INSECT PEST RISK ANALYSIS OF MAIZE IN BANGLADESH

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BY

S. M. MOYNUL ALAM
REGISTRATION NO.: 06-02063

A Thesis
Submitted to the faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
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CERTIFICATE

This is to certify that the thesis entitled, '**Insect Pest Risk Analysis of Maize in Bangladesh'** submitted to the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN ENTOMOLOGY** embodies the result of a piece of bona fide research work carried out by **S. M. Moynul Alam**, Registration No. **06-02063** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

Further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged by his.

Dated: June, 2013
Dhaka, Bangladesh

.....
Prof. Dr. Md. Razzab Ali
Supervisor

DEDICATED TO

MY

BELOVED PARENTS

LIST OF ABBREVIATIONS AND ACRONYMS

Sl. No.	Abbreviation	Full meaning
1.	AAEO	Assistant Agriculture Extension Officer
2.	AEO	Agriculture Extension Officer
3.	BADC	Bangladesh Agriculture Development Corporation
4.	BARI	Bangladesh Agricultural Research Institute
5.	BBS	Bangladesh Bureau of Statistics
6.	BRAC	Bangladesh Rural Advance Committee
7.	DAE	Department of Agricultural Extension
8.	DD	Deputy Director
9.	EU	European Union
10.	FAO	Food and Agriculture Organization
11.	FGD	Focus Group Discussion
12.	FY	Fiscal Year
13.	IPPC	International Plant Protection Convention
14.	ISPM	International Standard for phytosanitary Measures
15.	JAEO	Junior Agriculture Extension Officer
16.	NGO	Non Government Organization
17.	PRA	Pest Risk Analysis
18.	PP Wing	Plant Protection Wing
19.	QSSP	Quarantine Services Strengthening Program
20.	SAAO	Sub-Assistant Agriculture Officer
21.	UAO	Upazila Agriculture Officer
22.	USA	United States of America
23.	USDA	United States Department of Agriculture
24.	WTO	World Trade Organization

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Dated: June, 2013 **The Author**

SAU, Dhaka

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ABSTRACT

The study was conducted in the 40 upazilla of 20 selected major maize growing districts of Bangladesh during the period from January to April 2012 to find out the present status of insect pests of maize, their risks and management options. In light of this, various surveys with 400 maize farmers, 80 field level officials at upazilla level and 20 policy level officials of DAE at district were conducted through predesigned and pre-tested questionnaire in order to assess their knowledge about insect pests of maize including quarantine insect pests, their risks and management options/strategies. The data were analyzed using computer program SPSS 17.0 version. Almost all (100%) farmers chose rabi season for maize cultivation. Most (80%) of the farmers cultivated hybrid variety of maize as well as cultivated BRAC and BARI developed hybrid variety. Major (87%) source of maize seeds was seed dealer. The insect pest attack was the top ranking problem for maize cultivation. Major insect pests of maize were cutworm, armyworm, corn earworm, stalk/stem borer, white grubs, fall armyworm, corn seed maggot, corn leaf aphid and corn wireworm. Other insect pests of maize in Bangladesh were white grubs, grasshopper, termite, chinch bug, seed corn beetle, corn rootworm, sting bug and thrips. The infestation intensity of cutworm, armyworm and corn earworm were high in maize, while the others from medium to low intensity. Corn earworm, corn ear maggot, grain borer, grain weevil, Angoumois grain moth, Indian meal moth, seed corn maggot were designated as the major insect pests of stored maize grains, where corn earworm, corn ear maggot, Angoumois grain moth and Indian meal moth caused damage maize seeds with high intensity. Application of insecticides such as Dursban, Basudin, Furadan etc was the most widely used methods for controlling insect pests of maize in the field. The effective measures for preventing insect pests of maize seeds in storage were the storing of seeds in airtight container, use of botanicals, storing of seeds in polythene bag, use of insecticides in godown, use of fumigants like phostoxin tablet and maintenance of moisture content at low level. Cornstalk/stem borer, corn armyworm, fall armyworm, corn earworm, seed corn maggot and white grubs were the quarantine insect pests of maize in Bangladesh as reported by 45.0 to 85.0% policy level officials of DAE at district level. Outbreak of new insect pests, high intensity of crop damage, outbreak of disease infection through vector and outbreak of new insect biotype would be the major threats due to introduction of quarantine insect pest of maize in Bangladesh. Seed treatment, use of pest free imported hybrid seeds, cultural practices, farmers training to build up awareness, application of insecticides, quarantine barriers to prevent dispersion of quarantine insect pests and use of resistant maize variety were the most effective measures for controlling quarantine insect pests of maize.. Providing of training to the farmers regarding quarantine pest management, regular field visit and provide relevant advice to them were the most effective actions taken directly by the same respondents. Other actions taken were providing advice to use treated seeds, provide training to the DAE staffs and provide advice to use resistant maize variety. Strengthening of quarantine law enforcement, providing technical training to the quarantine personnel, judicious use of chemical fertilizers, improvement of existing quarantine laws, improvement of quarantine facilities would be the most effective measures to prevent quarantine insect pests of maize. The strengthening of existing quarantine station laboratories, establishment of modern quarantine laboratory, increase the skilled manpower regarding quarantine pests, proper identification of quarantine insect pests, training of concerned officials on quarantine pests, updating/strengthening of existing quarantine laws, strict application of quarantine laws, strengthening of quarantine services, enhancement of domestic production of hybrid seeds for maize would be the improvement strategies for existing quarantine services in Bangladesh.

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CHAPTER I

INTRODUCTION

Maize or corn (*Zea mays*) is belonging to the family of grasses (Poaceae). It is cultivated globally being one of the most important cereal crops worldwide. Maize is not only an important human nutrient, but also a basic element of animal feed and raw material for manufacture of many industrial products. The products include corn starch, maltodextrins, corn oil, corn syrup and products of fermentation and distillation industries. It is also being recently used as bio-fuel. So the importance of export and import of maize is an important issue of the world trade. The United States, China, Brazil and Mexico account for 70% of global production. India has 5% of corn acreage and contributes 2% of world production. The use of maize varies in different countries. In USA, EU, Canada and other developed countries, maize is used mainly to feed animal directly or sold to feed industry and as raw material for extractive/fermentation industries. In developing countries use of maize is variable. In Latin America and Africa the main use of maize is for food while in Asia it is used for food and animal feed. In fact in many countries it is the basic staple food and an important ingredient in the diets of people. Globally, it has been estimated that approximately 21% of the total grain produced is consumed as food (Shaw, 1988; Dowswell *et. al.*, 1996). Maize is the third most important cereal crop in Bangladesh, after rice and wheat. In Bangladesh it is mainly used for poultry feed, livestock's feed and human food in the form of various edible items. The production of maize in Bangladesh is popularizing for its multifarious use for food, feed and edible oil preparation (Ahad, 2003). The cultivation of maize is increasing day by day due to its diversified use, where the total area coverage and productions were 3.17 lakh acres with a production of 7.29 lakh metric tons in 2008-2009 and 3.75 lakh acres with a production of 8.87 lakh metric tons in 2009-2010 (BBS, 2011). The maize is richer in nutrition than rice and wheat, where it contains 11% protein including higher amount of essential amino acid, tryptophan and lysine. Besides these, because of yellow color, it contains 90 mg carotene or Vitamin A in each 100g grains (Hossain *et al.*, 2005). Therefore, maize would grow further to meet future nutrition, feed, and other demands, especially in view of the booming livestock and poultry producing sectors in the country.

There is an ample of opportunities for rapid expansion of maize area and production in Bangladesh through the dissemination of appropriate technology and commercialization of current market systems. Bangladesh Agricultural Research Institute (BARI) has already released high yielding maize varieties like Bornali, Shuvra, Khai Bhutra, Mohor, BARI Bhutta-5, BARI Bhutta-6, BARI Hybrid Bhutta-1, and then BARI Hybrid Bhutta 2, 3, 4, 5, 7, 9, 10, 11, 12, BARI Misty Bhutta 1 (Hossain *et al.*, 2005; Anon, 2013). This varietal development facilitated the increase cultivation in Kharif and Rabi season by the growers. Under the increasing trend of cultivation, the demand for hybrid seed is increasing rapidly and these are being imported from other countries. The climate of Bangladesh is characterized by a tropical monsoon with three main seasons having relatively little variation from month to month. Therefore, favorable agronomical characteristics are prevailing here to cultivate more maize crops in Bangladesh. But the production of maize in Bangladesh is attacked by pests like insects, diseases and weeds etc. As Bangladesh being the tropical and humid country, the infestation of insect pests is very common here. In addition to that due to increasing demand, hybrid maize seed are being imported from abroad and thus there is risk of introducing quarantine insect pests from other countries through seed. The quarantine insect pests are those which upon introduction from abroad can cause catastrophic losses to crops and those might be most dangerous for the host country. On the other hand, Bangladesh is surrounded by India and Myanmar from three sides- west, north and east leaving Bay of Bengal on the south. Bangladesh, India and Myanmar are popular as maize growing countries and therefore, there remain potential risks for presence of harmful quarantine maize pests in each country. The pathways of these pests may be both inter and intra country and threats of massive spread of quarantine pests and diseases through illegal carrying, boarder belt informal trade, and illegal black marketing and formal imports of seeds, plant materials, herbs, flood and rain waters, wind and natural disasters, etc. Hence, the quarantine pests are needed to be identified through this insect pest risk analysis study for future risk identification.

Research results reported by BARI (2006) that ten insects' attacks in maize among them four insects are considered as major pest. The studies show that cutworm (*Agrotis ipsilon*), stem borer (*Seamia inferens*), shoot borer (*Chilo pertellus*), leaf aphid (*Rhopalosiphium maidis*), cob borer/corn earworm (*Helicoverpa armigera*) are the major

insect pests of maize in Bangladesh. Among these insect pests, cutworm attacks seedling, stem borer and shoot borer attack maize stem and stalk from vegetative to flowering stage, leaf aphid attacks cob and silk of cobs, and cob borer/corn earworm attack and damage the cob during its formation. Hossain *et al.* (2005) reported that cutworm is the most destructive insect pest of maize in the field. Ahad (2003) reported that a number of insect pests cause damage maize, among them important ones are Asian maize borer (*Ostrinia furnacalis*), maize stem borer, (*Chilo partellus*), maize army worm (*Mythimna loreyi*), American bollworm (*Heliothis armigera*), maize aphid (*Rhopalosiphum maidis*), cutworm (*Agrotis ipsilon*), stem fly (*Atherigona varia soccata*), white grub (*Holotrichia* spp.), Thrips (*Caliothrips graminicola*), termite (*Odontotermes obesus*, *Microlemes anandi*). The research finding shows that various insect pests infested in different stages of the maize crop such as cutworms attack during seedling stages, stem and shoot borer attack during vegetative to flowering stage, leaf aphids during flowering stages and cob borers attack during cob formation stages. For enhancing production of maize, farmers used modern production technologies and cultural practices, used imported hybrid seed, chemical fertilizer, over and under use of insecticides, herbicides and fungicides against pests , irrigation, tillage, harrowing, weeding, thinning, spraying, harvesting, threshing, winnowing, drying storage, milling, grading, packaging, etc. Indeed, while some of these technologies are extensively used other technologies are very limited used due to availability of cheap labor. Hence there is a probability of risk associated with maize crops. Therefore, the present study was designed to identify the major insect pests of maize, their risks, damage potentials and way of management options.

Objectives

Considering the above points view in mind, present study was undertaken with the following objectives:

1. Listing of major insect pests of maize in Bangladesh,
2. To analyze the risks of insect pests of maize,
3. To identify the quarantine insect pests of maize in Bangladesh,
4. To find out the effective management options for controlling insect pests of maize.

CHAPTER II

REVIEW OF LITERATURE

Maize, *Zea mays* is belonging to the grasses family Poaceae. It is cultivated globally being one of the most important cereal crops worldwide. In Bangladesh, it is the third most important cereal crop in Bangladesh, after rice and wheat and cultivated in both rabi and kharif season. Maize is primarily of economic importance in the Bangladesh as poultry feed. A small proportion of maize is grown to produce sweet corn for human consumption (Nix, 2006). The changing global scenario is compelling policymakers to adhere to the regulations and obligations set by the World Trade Organization (WTO). The resulting new economic regime is expected to alter the economics of existing cropping systems, including maize, in terms of production, value added, and trade. To satisfy the prerequisite of WTO for maize trade, it is necessary to conduct pest risk analysis of maize in Bangladesh. Good number of research works has been done on different aspects of maize different parts of the world, but the insect pest risk analysis of maize in Bangladesh is the first step. Although considerable literature dealing with the risk analysis of maize in respect of insect pest identification and their management so far has been scare, some of the works related to the present study have been presented below under the following sub-headings:

2.1 General review on maize

Maize or corn (*Zea mays*) is a plant belonging to the family of grasses (Poaceae). It is cultivated globally being one of the most important cereal crops worldwide. Maize is not only an important human nutrient, but also a basic element of animal feed and raw material for manufacture of many industrial products. The products include corn starch, maltodextrins, corn oil, corn syrup and products of fermentation and distillation industries. It is also being recently used as biofuel. Maize is a versatile crop grown over a range of agro climatic zones. In fact the suitability of maize to diverse environments is unmatched by any other crop. It is grown from 58^{o}N to 40^{o}S, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000 mm of rainfall per year (Shaw, 1988; Dowswell *et. al.*, 1996) and with a growing cycle ranging from 3 to 13 months (CIMMYT, 2000).

However the major maize production areas are located in temperate regions of the globe. The United States, China, Brazil and Mexico account for 70% of global production. India has 5% of corn acreage and contributes 2% of world production

2.2. Geographic Origin and distribution of maize

The center of origin for *Zea mays* has been established as the Mesoamerican region, now Mexico and Central America (Watson & Dallwitz, 1992). Archaeological records suggest that domestication of maize began at least 6000 years ago, occurring independently in regions of the southwestern United States, Mexico, and Central America (Mangelsdorf, 1974). The Portuguese introduced maize to Southeast-Asia from the America in the 16th century. The maize was introduced into Spain after the return of Columbus from America and from Spain it went to France, Italy and Turkey. In India, Portuguese introduced maize during the seventeenth century. From India it went to China and later it was introduced in Philippines and the East Indies. Corn now is being grown in USA, China, Brazil, Argentina, Mexico, South Africa, Rumania, Yugoslavia and India. Various hypothesis have been proposed on the origin/domestication of maize (OECD, 2006). Teosintes (*Z. diploperennis* and *Z. mays* sp. *mexicana*) and *Tripsacum* species are often described as having roles in the domestication process of maize (Mangelsdorf, 1974; Galinat, 1988). An early hypothesis proposed that *Z. mays* sp. *mexicana* was the product of a natural hybridization of *Tripsacum* and *Zea* (Mangelsdorf, 1974). Further crossings of teosinte with wild maize are thought to have produced the modern races of maize. The possibility of intergeneric hybridization of either *Z. diploperennis* or *Tripsacum* with an extinct wild maize has also been proposed as the ancestral origin of *Z. mays* (Radu *et al.*, , 1997; Purseglove, 1972). Eubanks (1993, 1997a) suggests that domesticated maize may have arisen via human selection of natural hybrids between Tripsacum and perennial teosinte.

2.3. History of maize in Bangladesh

The Portuguese pioneers first to introduce maize (*Zea mays L.*) to the Indian subcontinent in the sixteenth century (Hellin and Erenstein, 2008). Centuries later, around mid-1900s, research and development (R&D) on maize emerged in Bangladesh (which was then considered to be East Pakistan, before the 1971 Liberation War).

In the early 1950s, the Economic Botany (Fibres) Division, under the Directorate of Agriculture (DOA) of East Pakistan, introduced a variety of popcorn and sweet corns, imported from the United States of America, with the intention of developing hybrid maize in the country. In the 1960's, maize research lost its priority and began to be perceived as a minor cereal crop, with the introduction of modern rice and high-yield wheat varieties resultant of the Green Revolution technology promotion of the times. Consequently, the continuity of the germplasm was abated over the course of time. There were, however, following studies conducted at the Government Dairy Farm in Savar, new composite maize variety fodder was introduced, and coined Savar-1, Savar-2 and JC-1. The germplasm of these fodder-types were since then maintained, but the characteristic unpopularity of maize persisted.

By the early 1980's, disproportionately little land was cultivated for maize in Bangladesh. In 1980 to 1981, only 2024 hectares of total cultivated land was planted with maize, with a total annual production of 1000 metric tons; this averaged a yield of 0.50 ton/ha (Hasan *et al.*, , 2008). However, with the rapid expansion of the country's poultry industry in 1990s and 2000s, the demand for maize grain as poultry feed increased manifolds. Initially, this demand was serviced by maize grain imported from Thailand, USA and other countries.

Gradually, with the concerted efforts of different public, private, national and international organizations, maize started gaining popularity as a lucrative cash crop. Farmers, especially, of northern and north-western parts of the country started capitalizing on this opportunity. Farmers increasingly started adopting maize cultivation, for its monetary benefits - it offered a higher and stable yield rate with fair market prices, resulting in better profitability compared to two other competitive crops *Boro* rice and wheat (in the *Rabi* season). Additionally, maize also served as food, feed and fuel in the rural area (Anon, 2013).

2.4. Variety of maize cultivated in Bangladesh

This study presents the many and varied varieties of maize cultivated in Bangladesh, and their widely diversified yield rate and prices. A significant proportion of the maize varieties are hybrids. The highest yielding brands are Indian Monsanto varieties, which are also amongst the most costly ones.

Bangladesh Agricultural Research Institute (BARI) has already released high yielding maize varieties like Bornali, Shuvra, Khai Bhutra, Mohor, BARI Bhutta-5, BARI Bhutta-6, BARI Hybrid Bhutta-1, and then BARI Hybrid Bhutta 2, 3, 4, 5, 7, 9, 10, 11, 12, BARI Misty Bhutta 1 (Hossain *et al.*, 2005).

Table 2.1. Maize variety in Bangladesh

SL. No.	Variety	Yield/Hectare (MT)	Market Share (%)
1	900 M Gold	9-11	15-18%
2	900 M	8-10	
3	827 K	7-8	
4	717 K	7-8	
5	Pacific 11	6-7	30-35%
6	Pacific 60	6-8	
7	Pacific 984	7-8.5	
8	Uttaran	6-7	
9	NK 40	8-8.5	13-16%
10	NK 46	7-8	
11	Pioneer 3056	7-8	20-25%
12	Super 42	7-8	
13	Kanok	5-6	
14	Hira 405	6-7	
15	Semco 100	6-7	
16	Others	5-6	15-20%

Source: Anon. (2013)

2.5. National demand-supply scenario for maize seed

The growth of the maize sector is a fairly recent phenomenon in Bangladeshi agriculture. Maize farming has been gradually gaining momentum over the past few decades. In the 2007-08 fiscal year (FY), the sector reached its peak, with a national demand for maize seed at 6876 MT (as compared to 538 MT in the 2001-02 FY). During that year, maize cultivation accounted for 0.38 million hectares of land. However, reflecting the major crash in the poultry industry in the following year resultant of the avian flu epidemic, the demand for maize also shrunk significantly. This, in turn, drastically decreased the demand for seed by farmers. This catastrophe negated the new found growth of the maize subsector, and dragged it back to chronic underperformance, to the effect that in the 2010-11 FY, the national demand was even lower than 2006 levels (BBS, 2012).

However, as the statistics illuminate, the national demand for seed has always been higher than its domestic supply. And such increasing and higher demand is being mostly met through imports followed by local production of hybrid seed by the Bangladesh Rural Advancement Committee (BRAC) and the Bangladesh Agricultural Development Corporation (BADC). The study unearthed an interesting practice amongst a few farmers, which does not seem technically feasible according to agro-science conventions. The team found that in certain cases, farmers sourced 10% of their seed demands from the seeds they had preserved from their previous year's production. Additionally, some degree of informal trade in border areas are also reported, which is used to meet a partial seed demand. Analyzing the data available for the last decade, it was found that on an average, over 80% of the domestic seed demand is satiated through imports. Among all varieties, Indian Monsanto seeds claim highest demand by farmers. An acute shortage of Monsanto seed was reported in the year before the study was initiated (2012). Importers actually got only 40% of the amount they demanded from its parent company, due to the increased worldwide and especially increased Indian domestic demands of the Monsanto seeds.

Maize is cultivated in almost all the districts of Bangladesh except in Narail District (Anon, 2013). Much like in the case for seeds, the gap in the maize market is filled by imports. Thus price prevails at import parity where world corn price dominates in the domestic market as well. Bangladesh usually imports from regional and neighboring countries, like India and Myanmar who have surplus maize production.

During the FY 2007-08, the national demand for maize was around 1.2 million MT, which was well met by the country's production of 1.35 million tons. Except for that period, Bangladesh has fallen short of meeting its national demand for every other year. Such shortfalls in production are typically offset by imports, and this has been the characteristic solution for all the years of domestic supply deficits. For the financial years of 2008-09, 2009-10, 2010- 11 and 2011-12, the country had to import almost 0.15, 0.25, 0.42, 0.45 and 0.14 MT maize kernels, respectively. The market distortion created by the disruption of demand due to the poultry industry crash as detailed earlier is projected to continue past the current year; this implies a grim outlook for the sector, especially when considering that even potential domestic maize production levels of 1.5 million tons in

2011-12 would not rectify the situation. The most sustainable and effective avenues for reducing import dependency and strengthening the maize sector are through increasing maize production during both the *Rabi* (spring) and *Kharif* (summer) seasons, and ensuring sufficient storage facilities. These components have recently been given the due considerations as essential for the development of the maize sector (BBS, 2012).

2.6. Production of maize in Bangladesh

Maize is the third most important cereal crop in Bangladesh, after rice and wheat. In Bangladesh it is mainly used for poultry feed, livestock's feed and human food in the form of various edible items. The production of maize in Bangladesh is popularizing for its multifarious use for food, feed and edible oil preparation (Ahad, 2003). The cultivation of maize is increasing day by day due to its diversified use, where the total area coverage and productions were 3.17 lakh acres with a production of 7.29 lakh metric tons in 2008-2009 and 3.75 lakh acres with a production of 8.87 lakh metric tons in 2009-2010 (BBS, 2011).

2.7.1. Insect pests of maize in Bangladesh

In Bangladesh, research results reported by BARI (2006) that ten insects' attacks in maize among them four insects are considered as major pest. The studies show that cutworm (*Agrotis ipsilon*), stem borer (*Seamia inferens*), shoot borer (*Chilo pertellus*), leaf aphid (*Rhopalosiphium maidis*), cob borer/corn earworm (*Helicoverpa armigera*) are the major insect pests of maize in Bangladesh. Among these insect pests, cutworm attacks seedling, stem borer and shoot borer attack maize stem and stalk from vegetative to flowering stage, leaf aphid attacks cob and silk of cobs, and cob borer/corn earworm attack and damage the cob during its formation. Hossain *et al.* (2005) reported that cutworm is the most destructive insect pest of maize in the field.

Ahad (2003) reported that a number of insect pests cause damage maize, among them important ones are Asian maize borer (*Ostrinia furnacalis*), maize stem borer, (*Chilo partellus*), maize army worm (*Mythimna loreyi*), American bollworm (*Heliothis armigera*), maize aphid (*Rhopalosiphum maidis*), cutworm (*Agrotis ipsilon*), stem fly (*Atherigona varia soccata*), white grub (*Holotrichia* spp.), Thrips (*Caliothrips graminicola*), termite (*Odontotermes obesus, Microlemes anandi*). The research finding shows that various insect pests infested in different stages of the maize crop such as

cutworms attack during seedling stages, stem and shoot borer attack during vegetative to flowering stage, leaf aphids during flowering stages and cob borers attack during cob formation stages.

2.7.2. Insect pests of maize worldwide

Among the several major insect pests of maize, the maize borer, *Chilo partellus* is the most destructive one causing heavy yield loss in maize. Summer and winter maize are reported to be damaged whereas winter maize is undamaged by this pest (Coppel *et al.*, , 1985, Sharma *et al.*, 2010). Foliage damage, stem tunneling, dead-heart, stem breakage, plant lodging, ear damage, and tassel damage are the various damages caused by this pest. Foliage damage, stem tunneling and dead heart are, however, the major ones that cause severe yield loss in maize (Chatterji *et al.*, 1969; Attri *et al.*, 1968; Mathur *et al.*, 1981).

The Asian corn borer, *Ostrinia furnacalis*, is a major pest of corn (maize) in eastern and south-eastern Asia. In Japan, five species of the *O. furnacalis* species complex (*O. furnacalis*, *O. orientalis*, *O. scapulalis*, *O. zealis* and *O. zaguliaevi*) occur (Mutuura & Munroe, 1970).

Ostrinia furnacalis is a species of moth in the family Crambidae, the grass moths. It is known by the common name Asian corn borer. Its distribution extends from China to Australia. It is well known as an agricultural pest on several crops, especially corn. It is one of the worst corn pests in Japan and China (Huang, *et al.*, 1998).

It is likely the worst pest insect on corn in the western Pacific region of Asia, and one of the worst pests overall, second only to maize downy mildew (Nafus and Schreiner, 1991).

This insect can cause devastating losses in a corn field. In the Philippines losses of 20 to 80% have been reported. In Taiwan it has reached 95%, and in the Marianas, 100% (Nafus and Schreiner, 1991).

The moth larva feeds on almost any part of the plant, damaging the fruit when it bores into the ear to feed on the silk and kernels. It also invades the tassels, where it feeds on pollen; detasseling the corn can help to reduce larval populations (Plant wise Knowledge Bank. CABI).

The primary host of corn leaf aphid is corn (maize). Alternative hosts include: barley, green beans, manila hemp, millets, papaya, potato, rice, squash and other Gramineae, sorghums, sugarcane, tobacco and wheat (Adams and Drew *et al.*, 1964).

The corn leaf aphid is cosmopolitan in distribution throughout the tropics, subtropics and warmer temperate regions. It has also been reported in Japan and southern Scandinavia. Introduced to Hawaii by commercial trade, this aphid was first reported on Oahu in 1906 and has since spread to all major islands (Blackman and Eastop *et al.*, 1984). This aphid infests all parts of the corn plant above ground. The most severe damage occurs to the tassel, often aphid populations become so dense within the protective sheath of the tassel that proper pollination does not occur and incomplete ears result. Leaves may become encrusted with aphids and wilt. Under sever conditions leaves will be dry and chlorotic. Corn leaf aphid excretes copious amounts of honeydew. This honeydew may attract attending ants, serve as media on which sooty mold may grow, and provides food for corn earworm moths and other pests of corn. This aphid is a vector of many virus diseases affecting cereals and other crops. Persistent viruses include barley yellow dwarf, maize leaf fleck, and millet red leaf. Non-persistent viruses include abaca mosaic, maize dwarf mosaic and sugar cane mosaic. In Hawaii it has been found to be a vector of cucumber mosaic virus (South celery mosaic strain), onion-yellow-dwarf virus and papaya ringspot virus (Foott, 1977).

Maize / corn (*Zea mays*) is the primary host for Western Corn Rootworm with adults and larvae feeding on different plant parts. Adults feed on flowering maize pollen, silks, leaves and young developing kernels. In North America adults also feed on a large number of other plants found around and within maize fields that flower in the summer and early autumn (Metcalf & Metcalf, 1993).

Short distance movement occurs when adults Western Corn Rootworm walk or fly at low elevations (<5 m above ground level) within and between fields. Such types of movement are responsible for low rates of spread. Greater spread occurs when newly mated females disperse aerially above 10 m. In laboratory trials, females were found to fly for up to 4 hours at a time, travelling up to 24 km in a single flight (Coats *et al.*, 1986).

Crop rotation is the major management option for Western Corn Rootworm (Levay *et al.*, 2006). Due to limited larval mobility, survival is restricted if eggs hatch and larvae

emerge in a field previously sown with maize, but now in rotation (Branson & Kryson, 1981). Branson (1989) suggests that the soil dwelling larvae have a restricted movement ability and those that do not feed on a host within 24h have a much reduced chance of surviving to adulthood, e.g. only 55% of larvae survive to adulthood if they do not feed on host roots within 24h; less than 5% survive to adulthood if they do not find a host within 72h. Hibberd *et al.,* (2003) suggest Western Corn Rootworm larvae can move just less than 50cm so, under most circumstances, they should be able to find host roots only if they hatch within a field crop of a host. Thus crop rotation is recognised as the most effective method of control for Western Corn Rootworm. The major insecticide applied to maize was chlorpyriphos that has historically been used against fruit fly (*Oscinella* fruit), but is active against Western Corn rootworm.

The larva of the moth *Helicoverpa zea* (formerly in the genus *Heliothis*) is a major agricultural pest. It can feed on many different plants (i.e. it is polyphagous) during the larval stage. Accordingly, the species has been given many different common names. When the larva consumes cotton, it is known as the cotton bollworm. When it consumes corn, it is known as the corn earworm. When it consumes tomatoes, it is known as the tomato fruitworm. It has also been known to consume many other crops. The adult moth is a pollinator and it is pictured on the right engaging in this process (Hardwick, 1965).

Helicoverpa armigera, a close relative of *H. zea* from which the latter evolved, is a major pest in Asia, Africa and Australia (Fitt, G.P. 1989).

Corn earworm is considered by some to be the most costly crop pest in North America. It is more damaging in areas where it successfully overwinters, however, because in northern areas it may arrive too late to inflict extensive damage. It often attacks valuable crops, and the harvested portion of the crop. Thus, larvae often are found associated with such plant structures as blossoms, buds, and fruits. When feeding on lettuce, larvae may burrow into the head. On corn, its most common host, young larvae tend to feed on silks initially, and interfere with pollination, but eventually they usually gain access to the kernels. They may feed only at the tip, or injury may extend half the length of the ear before larval development is completed. Such feeding also enhances development of plant pathogenic fungi. If the ears have not yet produced silk, larvae may burrow directly

into the ear. They usually remain feeding within a single ear of corn, but occasionally abandon the feeding site and search for another (Archer and Bynum, 1994).

The corn earworm occurs throughout temperate and tropical regions of the world. Unintentionally introduced to Hawaii from North America in 1930, this moth has become a common species and a serious pest of agricultural crops on all major islands in the State (Flint, 1985).

The global distribution of *Helicoverpa armigera* is in Asia, Africa and Oceania (EPPO, 2006). *H. armigera* is a highly polyphagous species. The most important crop hosts of which *H. armigera* is a major pest are tomato, cotton, pigeon pea, chickpea, sorghum and maize. Other hosts include dianthus, rosa, pelargonium, chrysanthemum, groundnut, okra, peas, field beans, soybeans, lucerne, Phaseolus spp., other Leguminosae, tobacco, potatoes, maize, flax, a number of fruits (Prunus, Citrus), forest trees and a range of vegetable crops (CAB, 2006; Multani and Sohi, 2002; Chandra and Rai, 1974; Gahukar, 2002; Kakimoto *et al.*, 2003).

A female may lay up to about 3,000 eggs (more than 400 in 24 h), mainly at night. Depending on the climatic conditions, 2 to 11 generations annually have been reported (EPPO, 2007; Shanower and Romeis, 1999). The wide geographic distribution over the world shows that *H. armigera* can establish in regions with (seasonal changes from) tropical climates (i.e. Africa, tropical Asia) to regions with a cooler temperate climate (i.e. Mediterranean area of the EU).

In regions with a cooler, temperate climate, *H. armigera* overwinters in a diapause stage (Kurban *et al.*, 2005). Feng *et al.* (2005) stated that gene flow is high because of large-scale migration of populations. Furthermore, *H. armigera* has developed resistance against insecticides. Field failures resulting from pyrethroid resistance have been reported from Australia, Thailand, Turkey, India, Indonesia and Pakistan (CAB International, 2006).

H. armigera can move very easily due to natural migration. Pedgley (1985) showed that *H. armigera* migrates up to 1,000 km to reach Britain and other parts of Europe from sources in southern Asia and northern Africa.

Sekulic *et al.* (2004) reported damage, mainly on maize, sunflower, soybean, tomato, pepper and beans, in the Voivodina Province of Serbia and Montenegro in the very warm summer of 2003. 93.7% of maize plants were infested, in sunflower crops 80-100% of the plants were damaged and 85.3% of the soybean pods were injured in August.

Fall armyworm, *Spodoptera frugiperda* (J.E. Smith), and Southwestern corn borer, *Diatraea grandiosella* Dyar, are economically important pests of maize (*Zea mays* L.) in the southeastern Asia. These insects attack plants in both the vegetative and reproductive stages of growth. Plant resistance is widely considered a desirable means for reducing losses to both insects. Breeding programs have been established at several locations to identify and develop maize germplasm with resistance to these and other Lepidoptera (Smith *et al.,* 1989, Widstrom 1989, Williams & Davis 1997).

Yield reductions in maize due to feeding of the fall armyworm have been reported as high as 34% (Carvalho, 1970; Cruz and Turpin, 1982; 1983, Williams and Davis, 1990; Willink *et al.,* 1991; Cruz *et al.,* 1996).

There is little or no data available on the effects of fumigants, contact insecticides or other control measures on most of the pests identified as stored grain pest of maize. Nonetheless, most are unlikely to be more tolerant than *Tribolium castaneum* to methyl bromide (Bond, 1989), *Sitophilus oryzae* to phosphine (Anon, 1997) or the lesser grain borer, *Rhyzopertha domininca* to heat (Banks & Fields, 1995).

According to the Food and Agriculture Organization [FAO], the worldwide losses in warehouses reach figures of 10 %; specifically in Brazil, these losses are around 20 % since the storage conditions in the countryside are poor (Gallo *et al.,* 2002).

The maize weevil *S. zeamais* can be found in the entire world's warm and tropical areas; it is the primary pest for maize, wheat, rice and sorghum. It can also grow in processed cereals, such as pasta, cassava, etc. (Pacheco and De Paula, 1995).

Heat can be used for the processing or devitalisation of grain and may be insecticidal. Temperatures above 50°C are insecticidal, and become rapidly more so as temperatures increase above this. All storage pests are killed by a few seconds exposure to either wet or dry heat of 65°C (Field, 1992; Banks, 1998).

CHAPTER III

MATERIALS AND METHODS

The changing global scenario is compelling policymakers to adhere to the regulations and obligations set by the World Trade Organization (WTO). The resulting new economic regime is expected to alter the economics of existing cropping systems, including maize, in terms of production, value added, and trade. To satisfy the prerequisite of WTO for maize trade, it is necessary to conduct pest risk analysis of maize in Bangladesh. Thus, "Pest Risk Analysis (PRA) of Maize and listing of Quarantine Pests" was undertaken to identify the insect, disease and weed pests of maize in major maize growing regions of Bangladesh and implemented by the "Quarantine Services Strengthening Program (QSSP)" under Plant Protection Wing of the DAE. The present research work was done as the part of "PRA of maize and listing of Quarantine Pests". Considering the objectives of the present study, the information were collected from relevant secondary documents, field survey for quantitative data from maize farmers as well as interview and group discussions with field level as well as policy level officials who are directly involved with maize cultivation in major maize growing areas in Bangladesh for qualitative data through pre-tested questionnaires in order to assess the knowledge of insect pests of maize, their risks and quarantine insect pests to make a list. Physical field visits were also conducted to make a real picture of the insect pests in maize. The Pest Risk Analysis (PRA) of Maize and listing of Quarantine Pests in Bangladesh was undertaken by the QSSP. The research methods used in the present study have been furnished in the following sub-headings:

3.1. Duration of the study

The field survey, interviews, group discussion with relevant respondents and direct field visits of major maize growing areas in Bangladesh were conducted during the period from January to April, 2012.

3.2. Study area

The survey study was conducted in 40 upzilla of selected 20 major maize growing districts of Bangladesh under the Rangpur, Rajshahi, Khulna, Barisal, Dhaka and Chittagong divisions. The questionnaires, the instrument for data collection, were pre-tested in two upzillas of Tangail and Manikganj districts prior to beginning of nationwide survey. The study districts and respective upazilla are presented sequentially below:

Table 3.1. Districts and Upazillas for survey the prevalence of insect pests of maize in Bangladesh

Sl. No.	Districts	Sample Upazilas surveyed	
		Name of Upazilla	Numbers
1	Rangpur	i. Rangpur Sadar, and ii. Mithapukur	2
2	Dinajpur	i. Dinajpur Sadar, and ii. Fulbari	2
3	Bogra	i. Sherpur, and ii. Adamdighi	2
4	Naogaon	i. Naogaon Sadar, and ii. Patnitala	2
5	Rajshahi	i. Tanor, and ii. Godagari	2
6	Pabna	i. Pabna Sadar, and ii. Atgoria	2
7	Sirajgonj	i. Sirajgonj Sadar, and ii. Ullapara	2
8	Jessore	i. Jessore Sador, and ii. Zikorghacha	2
9	Kushtia	i. Kushtia Sador, and ii. Daulatpur	2
10	Jhenidah	i. Jhenidah Sadar, and ii. Harinakundu	2
11	Chuadanga	i. Jibon nagor, and ii. Damurhuda	2
12	Faridpur	i. Faridpur Sadar, and ii. Nagorkanda	2
13	Tangail	i. Tangail Sador, and ii. Shakipur	2
14	Sherpur	i. Sherpur Sadar, and ii. Nakla	2
15	Mymensingh	i. Muktagacha, and ii. Fulpur	2
16	Kishoreganj	i. Kishoreganj Sadar, and ii. Kotiadi	2
17	Netrokona	i. Netrokona Sadar, and ii. Purbadhala	2
18	Manikganj	i. Manikganj Sadar, and ii. Saturia	2
19	Comilla	i. Comilla Sadar, and ii. Burirchong	2
20	Chittagong	i. Mirersarai, and ii. Satkania	2
Total	**20**		**40**

3.3. Respondents of the study

The field study was conducted to find out the present status of the insect pests of maize in the sampled districts of Bangladesh. The study was done through survey questionnaires, interviews and focus group discussion (FGD) with the relevant respondents. The five categories of respondents namely, maize farmers, policy and field level officers of Department of Agriculture Extension (DAE), pesticide dealers/traders and seed dealers/traders were interviewed through pre-tested questionnaires in 40 Upazillas of 20 selected major maize growing districts of Bangladesh as well as FGDs were also conducted through predesigned guidelines to assess the knowledge of insect pests of maize, their risks and quarantine insect pests to make a list in 20 sampled districts.

3.4. Sample size

In the field survey 10 maize farmers, one Sub-Assistant Agriculture Officer (SAAO), one Upazila Level Officer (UAO/Adl. UAO/AEO/AAEO/JEO/SAPPO) for each Upazilla and one District Level DAE Officials (DD/DTO/CPS/PPS/HS) for each district were interviewed by the predesigned questionnaires. In addition, information was also collected from one BARI scientists/researchers/BADC officials or concerned resource personnel. The sampled farmers were selected in consultation with the Upazila Agriculture Officer (UAO) and Sub-Assistant Agriculture Officer (SAAO) of DAE. The total sample size was 700 as shown below:

Table 3.2. Sample respondents of the field survey

Respondent(s)	Sample size
District Level Officials of DAE	20
Upazila Level Officials of DAE	40
Sub-Assistant Agriculture Officer (SAAO) of DAE	40
Maize farmers	400
Focus Group Discussion with DAE officials, BADC/Researchers organization personnel/pesticide dealer/seed dealer of the concerned district (20x10)	200
Total	**700**

3.5. Variables covered

Considering the study objectives the following variables were considered during development of questionnaire/FGD guidelines/checklist for data collection from the respondents.

1. Demographic **:** Name, Age, Sex
2. Social **:** Education, Profession
3. Employment : Designation, Experience
4. Study related indicators:
    - Seasons, variety of maize for cultivation;
    - Sources of maize seeds used cultivation;
    - Major problems for maize cultivation;
    - Name of major insect pests of maize in the field and storage;
    - Stages of maize crop attacked by the major insect pests;
    - Infestation intensity of major insect pests of maize in field and storage;
    - Relation of insect pests population with weed and weather factors;
    - Control measures practiced by the farmers against insect pests of maize in the field and storage;
    - Quarantine insect pests of maize in Bangladesh;
    - Major threats due to introduction of quarantine insect pests;
    - Preventive measures taken against quarantine insect pests of maize;
    - Control measures for quarantine insect pests of maize;
    - Suggestions for the improvement strategies for existing quarantine services in Bangladesh.

3.6. Development of study questionnaire

The draft survey questionnaires were prepared based on the objectives of the work and indicators for the study. The draft questionnaire were pre-tested in the selected study location and finalized with due care to be able to include appropriate questions for collection of necessary information from different levels and types of respondents to reflect the indicators relevant to the objectives of the study.

3.7. Method of data collection

Four types of data were collected for the study such as review of secondary documents, interview of field survey respondents, focus group discussion and direct field visit. The methods of data collection used in the study are presented below:

3.7.1. Review of secondary documents

The review of secondary documents was involved extensive data search following bibliographic listing of all possible secondary data sources. The secondary documents were reviewed about the issues/indicators of the study.

3.7.2. Interview of field survey respondents

Direct personal interview approach was adopted for collection of primary data. The personally contact was done with the respondents and obtained desired information by explaining the objectives of the study to the respondents. A set of pre-tested questionnaires (Appendix 1 & 2) were used during field survey for data collection. Reaching the target area, a respondent was selected and made self-introduction. Then, described the purpose of the interview and objectives of the study, and lastly filled up the data sheet. When selected, sit with the respondent and started data collection as per guideline and the set questionnaire following the techniques and procedures used during field pre-testing. After the completion of filling up of one questionnaire by one respondent then moved to the next to select another respondent to collect data and so on until get a respondent that meets the target respondent. The data were recorded only after fully being satisfied that the respondent was able to understand the question, and offering any of the probable answers in his own perception. The investigators had been made all efforts to have a friendly and open-minded interaction with the respondent instead of asking questions like a school teacher to his students. All questions have to be asked one by one, and data sheets were filled up on the spot and preserved carefully. The completed questionnaires were then packed and sealed by districts. The data collection was supervised the respective Research Supervisor and Co-supervisor. As per sample design, the 500 survey respondents had been interviewed for 40 sampled Upazillas of 20 selected districts.

3.7.3. Focus Group Discussion (FGD)

There is certain information that is difficult to fully capture by structured interviews within the limited time. Focus Group Discussion (FGD) method is, therefore, needed to get insight into this information. Thus, the planned FGDs were conducted with the participation of the respondents in 20 sampled districts. Each FGD was organized with at least 10 participants. Thus, a total of 200 participants were participated in 20 FGDs. The participants were chosen from different professional categories such as farmers who are directly involved with the maize cultivation; upazilla and district level DAE officials, officials of BADC/research organizations/NGOs, pesticide and seed traders etc in the sampled areas. The FGD was conducted at the office of Deputy Director of DAE for each sampled district and the participants were allowed them to speak freely and express their own views. The FGD session was guided by the researcher and encouraged the participants to talk freely and spontaneously about the issues of investigation using a guideline (Appendix 3). The key discussion points were recorded in black and white.

3.7.4. Field inspection

The field visits were carried out on the maize production activities and insect pests that were available in the farmers' maize field under the sampled areas. The field visits were undertaken mainly for the identification of major insect pests, their stages and level of infestation, and measures for combating major insect pests practiced by the farmers. The observation checklist (Appendix 4) for field visit was used during the collection of data from the maize field directly.

3.8. Data analysis

The analysis of the collected data was done using the computer software SPSS 17.0 version and Microsoft Office MS Excel. For the analysis of the data, descriptive statistical tools such as frequency distribution, measures of central tendency, graphs, correlation and regression were used.

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted in the 40 upazilla of 20 selected major maize growing districts of Bangladesh during the period from January to April 2012 to find out the present status of insect pests of maize including quarantine insect pests, their risks and management options. This study conducted as the part of "Pest Risk Analysis (PRA) of Maize and listing of Quarantine Pests" implemented by DAE was undertaken to enlist insect pests of maize in major maize growing regions of Bangladesh comprising 40 Upazilas under 20 districts considering 2 Upazilas from each of the districts. The research was implemented by the "Quarantine Services Strengthening Program (QSSP)" under Plant Protection Wing of the DAE. In light of this, various surveys and discussions were conducted through predesigned pre-tested questionnaire. The results obtained from the studies have been presented below sequentially in various forms and thus interpreted and discussed as to extract the findings systematically in line with the objective of the study.

4.1. Farmers' knowledge on insect pests of maize, their risks and management

The results of the farmers' knowledge on insect pests of maize and their risks have been discussed under the following sub-headings:

4.1.1. Selection of season and kinds of maize variety for cultivation

The environmental factors of the season vary the growth and yield of any crop as well as the incidence of insect pests associated with the crops. Among the maize farmers (400) participated in the survey study, all (100%) of them were engaged in Rabi season for maize cultivation, besides Rabi season, only 13.00% (52) farmers were also cultivated maize in Kharif season.

Most (79.5%) of the farmers had cultivated hybrid variety of maize in their field. Among them maximum (40.50%) farmers were familiar with the cultivation of BRAC developed hybrid variety, 21.75% farmers cultivated BARI developed hybrid variety and 17.25% farmers cultivated imported hybrid variety. Only 1.75% farmers were familiar with the cultivation of BARI developed HYV variety and 7.50% farmers with local variety.

From these findings it was revealed that Rabi was the most suitable season for maize cultivation that was practiced by almost all farmers.

It was also revealed that the hybrid varieties of maize were the most popular varieties to the farmers for cultivation, among which BRAC developed hybrid variety ranked first, whereas the imported hybrid variety of maize was also the popular variety for cultivation.

Table 4.1. Farmers' response on the selection of season for maize cultivation

Cultivated maize varieties	Selection of seasons			
	Rabi season		Kharif season	
	No. of respondent [N=400]	% Response	No. of respondent [N=52]	% Response
1. Local variety	30	7.50	4	7.69
2. BARI developed HYV	7	1.75	-	-
3. BARI developed hybrid variety	87	21.75	13	25.00
4. BRAC developed hybrid variety	162	40.50	12	23.08
5. Imported hybrid variety	69	17.25	14	26.92
6. Other variety	45	11.25	9	17.31

4.1.2. Source of maize seeds used by the farmers for cultivation

Maize farmers used maize seeds from different sources for cultivation. Among those most (86.75%) of the farmers used maize seeds from seed dealers/traders. Other important sources were pesticide dealers/traders, directly from BRAC, BADC, local market, research station and neighbors of the farmers.

Table 4.2. Farmers' opinion on the source of maize seeds used for cultivation

Source of maize seeds	Response on source of maize seeds	
	No. of respondent [N=400]	% Response
1. Seed dealer/traders	347	86.75
2. Pesticide dealer/traders	21	5.25
3. Directly from BRAC	13	3.25
4. BADC	9	2.25
5. Local market seed	6	1.50
6. Research station	2	0.50
7. Farmers neighbors' seed	2	0.50
8. Directly from importer	-	-
9. Agril. Extension Department	-	-
10. Farmers own seed	-	-
11. Other sources	4	1.00

4.1.3. Incidence of insect and other vertebrate pest infestation in maize field

According to the opinion expressed by the farmers, the incidence of insect pests in the maize field were cutworm, armyworm, corn earworm, corn leaf aphid, corn stem borer, white grubs, grasshopper, termite, wireworms, seed corn maggot, chinch bug, seed corn beetles, corn root aphid, corn rootworm, sting bug and thrips. Among these insect pests cutworm, armyworm and corn earworm ranked first, second and third, respectively expressed by the 51.30%, 52.00% and 62.7% farmers, respectively. More or less all stages of the maize crop were attacked by the different insect pests, where the dominating insect pest cutworm attacked at seedling stage; armyworm, earworm and corn leaf aphid attacked at vegetative and reproductive stage of the standing maize in the field. The infestation intensity of cutworm, armyworm and corn earworm were high expressed by the maximum farmers (44.4%, 61.10% and 46.30%, respectively). The vertebrate pest birds and rats were also identified as the dominant pests of maize in the field and caused damage at reproductive stage with low infestation intensity expressed by the maximum farmers, but birds caused higher damage to maize crops than rats.

Ahad (2003) reported that a number of insect pests cause damage maize, among them important ones are Asian maize borer (*Ostrinia furnacalis*), maize stem borer, (*Chilo partellus*), maize army worm (*Mythimna loreyi*), American bollworm (*Heliothis armigera*), maize aphid (*Rhopalosiphum maidis*), cutworm (*Agrotis ipsilon*), stem fly (*Atherigona varia soccata*), white grub (*Holotrichia* spp.), thrips (*Caliothrips graminicola*), termite (*Odontotermes obesus, Microlemes anandi*). The research finding shows that various insect pests infested in different stages of the maize crop such as cutworms attack during seedling stages, stem and shoot borer attack during vegetative to flowering stage, leaf aphids during flowering stages and cob borers attack during cob formation stages.

Table 4.3. Farmers' response on the incidence of insect and other vertebrate pest infestation in maize field

Name of insect pests	% Response on insect pest infestation					
	Presence of insect pests	Stage of crop infested	Infestation intensity			
			High	Medium	Low	Total
A. Seed, root & underground stem feeding insect pests						
1. Cutworm	51.3	Seedling stage	44.4	37.6	18.0	100.0
2. Wireworms	20.3	Seed and seedling stage	34.6	22.2	43.2	100.0
3. White grubs	23.0	Seeding & vegetative stage	17.0	13.0	70.0	100.0
4. Seed corn maggot	19.5	Seed and seedling stage	12.8	20.5	66.7	100.0
5. Chinch bug	9.0	Vegetative stage	8.3	27.8	63.9	100.0
6. Seed corn beetle	9.8	Seedling stage	2.6	25.6	71.8	100.0
7. Corn root aphid	6.8	Seeding stage	11.1	25.9	63.0	100.0
8. Corn rootworm	9.8	Seedling stage	15.4	10.2	74.4	100.0
9. Termite	22.5	Seedling, vegetative and reproductive stage	7.8	26.6	65.6	100.0
B. Stalk/stem borer						
10. Corn stem borer	22.3	Vegetative stage	3.4	28.1	68.5	100.0
11. European corn borer	-	-	-	-	-	-
C. Leaf feeders						
12. Armyworm	52.0	Vegetative & reproductive	7.2	31.7	61.1	100.0
13. Corn leaf aphid	16.3	Vegetative & reproductive	15.4	30.8	53.8	100.0
14. Grasshopper	37.5	Vegetative & reproductive	6.0	27.3	66.7	100.0
15. Corn flea beetle	9.0	Vegetative & reproductive	16.7	19.4	63.9	100.0
16. Stink bug	7.5	Vegetative stage	26.7	-	73.3	100.0
17. Thrips	3.3	Vegetative & reproductive	-	23.1	76.9	100.0
18. Spider mites	2.8	Vegetative & reproductive	-	45.5	54.5	100.0
D. Ear feeders						
19. Corn earworm	62.7	Vegetative & reproductive	23.5	30.2	46.3	100.0
20. Fall armyworm	15.3	Vegetative & reproductive	8.2	18.0	73.8	100.0
E. Vertebrate pests						
21. Birds	19.8	Reproductive stage	11.4	39.2	49.4	100.0
22. Rats	12.3	Reproductive stage	8.2	22.4	69.4	100.0

4.1.4. Storage of maize seeds by the farmers

Most (95.75%) farmers stated their opinion that they did not preserve maize seeds in storage, whereas only 4.25% farmers expressed that they store the maize seeds in storage. From this finding it was revealed that either the farmers sold their maize seeds just after harvest or they were not interested to store the maize seeds for future use or trade.

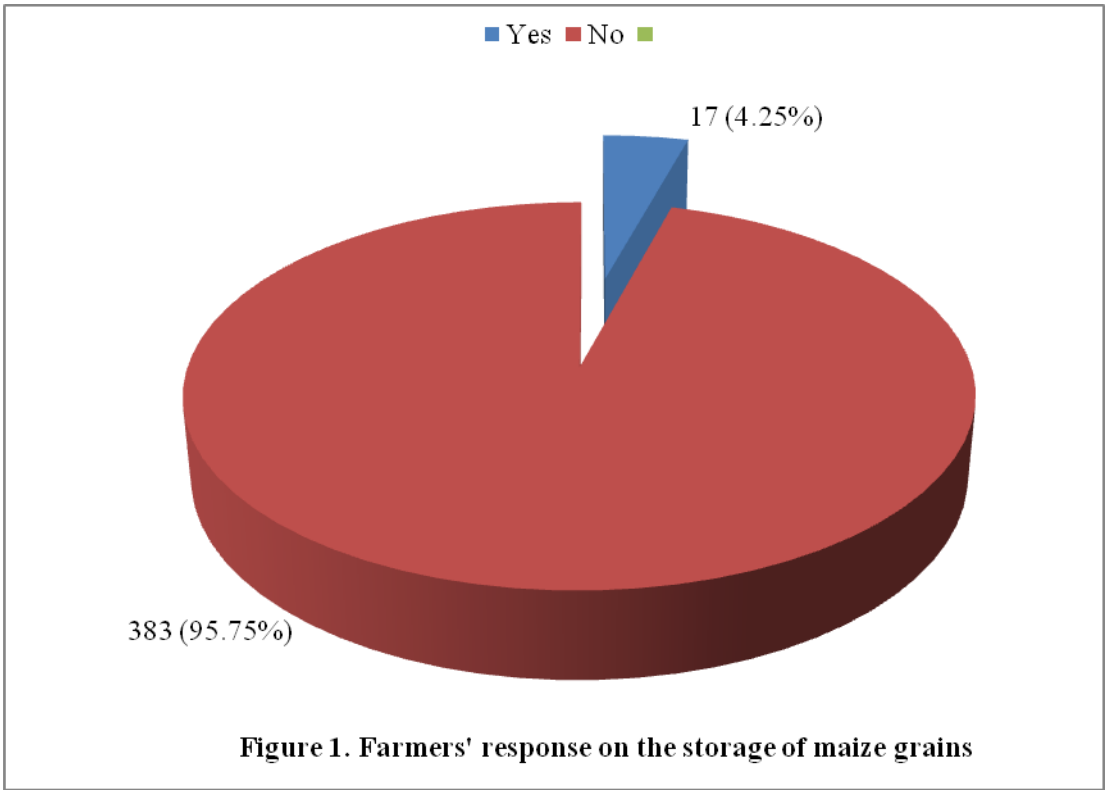

Figure 1. Farmers' response on the storage of maize grains

4.1.5. Incidence of insect pests in stored maize seeds

Considering the opinion expressed by the farmers, the incidence of insect pests of maize seeds in storage were corn ear worm, ear maggot, grain borer, grain weevil, Indian meal moth, Angoumois grain moth (rice moth), seed corn maggot. These insect were designated as pests by the few portion (0.3 to 3.0%) of the farmers. But most of the insect pests caused high damage to maize seeds. Polythene bag was the best container for preventing pest attack of maize seeds in storage than jute bag, bamboo *dhole*, tin and earthen container except ear maggot for which earthen container was the least suitable.

Table 4.4. Farmers' response on the insect pests attack in stored maize seeds

Insect pests	Response (%)									
	Presence of insect pests	Level of damage			Types of container used to prevent insect attack					
		High	Medium	Low	Jute bag	Poly bag	Bamboo *dhole*	Tin	Earthen container	Total
1. Corn ear worm	0.80	100.0	-	-		100.0	-	-	-	100.0
2. Ear maggot	0.30	100.0	-	-	-	-	-	-	100.0	100.0
3. Grain borer	1.00	50.0	25.0	25.0		75			25.0	100.0
4. Grain weevil	3.00	33.4	33.3	33.3	-	44.4	-	-	55.5-	100.0
5. Indian meal moth	0.50	50.0	50.0	-	-	-	-	-	-	-
6. Rice grain moth	1.30	80.0	-	20.0	-	-	-	-	-	-
7. Seed corn maggot	0.30	-	100.0	-	-	-	-	-	100.0	100.0
8. Other insects	3.00	50.50	33.25	16.25	-	-	-	-	-	

4.1.6. Control measures taken against insect pests in stored maize grains

Out of 400 farmers, only 2.00% asserted their opinion that they applied control measures against insect pests of maize seeds in storage, whereas 32.75% farmers expressed their opinion that they did not take any control measures against insect pests in stored maize seeds. But most (65.25%) of the farmers did not reply about the matter, i.e., they were not aware about taking any control measures against insect pests in stored maize grains or they had no necessity to take action. The later option was the appropriate for maize farmers, because they did not preserve the maize seeds in storage expressed by the farmers earlier. Similarly, among the farmers who said they took control measures, out of 8, all of them did not express about taking any types of preventive or curative measures against insect pests of maize seeds in storage.

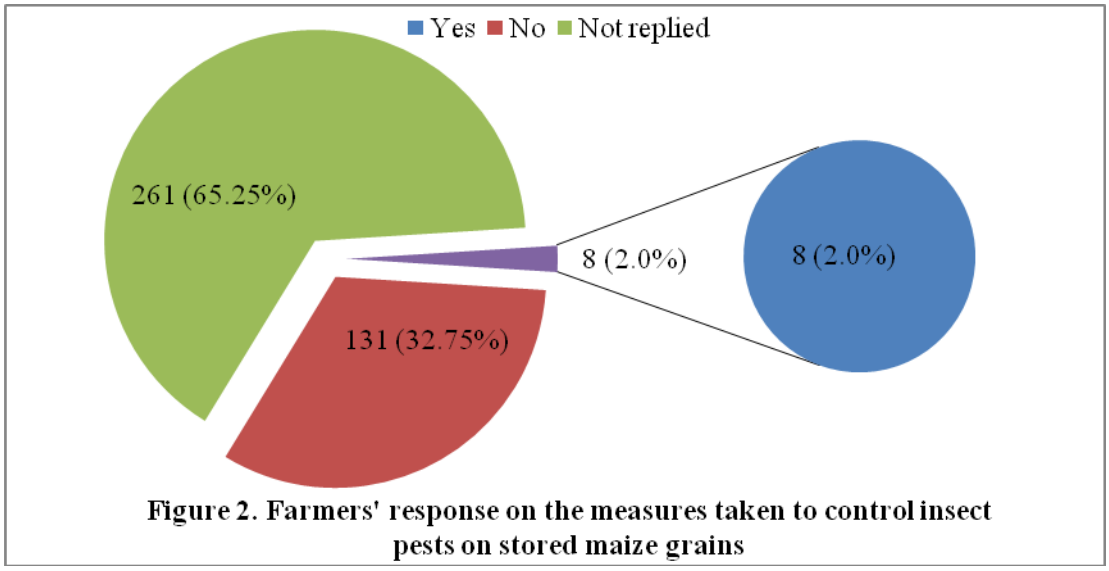

Figure 2. Farmers' response on the measures taken to control insect pests on stored maize grains

4.1.7. Measures taken to control insect pests of maize in the field

Among 400 farmers participated in the survey study, majority (47.75%) of them expressed their opinion that they took measures to control pests of maize in the field. But a large portion of the farmers did not reply the matter, i.e., whether they did not take any control measures for insect pest of maize in the field or they were not aware about the necessity to control insect pests of maize in the field.

Among 191 farmers, who took control measures, majority (58.64%) of them were taken curative measures to control insect pests of maize in their field, whereas 19.37% farmers took preventive measures and 37.17% farmers applied both preventive and curative measures for the control of insect pests in their maize field.

Table 4.5. Farmers' response on the measures taken to control insect pests of maize in the field

Types of response	**Response (%) on control measures taken**	
	No. of respondent [N=400]	**% Response [100%]**
Yes	191	47.75
No	49	12.25
Not replied	160	40.00
Total	**400**	**100**
Types of measures	**No. of respondent [N=191]**	**% Response**
Preventive	37	19.37
Curative	112	58.64
Both	71	37.17
Multiple response [=One respondent choose more than one options]		

4.1.8. Methods of control measures applied against insect pests of maize in the field

Among different preventive and curative measures, farmers applied different methods for the management of insect pests of maize in their field. Out of 400 farmers, most (95.00%) of them applied pesticides to control insect pests followed by use of imported hybrid maize variety (47.08%), use of resistant maize variety (45.0%). Other methods were use of cultural practices (34.58%), use of barrier crops to prevent dispersion of insect pests (30.0%), use of IPM methods (22.92%) and seed treatment through chemical pesticides (18.33%). From these findings it was revealed that chemical pesticides were the most popular and widely used methods to control insect pests of maize in the field.

Table 4.6. Farmers' response on the methods of pest control applied in the maize field

Methods of insect pest control	Response on the methods applied	
	Nos. [N=400]	% Response
Use of pesticides	228	95.00
Use of resistant variety	108	45.00
Use of imported hybrid maize variety	113	47.08
Seed treatment	44	18.33
Cultural practices for controlling insect pests	83	34.58
Use of barriers to prevent dispersion	72	30.00
IPM method	55	22.92
Others	53	13.25
Multiple response		

4.1.9. Sources of assistance and services received for controlling insect pests of maize

Source of assistance and services is the most important factor that can play the vital role to take the appropriate and effective control options need to be applied for the control specific insect pest problems infesting crops. Accordingly maize farmers in the study also took the assistance and services from different sources those were nearer to them. In this study, out of 400 farmers, majority (52.75% & 52.50%) of the farmers received assistance and services to control insect pests of maize from DAE officials and NGO personnel, respectively followed by neighbors (41.25%), pesticide/seed dealers (11.0%)

and personnel of research organization (10.75%). From these findings it was revealed that the DAE officials and NGO personnel played the major roles in providing the advice to the farmers in relation to take the appropriate and effective control measures against insect pests of maize.

Table 4.7. Farmers' response on the source of assistance and services received to control insect pests of maize

Source of assistance and services received	Response on source of assistance and services	
	Nos. [N=400]	% Response
1. DAE officials	211	52.75
2. Research organization personnel	43	10.75
3. NGO personnel	210	52.50
4. Pesticide/seed dealers	44	11.00
5. Neighbors	165	41.25
Multiple response		

4.1.10. Suggestions for better management options against insect pests of maize

According to the farmers' opinion, the best management practice applied against insect pests of maize in the field was the application of insecticide such as Dursban, Basudin, Furadan etc asserted by the 97.00% respondents. Other options for the better management of insect pests of maize were the application of flood irrigation especially for soil dwelling insect pests, use of integrated pest management (IPM) method and perching in the field maize to make facility for predatory birds as expressed by the 14.0%, 11.50% and 7.50% farmers.

Table 4.8. Farmers' opinion on better management practices for insect pest control of maize

Better pest management practices	Response on better management options	
	No. of respondent [N=400]	% Response
Application of insecticides such as Dursban, Basudin, Furadan etc	388	97.00
Use of IPM	46	11.50
Perching in the field to make facility for predatory birds	30	7.50
Flood irrigation especially for soil dwelling insect pests	56	14.00
Multiple response		

4.2. Field level officers' knowledge on insect pests of maize, their risks and management

The results of the Field Level Officers' knowledge on insect pests of maize, their risks and management options practiced by the farmers were acquired and these findings have been discussed under the following sub-headings:

4.2.1. Major problems for maize cultivation

Major problem identification of the maize cultivation is one of the most important factors to provide specific advice to the farmers to obtain better yield. Accordingly, the field level officers of DAE were asked about the major problems for maize cultivation. Out of 80 field level officers participated in the interview program, most (86.25%) of them asserted their opinion that insect pest attack was the top most of the major problem for maize cultivation followed by weed infestation (76.25%), disease infection (73.75%), lack of HYV variety (63.75%). Other problems for maize cultivation were the use of imported hybrid varieties, lack of irrigation facilities (23.75%), store grain pest attack, lack of marketing facilities, lack of farmers training on maize cultivation and pesticide as expressed by the 40.00%, 23.75%, 12.50%, 6.25%, 3.75% and 1.25%, respectively. From these findings it was revealed that insect pest infestation was the top most problem for cultivation of maize.

Table 4.9. Field level officers' opinion on the major problems for maize cultivation

Major problems	Response	
	No. of respondent [N=80]	% Response
1. Insect pest attack	69	86.25
2. Weed infestation	61	76.25
3. Disease infection	59	73.75
4. Lack of HYV variety	51	63.75
5. Use of imported hybrid variety	32	40.00
6. Lack of irrigation facilities	19	23.75
7. Store grain pest attack	10	12.50
8. Lack of marketing facilities	5	6.25
9. Lack of farmers training facilities on maize	3	3.75
10. Pesticides	1	1.25

4.2.2. Major insect pests of maize

Considering the opinion expressed by the field level officers of DAE, majority (46.25%) of them expressed their opinion that cutworm was the top most serious insect pest of maize followed by armyworm (28.75%), corn earworm (27.50%), fall armyworm (25.00%), grasshopper (22.50%), white grubs (20.00%), cornstalk borer (18.75%), wireworm (17.50%), corn leaf aphid (13.75%) and seed corn maggot (11.25%). Other insect pests of maize were the termite, seed corn beetle, corn rootworm, chinch bug, corn flea beetle, stink bug and thrips as expressed by the 6.25%, 6.25%, 5.00%, 3.75%, 1.25% and 1.25% field level officials of DAE, respectively. Among the participated respondents, 15.00% field level officials expressed that the mite was also the major pest of maize. Among the vertebrate pests of maize, birds and rats were the major damaging factors of maize in the field as expressed by the 62.50% and 30.00% respondents. Research results reported by BARI (2006) that ten insects' attacks in maize among them four insects are considered as major pest. The studies show that cutworm (*Agrotis ipsilon*), stem borer (*Seamia inferens*), shoot borer (*Chilo pertellus*), leaf aphid (*Rhopalosiphium maidis*), cob borer/corn earworm (*Helicoverpa armigera*) are the major insect pests of maize in Bangladesh. Among these insect pests, cutworm attacks seedling, stem borer and shoot borer attack maize stem and stalk from vegetative to flowering stage, leaf aphid attacks cob and silk of cobs, and cob borer/corn earworm attack and damage the cob during its formation. Hossain *et al.* (2005) reported that cutworm is the most destructive insect pest of maize in the field.

Table 4.10. Field level officers' response on the major insect and other pests of maize

Name of the pests	Response (%) on the major insect & other pests	
	No. of respondents [N=80]	% Response
A. Insect pests		
1. Cutworm	37	46.25
2. Armyworm	23	28.75
3. Corn earworm	22	27.50
4. Fall armyworm	20	25.00
5. Grasshopper	18	22.50
6. White grubs	16	20.00
7. Cornstalk borer (stem borer)	15	18.75
8. Wireworms	14	17.50
9. Corn leaf aphid	11	13.75
10. Seed corn maggot	9	11.25
11. Termite	5	6.25
12. Seed corn beetle	5	6.25
13. Corn rootworm	4	5.00
14. Chinch bug	3	3.75
15. Corn flea beetle	4	5.00
16. Stink bug	1	1.25
17. Thrips	1	1.25
B. Mite pest		
18. Mite	12	15.00
C. Vertebrate pests		
19. Birds	50	62.50
20. Rats	24	30.00
Multiple response		

4.2.3. Current status of harmful insect pests those were not seen earlier and sources of maize seeds used

The status of existing harmful insect pests of maize those were not seen earlier had been designated by the participated field level officials of DAE in essence to identify the probable quarantine insect pests of maize in Bangladesh. Out of 80 field level officials of DAE, most (78.75%) of them asserted that cutworm was the most seriously damaging insect pest of maize which was not seen earlier in the maize field followed by cornstalk borer (stem borer) armyworm, fall armyworm, corn earworm and corn root maggot as

expressed by the 71.25%, 61.25%, 58.75%, 56.25% and 47.50% field level officials of DAE, respectively. These insect pests mainly attacked almost all hybrid maize varieties especially Pacific, NK-40, 900M, 900M gold, Pinacle hybrid etc. The main sources of maize seeds used by the farmers in the study areas were the seed dealers and BADC. Hossain *et al.* (2005) reported that Bangladesh Agricultural Research Institute (BARI) has already released high yielding popular maize varieties such as Bornali, Shuvra, Khai Bhutra, Mohor, BARI Bhutta-5, BARI Bhutta-6, BARI Hybrid Bhutta-1, and then BARI Hybrid Bhutta 2, 3, 4, 5, 7, 9, 10, 11, 12, BARI Misty Bhutta 1. Anon, (2013) also reported the more or less similar findings.

Table 4.11. Field level officers' response on existing insect pests those were not seen earlier and preferable maize variety attacked & their sources

Insect pests those were not seen earlier	Response by the field level officials			
	Nos. [N=80]	% Response	Preferable maize variety attacked	Source of seeds
Cutworm	63	78.75	Pacific hybrid, NK-40, 900M, 900M gold	Dealer, BADC
Cornstalk/stem borer	57	71.25	Pinacle hybrid	Dealer, BADC
Armyworm	49	61.25	All hybrid varieties	Dealer, BADC
Fall armyworm	47	58.75	All hybrid varieties	Dealer, BADC
Corn earworm	45	56.25	All hybrid varieties	Dealer, BADC
Corn root maggot	38	47.50	Pacific, NK-40	Dealer, BADC

4.2.4. Relationship among insect pest, disease and weed infestation in maize field

Out of 80 field level officials of DAE participate in the survey study, most (76.25%) of the them expressed their positive opinion about relationship of insect pest infestation with disease and weed infestation in the maize field, whereas only 23.75% respondents expressed their negative

opinion.

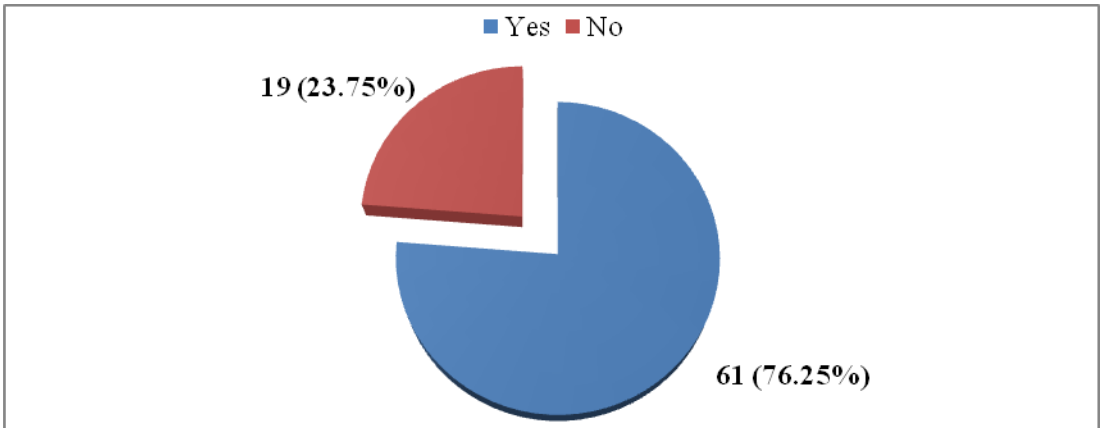

Figure 3. Field leevel officials' response on the relationship of insect infestation with disease and weed infestation in maize field

4.2.5. Degree of relationship among insect pests, diseases and weed infestation in the maize field

There was a positive and high degree of relationship among insect pest and disease incidence with weed infestation; as well as disease infection with the incidence of insect vector in the maize field. This result indicated that the insect infestation and disease infection become high when weed infestation become high expressed by the 44.50% and 45.25% field level officials of DAE, i.e., insect infestation and disease infection increased with the increase of the weed infestation. Similarly, disease infection become high when insect vector populations become high expressed by the 25.25% respondents, i.e., disease infection was increased with the increase of the vector population. But the maximum (50.75%) respondents did not reply about the degree of relationship between disease infection and vector population. From this finding it was revealed that weed infestation enhanced the insect pest infestation and disease incidence; similarly, insect vector also enhanced the incidence of disease infection in the maize field.

Table 4.12. Field level officials' response on the degree of relationship among insect pest, disease and weed infestation in the maize field

Relationship	Response (%) on the degree of relationship				
	High	Medium	Low	Don't Know	Total
1. Insect infestation high when weed infestation	44.50	20.00	9.20	26.30	100.0
2. Disease infection high when weed infestation	45.25	15.75	8.50	30.50	100.0
3. Disease infection high when vector insect	25.25	15.50	8.50	50.75	100.0

4.2.6. Major insect pests of stored maize grains and their damage

The field level officials of DAE participated in the survey study stated that major insect pests of stored maize grains were the corn earworm, grain borer, grain weevil, Angoumois grain moth, Indian meal moth, seed corn maggot and corn ear maggot as expressed by the 25.0%, 17.5%, 17.5%, 12.50%, 2.50%, 2.50% and 1.25% respondents, respectively. Among these insect pests corn earworm ranked first followed by grain borer and grain weevil. More or less all insect pests caused low to medium damage to maize seeds expressed by the maximum field level officers.

Table 4.13. Field level officials' response on the major insect pests of stored maize and their level of damage

Stored grain insect pests	Response (%)			
	Presence of insect pest	Level of damage		
		High	Medium	Low
1. Corn earworm	25.00	15.0	30.0	45.0
2. Grain borer	17.50	7.10	35.7	42.9
3. Grain weevil	17.50	14.3	35.7	42.9
4. Angoumois grain moth	12.50	-	-	-
5. Indian meal moth	2.50	-	-	-
6. Seed corn maggot	2.50	-	50	50
7. Corn ear maggot	1.25	-	-	100.0

4.2.7. Kinds of advice provided to the farmers for controlling insect pests and rat of stored maize grains

The kinds of advices provided to the maize farmers had been identified by the opinion of the field level officials of DAE participated in the survey study. Among 80 respondents, most (83.75%) of them asserted that they provided the advice to the farmers for the management of insect pests of maize in storage was the storing of maize seeds in airtight

container followed by use of botanicals such as neem leaf, neem oil, bishkatali leaf etc (66.25%) and storage of maize seeds in polythene bag (60.00%). Other effective advices provided to the farmers were the use of pesticides in godown, use of fumigant gases like phostoxin tablet and maintenance of moisture content at low level by sun drying of maize seeds as expressed by the 56.25%, 46.25% and 43.75% field level officials of DAE, respectively. Among the respondents, 31.25% of them also expressed their opinion that they advised to the farmers for the management of rat in storage.

Table 4.14. Field level officers' response on kinds of advice provided to farmers for the management of insect pests and rat of stored maize grains

Kinds of advices	Response on advice provided	
	No. of respondent [N=80]	% Response
1. Storing of seeds in airtight container	67	83.75
2. Use of botanicals such as neem leaf, bishkatali leaf, neem oil etc	53	66.25
3. Storing of seeds in polythene bag	48	60.00
4. Use of insecticides in godown	45	56.25
5. Use of fumigants like phostoxin tablet	37	46.25
6. Maintaining moisture content at low level by sun drying of maize seeds	35	43.75
7. Use of trap to control rat	25	31.25

4.2.8. Methods of controlling quarantine insect pests of maize

The options for controlling quarantine insect pests of maize had been identified and designated by the assertion of field level officials of DAE who were participated in the study program. Among 80 respondents, most (70.0%) of them expressed their opinion that seed treatment was the best method for controlling quarantine insect pests of maize than other methods. Other quarantine insect pest control methods were the use of insect pest free imported hybrid maize variety (61.3%), cultural practices as control measures (58.8%), awareness build up of the farmers by training (45.00%), use of insecticides (37.50%), providing the quarantine barriers to prevent dispersion of quarantine insect pests (27.50%) and use of resistant maize variety (20.0%).

Table 4.15. Field level officers' response on the methods of quarantine insect pests control in maize

Methods of control	Response on	
	No. of respondent [N=80]	% Response
1. Through seed treatment	56	70.00
2. Use of pest free imported hybrid variety	49	61.25
3. Cultural practices as control measures	47	58.75
4. Farmers training to build up awareness	36	45.00
5. Application of insecticides	30	37.50
6. Quarantine barriers to prevent dispersion	22	27.50
7. Use of resistant maize variety	16	20.00
Multiple response		

4.2.9. Suggestions for measures to be taken to prevent quarantine insect pests effectively in Bangladesh

Appropriate measures can play effective role in preventing quarantine insect pests in the context of existing quarantine system in Bangladesh. Consequently, suggestive measures had been identified by the field level officials of DAE through expressing their opinion during the survey study. Out of 80 participants, majority (73.75%) respondents asserted that the strengthening of quarantine law enforcement was the most effective measure need to be taken to prevent quarantine insect pests effectively in Bangladesh followed by providing technical training to concerned quarantine personnel for enhancement as expressed by the 71.25% respondents. Other effective measures were the judicious of chemical fertilizers, improvement of existing quarantine laws and regulations, improvement of quarantine facilities particularly identification of quarantine pests, and proper & effective control measures as expressed by the 52.50%, 51.25%, 50.00% and 40.00% field level officials of DAE, respectively.

Table 4.16. Suggestive measures need to be taken to prevent quarantine insect pests effectively in Bangladesh

Effective preventive measures	Response on	
	No. of respondent [N=80]	% Response
1. Strengthening of quarantine law enforcement	59	73.75
2. Providing technical training to concerned quarantine personnel for enhancement	57	71.25
3. Judicious use of chemical fertilizers	42	52.50
4. Improvement of existing quarantine laws and regulations	41	51.25
5. Improvement of quarantine facilities particularly identification of quarantine pests	40	50.00
6. Proper and effective control measures	32	40.00
Multiple response		

4.3. Policy level officers' knowledge on insect pests of maize and their risks management

A total of 20 Policy level officials of DAE participated as respondents one from each district of the study area. The results on the knowledge of the respondents in respect of insect pests of maize particularly on quarantine insect pests, their risks and management have been discussed under the following sub-headings:

4.3.1. Major insect pests and their infestation intensity in different growing seasons of maize

The major insect pests of maize and their infestation intensity in different maize growing seasons of Bangladesh had been identified and designated by the policy level officials of DAE at district level office. Among 20 officials participated in the study, almost all (100.00%) respondents expressed their opinion that the cutworm, armyworm, corn earworm, stalk/stem borer were the top ranking insect pests designated as major insect pests of maize followed by white grubs expressed by the 95.0% respondents. Other major insect pests of maize were the fall armyworm, corn seed maggot, corn leaf aphid, corn wireworm and grasshopper as designated by the 65.0%, 60.0%, 60.0%, 50.0% and 40.0% policy level officials of DAE.

According to the policy level officers' opinion, the infestation intensities of almost all insect pests of maize identified by these respondents were comparatively higher in Rabi season than Kharif season of maize cultivation. Among the insect pests identified by the respondents, cutworm, armyworm and corn earworm cause damage maize with high infestation intensity; whereas the stalk/stem borer, white grubs and fall armyworm cause damage maize with medium infestation intensity. On the other hand, corn seed maggot, corn leaf aphid and corn wireworm cause damage maize with medium to low infestation intensity, whereas only the grasshopper damage maize with low infestation intensity during rabi season. But all these insect pests damage maize with low infestation intensity during kharif season.

Table 4.17. Policy level officials' response on major insect pests of maize and their infestation intensity during rabi and kharif seasons

Maize pests	Response on the major insect pests and infestation intensity			
	No. of respondent [N=20]	% Response	Infestation intensity	
			Rabi	Kharif
1. Cutworm	20	100.00	High	Low
2. Armyworm	20	100.00	High	Low
3. Corn earworm	20	100.00	High	Low
4. Stalk/stem borer	20	100.00	Medium	Low
5. White grubs	19	95.00	Medium	Low
6. Fall armyworm	13	65.00	Medium	Low
7. Corn seed maggot	12	60.00	Medium to low	Low
8. Corn leaf aphid	12	60.00	Medium to low	Low
9. Corn wireworm	10	50.00	Medium to low	Low
10. Grasshopper	8	40.00	Low	Low

4.3.2. Effect of weather factors on the population increase of insect pests of maize

Along with others, weather factors also influence the insect pest population of maize. Accordingly, the relative effect of the weather factors such as temperature, relative humidity and rainfall had been designated by the respondents of the present study during the course of survey. Among 20 policy level officials of DAE, all (100.0%) of them

expressed their opinion that the weather factors influence the population increase of insect pests of maize.

Table 4.18. Policy level officials' response on the effect of weather factors on the population increase of insect pests of maize

Type of response	Response on the effect of weather factors	
	No. of respondents [N=20]	% Response
Yes	20	100
No	-	-
Total	**20**	**100**

4.3.3. Degree of relationship between weather factors and insect pest population of maize

The of effect also designated by the policy level officials of DAE as participated in the survey, out of 20 participants, most (70.0%) of them expressed that the degree of relationship between temperature and insect pest population was high, while other 30.0% said medium effect. On the other hand, most (85.0%) of the respondents asserted that degree of effect of both relative humidity and rainfall was medium with the increase of insect pest population in maize field, while others 15.0% respondents expressed that this relationship was high.

Table 4.19. Policy level officers' opinion on the degree of effect of weather factors on the increase of pest population

Weather factors	Response (%) on the degree of effect on insect pest population		
	High	Medium	Low
1. Temperature	70	30	-
2. Relative humidity	15	85	-
3. Rainfall	15	85	-

4.3.4. Current status of quarantine insect pests of maize in Bangladesh

The existing quarantine insect pests of maize had been identified and designated by the policy level officials of DAE at districts level. Among 20 respondents participated in the interview, most (85.00%) of them asserted that cornstalk/stem borer was the top ranking quarantine insect pest of maize in Bangladesh followed by armyworm and fall armyworm as stated by the 75.00% and 65.00% respondents, respectively. Other probable quarantine insect pests of maize as designated by the respondents were the corn earworm, corn root maggot, white grubs as expressed by the 55.00% and 45.00% policy level officials of DAE. The major sources of maize seeds collected and cultivated by the farmers were the seed dealers as expressed by the almost all respondents participated in the present survey study.

Table 4.20. Policy level officers' response on the status of existing quarantine insect pests of maize and source of maize seeds used for cultivation

Quarantine insect pests	Response by the policy level officials		
	No. of respondents [N=20]	% Response	Source of seeds
Cornstalk (stem) borer	17	85.00	Seed dealer
Armyworm	15	75.00	Seed dealer
Fall armyworm	13	65.00	Seed dealer
Corn earworm	12	60.00	Seed dealer
Corn root maggot	11	55.00	Seed dealer
White grubs	9	45.00	Seed dealer

4.3.5. Major threats due to introduction of quarantine insect pests of maize

Introduction of new quarantine insect pests in a new area may reproduce and grow rapidly because of escaping from their natural enemies at their native home, if the favorable conditions exist in the newly introduced area. Consequently, these newly introduced quarantine insect pests may cause different kinds threats for the crops. As well, these threats had been designated by the participated respondents during the course of survey.

Among 20 policy level officials of DAE participated in the study, almost all (100.0%) of the respondents expressed their opinion that the outbreak of new insect pest infestation was the top most threats that would be created due to the introduction of quarantine insect pests of maize followed by high intensity of crop damage as designated by 90.0% respondents. Other major threats were outbreak of new disease infection through vector insect and outbreak of new insect biotype as designated by the 85.0% and 70.0% respondents, respectively.

Table 4.21. Policy level officials' response on the major threats would be created due to introduction of quarantine insect pests of maize

Major threats	Response on major threats	
	No. of respondent [N=20]	% Response
1. Outbreak of new insect infestation	20	100.0
2. High intensity of crop damage	18	90.0
3. Outbreak of new disease infection	17	85.0
4. Outbreak of new insect biotype	14	70.0
Multiple response		

4.3.6. Direct action taken or monitoring for quarantine insect pests of maize in the field

Among the participants, majority (65.0%) of them expressed their opinion that they did not take any direct actions against quarantine insect pests of maize or did not monitor the maize field to identify the quarantine insect pests. On the other hand, only 35.0% respondents expressed that they took direct actions or monitoring was done for quarantine insect pests in the maize field.

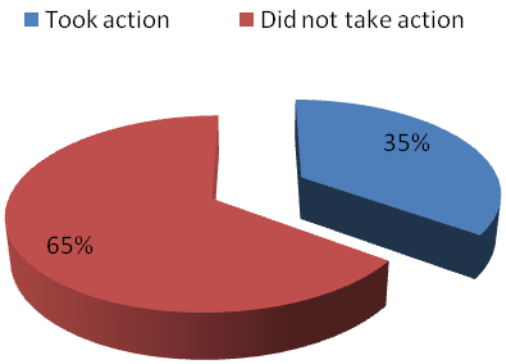

Figure 4. Policy level officials response on the direct action taken or monitoring for quarantine insect pests of maize

4.3.7. Kinds of direct action taken to keep the maize free from quarantine insect pests

The direct action taken by the policy level officials of DAE at district level to keep the maize free from quarantine insect pests had been identified and designated during the course of survey study. Among the policy level officials who (35.0% of total) had asserted that they taken direct action, maximum (42.86%) of them expressed that they provide training to the farmers regarding the management of quarantine insect pests of maize as well as they visited the farmers' maize field and provide relevant advice to them. Other important direct actions were provide advice to the farmers to use treated maize seeds, provide training to the DAE staffs and provide advice to the farmers to use resistant maize variety as expressed by the 28.57%, 14.29% and 14.29% respondents, respectively.

Table 4.22. Policy level officials' response on the kinds of direct action taken to keep the maize free from quarantine insect pests

Types of action taken	Response	
	No. of respondent [N=7]	% Response
1. Provide training to the farmers	3	42.86
2. Field visit and provide relevant advice	3	42.86
3. Advice to use treated seeds	2	28.57
4. Provide training to the DAE staffs	1	14.29
5. Advice to use resistant variety	1	14.29
Multiple response		

4.3.8. Adequacy of the existing quarantine services to control the quarantine pest of maize in Bangladesh

Adequate facilities of a country can play effective role in preventing or control the quarantine pests of any crops. The adequacy of the existing quarantine services in Bangladesh had also been opined by the participated district level DAE officials. Out of 20 participants, most (90.0%) of them stated that the existing quarantine services in Bangladesh were not adequate to control the quarantine insect pests of maize, conversely only 10.0% respondents asserted that the existing quarantine services were adequate.

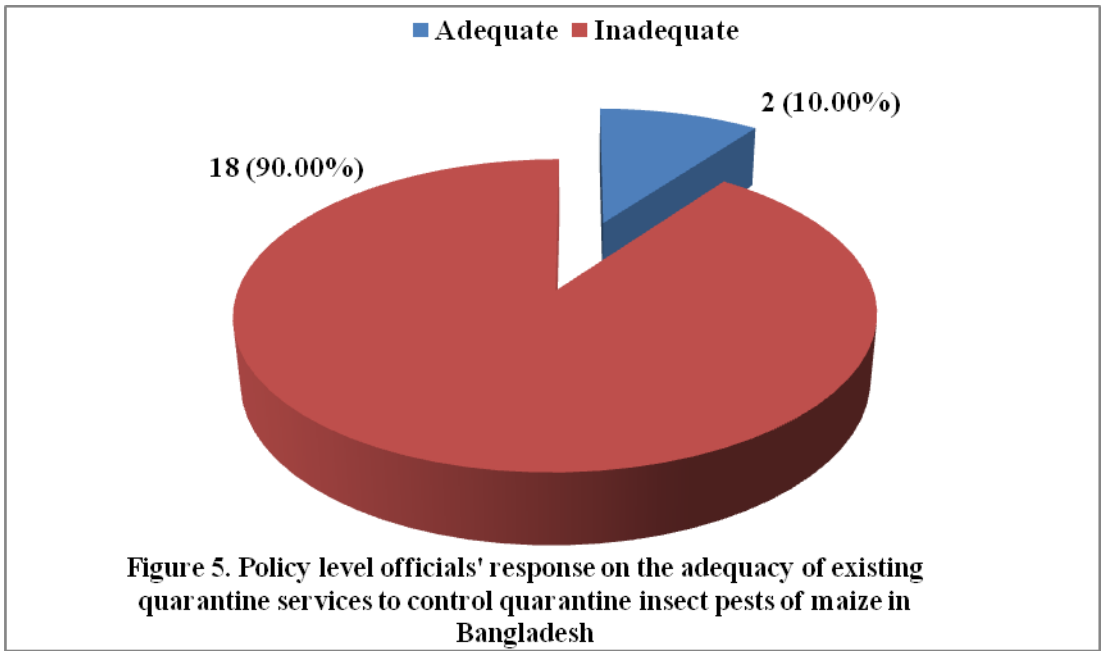

Figure 5. Policy level officials' response on the adequacy of existing quarantine services to control quarantine insect pests of maize in Bangladesh

4.3.9. Suggestions for the improvement of quarantine services to control quarantine insect pests in Bangladesh

Considering the opinion expressed by the policy level officials participated in the survey, out of 20 respondents, majority (55.0%) of them affirmed that the strengthening of existing quarantine station laboratories would be the most effective improvement strategy for quarantine services in Bangladesh to control quarantine insect pests of crops including maize. Other improvement strategies would be the establishment of modern quarantine laboratory, increase the skilled manpower regarding quarantine pests, proper identification of quarantine insect pests, training of DAE officials on pest management especially quarantine pests, updating/strengthening of existing quarantine laws, proper application of quarantine laws, strengthening of quarantine services, enhancement of in-country production of hybrid seeds for maize as suggested by the 15.0%, 30.0%, 25.0%, 40.0%, 25.0%, 30.0%, 10.0% and 5.0% policy level officials, respectively.

Table 4.23. Policy level officials' response on the suggestive improvement strategies for quarantine services to control quarantine insect pests in Bangladesh

Improvement strategies	**Response on improvement strategies**	
	Nos. [N=20]	**% Response**
1. Strengthening of quarantine station laboratory	11	55.0
2. Establishment of modern quarantine laboratory	3	15.0
3. Increase of skilled manpower	6	30.0
4. Proper identification of quarantine insect pests	5	25.0
5. Training of DAE officials on pest management	8	40.0
6. Updating/strengthening of quarantine laws	5	25.0
7. Proper application of quarantine laws	6	30.0
8. Strengthening of quarantine services	2	10.0
9. Enhancement of in-country production of hybrid seeds	1	5.0
Multiple response		

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted in the 40 upazilla of 20 selected major maize growing districts of Bangladesh during the period from January to April 2012 to find out the present status of insect pests of maize, their risks and management options. In light of this, various surveys with 400 maize farmers, 80 field level officials and 20 policy level officials of DAE were conducted through predesigned and pre-tested questionnaire in order to assess their knowledge about insect pests of maize including quarantine insect pests, their risks and management options/ strategies. A total of 20 focus group discussions with DAE officials, BADC/research organization personnel, pesticide and seed dealers were also done to validate the survey findings. The findings of the studies have been summarized and concluded below:

SUMMARY

Season and variety for maize cultivation: Almost all (100%) farmers chose rabi season for maize cultivation, but only 13.0% farmers selected Kharif season too. Most (80%) of the farmers had cultivated hybrid variety of maize. Among them 40.50% farmers were familiar with the cultivation of BRAC developed hybrid varieties, while others cultivated BARI developed hybrid variety and imported hybrid variety. Only few (1.75%) farmers were familiar with the cultivation of BARI developed HYV variety. The major (87%) source of maize seeds used for cultivation was the seed dealer, while other sources were BRAC, BADC and pesticide dealer.

Major problems for maize cultivation: The major problems for maize cultivation were the insect attack, disease infection, weed infestation, lack of HYV maize variety as reported by the majority (63.75 to 86.25%) of the field level officials of DAE participated in the survey, where insect pests attack ranked first. Other problems were the use of imported hybrid maize varieties, lack of irrigation facilities, stored grain maize pest attack, lack of marketing facilities, lack of farmers training facilities on maize cultivation and pesticides, where pesticides ranked last (1.25%).

Major insect and vertebrate pests of maize in the field: The incidence of insect pests in the maize field were cutworm, armyworm, corn earworm, corn leaf aphid, corn stem borer, white grubs, grasshopper, termite, wireworms, seed corn maggot, chinch bug, seed corn beetles, corn root aphid, corn rootworm, sting bug and thrips. Among these insect pests, majority (50.0 - 100.0%) of the district level officials of DAE designated that cutworm, armyworm, corn earworm, stalk/stem borer, white grubs, fall armyworm, corn seed maggot, corn leaf aphid and corn wireworm were the major insect pests of maize in the field, where cutworm, armyworm, corn earworm and stalk/stem borer altogether ranked first. The infestation intensity of cutworm, armyworm and corn earworm were high in maize, while the others from medium to low intensity. The dominating insect pest cutworm attacked at seedling stage, armyworm, earworm and corn leaf aphid attacked at vegetative and reproductive stage. The vertebrate pest birds and rats were also identified as the dominant pests of maize in the field and caused damage at reproductive stage with low infestation intensity expressed by the maximum farmers, but birds caused higher damage to maize crops than rats.

Major insect pests of stored maize grains: Corn earworm, corn ear maggot, grain borer, grain weevil, Angoumois grain moth, Indian meal moth, seed corn maggot were designated as the major insect pests of stored maize grains. Among these insect pests, corn earworm, corn ear maggot, Angoumois grain moth and Indian meal moth caused damage maize seeds with high infestation intensity (50.0% to 100.0%), where corn earworm and ear maggot ranked first. Farmers usually preferred polethyne bag and earthen container to prevent these insect pest infestations in storing their maize grains.

Relationship of insect pest population with disease, weed infestation and weather factors: The weed infestation enhanced the insect pest population, while insect vector population also enhanced the incidence of disease infection in the maize field. Similarly, temperature enhanced the insect pest population at higher level, while relative humidity and rainfall enhanced the insect pests population with medium level of infestation in the maize field.

Control measures for insect pests of maize in the field: The most widely used methods for controlling insect pests of maize was the application of insecticides such as Dursban, Basudin, Furadan etc as identified by the 97.0% farmers participated in the study. Other effective management options were the use of integrated pest management (IPM) method, perching in the field maize to make facility for predatory birds and application of flood irrigation especially for soil dwelling insect pests of maize as asserted by the 7.50% to 14.0% farmers.

Control measures of insect pests of stored maize: Polythene bag was the best container for preventing insect pest attack in maize seeds in storage followed by earthen container. The effective measures for preventing insect pests of maize seeds in storage were the storing of seeds in airtight container, use of botanicals such as neem leaf, bishkatali leaf, neem oil etc, storing of seeds in polythene bag, use of insecticides in godown, use of fumigants like phostoxin tablet and maintenance of moisture content at low level by sun drying of maize seeds as suggested by 43.75 to 83.75% field level officials of DAE, where storing of maize seeds in airtight container ranked first. The use of trap to control rat in storage was also the effective measures suggested by the same.

Quarantine insect pests of maize: The harmful insect pests of maize those were not seen earlier in the maize field were cutworm, stem borer, armyworm, fall armyworm, corn earworm and corn root maggot as reported by 47.0 to 78.75% field level officials of DAE participated in the study. Consequently, the quarantine insect pests of maize in Bangladesh were the cornstalk/stem borer, corn armyworm, fall armyworm, corn earworm, seed corn maggot and white grubs as reported by the 45.0 to 85.0% district level officials of DAE. Among them corn earworm and corn armyworm ranked first and second, respectively.

Major threats due to introduction of quarantine insect pests: The major threats would be created due to introduction of quarantine pest of maize were outbreak of new insect pests, high intensity of crop damage, outbreak of disease infection through vector and outbreak of new insect biotype as asserted by the 70.0 to 100.0% policy level officials of DAE participated in the course of study.

Control measures of quarantine insect pests of maize: The effective measures for controlling quarantine insect pests of maize were the seed treatment, use of pest free imported hybrid seeds, cultural practices, farmers training to build up awareness, application of insecticides, quarantine barriers to prevent dispersion of quarantine insect pests and use of resistant maize variety as reported by 20.0 to 70.0% field level officials of DAE, where seed treatment ranked first.

Action taken to prevent quarantine insect pests of maize: Only 35.0% respondents took direct actions against quarantine pests of maize as reported by the policy level officials of DAE. The effective actions were providing training to the farmers regarding the management of quarantine insect pests of maize, visiting of maize farmers' field and provide relevant advice to them as stated by 42.86% respondents. Other effective actions were providing advice to the farmers to use treated maize seeds, provide training to the DAE staffs and provide advice to the farmers to use resistant maize variety.

Effective measures need to be taken to prevent quarantine insect pests of maize:

Strengthening of quarantine law enforcement would be the most effective measure to prevent quarantine insect pests effectively as asserted by 73.75% field level officials of DAE. Other measures would be the providing of technical training to concerned quarantine personnel for enhancement, judicious use of chemical fertilizers, improvement of existing quarantine laws and regulations, improvement of quarantine facilities particularly identification of quarantine pests, and appropriate control measures as stated by 40.0 to 71.25% respondents.

Suggestive improvement strategies for existing Quarantine services in Bangladesh: The existing facilities for quarantine services were not sufficient to cope with the quarantine insect pests of maize in Bangladesh as reported by 90.0% district level officials of DAE participated in the survey study. The suggestive improvement strategies for existing quarantine services to control quarantine insect pests would be the strengthening of existing quarantine station laboratories, establishment of modern quarantine laboratory, increase the skilled manpower regarding quarantine pests, proper identification of quarantine insect pests, training of concerned officials on quarantine pests, updating/strengthening of existing quarantine laws, strict application of quarantine laws, strengthening of quarantine services, enhancement of in-country production of

hybrid seeds for maize as suggested by the 5.0 to 55.0% respondents, where strengthening of existing quarantine station laboratories ranked first followed by establishment of modern quarantine laboratory.

CONCLUSION

- Almost all (100%) farmers chose rabi season for maize cultivation, but few (13.0%) of them chose Kharif season.
- Most (80%) of the farmers had cultivated hybrid variety of maize. Other farmers also familiar with the cultivation of BRAC developed hybrid variety, BARI developed hybrid variety and imported hybrid variety.
- The major (87%) source of maize seeds used for cultivation was the seed dealer, other sources were BRAC, BADC and pesticide dealer.
- The insect pest attack was the top ranking problem for maize cultivation identified by the majority (86.25%) of the field level officials of DAE than any other problems faced by the farmers.
- Cutworm, armyworm, corn earworm, stalk/stem borer, white grubs, fall armyworm, corn seed maggot, corn leaf aphid and corn wireworm were the major insect pests of maize in the field, as reported by the majority (50.0 - 100.0%) of the district level officials of DAE, where cutworm, armyworm, corn earworm and stalk/stem borer jointly ranked first. Other insect pests of maize in Bangladesh were white grubs, grasshopper, termite, chinch bug, seed corn beetle, corn rootworm, sting bug and thrips.
- The vertebrate pest such as birds and rats were also identified as the dominant pests of maize in the field, where birds caused higher damage to maize crops at cob formation stage.
- The infestation intensity of cutworm, armyworm and corn earworm were high in maize, while the others from medium to low intensity. The dominating insect pest cutworm attacked at seedling stage, armyworm, earworm and corn leaf aphid attacked at vegetative and reproductive stage.

- Corn earworm, corn ear maggot, grain borer, grain weevil, Angoumois grain moth, Indian meal moth, seed corn maggot were designated as the major insect pests of stored maize grains, where corn earworm, corn ear maggot, Angoumois grain moth and Indian meal moth caused damage maize seeds with high intensity (50.0% to 100.0%) of which corn earworm and corn ear maggot jointly ranked first.
- The weed infestation enhanced the insect pest population, while insect vector population enhanced the incidence of disease infection in the maize field. Similarly, temperature enhanced the insect pest population at higher level, while relative humidity and rainfall enhanced the insect pest population with medium level of infestation in the maize field.
- Application of insecticides such as Dursban, Basudin, Furadan etc was the most widely used methods for controlling insect pests of maize as identified by 97.0% farmers.
- The effective measures for preventing insect pests of maize seeds in storage were the storing of seeds in airtight container, use of botanicals, storing of seeds in polythene bag, use of insecticides in godown, use of fumigants like phostoxin tablet and maintenance of moisture content at low level as suggested by 43.75 to 83.75% field level officials of DAE, where storing of maize seeds in airtight container ranked first.
- Cornstalk/stem borer, corn armyworm, fall armyworm, corn earworm, seed corn maggot and white grubs were the the quarantine insect pests of maize in Bangladesh as reported by 45.0 to 85.0% policy level officials of DAE at district level. Among them corn earworm ranked first.
- Outbreak of new insect pests, high intensity of crop damage, outbreak of disease infection through vector and outbreak of new insect biotype would be the major threats due to introduction of quarantine insect pest of maize in Bangladesh as asserted by the 70.0 to 100.0% policy level officials of DAE, where outbreak of new insect pests ranked first.
- Seed treatment, use of pest free imported hybrid seeds, cultural practices, farmers training to build up awareness, application of insecticides, quarantine barriers to prevent dispersion of quarantine insect pests and use of resistant maize variety

were the most effective measures for controlling quarantine insect pests of maize as reported by 20.0 to 70.0% field level officials of DAE, where seed treatment ranked first.

- Only 35.0% policy level officials of DAE participated in the study took direct actions against quarantine insect pests of maize. Providing of training to the farmers regarding quarantine pest management, regular field visit and provide relevant advice to them were the most effective actions taken directly by the same respondents. Other actions taken were providing advice to use treated seeds, provide training to the DAE staffs and provide advice to use resistant maize variety.
- Strengthening of quarantine law enforcement, providing technical training to the quarantine personnel, judicious use of chemical fertilizers, improvement of existing quarantine laws, improvement of quarantine facilities would be the most effective measures to prevent quarantine insect pests of maize as asserted by 40.0 to 73.75% field level officials of DAE, where strengthening of quarantine law enforcement ranked first.
- The existing facilities for quarantine services were not sufficient to cope with the quarantine insect pests of maize in Bangladesh as reported by 90.0% district level officials of DAE. The strengthening of existing quarantine station laboratories, establishment of modern quarantine laboratory, increase the skilled manpower regarding quarantine pests, proper identification of quarantine insect pests, training of concerned officials on quarantine pests, updating/strengthening of existing quarantine laws, strict application of quarantine laws, strengthening of quarantine services, enhancement of in-country production of hybrid seeds for maize would be the improvement strategies for existing quarantine services in Bangladesh as suggested by 5.0 to 55.0% respondents, where strengthening of existing quarantine station laboratories ranked first followed by establishment of modern quarantine laboratory.

RECOMMENDATIONS

- The study strongly recommends for a systematic technical training program to educate the farmers and an intensive training program for the field level officials of DAE about identification of insect pests including quarantine insect pests especially of maize.
- The study also recommends for making a plan for building awareness among the concerned farmers for insect pest management especially for maize.
- The study considers that the existing quarantine services for preventing insect pests are not adequate and effective. The study recommends that the facilities for quarantine services in all the respective places should be strengthened with proper manpower, modern logistic support facilities and services.
- The laboratory for testing quarantine seeds must be supported by necessary equipment, scientists, technicians, and sufficient logistic, funds, and authority.
- A strong special linkage need be established among Hybrid Maize producing, testing, importing, monitoring, extension service agencies such as BARI, BRAC, BADC, and DAE for a coordinated effort targeting combating the maize infestation and promotion of the maize production as a potential economic crop in future.

CHAPTER VI

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APPENDICES

Appendix-1

Department of Entomology
Sher-e-Bangla Agricultural University
Dhaka-1207

Questionnaire for Maize Farmers

Serial					Cell Phone											

1. Personal information

Name of Respondent:…… Village:……..… Agri Block …….

Upazila…….……. District: ……...… Education: ……..……..
Age-------- Sex-------- Profession ……..…….

2. Selection of season and maize variety for cultivation

Name of Variety Used	Season for maize cultivation	
	Rabi	Kharif
1. Local Variety		
2. BARI HYV Variety		
3. BARI Hybrid variety		
4. Imported Hybrid variety		
5. Other Variety(if any)		

3. Sources of purchasing seeds

Sources of maize seeds	**Put tick mark**
1. From Seed Dealer	
2. From Pesticide Dealer	
3. From BADC	
4. Directly from Importer	
5. From Agril. Extension Dept.	
6. From Research Station	
7. Farmers' own seed	
8. Neighbor seed	
9. Purchase from local market	
8. Other sources(if any)	

5. Insects infestation in maize field (please put √)

Name of Insects pest	Incidence of insect pest (Y/N)	Stage of infestation of maize crop			Incidence/severity		
		Seedling	Vegetative	Reproductive	High	Moderate	Low
1. Termites							
2. Cutworm							
3. Corn borer							
4. Com leaf aphid							
5. Fall Armyworm							
6. Grasshoppers							
7. African pink borer							
8. African maize stem borer							
9. Corn stunt leafhopper							
10. European corn borer							
11. Diabrotica beetle and rootworms							
12. Maize bill bug and billbug grub							
13. Spider mites							
14. Southwestern maize borer							
15. Sugarcane borer							
16. Spotted sorghum stem borer							
17. White grub							
18. Wireworm							
19. Others (if any)							

6. Is there any relationship among insect, disease and weed pest infestations in the maize field? ☐
Yes = 1, No=2]

7. If yes, what is the relationship among insect, disease and weed incidence in maize field?

7.1 Insect population high when weed incidence is: ☐

1. high, 2. medium, 3. low and 4. don't know

7.2 Disease incidence high when weed incidence is: ☐

1. high, 2. medium, 3. low and 4. don't know

7.3 Disease incidence high when incidence of insect vector is: ☐

1. high, 2. medium, 3. low and 4. don't know

8. Insect pests infestation in stored maize grains (please put √)

Insect pests	Incidence of insect pests (Y/N)	Extent of Damage			Types of container used for storing maize grains					
		High	Medium	Low	Poly bag	Jute bag	Bamboo dhole	Tin	Earthen container	Plastic container
1. Corn earworm										
2. Ear maggot										
3. Grain borers										
4. Grain weevils										
5. Indian meal moth										
6. Angoumois grain moth										
7. Seedcorn maggot										
8. Rats and birds										
9. Others (if any)										

9. Whether any control measures taken against insect pests in your store maize? ☐
[Yes=1, No=2]

10. What preventive/curative measures are taken against these stored insect pests?

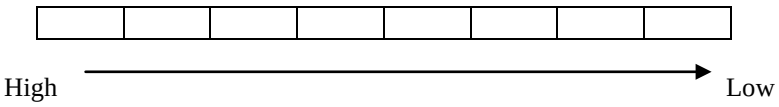
a. Preventive (name):
…….

b. Curative (name):
……...

11. Whether any control measures taken against the insect pests of maize in the field? ☐
[Yes = 1, No=2]

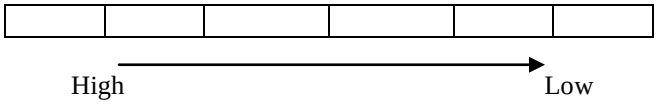
12. If yes, what control measure is used against the insect pests in maize field? ☐
[Preventive=1, Curative=2, Both=3]

13. How do you control insect pests in the maize field? Put numbers



[Through pesticides = 1, use resistant variety = 2, use imported hybrid maize = 3, seed treatment method = 4, cultural practices and control measures = 5, barriers to dispersion = 6, IPM method = 7, others (please specify) = 8]

14. From where you usually receive assistance and services in controlling insect pests of maize?



[From DAE= 1, From Research =2, From Dealers =3, from Ngo=4, from neighbors=5, Others=6]

15. Put your suggestions for better management of insect pests of maize.

1……
2……..……
…
3……..……
…
4……..……
…
5……..……
…

Signature with date

Appendix-2

Department of Entomology
Sher-e-Bangla Agricultural University
Dhaka-1207

Questionnaire for Field Level Officers of DAE

Serial					Cell Phone											

1. Personal information

Name of Respondent:…… ……. Position:
……

Upazila……..……. Union: ……. Block …….
District:……

1. **Position:** [UAE=1, AEO=2, AAEO/JAEO=3, SAPPO=4, SAAO=5, Other (please specify) =6] ☐

2. Total length of your service in the field level under the department of Agricultural Extension: [Years] ☐

3. **What are the major problems of maize cultivation in your area? Please tick (√) marks** ☐

Insect attack =1		Disease attack =2		Weed attack=3,		HYV variety =4	
Imported Hybrid variety =5		Irrigation =6		Store grain pest attack=7		Marketing facilities = 8	
Farmers training facilities on Maize =9		Pesticides and pest control measures =10		Use of unbalanced doses of Chemical Fertilizers =11		Others (if any) =12	

4. Are there any insect pest infestation or disease infection occurred that were not seen earlier? [Yes/No] ☐

5. If yes, please mention the name of insect pests with variety of maize attacked including source of seed used.

Insect pests	Occurred in maize variety	Sources of seeds	Stages of attacks
1.			
2.			
3.			
4.			
5.			

6. Name the major insect pests of maize found in the field (Please put √ mark)

Name of Insects pest	Varity	Damage Symptoms	Infestation stage of maize crop			Incidence/severity		
			Seedling	Vegetative	Reproductive	High	Moderate	Low
1. Cutworm								
2. Corn borer								
3. Com leaf aphid								
4. Termites								
5. Fall Armyworm								
6. Grasshoppers								
7. African pink borer								
8. African maize stem borer								
9. Corn stunt leafhoppers								
10. European maize borer								
11. Diabrotica beetles and rootworms								
12. Maize billbugs and billbug grubs								
13. Spider mites								
14. Southwestern maize borer								
15. Sugarcane borer								
16. Spotted sorghum stem borer								
17. White grubs								
18. Wireworms								
19. Others (if any)								

10. Inset pests infestation in stored maize grains (Please put √ mark)

Insect pests	Variety	Presence of insect pest (Y/N)	Extent of Damage			Types of Store Material used				
			High	Moderate	Low	Poly bag	Jute bag	Bam boo dole	Tin	Earthen pot
1. Corn earworm										
2. Ear maggot										
3. Grain borers										
4. Grain weevils										
5. Indian meal moth										
6. Angoumois grain moth										
7. Seedcorn maggot										
8. Seedcorn maggot										
9. Rats and birds										
10. Others (if any)										

11. Whether any control measures are taken against insect pests of stored maize? Put number ☐
[Yes=1, No= 2]

If yes: Name Control Methods:……

12. Is there any relationship among insect, disease and weed pest infestations in the maize field? ☐
[Yes = 1, No=2]

13. If yes, what is the relationship among insect, disease and weed incidence in maize field?

13.1. Insect population high when weed incidence is: ☐
[1. high, 2. medium, 3. low, 4. don't know]

13.2 Disease incidence high when weed incidence is: ☐
[1. high, 2. medium, 3. low, 4. don't know]

13.3 Disease incidence high when incidence of insect vector is: ☐
[1. high, 2. medium, 3. low, 4. don't know]

14. What are the measures may be taken for suitable for controlling insect pests of maize?

High → Low

[Improve the laws and regulations of quarantine = 1, strengthen law enforcement = 2, forecasting and providing technical training to concerned persons for enhancement=3, agricultural control=4, chemical control of the goods = 5. others (please specify) = 6]

Signature of with date

Appendix -3

Department of Entomology
Sher-e-Bangla Agricultural University
Dhaka-1207

Questionnaire for Policy Level Officers of DAE

Serial					Cell Phone											

1. Personal information

Respondent Name: …… Designation: ……..……..
Upazila : ……..…… District ……..……

2. Position: [ ]
[Deputy Director =1, District Training Officer=2, CPS=3, PPS=4, Researcher=5, Scientist of BARI =6, BADC seed officials =7, Other (please specify) = 8]

3. What are the major insect pests of maize observed in your area? Put numbers into 8 blank cells

Termites =1
Corn borer = 2
Grasshoppers =3
Cutworms =4
Fall Armyworm =5
Spotted sorghum stem borer =6
White grubs =7
Corn leaf aphid =8
African pink borer =9
African maize stem borer =10
Corn stunt leafhoppers =11
European maize borer =12
Diabrotica beetles and rootworms=13
Maize billbugs and billbug grubs =14
Spider mites =15
Southwestern maize borer =16
Sugarcane borer =17
Wireworms =18,
Others (if any) =19

4. What is the major and minor store grain pests attack in stored Maize as per information received? Put nos. into 6 blank cells

[Corn earworm =1, Ear maggot =2, Grain borers =3 , Grain weevils =4, Indian meal moth =5, Angoumois grain moth =6, Seedcorn maggot =7, Seedcorn maggot =8, Others (if any)=9]

5. Do you think that any quarantine insect pest of maize found in the maize field in your area or elsewhere in Bangladesh ? [ ]
[Yes = 1, No = 2],
If yes, please tell name of the quarantine insect pests of maize
1.……. …….. ……
2. ……. ……. ……
3. …… ……. ……..……..
4. ……. …….

6. Is there any influence of weather factors (temperature, rainfall and rainfall) on the population of insects, diseases and weeds in maize field? [Yes = 1, No = 2] [ ]

6. If yes, what type of influence of weather factors is observed on the population of insects, diseases and weeds in maize field? [Put tick (√) mark in the blank cells]

Insect pests	Influence of weather factors								
	Temperature			Relative humidity			Rainfall		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
1.									
2.									
3.									
4.									
5.									

8. What are the major risks/threat of coming new quarantine pests in our country? (Put √)

1. Introduction of new insects/diseases/weeds,
2. New biotypes of pests (Insects/pathogen),
3. Increase intensity of crop damage,
4. Others--------

9. Have you taken any direct steps or monitored the quarantine insect pests of maize in the field? [Yes = 1, No = 2]

If yes, how ……..……

……..……...

10. Do you think the existing facilities of quarantine service are sufficient to cope with the diseases and pest control of Maize in our country? [Yes = 1, No = 2]

If not, please give your suggestions for improvement of control of quarantine pests in our country

1……

2……..…….

3…….

4…….

5…….

Signature of with date

Appendix-4

Department of Entomology
Sher-e-Bangla Agricultural University
Dhaka-1207

Observation Checklist for Maize Field Visit

Serial					Cell Phone											

1. Location
Village:……..… Agri. Block …….

Upazila…….……. District: ……..…

2. Features for recording data from the observed field

Name of the insect pest	Stage of insect pests attacked crop	Growth stage of the standing maize plant in the field	Stage of maize attacked	Comments
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

Signature with date