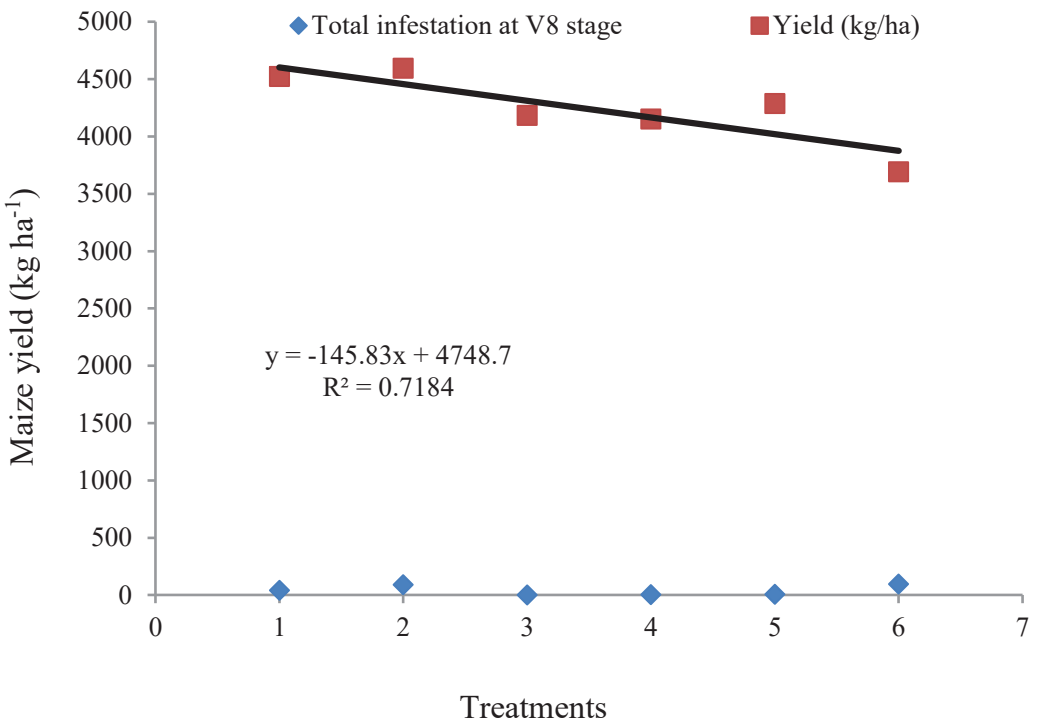


Fig. 3. Relationship between total FAW infestation (%) and yield (kg ha^{-1}) of maize grain. Where, 'y' represented yield (kg ha^{-1}) and 'x' represented total FAW infestation (%)

CONCLUSION

The application of biopesticides, such as SNPV and Fawligen, has proven highly effective in reducing FAW infestations and enhancing maize yields. Although infestation levels during the vegetative stage were somewhat higher with these treatments, SNPV and Fawligen demonstrated superior overall performance in FAW control and yield improvement. Tracer, Success, and Coragen were also effective

in managing FAW symptoms, though their impact on yield varied. Predictably, the control group showed consistently high infestation levels and the lowest yield, underscoring the critical importance of effective pest management in maize cultivation. Given the high yields, ecological safety, and health benefits associated with biopesticides, SNPV and Fawligen are particularly recommended for FAW management.

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LOCAL PEOPLE'S PERCEPTIONS AND KNOWLEDGE LEVELS ABOUT OWLS AND THEIR CONSERVATION TO COMBAT RATS IN THREE DISTRICTS OF BANGLADESH

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ABSTRACT

The study was aimed to assess the knowledge, perception and attitude of people about owl and their conservation to combat rats. During the survey more than 90 people were asked to collect information regarding the owl population from three localities of Gazipur, Rajshahi and Jashore districts. The survey was conducted about the farmer's knowledge, attitude, and perception of owls to combat rats. The questionnaire was divided into different parameters viz., familiarity, owl awareness, misconception, food habits and conservation aspects of owl. Most of farmers (77.22 %) replied that they had seen only one species whereas 23.33% farmers reported on two species, 3.33% farmers reported three species. The familiarity of respondent about the spotted owlet, eagle owl and barn owl was 50%, 43.33% and 32.22%, respectively. More than 70 % gave positive and 28.89% gave negative response about owl. About 87.77% thought that owl had no harmful effect on human and the environment, only 14.44% thought owl is not good for us. Maximum respondent (93.33%) opined that they were known about the food habit of owl. Out of them cent percent opined that rat is the main food of owl. More than 76% respondent mentioned that public awareness can be an important tool for owl conservation whereas 15.55% mentioned on creating un-disturbing habitat or reserve areas and only 7.77% respondent opined to encourae tree plantation program.

Keywords: Awareness, knowledge, familiarity, misconception, conservation, owls, survey combating rats.

INTRODUCTION

Rats are one of the most important pests in crop fields in tropical Asian countries. The female rat becomes sexually mature when it becomes 3-4 months old. In plantations and fields, a female rat can reproduce once in every two months, giving

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birth to between four and eight offspring per litter (Singleton et al, 2003). At this rate, the rat population has the potential to increase 500 times each year. Due to the high reproductive rate of rats, an "explosion" of rat population is a common occurrence in plantations if no adequate control measure taken. The Barn owl (*Tyto alba*) has been found to be a very effective biological agent for controlling rats. Its use not only increases farmers' income by reducing rice losses and saving the cost of chemical rat killer, but it also saves crop fields from chemical pollution. An additional benefit is that the farmers become less exposed to harmful chemicals (Shehab, 2005, Smal, 1987).

Globally, local ecological knowledge and its role in wildlife conservation are increasingly receiving much attention (Huntington 2011, Berkes *et al*. 2000, Mmassy and Roskaft 2013). Local ecological knowledge is valuable in areas where human communities live inside and around protected areas (Trakolis 2001, Gandiwa *et al*. 2012). This knowledge is derived from the long-standing relationships between local people and their surrounding environment resulting in local people having good understanding about natural resources conservation through resource use, education and conservation awareness programs (Jalilova and Vacik 2012, Gandiwa *et al*. 2014). Information about local people's knowledge and perceptions about conservation is important in conserving wildlife and evaluating the success of conservation projects (Soto *et al*. 2001, Sundaresan *et al*. 2012).

The symbolic beliefs often shape the way in which animals are socially perceived and could condition human attitudes toward them. According to the socio-environmental context, they could raise positive protection attitudes or, conversely, they could generate aggressive attitudes which affect biological conservation goals (Campbell and Lancaster 2010, Silva-Rodríguez *et al*. 2006, Marques 2005). For example, in some rural communities, local people believe that certain nocturnal birds bring news (bad and good) when their song is heard in the village. As a result, people traditionally protect these birds, killing them being forbidden (Aillapan and Rozzi 2004, Silva-Rodríguez *et al*. 2006)

Owl is an important biological control agent for rat management. In Bangladesh owl's species are gradually decreasing day by day due to lack of

breeding places. Owls create their nests usually in large tree hole. Large trees are gradually destroyed day by day and so their breeding sources are also decreased. Local people's perceptions and attitude are also important about owl for natural conservation. This type of information is scanty in Bangladesh. In this context, the present study was conducted to know the local people's knowledge, perceptions and attitudes about owls and their ways of conservation.

MATERIALS AND METHODS

The study was conducted at three locations of Bangladesh namely sadar upazila of Gazipur, Mohanpur upazila of Rajshahi and sadar upazila of Jashore districts during July 2018 to June 2019. The study used an interview-administered questionnaire. The questionnaire included both open-ended and fixed response questions. The questionnaire was designed to evaluate the knowledge and perceptions of local people about Owl. Interviews were conducted in residents' homes, gardens, places of business, or in village streets. Interviewers recorded all responses directly using standardized survey forms. All interviews were conducted by a research assistant who had successfully completed at least twelve years of Higher Secondary Education (HSC) recruited from the local community, through oral interviews carried out during day in local language. The total response time was approximately 15 to 25 min. The research assistant administering the survey made initial contact in each village with the local village leaders to seek permission. A total of 21 sampling sites were selected for the survey. The maximum sampling sites were in rural areas. The following parameters were the part of questionnaire viz., crop cultivation, rat damage intensity in cultivated crop, rat management, familiarity with owls (owl sighting, types of owls, choice of owl), misconceptions about owls (sign of bad omen), awareness about owls, owl food habit, usefulness of owls and conservation etc. Data were grouped and summed by response categories. The responses were recorded on a data sheet and later transcribed into English and entered into a Microsoft Excel 2010 database. Where multiple responses were possible on an open-response question, data are presented as the percentage (%) of respondents giving each response, and may sum to over 100%.

RESULTS

Cultivation, rat damage information and management: Bangladesh is an agricultural country where majority of the rural population are involved in crop cultivation. Almost all farmers were medium to poor financially. The main crop in Bangladesh is rice. There were some landless farmers cultivated vegetables and other crops as main crop in their homestead areas. Majority of farmers (84.44%) reported that rice was their main crop whereas 15.55% farmer reported to cultivated wheat and only 11.11% farmers opined that they cultivate vegetables as their main crops (Table 1).

Table 1. Farmers' response on cultivation of main crop in the study area during 2018-19

District	Farmers' response on			
	Rice	Wheat	Vegetables	Other
Rajshahi	23	10	7	-
(n=30)	(76.67%)	(33.33%)	(23.33%)	-
Gazipur	30	0	0	-
(n=30)	(100%)	(0.00%)	(0.00%)	-
Jashore	23	4	3	-
(n=30)	(76.67%)	(13.33%)	(10.00%)	-
Average	25.33	4.67	3.33	-
(n=30)	(84.44%)	(15.55%)	(11.11%)	-

The perceived main limitation to rice cultivation was insect pest followed by rat as the second most problems of this crop. About 51% farmers reported that their crop fields were moderately damaged by rat whereas 34.44% farmers reported high damage and only 14.44% famers reported that the intensity of rat damage in their crop fields was very high (Table 2).

Table 2. Farmers' response on damage intensity in rice and wheat by rat in the study area

District	Farmers' response on		
	Very high	High	Medium
Rajshahi	3	12	15
(n=30)	(10.00%)	(40.00%)	(50.00%)
Gazipur	0	0	30
(n=30)	(0.00%)	(0.00%)	(100%)
Jashore	10	19	1
(n=30)	(33.33%)	(63.33%)	(3.33%)
Average	4.33	10.33	15.33
(n=30)	(14.44%)	(34.44%)	(51.11%)

Farmer used a range of methods to control rats. Most of the farmers (83.33%) used poison baiting whereas 24.44% farmers attempted to control rat by setting trap in their crop field. A small number of farmers (3.33%) did not use either trap or poison as control measure (Table 3), they used only some indigenous techniques for controlling rodents in their crop fields.

Table 3. Farmers' response on rat management techniques generally used for controlling the rats in their crop fields

District	Farmers' response on		
	Setting traps	Poison baiting	Others
Rajshahi (n=30)	16 (53.33%)	24 (80.00%)	0 (0.00%)
Gazipur (n=30)	0 (0.00%)	30 (100.00%)	0 (0.00%)
Jashore (n=30)	6 (20.00%)	21 (70.00%)	3 (10.00%)
Average (n=30)	7.33 (24.44%)	25 (83.33%)	1 (3.33%)

Familiarity with owls: Out of the total 90 people who responded to the questionnaire, 97.77% were familiar with owl whereas only 2.22% farmers had not seen owl in their entire life time (Table 4). The species related awareness varied among respondent of various locations in the study area. Most of the farmers (77.22 %) replied that they had seen only one species whereas 23.33% farmers reported two species, 3.33% farmers reported three species and only 1.11% farmers had seen more than three species is their localities (Table 5). On species related awareness of owls, they did not know the species name. They were able to express only the local names of observed owl species. Fifty percent farmers indicated owl species having little spotted owlet whereas 43.33% farmers mentioned it as an Eagle Owl) and only 32.22% farmers observed the Burn owl (Table 6).

Table 4. Farmers' response on the status of Owl as familiar bird in the study area

District	Farmers' response on owl observation	
	observed	Not observed
Rajshahi (n=30)	28 (93.33%)	2 (6.67%)
Gazipur (n=30)	30 (100%)	0 (0.00%)
Jashore (n=30)	30 (100%)	0 (0.00%)
Average (n=90)	29.33 (97.77%)	0.66 (2.22%)

Table 5. Farmers' response on the number of owl species known to them in the study area

District	Farmers' response on no. of owl species			
	One	Two	Three	Four
Rajshahi (n=30)	15 (50.00%)	15 (90.00%)	0 (0.00%)	0 (0.00%)
Gazipur (n=30)	30 (100%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Jashore (n=30)	20 (66.67%)	6 (20.00%)	3 (10.00%)	1 (3.33%)
Average (n=90)	21.66 (72.22%)	7 (36.66%)	1 (3.33%)	0.33 1.11%)

Table 6. Farmers' response on the name of owl species known by them in the study area

District	Farmers' response on owl species known to them			
	Barn owl	Eagle owl	Spotted owlet	Others
Rajshahi (n=30)	16 (53.33%)	23 (76.67%)	6 (20.00%)	0 (0.00%)
Gazipur (n=30)	0 (0.00%)	0 (0.00%)	30 (100.00%)	0 (0.00%)
Jashore (n=30)	13 (43.33)	16 (53.33%)	9 (30.00%)	0 (0.00%)
Average (n=90)	9.66 (32.22%)	13 (43.33%)	15 (50%)	0 (0%)

Awareness level of owls: A high percentage of respondents gave a positive response regarding the consumption of rats by owl while the rest responded negatively. More than 71% of the farmers who positively responded they considered owl as bird but 28.89 % responded did not like owl (Table 7).

Table 7. Farmers' response on their choices of owl as a bird in the study area

District	Farmers' response on owl as a bird	
	Yes	No
Rajshahi (n=30)	27 (90.00)	3 (10.00%)
Gazipur (n=30)	28 (93.33%)	2 (6.67%)
Jashore (n=30)	9 (30.00)	21 (70%)
Average (n=90)	21.33 (71.11%)	8.66 (28.89%)

Misconception about owls: Majority of the farmers (87.77%) thought that owl had no harmful effect on human and the environment, only 14.44% thought that owl is not good for them. About 15% farmers reported that it has evil effect on human being (Table 8) and a very small number of the respondents were ignorant. A proportion of participants (81.11%) showed positive emotion when seeing owls, while 18.89% showed negative emotion (Table 9).

Table 8. Farmers' response on the harmful effects of owl in the study area

District	Farmers' response on harmful effect of owl			
	Yes (harmful)	No (Not harmful)	Evilomen	Others
Rajshahi (n=30)	3 (10.00%)	27 (90.00%)	3 (10.00%)	0 (0.00%)
Gazipur (n=30)	0 (0.00%)	30 (100.00%)	0 (0.00%)	0 (0.00%)
Jashore (n=30)	10 (33.33%)	22 (73.33%)	11 (36.67%)	21 (70.00%)
Average (n=90)	4.33 14.44%)	26.33 (87.77%)	4.66 (15.56%)	7 (23.33%)

Table 9. Farmers' response on positive/negative emotion about owl in the study area

District	Farmers' response on positive/negative emotion about owl	
	Positive emotion	Neative emotion
Rajshahi (n=30)	6 (20.00)	24 (80.00%)
Gazipur (n=30)	0 (0.00%)	30 (100.00%)
Jashore (n=30)	11 (36.67%)	19 (63.33%)
Average (n=90)	5.66 (18.89%)	24.33 (81.11%)

Owls Food habits: Regarding the question related to owls food habit, majority of the respondent (93.33%) answer that they knew about the food habit of owl. Out of them cent percent opined that rat is the main food of owl, whereas 22.22% respondent thought insect is the main food and only 7.77% respondent opined shrew is the main food for owl (Table 10).

Table 10. Farmers' response on the food habits of owl in the study area

District	Known	Unknown	Farmers' response on the food habits of owl			
			Rat	Shrew	Insect	Others
Rajshahi (n=30)	30 (100%)	0 (0.00%)	30 (100%)	1 (3.33%)	9 (30.00%)	0 (0.00%)
Gazipur (n=30)	30 (100%)	0 (0.00%)	30 (100%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Jashore (n=30)	24 (80%)	6 (20%)	30 (100%)	6 (20%)	11 (36.67%)	0 (0.00%)
Average (n=90)	28 (93.33%)	2 (6.66%)	30 (100%)	2.33 (7.77%)	6.66 (22.22%)	0 (0%)

Benefit and conservation of owl: Question regarding the beneficial effect of owl, about 85% farmers replied that owl has a beneficial effect on the nature. Only 14.44% farmers thought it has no impact on nature. Majority of the farmers (85.55%) considered owl as a rat eater whereas 11.11% farmers considered it as environment

protector (Table 11). Regarding the conservation of owl 61% respondent opined that there is no necessity to conserve whereas 38.89% respondent opined that owl should be conserved. Question regarding way of owl conservation. 76.66% respondent mentioned that public awareness could be an important tool for owl conservation whereas 15.55% mentioned on creating un-disturbing habitat or reserve areas and only 7.77% respondent opined on strengthening of tree plantation program (Table 12).

Table 11. Farmers' response on the usefulness of owl in the study area

District	Farmers' response on				
	Usefulness		Helpful as		
	Yes	No	Environment Protector	Rat eater	Others
Rajshahi (n=30)	28 (93.33)	2 (6.67%)	6 (20.00%)	24 (80.00%)	0 (0.00%)
Gazipur (n=30)	30 (100%)	0 (0.00%)	0 (0.00%)	30 (100.00%)	0 (0.00%)
Jashore (n=30)	19 (63.33%)	11 (36.67)	4 (13.33%)	23 (76.67)	3 (10.00%)
Average (n=90)	25.66 (85.55%)	4.33 (14.44%)	3.33 (11.11%)	25.66 (85.55%)	1 (3.33%)

Table 12. Farmers' response on the conservation of owl in the study area

District	Farmers' response on					
	Need to conserve		Owl conservation options			
	Yes	No	Tree plantation	Not disturbing	Public awareness	Others
Rajshahi (n=30)	30 (100%)	0	7 (23.33)	8 (26.67)	15 (50.00)	0 (0.00%)
Gazipur (n=30)	0 (0.00%)	30	0 (0.00%)	0 (0.00%)	30 (100%)	0 (0.00%)
Jashore (n=21)	5 (16.67)	25 (83.33%)	0 (0.00%)	6 (20.00%)	24 (80.00%)	0 (0.00%)
Average (n=90)	11.66 (38.89%)	18.33 (61.11%)	2.33 (7.77%)	4.66 (15.55%)	23 (76.66%)	0 (0%)

DISCUSSION

The survey was conducted to assess the farmer's knowledge, attitude, and perception about owls. The questionnaire was divided into different parameters viz., familiarity, own awareness, misconception, food habits and conservation aspects of owl. The familiarity of respondent with spotted owlet, eagle owl and barn owl was 50%, 43.33% and 32.22%. respectively. More than 70 % gave positive and 28.89% gave negative response about owl activity. About 87.77% thought that owl had no harmful effect on human and the environment, only 14.44% thought owls are not beneficial. Maximum respondent (93.33%) knew about the food habit of owl. Out of them cent percent know that rat is the main food of owl. More than76% respondent mentioned that public awareness can be an important tool for owl conservation whereas 15.55% mentioned on creating un-disturb habitat or reserve areas and only 7.77% respondent opined about the encouragement of tree plantation program.

In Madurai, Tamil Nadu of India, Santhanakrishnan *et al.* (2012) reported that 54.2% of the respondents knew about two owl species 'Barn Owl' and Little about Spotted Owlet, 28.3% of the respondents told that rats are the staple food item while 30.1% knew about insects as food. More than 60% of respondents believed that owls are being hunted for food; 23.7% believed for its medical use. Of the respondents 69% showed strong belief superstitions about owls; 86% linked owls with sudden death while 72.3% responded that they have not seen such death directly but have heard of it; 19.4% mentioned it as a sign of evil and misfortune. Nearly 56% of respondents were of the view that artificial nest boxes attract owls towards agriculture fields and 65% confirmed the use of nest boxes as perching sites. Majority of people were classified as bad omen (53.2%) while 2.5%% were considered owls as beneficial; 14.5% emphasized that owls are birds; 6.2% considered them harmful while 3.5% as fearing birds.

In Panjab of Pakistan, Rashid *et al*. (2021) revealed that about 95% of people were familiar with owls in the agro-ecosystem. Only 15.6% of people thought that owls should be eliminated; 23.0% were of the opinion that owl's presence in a locality leads to ruination; 33.3% agreed that the owl's presence was a sign of bad omen; 41.8% considered them as signs of foolishness; 47.0% believed that owl's body parts were used for black magic purposes. In contrast, 50% of people acknowledged that owls are beneficial to humans; 60.3% knew that owls are the

enemies of rodents, 67.7% agreed that they are suppressors of rats and mice and 63.8% agreed that artificial nest boxes can serve as their nests and roosts. It was encouraging to know that 74.8% showed their willingness to enhance the owl's population on their farms, and 74.0% were willing to permit the installation of nest boxes in or near the villages. The study of attitudes of respondents towards owl will help to develop an effective conservation strategy and to boost owl's population in croplands for biological control of rats and mice.

Rodents are nocturnal mammals that are the destructive pest of agricultural crops. Destructive habits of rodents possess heavy economic loss to the agriculturists. In the agro-ecosystems, rodents caused significant damage to cereal crops (Jacob and Tkadlec 2010). Loss caused by the rodents to cereal crops such as rice, wheat, and maize is between 5–10% at the pre-harvest level in India and China. Post-harvest damage of these cereal crops is higher than pre-harvest loss (Abass *et al.* 2014). The average damage caused by rodents to cereal crops in Sichuan, province of China was studied as 320 kg ha^{-1} (Singleton and Brown 2003). The damage caused by the rodents in Philippines is 13.2% in the wet season while 8.1% in dry seasons (Stuart *et al.* 2011). The average damage caused by rodents to cereal crops such as wheat (10%), rice (19%), sugar cane (7.5%) and groundnuts (5.3%) (Beg *et al.* 2010).

Owls are also a nocturnal bird and prey at night. Rat and owl both are active at night, so it is easy to manage rat at night by owl. Owls are considered effective biological control agents for rats and mice populations in cultivated fields. (Mahmood-ul-Hassan *et al.* 2007 found during the pellet analysis of Barn Owl that consumption of rats and mice population at central Punjab (28%), at southern Punjab (14%) and southern Balochistan (93%). Variation in the dietary composition depends upon time of crop cultivation, harvest, and cropping pattern. The regurgitated pellets of Barn Owl in lower Sindh of Pakistan revealed small remnants of mammals (84%) and birds (25%) while from six districts of central Punjab (Pakistan), 75% of the diet of Barn Owl are comprised of *Suncus murinus* (Mushtaq-ul-Hassan *et al*. 2007). Insects were the main staple items of Little Spotted Owlet but the rodents stood at secondary importance.

It requires time to acknowledge owls as a biological control agent in the cultivated crop and different methods should be conducted to conserve Barn Owls.

The installation of nest boxes within a 500 m radius in agricultural fields plays a significant role in cultivated field at Beit Se'an valley, Israel. During five years, 86.7% of the nest boxes were occupied by Barn Owls. Erection of nest boxes is a very effective method for increasing Barn Owl population in agriculture fields (Meyrom *et al.* 2009).

Most of the misconceptions are related to stories of old times, when people were more fearful and tried to get the answer about their lives and the environment. Now the attitude of people, on the whole, was in favor of the owls. Decidedly more people had a soft corner for the owl because of their role in inhibiting the populations of rats and mice. This sort of attitude will make things easier for workers desiring to bring owl closer to cropland for biological control of rat populations.

CONCLUSION

Based on the findings it may be concluded that the people are little concerns about wildlife diversity and conservation. However, their concept can be interpreted in different ways depending on professional differences and knowledge levels of the respondents. The respondents have relatively limited knowledge about wildlife especially owl depending on sites. There is need to raise awareness on the importance of wildlife diversity and conservation through organizing training programs, seminars and workshops at different levels. These approaches would encourage the local people's concerns about the Owl conservation activities.

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TAXONOMIC ACCOUNT OF ORB-WEAVING SPIDER GENUS *CYRTARACHNE* THORELL, 1868 (ARANEAE: ARANEIDAE: CYRTARACHNINAE) FROM BANGLADESH

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ABSTRACT

Taxonomic study on some orb-weaving spiders of the genus *Cyrtarachne* Thorell was carried out in Khulna, the southwest part of Bangladesh. Two species were recorded during the study of which *C. ovata* sp. n. was identified as new to science and *C. sundari* Tikader was recorded earlier from this country. Illustrated description and distribution together with key to the species of Bangladesh are presented herewith.

Keywords: Araneae, Araneidae, Bangladesh, *Cyrtarachne*, Cyrtarachninae, Taxonomy.

INTRODUCTION

Orb-weaving spiders (Family: Araneidae) are one of the attractive and common predatory arachnids in the crop-fields and gardens of Bangladesh. These are known to all by their peculiar orb-weaving mechanism and different typical geometrical webs on which they stay and catch the crop pest insects (Biswas and Raychaudhuri 2019). Members of the genus *Cyrtarachne* Thorell are small to medium in size (ranges from 8 mm to 12 mm) with attractive colour and peculiar body shapes. They usually spin the webs in the dusk (during sundown) and stay therein long time to catch the preys.

The genus was first erected by Thorell in 1868 with the type-species *C. gr*ubei (Keyserling 1864) and at present, it is composed of 55 species worldwide (World Spider Catalog 2024, Mikhailov 1997). In Bangladesh, only three species of this genus was recorded earlier (Okuma *et al.*1993, Chowdhury and Nagari

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1981, Biswas 2019, Begum and Biswas 1997, Biswas and Raychaudhuri 2019). But a good number of records are found in different Asian countries like - India (Tikader 1960, 1963, 1982; Jose 2011, Ahmed *et al*. 2015, Sen *et al.* 2015, Jwala *et al.* (2022), China (Yin *et al.* 1997, Yin and Zhao 1994, Song *et al.* 1999), Japan (Yaginuma 1986, Tanikawa 2007, 2013), Korea (Namkung 2003, Namkung and Kim 1985, Kim and Lee 2012), Singapore (Koh 1989), The Philippines (Barrion and Litsinger 1995) etc. The present paper describes two araneid species –*C, sundari* Tikader and *C. ovata* sp. n. of which one is identified as new to science. *C. sundari* is a new record for the area of present study and only some of its diagnostic characters are used. A key to all the species recorded in Bangladesh are presented herewith.

MATERIALS AND METHODS

Collection and Preservation: Specimens of this study were collected from different areas of Bangladesh. Collections were made by jerking the branches of shrubs on an inverted umbrella placed underneath the plant. The collected specimens were then transferred to a Petri dish filled with 70% ethyl alcohol for sorting. After sorting, the specimens were placed in separate glass vials for future identification. After identification, the specimens are preserved permanently in Audmans' preservatives following Lincoln and Sheals (1985) and Tikader (1987).

Identification and Study: The specimens were identified by study of various taxonomic characters *viz.*, – body shape, colour, eye pattern, structure of legs, cheliceral dentition, pedipalp, epigyne etc. The pedipalp and female epigynum were dissected out from the body and boiled in 10% KOH for 2-3 minutes following Levi (1965) and Tikader (1987). The identifying characters were studied following different important books and pulications of different authors of home and abroad like – Davies (1988), Tikader (1982, 1987), Yaginuma (1986), Chen and Zhang (1991), Yin *et al.* (1997), Song *et al*. (1999), Dondale *et al*. (2003), Tanikawa (2007), Biswas (2009) and Kim and Lee (2012).

After identification, the species were later confirmed from the Arachnida section, Zoological Survey of India, Kolkata.

Illustration and Photograph: All the drawings of the species were illustrated by a Camera Lucida fitted with Stereo zoom Binocular Microscope. Legs and palpal

measurements were taken under the same in the following sequences: femur. Patella, tibia, metatarsus, tarsus and total length. All the measurements are taken in millimeters (mm).

The photographs were taken in the laboratory by a Camera fitted Microscope (model SV8, Zeiss).

Type deposition: All the identified types are now in the laboratory of the Department of Zoology, Khulna Government Womens' College, Khulna, and will be deposited to the Museum of the Department of Zoology, University of Dhaka, in due course of time.

RESULTS AND DISCUSSION

Taxonomic account

Family : ARANEIDAE Clerck, 1757
Subfamily : Cyrtarachninae O.P. Cambridge,1871
Tribe : Cyrtarachnini O.P. Cambridge, 1871
Genus : ***Cyrtarachne*** Thorell, 1868
Type-species : *C. grubei* (Keyserling, 1864)
1868. *Cyrtarachne* Thorall, *Eng. Resa. Arachn*., : 10.
1878. *Dema* : Karsch, *Z. ges. Naturw.,* **51** : 801.
1895. *Cyrtarachne* : Simon, *Hist. Nat. Araign*., **1** (4) : 880.
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2009. *Cyrtarachne*; Biswas (Ahmed ed.), *Flora & fauna of Bangladesh*, **18**(1):149
2024. Cyrtarachne :*World Spider Catalog,* Version 24.5, Nat. Hist .Mus. Bern, Online – http://www.wsc.nmbe.ch (accessed 21th Nov. 2024)

Distribution: ASIA, AUSTRALIA, AFRICA.

Key to the species of genus *Cyrtarachne* Thorell in Bangladesh

1. Abdomen triaguar, with distinct humps and sagilla; inner and outer margins of chelicerae with 2 and 1 teeth; sternum roughly triangular .... *C. sundari**

_ Abdomen never as above; cheliceral teeth when present, never with such combination; sternum never as above 2

2. Abdomen rhomboid; cheliceral margins with teeth; cephalothorax wider than long; sternum heart-shaped 3

_ Abdomen elongately ovoid; cheliceral margins without any teeth; cephalothorax longer than wide; sternum cylindrical .... *C. ovata* n.sp.

3. Abdominal dorsum medially strongly reticulate, marginally and poste decorated, without any sigilla; cervical furrows distinct ; chelicerae parallel sided with 4 teeth on outer margin, anteromedian and lateral eyes marginal and on protuberences. ..... *C. biswajiti**

_ Abdominal dorsmum weakly reticulate centrally, medially with a branch with a pair of distinct sigilla; cervical furrows weakly impressed; chelicerae not parallel-sided, with 3 teeth on outer margin; eyes never marginal and protuberance ..... *C. kaikobadi**

* - marked species are described earlier and used here only to complete the couplet of the key. Species *C. sundari* is a new record for the present study.

Description of the new species

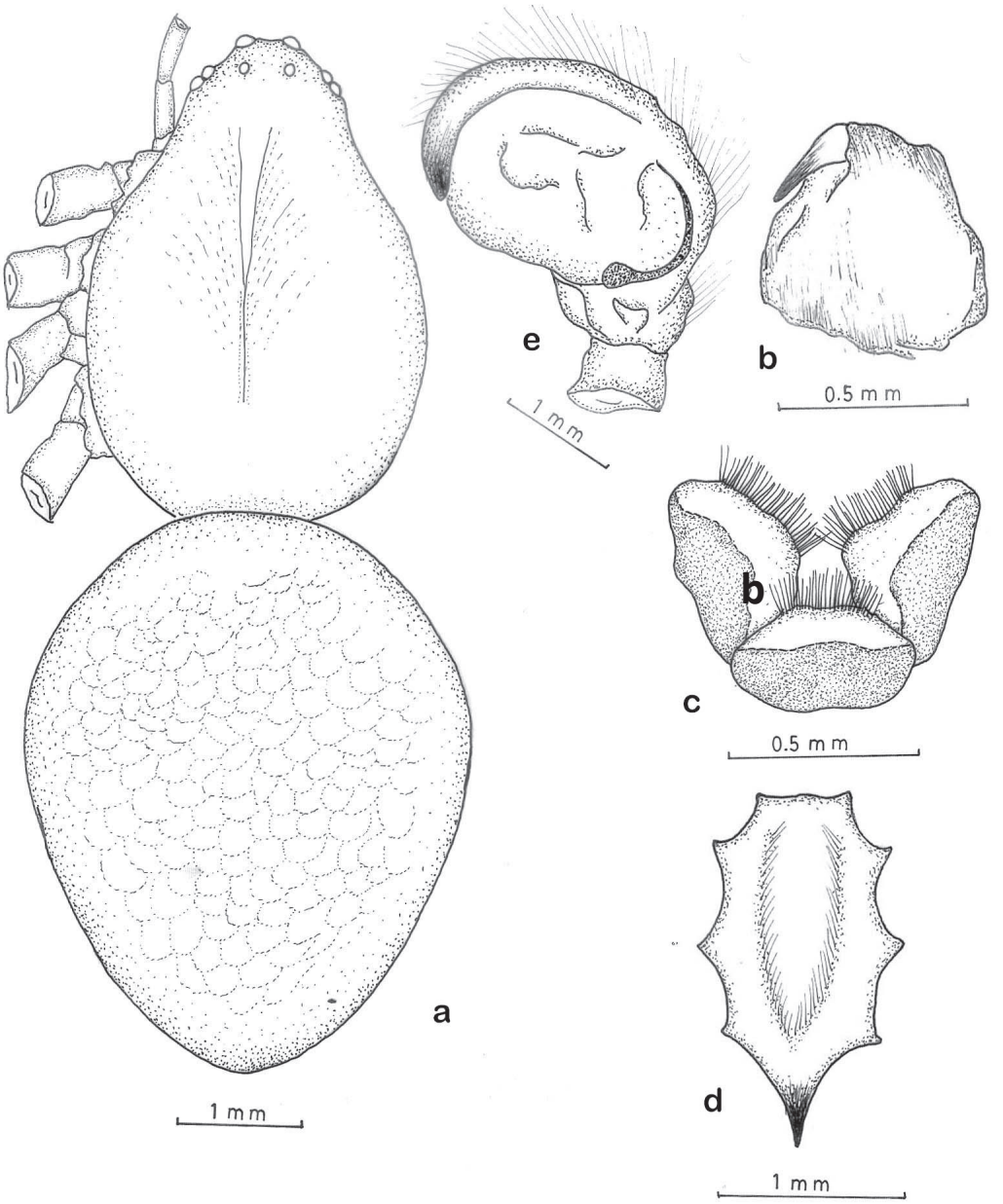
1. *Cyrtarachne ovata* sp. n.

(Figs. 1a – 1e; Plate- Ia)

Material examined: Holotype: 1 male, Savar, district Dhaka, 18. IV. 1995, Coll. V. Biswas (preserved in Audmans' preservatives).

Paratype: 2 males, Terosree, district Manikganj, 07. VIII. 1997, Coll. V. Biswas (preserved in same preservative).

Allotype: Nil.



Figs. (1a-1e): ***Cyrtarachne ovata*** **sp. n**
a. Whole body (dorsal view); b. Chelicerae; c. Maxillae & labium; d. Sternum; e. Male palp.

General: Body small, yellowish brown in colour. Cephalothorax yellowish-brown ; legs brown ; abdomen pale yellow with silver-white markings. Total body length 8.80 mm. Carapace 2.90 mm long, 2.20 mm wide; abdomen 5.90 mm long and 5.00 mm wide.

Cephalothorax: Longer than wide, anteriorly narrowing and broad medially; cephalic region raised with 2 anteriorly radiating radii. Eyes pearly yellow; anteromedians slightly larger, rest similar; both rows of eyes recurved; lateral closed, placed marginally; lateral and anteromedian eyes situated on tubercles; ocular quad wider than long, narrowing posteriorly; anterior margin (between anteromedian eyes) slightly concave. Chelicerae dark brown, broad basally, margins without any teeth (Fig. 1b). Maxillae brown, longer than wide, anteriorly wide and scopulate (Fig. 1c). Labium brown, wider than long, bowl-shaped, anteriorly scopulate (Fig. 1c). Sternum brown, longer than wide, cylindroid, posteriorly pointed, medially with fine pubescence (Fig. 1d). Legs long and slender, clothed with spines and hairs; leg formula 4123 and the measurements (in mm) of leg segments are shown in Table -1. Male palp as in Fig. Ie.

Table 1. Measurements (mm) of leg segments of *Cyrtarachne ovata* n. sp.

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	2.00/2.00	0.90/0.90	2.00/2.00	1.50/1.50	0.60/0.60	7.00/7.00
II	2.10/2.10	0.60/0.60	2.00/2.00	1.00/1.00	0.60/0.60	6.30/6.30
III	1.70/1.70	0.50/0.50	1.20/1.20	0.90/0.90	0.40/0.40	4.70/4.70
IV	2.50/2.50	0.90/0.90	2.00/2.00	1.20/1.20	0.50/0.50	7.10/7.10

Abdomen: Brown, oval, anteromedially wide and posteriorly narrowed ; dorsum with silvery decoration. Female unknown and will describe when available in collection.

Distribution: BANGLDESH: Dhaka and Manikganj (type locality).

Etymology: The species is named due to the oval shape of the abdomen.

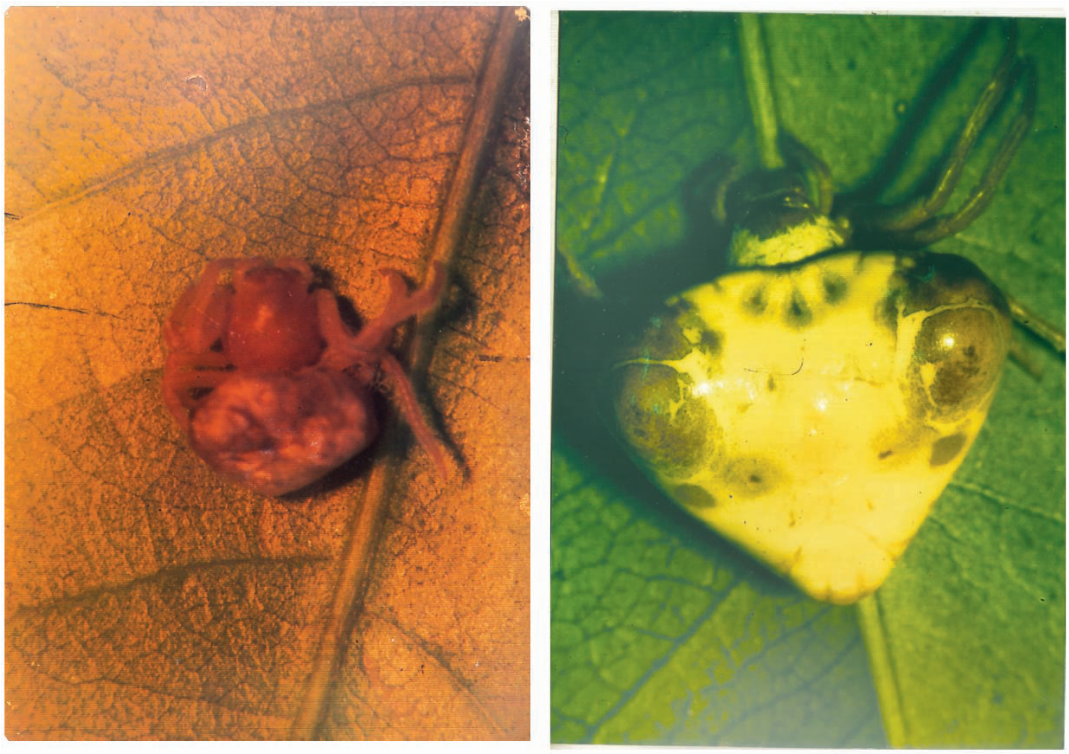


Plate I. Photographs of *C. ovata* n.sp. & *C. sundari* Tikader, a. *C. ovata* n.sp. (dorsal); b. *C. sundari* Tikader

Remarks: None of the congeneric species of *Cyrtarachne ovata* n. sp. (Tikader 1982; Shinkai and Takano 1984; Koh 1989; Yaginuma 1986; Barrion and Litsinger 1995; Yin *et al.* 1997; Song *et al.* 1999; Namkung and Kim 1985; Majumder 2005; Kim and Lee 2012; Tanikawa 2013) have the following diagnostic characters –

1. Anteriorly produced cephalothorax and posterior oval shaped abdomen,
2. Cheliceral margins without any teeth,
3. Sternum cylindrical,
4. Maxillae and labium are typical and
5. Typical bulb-like male palps.

The species, is thus, recognized as new to science.

2. *Cyrtarachne sundari* Tikader

(Figs. 2a-2e : Plate – Ib)

1963. *Cyrtarachnesundari*Tikader, *J. Bombay nat. Hist. Soc.,***60** (1) : 271.
1982. *Cyrtarachnesundari* :Tikader, *Fauna of India, Araneidae*, **2** (1) : 150.
2005. *Cyrtarachnesundari* : Majumder, *Mem. Zool. Surv. India*, **20** (3) : 9.
2006. *Cyrtarachnesundari* :Platnick, *World Spider Catalog,* Version 6.5 : 1142.
2009. *Cyrtarachnesundari* : Biswas, *Encycl. flora & fauna of Bangladesh,***18** (1) : 149
2019. *Cyrtarachnesundari* : Biswas, *Bangladesh J. Zool.,***47** (2) : 192.
2024. *Cyrtarachnesundari* :*World Spider Catalog,* Version 24.5, Nat. Hist. Mus. Bern., Online – http://www.wsc.nmbe.ch (accessed 14th Nov., 2024)

Material examined: 1 female, Japhlong, district Sylhet, 12. I. 1993, Coll. V. Biswas; 1 female, Mirpur botanical garden, Dhaka, 14. III. 1998, Coll. V. Biswas ; 2 females, district Bagerhat, 08. VII. 2000, Coll. V. Biswas ; 1 female , ADI, Daulatpur, Khulna, 15. II. 2002, Coll. V. Biswas.
Male was not found and should be described after collection.

General: Body triangular, robust, greenish-white in colour with two dorsal blackish-brown coloured humps. Cephalothorax and legs brown; abdomen yellow-brown. Total body length 10.00 mm. Carapace 3.50 mm long, 3.80 mm wide; abdomen 6.50 mm long and 6.50 mm wide.

Remarks: The detailed characters of different body-parts and appendages of this species (*C. sundari* Tikader) did not describe as it is described earlier by Biswas and Rachaudhuri (2019) from this country. Therefore, only the main general characters andacoloured photograph is shown.
Distribution: BANGLADESH: Sylhet, Dhaka, Bagerhat, Khulna; India (Tikader 1963, ’82; Majumder 2005).

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EFFECTIVENESS OF BIORATIONAL INSECTICIDES APPLIED ON SWEET GOURD FOR CONTROLLING RED PUMPKIN BEETLE

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ABSTRACT

The red pumpkin beetle (*Aulacophora foveicollis*) is the critical insect pests of sweet gourd according to their high relative abundance in the field. To evaluate the effectiveness of different biorational insecticides against red pumpkin beetle the present study was conducted in the experimental field of entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during January 2023 to June 2023. With average temperature of 25.8°C and relative humidity of 91.2% during experimental period, seven different biorational insecticides were applied for field evaluation. The treatments of the experiment were Neem oil, Mahogony oil, Bio-clean 5 SL (De-limonin 5%), Bio-action 1.5 SL (Matrine 1.5%), Biotrin 0.5 AS (Matrine 0.5%), Spinomax 44.03 SC (Spinosad 44.03% w/w), BiomaxM 1.2 EC (Abamectine 1.2%) with an untreated control (using water only) for comparison. The lowest abundance of red pumpkin beetle at early cropping stage (4.0) and late cropping stage (2.7); rate of infestation at early cropping stage (89.7%) and late cropping stage (91.3%); leaf area damage (10.0%) and late cropping stage (3.7%) was observed in Biotrin 0.5 AS treated plot. The lowest floral infestation (8.3%) was also observed in Biotrin 0.5 AS treated plot. Biotrin 0.5 AS performed better than other biorational insecticides in all the aspects of controlling red pumpkin beetle.

Keywords: Red pumpkin beetle, sweet gourd, biorational insecticides, Biotrin 0.5 AS.

INTRODUCTION

Cucurbitaceae is one of the largest and most crucial vegetable families grown worldwide. It contains 965 species under 134 genera (Khandaker *et al.* 2018). Sweet gourd, a very popular vegetable under the Cucurbitaceae family, is cultivated

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in 6.83% of the land area in Bangladesh (Islam *et al.* 2017). In Bangladesh, about 1.78 lakh MT (Metric Tons) of sweet gourd is produced in the Rabi season and 1 lakh MT of sweet gourd is produced in the Kharif season (BBS 2015). Sweet gourd is very vulnerable to attack by several insect pests. A total of 21 arthropod species attacks cucurbitaceous crops in Bangladesh. Among them, 20 are insects and 1 is mite species (Ali *et al.* 2016). The red pumpkin beetle (*Aulacophora foveicollis*) is one of the most critical insect pests of sweet gourd according to their high relative abundance in the field (Nancy *et al.* 2018). In Bangladesh, the red pumpkin beetle (*Aulacophora foveicollis*) is the most devastating insect pest of sweet gourd. The damage potential of red pumpkin beetle is one of the most critical constraints of sweet gourd production in Bangladesh (Khan 2014). Red pumpkin beetles attack young plants, leaves, and flowers. It feeds on both the upper and lower surface of the leaves and produces a characteristic circular ring-like injury. They are capable of causing 30 to 100% yield loss of sweet gourd (Afroz *et al.* 2020). Farmers in Bangladesh mainly uses Malathion, an organophosphate insecticide to control red pumpkin beetle (Hasan *et al.* 2013). Furthermore, synthetic insecticides such as Karate 2.5 EC, Ripcord 10 EC and Shobicron 425 EC are frequently used for controlling cucurbit fruit flies in Bangladesh (Ahmed *et al.* 2022). These synthetic insecticides has hazardous effects on human health, the environment and other biodiversity (Rahaman & Prodhan 2007). Chemical insecticides may cause cancer, damage the nervous, reproductive, and immune systems, and induce hepatotoxicity in both acute and chronic form (Cataudella *et al.* 2012). Biorational insecticides are safe, environmentally friendly and less toxic insecticides for controlling insects (Horowitz & Ishaaya 2004). It degrades quickly and less hazardous to biodiversity. Different studies showed positive reports for controlling red pumpkin beetle by using biorational insecticides. Therefore, biorational insecticides can be a sustainable solution for the management of red pumpkin beetle infesting sweet gourd.

MATERIALS AND METHODS

The research was carried out in the experimental field of Department of entomology Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, during the period of January to June 2023. Total 24 plots were prepared with 3

replications; each block containing 8 plots. The area of the plots was 3m × 2m with 1m plot to plot distance and 1m block to block distance. During the experimental period the temperature fluctuated between 10° to 40°C with an average of 25.8°C and relative humidity was ranged from 91.2% to 93% with an average of 80%. The experiment was conducted by Randomized Complete Block Design (RCBD) with three replications and eight treatments including an untreated control. The treatments were as follows:

Neem oil @ 5ml/L of water+1–2 drops Tween 20, Mahogony oil @ 5ml/L of water+1–2 drops Tween 20, Bio-clean 5 SL (De-limonin 5%) @ 1ml/L of water, Bio-action 1.5 SL (Matrine 1.5%) @ 3ml/L of water, Biotrin 0.5 AS (Matrine 0.5%) @ lml/L of water, Spinomax 44.03 SC (Spinosad 44.03% w/w) @1ml/L of water, BiomaxM 1.2 EC (Abamectine 1.2%) @ 1ml/L of water and an untreated control.

"BARI Mistikumra-1" seedlings were transplanted the experimental field with the plant to plant and row to row distance of 1m in both the cases. Each plot was containing 6 pits of 45cm of diameter and 45 cm depth. Every pit was mixed up with the proper quantity of decomposed cow dung and farmyard manure. The fertilizer was applied according to Fertilizer Recommendation Guide 2018 such as urea 55–85kg/ha, MoP 28–55kg/ha and TSP 45–50kg/ha (FRG 2018). Different intercultural operations such as weeding, loosening of soil, irrigation, setting up bamboo trellis and fertilization was done time to time for optimum growth of plants.

The treatments were applied when approximately 5% infestation was recorded; 15 days after transplanting. The treatments were applied at 7 days intervals. Total 6 application of biorational insecticides were done till the last harvest. The data were recorded on population abundance of red pumpkin beetle, number of red pumpkin beetle from randomly selected 5 vines (1m top length), percent leaf infestation, percent damage severity after 48h of application. The healthy and infested fresh leaf weight and dry leaf weight data was recorded. The floral infestation data was taken after 48h of spraying. The data was analyzed by using IBM SPSS Statistics 20 and RStudio software. In IBM SPSS, a one-way ANOVA was performed followed by Duncan's Multiple Range Test (DMRT) to separate means. The p-value was determined using RStudio at a significance level of 5%.

RESULTS AND DISCUSSION

Effect of biorational insecticides on red pumpkin beetle at early cropping stage: The Table 1 represents the effect of biorational insecticides on abundance and leaf infestation by red pumpkin beetle at early cropping stage. All the treatments applied in the experimental field showed the significant level of variation for number of red pumpkin beetle per plot, rate of leaf infestation and damage severity at early cropping stage. After first three consecutive spray, highest mean number of red pumpkin beetle per plot was seen in untreated control (23.3) plot, followed by Mahogony oil treated plot (10.3). Bio-Clean 5 SL and BiomaxM 1.2 EC showed the same number of red pumpkin beetle per plot (8.7), followed by Bio-action 1.5 SL (8.0) treated plot. The lowest number of red pumpkin beetle was found in Biotrin 0.5 AS (4.0), followed by Spinomax 44.03 SC (5.3) and Neem oil treated plot (7.0) treated plot.

The highest rate of leaf infestation was found in untreated control (98.9%), followed by neem oil (91.9%), BiomaxM 1.2 EC (90.1%) and Bio-action 1.5 SL (89.9%). The lowest rate was found in Spinomax 44.03 SC (87.7%). Mahogony oil and Bio-Clean 5 SL showed almost the same rate of leaf infestation (89.6%), followed by Biotrin 0.5 AS (89.7%).

The damage severity was measured by visual inspection. The highest damage severity was observed in untreated control plot (18.5%). The Bio-Clean 5 SL, Bio-action 1.5 SL and BiomaxM 1.2 EC treated plot showed the same rate of damage severity (13.5%), followed by Mahogony oil (13.0%). The lowest rate of damage severity was observed in Biotrin 0.5 AS (10.0%) treated plot, followed by Spinomax 44.03 SC (11.3%) and Neem oil (12.6%).

The highest percentage of reduction of damage severity over control was observed in Biotrin 0.5 AS (42.9%), followed by Spinomax 44.03 SC (36.9%) and Neem oil treated plot (31.5%). The Mahogony oil and Bio-Clean 5 SL showed the same percentage of reduction of damage severity over control (28.0%). The lowest percentage of reduction of damage severity over control was observed in Bio-action 1.5 SL and BiomaxM 1.2 EC treated plot (26.8%).

Parvin *et al*. (2023) reported that, during the summer season the lowest abundance of red pumpkin beetle was observed in Sunmectin 1.8 EC (Abamectin)

tread plot which was 3.0 at early cropping stage and 1.6 per plant at late cropping stage among six biorational insecticides applied on ash gourd. The result is almost closer to the present study. Depending on sweet gourd variety, the abundance ranges from 3.1 to 4.0 and the rate of leaf infestation ranges from 28.5% to 34.8% at early cropping stage (Kamal *et al*., 2014). Depending on weather condition this percentage may vary. In the research, muskmelon showed the highest percentage of leaf infestation 89.3% over control (Khan, 2018). Khan *et al*. (2011) reported that, depending on cucurbit varieties leaf area damaged by the red pumpkin beetle ranges from 0.0 to 70%. He found that, the red pumpkin beetle causes the highest (58.0%) leaf area damage in sweet gourd.

Table 1. Effect of different biorational insecticides on abundance and leaf infestation by red pumpkin beetle after 48 hours of spraying at early cropping stage

Treatment	Number of RPB	Rate of leaf infestation (%)	Damage severity (%)	Reduction of damage severity over untreated control (%)
Neem oil	7.0b	91.9ab	12.6b	31.5
Mahogony oil	10.3b	89.6b	13.0b	28.0
Bio-Clean 5 SL	8.7b	89.6b	13.5b	28.0
Bio-action 1.5 SL	8.0b	89.9b	13.5b	26.8
Biotrin 0.5 AS	4.0b	89.7b	10.0b	42.9
Spinomax 44.03 SC	5.3b	87.7b	11.3b	36.9
BiomaxM 1.2 EC	8.7b	90.1b	13.5b	26.8
Untreated control	23.3a	98.9a	18.5a	
CV (%)	6.1%	10.1%	16.5%	

In a column, means having similar letter(s) are not significantly different at 5% level of significance (P=0.05%) according to Duncan's Multiple Range Test (DMRT).

Effect of biorational insecticides on red pumpkin beetle at late cropping stage: The Table 2 represents the effect of biorational insecticides on insect pest abundance and leaf infestation of red pumpkin beetle at late cropping stage. After last three consecutive spray, the highest mean number of red pumpkin beetle per plot was seen in untreated control (10.3) plot, followed by Mahogony oil (6.3). The Bio-Clean 5 SL and BiomaxM 1.2 EC treated plot showed almost the same number of red

pumpkin beetle (4.7), following that of Neem oil and Bio-action 1.5 SL (4.3). The lowest number of red pumpkin beetle was found in Biotrin 0.5 AS (2.7) treated plot followed by Spinomax 44.03 SC (3.3) treated plot.

The highest rate of leaf infestation was found in untreated control (100%) plot, followed by Bio-Clean 5 SL (99.0%), Bio-action 1.5 SL (92.8%), Mahogony oil (92.2%) and Neem oil (91.9%). Th lowest percentage of leaf infestation was found Spinomax 44.03 SC (91.0%), followed by Biotrin 0.5 AS (91.3%) and BiomaxM 1.2 EC (91.8%).

The highest damage severity was observed in untreated control plot (7.0%), followed by Mahogony oil (5.1%). Bio-action 1.5 SL and BiomaxM 1.2 EC and showed almost the same rate of damage severity (4.8%). This was following that of Neem oil and Bio-Clean 5 SL which showed the same rate of damage severity (4.2%). The lowest percentage of damage severity was observed in Biotrin 0.5 AS (3.7%), followed by Spinomax 44.03 SC (4.1%) treated plot.

The highest percentage of reduction of damage severity over untreated control was observed in Biotrin 0.5 AS (42.9%), followed by Spinomax 44.03 SC (41.4%). Neem oil and Bio-Clean 5 SL showed almost the same percentage of reduction over untreated control (40.0%), followed that of Bio-action 1.5 SL and BiomaxM 1.2 EC expressed the same rate of reduction over control (31.4%). The lowest percentage of reduction over control was observed in Mahogony oil (27.1%). As the plant matures, the plant tissue becomes hard and the damage severity reduces with time. There is another reason, continuous spraying of biorational insecticides. The insect abundance is reduced with time, so the damage severity is lower in the later three sprays.

At fruiting stage, the abundance of red pumpkin beetle ranges from 3 to 3.3 per plant and the rate of leaf infestation ranges from 12 to 17% depending on sweet gourd variety *(Kamal et al*., 2014). Parvin *et al*. (2023) found that, the reduction of abundance of red pumpkin beetle over control ranged from 30 to 65% on ash gourd plant. The highest reduction over control (65.0%) was observed in Sunmectin 1.8 EC treated plot at late cropping stage.

Table 2. Effect of different biorational insecticides on abundance and leaf infestation by red pumpkin beetle after 48 hours of spraying at late cropping stage

Treatment	Number of RPB	Rate of leaf infestation (%)	Damage severity (leaf area damage)	Reduction of damage severity over untreated control (%)
Neem oil	4.3b	91.9b	4.2b	40.0
Mahogony oil	6.3b	92.2b	5.1b	27.1
Bio-Clean 5 SL	4.7b	99.0b	4.2b	40.0
Bio-action 1.5 SL	4.3b	92.8b	4.8b	31.4
Biotrin 0.5 AS	2.7b	91.3b	3.7b	47.1
Spinomax 44.03 SC	3.3b	91.0b	4.1b	41.4
BiomaxM 1.2 EC	4.7b	91.8b	4.8b	31.4
Untreated control	10.3a	100a	7.0a	
CV (%)	4.8%	7.2%	13.2%	

In a column, means having similar letter(s) are not significantly different at 5% level of significance (P=0.05%) according to Duncan's Multiple Range Test (DMRT).

Effect of biorational insecticides on leaf weight: The Table 3 represents the effect of biorational insecticides on fresh and oven dry leaf weight of sweet gourd plant. There was significant difference among all leaf weights. Leaf weights were measured by a digital weighing machine. The fresh leaf weight was measured directly after collection from the experimental field. In case of dry leaf weight, the leaves were dried in a hot air oven at 55° C for 48 hours.

The highest weight of 5 healthy fresh leaf was measured in Neem oil (26.8g), followed by Spinomax 44.03 SC (23.2g), Mahogony oil (22.1g) and Bio-Clean 5 SL (22.0g) treated plot. The same weight was measured from Bio-action 1.5 SL and BiomaxM 1.2 EC treated plot (21.9g). The lowest weight was measured in untreated control (18.7g), followed by Biotrin 0.5 AS (21.4g).

The highest weight of 5 Infested fresh leaf was measured in Neem oil (21.4g), followed by Spinomax 44.03 SC (20.2g), Biotrin 0.5 AS (18.8g), Mahogony oil (17.1g) and Bio-Clean 5 SL (16.7g) treated plot. The lowest leaf weight was measured in untreated control (12.6g), followed by BiomaxM 1.2 EC (14.9g) and Bio-action 1.5 SL (15.3g) treated plot.

The highest weight of 5 healthy dry leaf was measured jointly in Neem oil and Biotrin 0.5 AS (6.1g) treated plot, following that of almost the same weight was measured from Bio-action 1.5 SL, Spinomax 44.03 SC and BiomaxM 1.2 EC treated plot (6.0g). The lowest weight was measure from untreated control (5.5g), followed by same weight (5.9g) was measured from Mahogony oil and Bio-Clean 5 SL treated plot.

The highest weight of 5 infested dry leaf was measured from Neem oil (5.5g) treated plot, followed by Biotrin 0.5 AS (5.2g), Spinomax 44.03 SC (5.1g), Bio-Clean 5 SL (4.6g) and Bio-action 1.5 SL (4.1g) treated plot. The lowest weight was measured form untreated control (3.1g), followed by Mahogony oil (3.5g) and BiomaxM 1.2 EC (3.9g) treated plot.

The highest dry and fresh leaf weight was measured from Neem oil treated plot. Several scientists have proved neem products and byproducts have growth-promoting properties in plants (Rehman *et al*., 2021).

Table 3. Effect of biorational insecticides on fresh and oven dry leaf weight (w/w) of sweet gourd plant

Treatment	5 Healthy fresh leaf weight (g)	5 Infested fresh leaf weight (g)	5 Healthy dry leaf weight (g)	5 Infested dry leaf weight (g)
Neem oil	26.8a	21.4a	6.1a	5.5a
Mahogony oil	22.1b	17.1abc	5.9a	3.5cd
Bio-Clean 5 SL	22.0b	16.7bcd	5.9a	4.6abc
Bio-action 1.5 SL	21.9b	15.3cd	6.0a	4.1abcd
Biotrin 0.5 AS	21.4bc	18.8abc	6.1a	5.2ab
Spinomax 44.03 SC	23.2b	20.2ab	6.0a	5.1ab
BiomaxM 1.2 EC	21.9b	14.9cd	6.0a	3.9bcd
Untreated control	18.7c	12.6d	5.5b	3.1d
CV (%)	10.4%	8.3%	8.7%	9.4%

In a column, means having similar letter(s) are not significantly different at 5% level of significance (P=0.05%) according to Duncan's Multiple Range Test (DMRT).

Effect of biorational insecticides on floral infestation: The Table 4 represents the effect of biorational insecticides on floral infestation by red pumpkin beetle. The highest number of infested flowers was counted from untreated control (9.3) plot, followed by Mahogony oil (8.7), BiomaxM 1.2 EC (5.7), Bio-Clean 5 SL (5.3) and

Bio-action 1.5 SL (4.7) treated plot. The lowest number was observed from Biotrin 0.5 AS (2.0), followed by Spinomax 44.03 SC (3.0) and Neem oil (3.3) treated plot.

Again, the highest number of healthy flowers was counted from Spinomax 44.03 SC (23.3) treated plot, followed by Mahogony oil (22.7). The same number of healthy flowers was counted from Bio-Clean 5 SL, Bio-action 1.5 SL and Biotrin 0.5 AS treated plot (22.3). The lowest number of healthy flowers was counted from untreated control (16.0), followed by BiomaxM 1.2 EC (21.3) and Neem oil (22.0) treated plot.

The highest percentage of floral infestation was observed form untreated control (36.8%) plot, followed by Mahogony oil (27.7%), BiomaxM 1.2 EC (21.0%), Bio-Clean 5 SL (19.2%) and Bio-action 1.5 SL (17.3%) treated plot. The lowest percentage was observed from Biotrin 0.5 AS (8.3%), followed by Spinomax 44.03 SC (11.2%) and Neem oil (13.1%) treated plot.

According to the findings of Parvin *et al*. (2023), at late cropping stage, the floral infestation ranges from 8.6 to 28.9% in different biorational insecticides treated plot in ash gourd. The lowest floral infestation was observed in Biotrin 0.5 AS (8.6%) treated plot which is almost similar to present findings.

Table 4. Effect of biorational insecticides on floral infestation by red pumpkin beetle

Treatment	Number infested flower	Number healthy flower	Floral infestation (%)
Neem oil	3.3c	22.0a	13.1c
Mahogony oil	8.7ab	22.7a	27.7ab
Bio-Clean 5 SL	5.3ab	22.3a	19.2bc
Bio-action 1.5 SL	4.7bc	22.3a	17.3bc
Biotrin 0.5 AS	2.0c	22.3a	8.3c
Spinomax 44.03 SC	3.0c	23.3a	11.2c
BiomaxM 1.2 EC	5.7abc	21.3a	21.0bc
Untreated control	9.3a	16.0b	36.8a

In a column, means having similar letter(s) are not significantly different at 5% level of significance (P=0.05%) according to Duncan's Multiple Range Test (DMRT).

CONCLUSION

The Biotrin 0.5 AS (Matrine 0.5%) @ lml/L of water at 7 days interval showed the best result for controlling red pumpkin beetle among all the biorational insecticides. So, Biotrin 0.5 AS might be an effective and sustainable biorational insecticide to restrict the red pumpkin beetle population reaching at the economic injury level.

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Scientific Note

PREVALENCE AND ABUNDANCE OF INSECT PESTS IN TRANSPLANTED AMAN RICE ECOSYSTEM

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Rice is the staple food of Bangladesh grown in Aus, Aman and Boro seasons. Most of the cultivable lands are occupied by rice in Aman season. Insect pests are the major concern of rice cultivation. Different species of insects are found in rice field based on growing seasons and localities. The study was conducted in T. Aman season around Patuakhali Science and Technology University (PSTU) to know the prevalence and abundance of insect pests in T. Aman rice ecosystem. Sweeping net was used to collect the insect samples. The prevailing insect pests were rice bug (*Leptocorisa acuta* Thun.), green leafhopper (*Nephotettix virescens* Dis.), brown planthopper (*Nilaparvata lugens* Stal), short horned grasshopper (*Hieroglyphus daganensis* Krauss), long horned grasshopper (*Tettigonia viridissima* Krauss), leaf roller caterpillar (*Cnaphalocrocis medinalis* Guenee), green horned caterpillar (*Melanitis leda* Lin.), yellow stem borer (*Scirpophaga incertulas* Walker), rice caseworm (*Parapoynx stagnalis* Zeller), rice pollen beetle (*Chiloloba acuta* Wied.) and rice skipper (*Pelopidas mathias* Fab.). Among these pests, green leafhopper (51.96% relative abundance) and brown planthopper (21.79% relative abundance) were the most abundant while rice pollen beetle was the least abundant (0.565%). These insect pests belong to 9 different families under the orders of Hemiptera, Orthoptera, Lepidoptera and Coleoptera.

Keywords: Rice, Aman season, Insect pests, Prevalence, Relative abundance

Rice (*Oryza sativa*) is the staple food of the peoples of Bangladesh and many other countries in the East and South Asia, the Middle East, West Indies and Latin America (Sharif *et al*. 2014). Rice is nutritionally rich containing significant amount of protein, polyphenol, sugar, amino acids and many others (Khatun and Mollah 2021). Different bioactive compounds present in rice also have antioxidant and anti-inflammatory activity (Khatun and Mollah 2024). In Bangladesh, rice is cultivated in more than 11.6 million hectares area producing 34 million tons of milled rice

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in 2012 (IRRI 2014). It occupies 75% of the total cropped areas (Ganesh Kumar *et al*. 2012) providing about 75% of the calories and 55% of the proteins necessary in the average daily diet of Bangladeshis (Bhuiyan *et al*. 2004). Globally, people get more than one-fifth of total calories from rice consumption (Sogawa 2015). Rice-feeding insect pests are the major constraint for successful production of rice which have been serious threat to food security as well. In Bangladesh, more than two hundred insect species are known to occur in rice ecosystems (Islam and Catling 2012, Ali *et al.* 2017) of which 20-33 species can cause economic yield losses if large numbers are present (Ali *et al.* 2021). Insect pests hampering growth and yield of rice includes brown plant hopper (*Nilaparvata lugens*), small brown planthopper (*Laodelphax striatellus* Fallen), rice leaf folder (*Cnaphalocrocis medinalis* Guenee), rice hispa (*Dicladispa armigera* Oliver), yellow stem borer (*Scirpophaga incertulas* L.), white-backed planthopper (*Sogatella furcifera* Horvath), rice bug (*Leptocorisa acuta* Thun.), ear cutting caterpillar (*Mythimna separata* Walker), rice gall midge (*Orseolia oryzae* Wood-Mason), etc. (Sogawa 2015, Liu *et al.* 2016**;** Ali *et al.* 2021). Among the insect pests, green leafhopper, brown plant hopper, white backed planthopper and yellow stem borer are most prevalent and abundant in all rice growing seasons (Afrin *et al.* 2019). The planthoppers (Hemiptera: Delphacidae) cause direct damage to plants by sucking the cell sap from the base of the plants (Ali *et al.* 2012) and indirectly they transmit rice ragged stunt (RRSV) and rice grassy stunt (RGSV) viruses (Hibino 1996). Outbreak of planthopper results drastic yield loss of rice and their control become less effective (BRRI 2009, Heong *et al.* 2015). Yellow stem borer attacks the rice plant at both vegetative and reproductive stage causing dead-heart and white head symptoms, respectively. This pest usually causes grain yield losses of 3-95% (Heinrichs *et al.* 1985).

Insect pests in rice field are specific to seasons and localities although some are available throughout the country irrespective of seasons. It was reported that prevalence of insect pests in Rangpur are green leafhopper, white leafhopper, grasshopper, yellow stem borer, white stem borer, rice leafroller, rice hispa, rice bug, long horned cricket, short- horned grasshopper, and long-horned grasshopper while at Barishal are yellow stem borer, rice leaf roller, rice hispa, long-horned cricket, long-horned grasshopper, short-horned grasshopper and green leafhopper indicating more at Rangpur than Barishal (Ali *et al.* 2017). The present study aimed at investigating the prevalence and abundance of insect pests in rice ecosystem at T. Aman season around Patuakhali Science and Technology University.

Study site: The study was conducted adjacent to Patuakhali Science and Technology University (PSTU), Dumki, Patuakhali, Bangladesh. The specific study sites included Muradia, Sreerampur and Angaria unions of Dumki upazila (sub-district). This area belongs to 22.46424°N 90.38252°E with an elevation of 1.0 m from the sea level (Hasan *et al.* 2014).

Soil type and land preparation: The study area is located under Active Ganges Floodplain (AEZ 10) Agro-Ecological Zone possessing calcareous, alluvium, and calcareous brown floodplain soils containing low organic matter and alkalinity. The fertility level was medium with N deficiency, soil pH ranged from 5.8 to 6.5, and cation exchange capacity (CEC) was 25.58 with silty clay loam textured soil (Khatun and Mollah 2023). The climate was characterized by alternate hot and cold seasons. The soil was prepared by repeated tillage and fertilized properly for successful crop production. Fertilization, transplanting and weeding were conducted following Khatun *et al.* (2020).

Sampling insect pests and their identification: Insects were sampled in all locations at the maximum tillering stage of rice. A sweep net (40-cm diameter) was used to collect insect pests in all plots. Ten complete sweeps were made randomly at the canopy level of the plants. The collected insect samples were kept in labelled bags and transported to the laboratory for sorting, identification and counting. The collected specimens after sorting out to family level were stored in 30 ml vials containing 70% (v/v) ethanol with few drops of glycerine and preserved in insect storage boxes for identification up to species level. These samples were identified with the help of a compound microscope, matching with the pictures and discussion with the experts.

Data processing and presentation: All the collected data were entered into Microsoft Excel to calculate relative abundance of any specific insect pests following the formula described by Mollah and Rahman (2012)**:**

$$\text{Relative abundance (\%)} = \frac{\text{Number of specific insect}}{\text{Total number of all insects}} \times 100$$

Graphical data were prepared using Sigma Plot 12.5 software (https://sigmaplot.software.informer.com/12.5/)

Prevalence of insect pests in rice field: In transplanted Aman rice field, ten insect pests were observed at Dumki of Patuakhali district. The prevalent insect pests were rice bug, green leafhopper, brown planthopper, short-horned grasshopper, long-horned grasshopper, leaf roller caterpillar, green horned caterpillar, yellow stem borer, rice caseworm, rice pollen beetle and rice skipper (Table 1, Fig. 1). Among the three different locations, rice bug, green leafhopper, brown planthopper, short-horned grasshopper, long-horned grasshopper and leafroller caterpillar was found in all locations. Rice pollen beetle and yellow stem borer was not found in location 2. Rice caseworm was found in location 1 and 2. Rice skipper was found in location 2 and 3. Therefore, the maximum insect was found in location 3. Ali *et al*. (2017) reported that yellow stem borer, rice leafroller, rice hispa, long-horned cricket, long-horned grasshopper, short-horned grasshopper and green leafhopper were prevalent in Barishal. However, in Sylhet green leafhopper, white leafhopper, rice hispa, long-horned grasshopper, short-horned grasshopper, rice bug, and caseworm were more abundant in Aman rice (Suhel *et al*. 2017).

Table 1. Prevalence of insect pests in Aman rice field at Dumki, Patuakhali

Sl.	Name of the insect pests identified		
	Location 1	*Location 2*	*Location 3*
1	Rice bug	Rice bug	Rice bug
2	Green leafhopper	Green leafhopper	Green leafhopper
3	Brown plant hopper	Brown planthopper	Brown planthopper
4	Short-horned grasshopper	Short-horned grasshopper	Short-horned grasshopper
5	Long-horned grasshopper	Long-horned grasshopper	Long-horned grasshopper
6	Leafroller caterpillar	Leaf roller caterpillar	Leafroller caterpillar
7	Green horned caterpillar	Green horned caterpillar	Not found
8	Rice yellow stem borer	Not found	Rice yellow stem borer
9	Rice caseworm	Rice caseworm	Not found
10	Rice pollen beetle	Not found	Not found
11	Not found	Rice skipper	Rice skipper

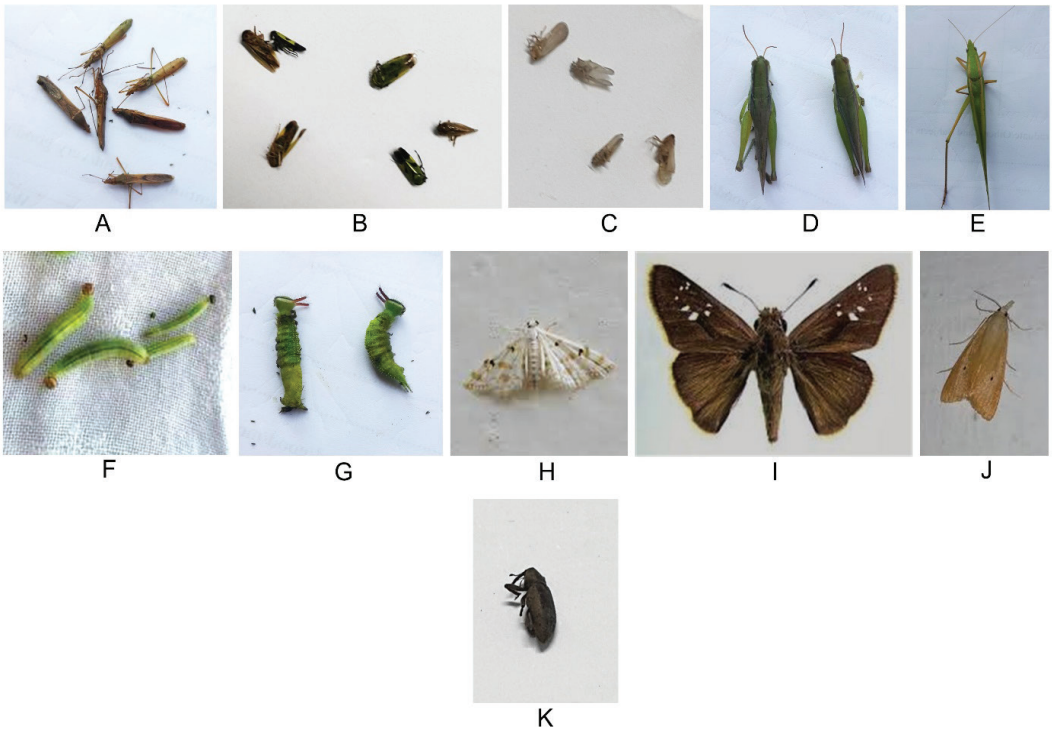


Fig. 1. The prevalent insect pests in rice field**. A.** Rice bug **B.** Green leafhopper **C.** Brown planthopper **D.** Short horn grasshopper **E.** Long horn grasshopper **F.** Leaf roller caterpillar **G.** Green horned caterpillar **H.** Rice caseworm **I.** Rice skipper **J.** Yellow stem borer **K.** Rice pollen beetle.

Abundance of insect pests in Amon rice field: Among the prevailing insect pests, green leafhopper was most abundant (93.00) which was followed by brown planthopper (39.00), and short-horned grasshopper (11.00) while rice pollen beetle was least abundant (1.00) (Table 2). However, the rice bug (6.00), long horned grasshopper (6.00), rice leaf roller caterpillar (6.00), green horned caterpillar (5.00), yellow stem borer (3.00), rice caseworm (4.00) and rice skipper (5.00) were moderately abundant in the field (Table 2). The number of green leafhopper was 31.00, 40.00 and 22.00 in location 1, 2 and 3, respectively (Table 2). Brown planthopper was also another prevalent insect in the rice field and the number was 19.00, 12.00 and 8.00 in location 1, 2 and 3, respectively (Table 2). The relative abundance of

these insect pests, green leafhopper (GLH, 51.96%) was highly abundant which was followed by brown planthopper (BPH, 21.79%) and short horned grasshopper (SHG, 6.15%) while rice pollen beetle (RPB, 0.56%) was least abundant which was followed by rice bug (RB, 3.35%), long horned grasshopper (LHG, 3.35%), rice skipper (RS, 2.79%), leaf roller caterpillar (LRC, 3.35%), rice caseworm (RC, 2.23%) and yellow stem borer (YSB, 1.68%) (Fig. 2). Afrin *et al.* (2019) reported that yellow stem borer and green leafhopper were most abundant in Barishal. On the other hand, in Sylhet green leafhopper was more abundant which was followed by white leafhopper, short-horned grasshopper, rice hispa, rice bug and others (Suhel *et al*. 2017). However, intercropping or mixed cropping contribute to increase the abundance and prevalence of insect pests in the field (Mala *et al*. 2020a). Another, strategy named push-pull also effective to increase prevalence and abundance of both pests and beneficial insects (Mala *et al*. 2020b).

Table 2. Abundance of insect pests in rice field at Dumki, Patuakhali

Sl.	Name of the insect pests collected and identified	Number of insects from 10 sweeps			Total number
		Location 1	*Location 2*	*Location 3*	
1	Rice bug	2.00	2.00	2.00	6.00
2	Green leafhopper	31.00	40.00	22.00	93.00
3	Brown plant hopper	19.00	12.00	8.00	39.00
4	Short-horned grasshopper	3.00	5.00	3.00	11.00
5	Long-horned grasshopper	2.00	2.00	2.00	6.00
6	Leafroller caterpillar	2.00	1.00	3.00	6.00
7	Green horned caterpillar	2.00	3.00	0.00	5.00
8	Yellow stem borer	2.00	0.00	1.00	3.00
9	Rice caseworm	2.00	2.00	0.00	4.00
10	Rice pollen beetle	1.00	0.00	0.00	1.00
11	Rice skipper	0.00	3.00	2.00	5.00

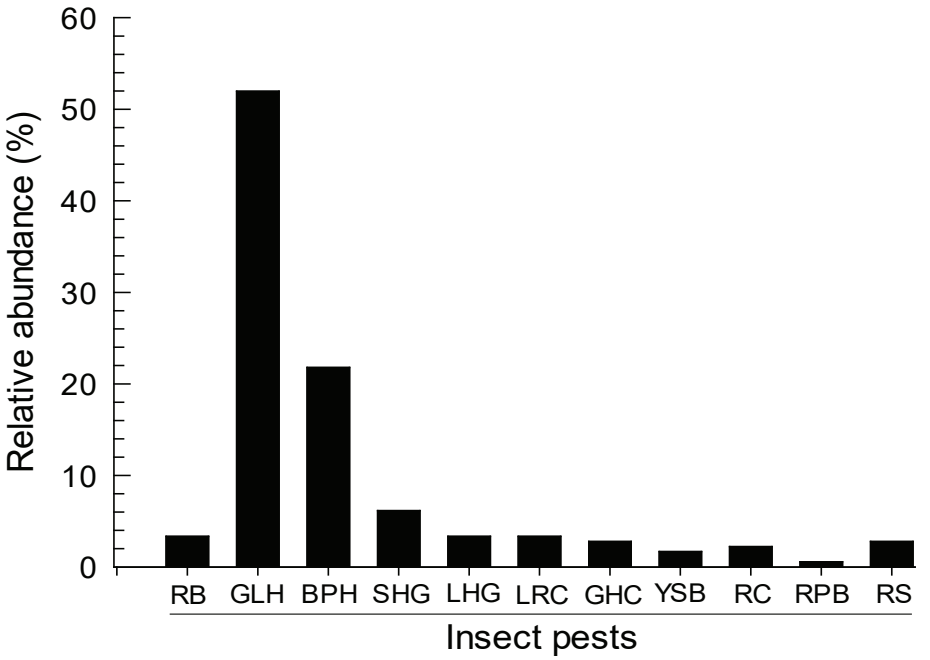


Fig. 2. Relative abundance (%) of insect pests in the rice field at Amon season. RB, rice bug; GLH, green leafhopper; BPH, brown planthopper; SHG, short horned grasshopper; LHG, long horned grasshopper; LRC, leaf roller caterpillar; GHC, green horned caterpillar; YSB, yellow stem borer; RC, rice caseworm; RPB, rice pollen beetle; RS, rice skipper.

Taxonomic status of prevalent insect pests: The prevalent insect pests belong to 9 different families of 4 different orders. Among the insect pests, rice bug (*Leptocorisa acuta* Thun.) belongs to Alydidae family, green leafhopper (*Nephotettix virescens* Dis.) belongs to Cicadellidae family, brown planthopper (*Nilaparvata lugens* Stal) belongs to Delphacidae, short horned grasshopper (*Hieroglyphus daganensis* Krauss) belongs to Acrididae family, long horned grasshopper (*Tettigonia viridissima* Krauss) belongs to Tettigoniidae family, Leaf roller caterpillar (*Cnaphalocrocis medinalis* Guenee), yellow stem borer (*Scirpophaga incertulas* Walker) and rice caseworm (*Parapoynx stagnalis* Zeller) belongs to Crambidae family, rice skipper (*Pelopidas mathias* Fab.) belongs to Hesperiidae family and rice pollen beetle (*Chiloloba acuta* Wied.) belongs to Cetonidae family (Table 3). From these family,

Alydidae, Cicadellidae and Delphacidae belongs to Hemiptera order, Acrididae and Tettigoniidae belongs to Orthoptera order, Crambidae and Hesperiidae belongs to Lepidoptera order and Cetonidae belongs to Coleoptera order (Table 3).

Table 3. Taxonomic identity of the insect pests in rice field at Dumki, Patuakhali

Common name	Scientific name	Family name	Order name
Rice bug	*Leptocorisa acuta* Thun.	Alydidae	Hemiptera
Green leafhopper	*Nephotettix virescens* Dis.	Cicadellidae	Hemiptera
Brown plant hopper	*Nilaparvata lugens* Stal	Delphacidae	Hemiptera
Short-horned grasshopper	*Hieroglyphus daganensis* Krauss	Acrididae	Orthoptera
Long-horned grasshopper	*Tettigonia viridissima* Krauss	Tettigoniidae	Orthoptera
Leafroller caterpillar	*Cnaphalocrocis medinalis* Guenee	Crambidae	Lepidoptera
Green horned caterpillar	*Melanitis leda* Lin.	Nymphalidae	Lepidoptera
Yellow stem borer	*Scirpophaga incertulas* Walker	Crambidae	Lepidoptera
Rice skipper	*Pelopidas mathias* Fabricius	Hesperiidae	Lepidoptera
Rice caseworm	*Parapoynx stagnalis* Zeller	Crambidae	Lepidoptera
Rice pollen beetle	*Chiloloba acuta* Wied.	Cetonidae	Coleoptera

In the transplanted Aman rice field, eleven insect pests were found. The prevailing insect pests were rice bug (Alydidae: Hemiptera), green leafhopper (Cicadellidae: Hemiptera), brown planthopper (Delphacidae: Hemiptera), short-horned grasshopper (Acrididae: Orthoptera), long-horned grasshopper (Tettigoniidae: Orthoptera), leafroller caterpillar (Crambidae: Lepidoptera), green horned caterpillar (Nymphalidae: Lepidoptera), yellow stem borer (Crambidae: Lepidoptera), rice caseworm (Crambidae: Lepidoptera), rice skipper (Hesperiidae: Lepidoptera) and rice pollen beetle (Cetonidae: Coleoptera). Green leafhopper (51.96% relative abundance) was most abundant, brown planthopper (21.79% relative abundance) was moderately abundant and rice pollen beetle was least abundant (0.565%) among the rice insect pests.

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Scientific Note

FARMERS' RESPONSE ON MUNG BEANS CULTIVATION AND PEST MANAGEMENT PRACTICES IN SELECTED COASTAL DISTRICTS OF BANGLADESH

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A comprehensive survey was conducted by extensive tour in Patuakhali, Barguna, Barisal, Jalokathi and Pirojpur coastal districts of Bangladesh to know the farmer's perception on the insect pests attacking mung bean and their management practices adopted by them during January to April 2019. Results of survey revealed that among the respondents (farmer's) the highest rate of mungbean farmers (66.00%) cultivated local mung bean variety followed by BARImung 6 (8.00%) and BARImung 5 (6.00%). Most (90.00%) of the mung bean growers opined that insect pests viz., flea beetle, leaf roller, whitefly, jassid, aphid, thrips and pod borer complex (*Maruca* sp and *Helicoverpa* sp.) attacked mung bean at different growth stages, among which flea beetle and pod borer were the most damaging insect pests. The rate of knowledge of farmers about mung bean insect pest infestation was 48.00% (thrips), 40.50% (aphid), 37.00% (leaf roller), 31.00% (white fly), 21.00% (jassids) and 15.50% (hairy caterpillar). Mung bean growers applied only chemical pesticides where majority (18.50%) of the growers sprayed virtako 40 WG followed by karate 2.5EC (13.80%) and voliam flexi 300SC (12.50%) while 1.50% growers applied actara for the management mungbean insect pests.

Keywords: Farmers' response, insect pest problems, pest management, pesticides

Mung bean *(Vigna radiata* L.*)* is the most important legume crops in Asia and gaining popularity in other continents (MoA 2011). Currently, mung bean is cultivated on more than 7.3 million hectares worldwide and produced 5.3 million tones (Nair *et al*. 2022). It contains about 51% carbohydrate, 26% protein, 4% mineral, and 3% vitamins (Yadav *et al*. 1994). Furthermore, it has the capacity to fix atmospheric nitrogen for the sustainability of agriculture (Ali and Gupta 2012).

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Mung bean seeds have a significant amount of vitamin C, iron and calcium when sprouted (Gwag *et al*. 2010). The immature grains of the mungbean are consumed as a vegetable and provide plant protein, fiber and phytonutrients, all of which have significant health advantages. In East and Southeast Asia, mung bean is commonly used to produce bean sprouts as well as to produce transparent noodles and mung bean paste, while in East Africa, it is more commonly consumed as a bean stew (Nair and Schreinemachers 2020). Mung bean is mainly grown by farmers because it is a potential rotational crop, has high market value, easily grows with minimum soil moistures with little or no land competing in the bulge, a short maturity period, an alternative option of animal feed and can be easily grown with a minimum labour requirement. Among several biotic and abiotic stresses, attack of insect pests is one of the major limiting factors of mung bean production. There have been reports of several insect pests infesting mungbean, causing significant losses by harming the various parts (seedlings or germs, leaves, stems, blooms, buds and pods, etc.) of the plants (Karim and Rahman 1991). Mung bean attacks by greater than 64 species of insect pests (Lal 1985). The most significant ones include stem flies, pod borers, spotted pod borer, pod bug, flea beetles, aphids, thrips, whiteflies, leaf hoppers and hairy caterpillars. Insect pests are responsible for 42% and 58% losses at pre-flowering and post-flowering stages, respectively of mung bean (Malik 1992). Since adoption responses of mung bean farmers on cultivation, insect pest occurrence and their management practices are important for increasing the production as well as productivity levels, hence this study was undertaken to know the farmers' responses on mung bean cultivation, insect occurrence, and its management problems faced and suggestions to overcome these problems.

The survey was conducted in 5 major mung bean growing coastal districts of Bangladesh viz., Barishal, Patuakhali, Barguna, Jalokathi and Pirojpur. In the survey program, a total of 10 Upazilas (two from each district) were selected under 5 sampled districts. The selection of respondents (mung bean farmers) was made on a stratified sampling technique for sampled districts and simple random sampling technique. Twenty mung bean farmers were interviewed face-to-face through pre-tested questionnaire from each selected upazila of the district. Thus, a total number of 200 farmers were selected through random sampling method from among the mung bean growers and interviewed personally. The selected upazilas were Barguna

sadar, Amtoli from Barguna, Patuakhali sadar and Dumki from Patuakhali, Barishal sadar and Banaripara from Barishal, Pirojpur sadar and Bhandaria from Pirojpur, Jalokathi sadar and Nalcity from Jalokathi district. The used variables/indicators were demographic: address, age, sex, social education, profession, area of mung bean cultivated land, name of used variety/varieties, incidence of their known insect pests, pests control measures practiced by them in the field. The field level data collection was taken from January to April 2019. Collected data were classified, tabulated and analyzed by using statistical method WASP program for frequency and percentage.

Major varieties cultivated by farmers: Most (66.00%) of the mung bean farmers cultivated local mung bean varieties due to high market price (Table 1). On the other hand, 8.00% farmers cultivated in BARI mung- 5 and 26.0% famers cultivated in BARI Mung- 6.

Table 1. Cultivated mung bean verities by the farmers

Varieties	Respondents	
	No. of respondent [N=200]	Percentage
BARI Mung - 5	16	8.00
BARI Mung - 6	52	26.00
Local Mung	132	66.00
Total	200	100

Major problems faced by farmers during mung bean cultivation: Most (92.00%) of the mung bean farmers opined that the insect pest attack was the major problem. Besides, the lack of training (76.00%) among the mung bean farmers followed by lack of modern varieties (64.50%), high price of pesticides (62.0%) and lack of marketing facilities (60.50%) were faced. Conversely, the lowest (47.00%) proportion of farmers reported about the weed infestation followed by lack of irrigation facilities (52.50%) which were the major problems faced by the farmers during mung bean cultivation (Table 2).

Table 2. Problems faced by the farmers during mung bean cultivation

SL No.	Major problems	Major problems faced by the farmers	
		No. of respondents [N=200]	Percentage
1	Insect pest attack in field	184	92.00
2	High price of pesticides	125	62.00
3	Lack of modern verities	129	64.50
4	Lack of irrigation facilities	105	52.50
5	Lack of marketing facilities	121	60.50
6	Lack of farmers training facilities	151	76.00
7	Weed infestation	94	47.00

Knowledge on the use of insecticides of mung bean growers: Among the respondent the highest rate (42.50%) of mung bean growers had moderate knowledge on insecticides use followed by 39.00% had low knowledge. On the other hand, the lowest percent (7.50%) mung bean growers had no knowledge on insecticides use followed by 11.00% who had high knowledge (Fig. 1).

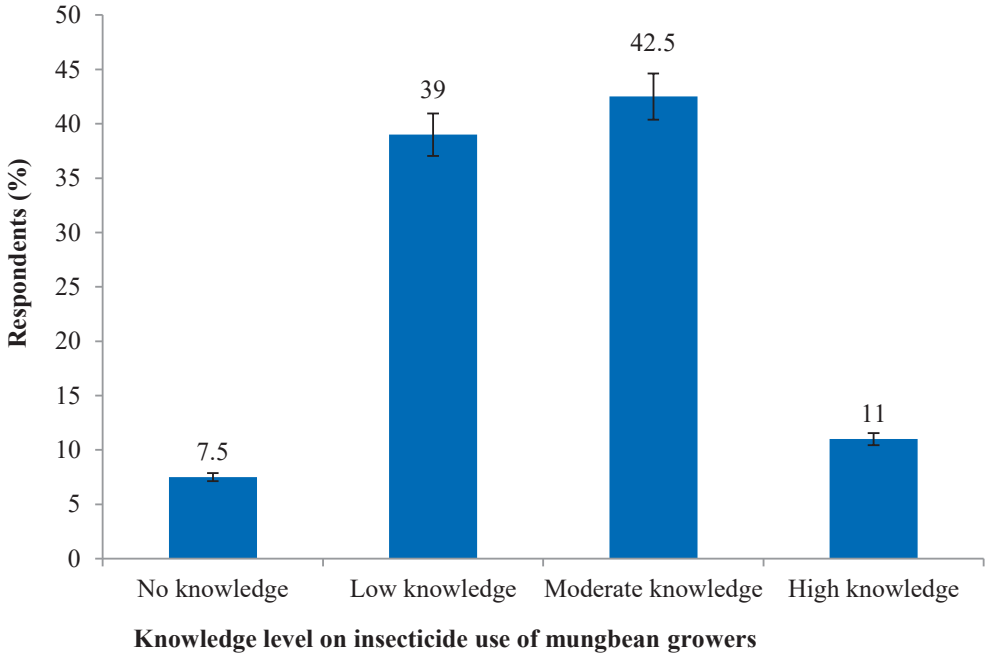


Fig. 1. Levels of knowledge on the use of insecticides among the mung bean growers

Seasonal occurrence of insect pests in mung bean: Results revealed that, out of 200 respondents, 100.00% farmers reported that pod borer infestation was found as the highest followed by flea beetle (87.50%) infesting mung bean. Whereas, 48.00% farmers reported that the mung bean was attacked by thrips, followed by aphid (40.50%), leaf roller (37.00%), whitefly (31.00%), mite (24.00%), jassids (21.00%) and hairy caterpillar (15.50%) (Table 3).

Table 3. Farmers' response on occurrence of insect pests of mungbean in the field

Name of insect pests	Response on pest incidence	
	No. of respondents [N=200]	Percentage
Pod borer	200	100.00
Flea beetle	175	87.50
Thrips	96	48.00
Aphids	81	40.50
Leaf roller	74	37.00
Whitefly	62	31.00
Mite	48	24.00
Jassids	42	21.00
Hairy caterpillar	31	15.50

Opinion on chemical insecticides used for controlling insect pests of mung bean: Majority of the mung bean farmers (18.50%) farmers sprayed Virtako 40 WG in mung bean field but Voliam flexi was sprayed by 12.50% farmers which was followed by Nitro 505 EC (9.50%). However, the lowest (0.50%) opinion expressed by the mung bean farmers who sprayed karate 2.5 EC in mung bean field, which was followed by Actara (1.50%), Mite Scavenger 250 EC (2.00%), Vertimec 1.8 EC (2.50%) (Table 4).

Table 4. Farmers' response on the use of pesticides used for managing insect pests of mung bean in field

Trade name of insecticides	Generic name of insecticides	Response on insecticide effect % Response
Virtako 40 WG	Thiomethoxam+Chlorantrainliprole	18.50
Voliam flexi	Thiomethoxam+Chlorantrainliprole	12.50
Nitro 505 EC	Chlorpyrifos+ Cypermethrin	9.50 8.50
Raise 20 SL	Imidacloprid	7.50
Imitaf 200 SL	Imidacloprid	6.50 6.00
Malathion 57 EC	Organophosphorus	5.50
Dimeothion 40 EC	Organophosphorus	4.50
Amithrin plus	Abamectin + Betacypermethrin	4.00 4.00
Salvo 20 SP	Acetamiprid	
Contaf 50 EC	Hexaconazole	
Amistertop	Azoxystrobin +Difencoazole	
Admire 200 SL	Imidacloprid	3.50
Ripcord 10 EC	Cypermethrin	3.00
Vertimec 1.8 EC	Abamectin + Beta cypermethrin	2.50
Mite scavenger 250 EC	Abamectin + Beta cypermethrin	2.00
Actara	Thiomethoxam	1.50
Karate 2.5 EC	Lambda cyhalothrin	0.50
Total		100

Over 87 percent of the farmers reported flea beetle was also a problem for mung bean cultivation. Some farmers who planted mung beans in larger areas wanted to take advantage of the high price of mung beans in the market. Minimum number of the farmers had adopted improved varieties, recommended seed rate, spacing, time and method of sowing. Hundred percent of the farmers mentioned that pod borers were the most important constraints of mung bean production in the study area. The findings of the present study were almost supported by Shilpkar *et al.* (2021) who reported that majority (52.50%) farmers belonged to medium adoption category followed by 40.83 per cent belonged to low adoption level. Meanwhile, some of the respondents opted to utilize smaller land areas because of high production expenses, limited time to tend their farms, and the fear of losing money due to uncertainties in

the country's agriculture sector (Domingo 2023). Besides that, a lack of access to high quality pesticides at a reasonable cost also a significant challenge for farmers. Most of the farmers have also suffered from getting high yielding varieties, a poor sale price during harvesting, price volatility, postharvest loss due to attack of weevils. Mung bean farmers were challenged by the high cost of farm inputs, the low farmgate price of mung bean at harvest, farm destruction caused by stray farm animals, the threat of wide spread pest infestation, and the low volume of production (Domingo 2023). Based on findings, it is suggested that the management limitations can be minimized by assuring availability of fertilizers and acquiring skill for seed treatment by the farmers. The study suggests that the above practices which had low adoption by farmers should be given due attention by extension agencies, so that the existing level of adoption of such practices can be increased.

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