SCREENING FOR SEED BORNE PATHOGENS AND FIELD DISEASES OF SOME SELECTED EXOTIC VEGETABLES IN BANGLADESH

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CERTIFICATE

This is to certify that the thesis entitled**, "*SCREENING FOR SEED BORNE PATHOGENS AND FIELD DISEASES OF SOME SELECTED EXOTIC VEGETABLES IN BANGLADESH*"** submitted to the Department of Plant Pathology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN PLANT PATHOLOGY** embodies the results of a piece of bona fide research work carried out by **KHALEDA AKTER** bearing Registration No**. 13-05775** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 26.11.2015
Place: Dhaka, Bangladesh

.....
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Dedicated To

My

Beloved Parents

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ABSTRACT

An experiment was conducted at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2013 to March 2014 to study on screening of seed borne pathogens and field diseases of some selected exotic vegetables in Bangladesh. Five most popular exotic vegetables were taken for this experiment namely broccoli, Chinese cabbage, capsicum, squash and lettuce and three most cultivated varieties were used for each varieties. In seed health test, *Aspergillus niger*, *A. flavus*, *Chaetomium* sp. were found in broccoli. Whereas, in Chinese cabbage, capsicum and squash, *A. niger* and *A. flavus* were observed. In lettuce seed, *Bipolaris* sp., *Chaetomium* sp. and *Curvularia* sp. were identified. In seed bed, Alternaria leaf spot was found in broccoli and Chinese cabbage seedlings. Whereas, damping off was observed in lettuce seedlings. Besides this, powdery mildew was found in squash and mosaic disease was observed in capsicum and squash seed bed. In field condition, disease incidence and severity were recorded at three different times during growing seasons. Alternaria leaf spot (*Alternaria* spp.) was found in broccoli, Chinese cabbage and lettuce and the highest incidence and severity of alternaria leaf spot was recorded in Premium Crop variety of broccoli (19 and 8%). In Chinese cabbage, the highest incidence and severity of alternaria leaf spot was found in Big King (24 and 6.67%) and in case of lettuce, the highest incidence and severity of alternaria leaf spot was observed in Green Wave variety (13.67 and 4%). Mosaic (CMV) disease was observed in capsicum and squash and in capsicum the highest mosaic incidence was recorded in Capsicum First 104 (36.33%) and in squash the highest incidence of mosaic disease was observed in Hybrid Squash (28.33%). In case of powdery mildew (*Oidium* sp.) the highest disease incidence was found in Squash F_1 Barbuda (42.33%). In capsicum for leaf curl (YLCV) disease the highest disease incidence was observed in Sweet pepper (31.67%). The yield was showed significant variation among the varieties. In case of all diseases, it was observed that disease incidence and severity was gradually increased with the age of the plant and minimum incidence and severity gave the maximum yield.

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CHAPTER 1

INTRODUCTION

Bangladesh has an overwhelmingly agricultural economy. Agriculture accounts for 32% of its gross domestic product (GDP), and absorbs 63% of the country's labor force. Sustained government investment in irrigation facilities, rural infrastructure, agricultural research, and extension services has helped Bangladeshi farmers to achieve dramatic increases in agricultural production. The process of agricultural production is, however, underpinned by the increasing use of agrochemicals and multiple cropping and while significant production transformation has been achieved and food production has more than doubled since independence in 1971, these have mostly supported the country's large population base rather than uplifting the living standards of the average citizen. Food security still remains a major development issue. Thus, the government of Bangladesh has called for a departure from "rice-led" growth to a more diversified production base that includes several non-rice crops (Hoque, 2000). Diversification into vegetable crops and increasing commercialization can support the development of the agricultural sector in several ways.

More than 60 types of vegetables of indigenous and exotic origin are grown in Bangladesh. Based on the growing season, vegetables are categorized as summer/rainy season vegetables, winter vegetables, and all-season vegetables. Of the summer vegetables, various cucurbits, cowpea, hyacinth bean, stem amaranth, several aroids and Indian spinach are predominant. Winter vegetables include tomato, cabbage, Chinese cabbage, cauliflower, eggplant, carrot, spinach, bottle gourd, bush bean and radish. Crops like okra, heat-tolerant tomato, eggplant, carrot, spinach, many leafy vegetables and small onion are grown all year round. Summer vegetables are cultivated during the monsoon season from May to October. On the other hand, winter vegetables are grown from November to April.

The production of vegetables is higher during winter (60 to 70%) and most districts produce marketable surplus during that season. Vegetable production in Bangladesh has increased between 1980 and 2003; total vegetable production area was 7.65 ha where as total production was 130.37 lac m ton (Summer 92.30 + Winter 39.91), with an average annual growth rate of 2.8%. Most of this growth can be attributed to area expansion (2.6%) and only a small share to yield increases (0.2%). Current yields are 5.8 t/ha, as compared to 5.7 t/ha in 1980. The share of area under vegetable cultivation in total arable land has nearly doubled from 1980 to 2002, from 1.9% up to 3.6% (ADB, 2001).

Exotic vegetable are those which are introduced to our country from abroad or foreign countries. Growing of exotic vegetable is more profitable business than cultivation of traditional vegetables (Rashid, 1993).

Globalization has brought many opportunities and changes in developing, countries like India, Bangladesh, etc. The most visible change which we can notice is the food habits, among the new generations. Exotic vegetables are mainly grown for city market and now days they are high demand because of high value, high nutrition, export market, contact farming, less area required, change in the lifestyle, growing demand.

So, this is very clear that cultivation of these vegetables is one of the faster growing industries with high profit margin than traditional vegetables. With the introduction of new food chains like KFC, Pizza Hut and so on, the people in Bangladesh are now developing new test buds to accept new food items. Preparation of these food items need many exotic vegetables like broccoli, Chinese cabbage, Capsicum, lettuce, squash, asparagus, olives etc some of which imported from other countries. Due to few supplies of these vegetables becomes very costly in the market of Bangladesh.

Broccoli (*Brassica oleracea*) is one of the exotic winter vegetable of Bangladesh that introduced several years ago. Although it was originated from temperate region, has been distributed in both the sub-tropical and tropical areas.

Chinese cabbage (*Brassica campestris* var. *pekinensis*) is an important leafy, herbaceous vegetable widely grown crop belonging to the family Cruciferae and said to be originated in China (Rashid, 1999). From China it was extended towards Japan, Korea, Thailand, and Indonesia. It is also a well known and widely distributed crop within Asia and has been introduced successfully into parts of Central America, West Africa, America, Canada and Europe (Talekar and Selleck, 1982). Chinese cabbage is an efficient food crop, a good cash crop, an appetizing food item and valuable source of vitamin C, calcium and crude fiber in human diet (Talekar and Griggs, 1981).

Lettuce (*Lactuca sativa* L.) belongs to the largest dicotyledonous family in plant kingdom, the Compositae. It is one of the most popular salad plants and occupies the lion share among salad crops in the world. It is an annual leafy herb with a milky juice. It produces a short stem early in the season, a cluster of leaves varying considerably in shape, character and color in different varieties. Later in the season a seed stalk is produced (Ryder, 1979). It is mainly a cold loving crop. It does best when the day temperature is 18°C to 25°C and the night temperature is 10°C to 15°C (Ryder, 1998). Lettuce is earlier introduced crop in our country, but its production package is not yet clear to our farmers. Although a various factors responsible for higher yield, the cultivar itself plays a great role. There is a wide scope for increasing the leaf yield as well as seed production of this crop that is suitable in our country.

Capsicum is variously called as green pepper, sweet pepper, bell pepper, etc. In shape and pungency it is different from chili. It is fleshy, blocky, of various shapes, more like a bell and hence named bell pepper. Pepper (*Capsicum annuum*

L.) is an important spice and vegetable crop in the tropics and subtropics. Not only is pepper valued for its spicy taste, it is also one of the richest sources of vitamin A, vitamin C and acidic phenolic compounds, which are important antioxidants (Howards, 2000). Pepper contains moderate to high levels of flavonoids–phytochemicals that are important antioxidant components of a plant-based diet.

Squash (*Cucurbita pepo*) is a member of the cucurbit family, which consists of a number of warm-season vegetables including watermelon, cantaloupe, cucumber, and pumpkins. Squash are classified into several types based on fruits, shape and color.

Vegetable crops are frequently infected by fungal pathogens, which can include seed borne fungi. In such cases, the pathogen is already present within or on the seed surface, and can thus cause seed rot and damping-off of seedling. Treatment of vegetable seeds has been shown to prevent plant disease epidemics caused by seed borne fungal pathogens. These vegetables are highly susceptible to diseases and pest hence they needs immense care while cultivation. In Bangladesh alternaria leaf spot, clubroot, mildew, greymold, bacterial soft rot, black-leg of broccoli and Chinese cabbage; anthracnose, cercospora leaf spot, mosaic in capsicum; leaf spot in lettuce; angular leaf spot, downy mildew, and powdery mildew in squash are reported to be major diseases.

Furthermore, cultivation of these exotic vegetable arise some problems such as; high input cost, expertise labour required, crops failure due to seed borne disease, less keeping quality and so on. Bangladesh imports seeds of many exotic vegetable, almost all of which are hybrids. So screening for seed borne pathogen of exotic vegetables is needed.

Considering the above facts and points, the present study has been designed with the following objectives:

- To evaluate the seed health status of selected exotic vegetables in Bangladesh.
- To study the diseases of selected exotic vegetables under natural epiphytic condition.
- To measure the disease incidence and disease severity of exotic vegetables under field condition.

CHAPTER 2
REVIEW OF LITERATURE

2.1 Diseases of Chinese cabbage (*Brassica campestris* var. *pekinensis*) and broccoli (*Brassica oleracea*)

Alternaria blight or grey blight disease is a very common on almost all the members of the family Cruciferae of which Chinese cabbage, broccoli is a member. Two species of *Alternaria viz. Alternaria brassicae* and *Alternaria brassicicola* cause theis disease. Therefore, this review was not limited to only chinese cabbage and broccoli.

Lakshman and Karuna (2003) studied the effect of longevity and location of two *Alternaria* spp. in broccoli seed during storage. Infected seeds of broccoli were examined immediately after harvest by deep freezing method for the prevalence of fungi. Seeds were further separated into lots for storage studies at room temperature (4-38°C) and in cold storage (5 or -2°C). The recoveries of fungi on seeds were observed at monthly intervals from April 1999 to November 2000. Seeds collected were categorized as trace, mild, moderate and severely infected. Healthy seeds were also taken from healthy siliquae. Seed infection of *Alternaria brassicicola* was 36.3% which was higher compared to infection of *Alternaria brassicae* (28.8%) immediately after harvest. The seed borne inoculum of *Alternaria brassicae* and *Alternaria brassicicola* reduced to a minimum of 9.5 and 9% respectively, in the end of storage period.

Khoda *et al.* (2003) reported about application of foliar fungicides to control Alternaria blight disease of cauliflower. They used Rovral 50 WP (0.20%, iprodione), Dithane M- 45 (0.25%, mancozeb), Ridomil (0.10%, metalaxyl), Bavistin (0.25%, carbendazim) and Knowin (0.25%, carbendazim). The maximum reduction in severity Alternaria blight and the highest increase of seed yield over

control were achieved with Rovral 50 WP (0.210%) followed by Dithane M 45(0.25%).

Sandhu (1992) stated that Alternaria blight of cauliflower / cabbage can be reduced by application of organic manure. The disease caused by *Alternaria brassicae* had become serious problem for cabbage/cauliflower cultivation as seed crop in the India.

Blok *et al*. (2000) studied that control of soil borne plant pathogens of broccoli by incorporating fresh organic amendments followed by tarping. After 15 weeks, survival of *Fusarium oxysporum* f. sp. *asparagi*, *Rhizoctonia solani*, and *Verticillium dahliae* in inoculum samples buried 25 cm deep was strongly reduced in amended, covered plots in both experiments.

2.2 Disease of capsicum (*Capsicum annum* L)

The threatening incidence of viral diseases of crops was well recognized all over the world. However, the virus diseases of chilli as reported by various scientists in different parts of the world are reviewed as follows:

Lockhart and Fischer (1974) reported that *Potato virus Y* infection of peppers in Morocco resulted in greatly reduced fruit set.

Simons (1955) found that Cucumber mosaic virus (CMV) was transmitted by *Myzus persicae* and *Aphis rumicis* and acquisition threshold period was between 5 and 10 minutes for both the aphids.

Ramakrishna (1959) reported that *Chili mosaic virus*, CMV and *chili leaf curl virus* were the most important viruses of chili in Srilanka.

Boswell *et al*. (1959), Agrios *et al*. (1984), Josshi and Dubey (1973) noted that CMV causes a severe reduction in fruits no. in infected pepper plants. The mechanism of this reduction in fruit numbers, and the increased bud, and flower drop may be related to the effect of CMV on pollen grain viability.

Boswell *et al*. (1959); Laborde and Pozo (1982) reported that pepper is attacked by a number of virus diseases which cause serious economic losses.

Ohta (1970) observed the pollen sterility of pepper occurring due to an S-cytoplasm factor by infection with *Tobbaco mosaic virus*, *Broad bean wilt virus* or *Cucumber mosaic virus*.

Aillaud *et al*. (1972) showed that pepper plants developed a number of abnormalities of both male and female parts of the flowers, including disfunctional pollen and petaloid anthers after inoculation with CMV.

Smith (1972) suggested that in systematic characterization of plant viruses. The symptoms are considered to be important tools which contribute much in preliminary identification of plant viruses. The author studied many different viruses of various crops including chili.

Mishra and Shrivanath (1977) reviewed the major virus diseases of crops occurring in India and Srilanka, respectively. In both the countries CMV, TMV and PVY are listed to be the major viruses infecting chili.

The immense importance of symptoms produced by plant virus for preliminary screening of field samples in any virus disease diagnosis programmed has been reported by Bos (1978).

Yeh (1979) reported that in Taiwan, PVY was first isolated and purified from tomato. The virus has been found to attack several other plants including chili in Taiwan.

The common prevalence of CMV, TMV and PVY in chili and several other crops in Bangladesh have been reported by Akanda (1991) and Akanda *et al*. (1991a. 1991b). The reports described these viruses as serious diseases for several crops including chili since the yield damage due to infection of these viruses have been reported to be very high.

CMV, TMV, and TYLCV are described as the major viruses of chili in terms of prevalence and yield loss as reported by Loebenstein and Thollappilly (2003).

Green and Kallo (1994) listed Tomato yellow leaf curl virus (TYLCV) and Tomato leaf curl virus (TLCV) as the major viruses of pepper and tomato in all the tomato and pepper growing regions. They also included the CMV, TMV and PVY as similar menaces of both crops.

Fakir (1980) listed two important seed borne fungal pathogen namely *Colletotrichum capsici* and *Cercospora capsici* in chilli from Bangladesh.

Tripathi *et al.* (1984) isolated 18 fungi from fruits and seeds of capsicum. Among all the fungi encountered *A. flavus* and *A. niger* were most frequently isolated with seeds.

Adiver (1987) observed that germination of discolored seeds of *C. annum* was considerably reduced by most commonly seed borne fungi namely *Colletotrichum, Cladosporium, Alternaria, Drechslera, Curvularia,* and *Chaetomium* spp. These fungi affected root elongation more adversely than shoot elongation.

2.3. Diseases of squash (*Cucurbita pepo*)

Agrios (1978) and Francki *et al*. (1979) found that Cucumber mosaic virus exists in numerous strains that differ somewhat in their hosts, in the symptoms they produce, in the ways they are transmitted, and in other properties and characteristics.

Gallitelli (2000) reported that symptoms of cucumber mosaic can vary greatly depending on the host, virus strains, presence or absence of virus satellite RNAs. Symptoms ranged from yellowing, mosaic, malformation on the leaves to ring-spots or line patterns. Due to early infections of CMV, severe foliar mosaic symptoms and fruit deformations is observed on squash, and especially the latter symptom has negative effects on marketability.

Lovisolo (1980) reported that more than 25 viruses, including at least seven potyviruses,infect cucurbits naturally.

2.4. Diseases of lettuce (*Lactuca sativa* L)

Richard (2004) reported that, lettuce is the world's most popular leafy salad vegetable. Various types of lettuce are cultivated across the globe, primarily for human consumption of their fresh, succulent leaves. Over 75 lettuce disorders of diverse causes and etiologies have been described. While some diseases are limited in their importance and distribution, a significant number are present wherever *Lactuca sativa* L. is grown. Many are capable of causing devastating losses in yield and quality under favorable conditions. Lettuce diseases are broadly divided into infectious and non-infectious disorders. Of the important infectious diseases fungi and viruses account for the bulk.

Nine fungal diseases including anthracnose, bottom rot, Cercospora leaf spot, damping-off, downy mildew, drop, gray mold, Septoria leaf spot, and southern blight. Five viral diseases are beet western yellows, lettuce big-vein, lettuce infectious yellows, lettuce mosaic, and tomato spotted wilt. The sole phytoplasmic lettuce disease is aster yellows. Of five important bacterial diseases, four are foliar disorders: bacterial leaf spot, marginal leaf blight, soft rot, and varnish spot. Corky root is the only bacterial root disease. In contrast, all nematode pathogens lesion, needle, and root-knot nematodes, infect lettuce roots. Three important non-infectious disorders are namely brown stain, pink rib, and tipburn. These are mainly disorders of mature or postharvest lettuce.

CHAPTER 3

MATERIALS AND METHODS

This chapter includes materials and methods that were used in conducting the experiment. It consists of a short description of locations of the experimental site, period, characteristics of soil, climate, materials used for the seedlings, layout and design of the experiment, land preparation, manuring and fertilizing, transplanting of seedlings, intercultural operations, irrigation, harvesting, data collection and statistically analysis etc. The details regarding materials and method of this experiment are presented below under the following heading:

3.1 Experimental site

The experiment was carried out in the seed health laboratory, Department of Plant Pathology and Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka-1207. The field experimental site was situated in 23°74´ N latitude and 90°35´ E longitude with an elevation of 8.2m from sea level (Anon, 1989).

3.2 Experimental period

The experiment was conducted during the period from October 2013 to March 2014.

3.3 Climate

The geographical situation of the experimental site was under the subtropical climate characterized by three distinct seasons the monsoon or rainy season from November to February and the pre-monsoon period from March to April and monsoon period from May to October (Edris *et al*., 1979). The total annual rainfall of the experimental site was 28.55 mm and average monthly maximum and minimum temperature were 24.40°C and 19.32°C, respectively. A detail of

the meteorological data of air temperature, relative humidity, rainfalls and sunshine during the period of the experiment was collected from the Climate Division of Bangladesh Meteorological Department.

3.4 Soil characteristics

The soil of the experimental site was non-calcarious dark grey and belongs to the Madhupur tract (UNDP, 1988). The experimental site was medium high land; pH of the soil was 5.6. The characteristics of the soil under the experimental plot were analyzed in the SRDI, Soil Testing Laboratory, Khamarbari, and Dhaka.

3.5 Planting materials

Five vegetables seeds and three varieties of each seeds were used in this experiment. Seeds were collected from different seed dealers of Siddique Bazar, Dhaka (Table 1 and Figure 1).

3.6 Laboratory experiment

3.6.1 Seed health study by blotter method

The collected seed samples of exotic varieties were analyzed for the presence of major seed borne fungal pathogens by blotter method following the International rules for Seed Testing (ISTA, 1999). Four hundred seeds were tested for each variety. Twenty-five seeds were placed on three layers of moist blotting paper (Whatman no.1) in each glass petridish. The petridishes were incubated at 25±1 □c under 12\12 hrs darkness cycle for 7 days. Each seed was observed under stereomicroscope (7 days after incubation) in order to record the presence of fungal colony based on growth habit. In doubtful cases temporary slides were prepared from the fungal colony and observed under compound microscope. Appropriate keys were consulted for identification of the fungi. The results were presented as percent incidence for individual pathogen.

Table 1. Details of the varieties of selected exotic vegetables

Vegetables	Variety	Line/Cross combination	Origin	Imported and marketed by	Source of collection
Chinese cabbage	Bigking	F1 hybrid	Thailand	Allauddin seed company	Siddique Bazaar, Dhaka
	Summer emperor	Hybrid F1	Hefei, China	-	Siddique Bazaar, Dhaka
	Blues	(G-HA04)	Kyoto, Japan	Takii & Co.	Siddique Bazaar, Dhaka
Lettuce	Green Wave	-	Taiwan	Known you seed Co., Ltd.	Siddique Bazaar, Dhaka
	Grand Rapid	(OP)	Bangkok Thailand	East Bengal seed Co.	Siddique Bazaar, Dhaka
	Ky Grand Rapid	(P-LE02)	Kyoto, Japan	Takii & Co.	Siddique Bazaar, Dhaka
Squash	Squash F1	GS-1	Hefei, China	Winall hi-tech seed co.	Siddique Bazaar, Dhaka
	Hybrid Squash	-	Mumbai, India	Kashem Seed Company	Siddique Bazaar, Dhaka
	Squash Hybrid	F1 Barbuda	USA	Bakker Brothers	Siddique Bazaar, Dhaka
Capsicum	First 104	-	Hefei, china	Winall hi-tech seed co.	Siddique Bazaar, Dhaka
	Sweet Pepper	-	Hefei, china	Winall hi-tech Seed Co.	Siddique Bazaar, Dhaka
	California wonder	-	China	Bakker Brothers	Siddique Bazaar, Dhaka
Broccoli	Premium crop	(G-BRO1)	Kyoto, Japan	Takii & Co., Ltd.	Siddique Bazaar, Dhaka
	Imperial Sakata	F1 hybrid	Japan	----	Siddique Bazaar
	Green Magic	F1 hybrid	Japan	----	Siddique Bazaar

Figure 1. Vegetable seeds of different varieties of selected exotic vegetables

3.6.2 Isolation and identification of the causal organisms

The fungus was isolated from infected plants by following standard procedures (Dasgupta, 1981; Agostini and Timmer, 1992). Diseased samples were collected from the field and carried to the laboratory in polythene bags. The collected samples were cut into the convenient size (1 cm^2) in advance if lesion margin where healthy and diseased tissues remain together. The cut pieces were surface disinfected by 1% NaOCl solution for 2-3 minutes. The cut pieces were washed in sterilized water. Excess water was removed with the help of sterilized blotting paper. The cut pieces were then placed on three layer moistened paper and incubated at room temperature until fungal growth. Mycelia and conidia produced in cut pieces was transferred onto new Potato Dextrose Agar plates (PDA) and incubated at room temperature for 7 days. The fungal pathogen was identified by observing the morphological features, cultural and conidial characters under compound microscope as described by Sutton (1980 and 1992). Photographs of the mycelium, conidiophores and conidia of the pathogen were also taken under microscope. The purified culture of the pathogen was stored in the PDA slants at 4°C for further use.

3.6.3 Identification of viral disease

Initially the virus diseases were identified by symptomological study through visual observation of typical symptoms of CMV, PVY and TYLCV infection like mosaic, mottling, curling (up or downward), chlorosis, yellowing, smaller leaflets, stunting etc. of the plant (Green and Kallo, 1994). The symptoms appeared in the naturally infected capsicum, squash plants were closely and carefully observed. The symptoms developed in the foliar parts of the plants including leaves, flowers and fruits were noted. The photographs of the infected plants and fruits were also taken for further illustration.

3.7 Seed bed preparation

The seedlings were raised at the Horticultural Farm, SAU, Dhaka under special care in a 3m x 1m size seed bed (Figure 2). The soil of the seed bed was well ploughed with a spade and prepared into loose friable dried masses and to obtain good tilth to provide a favorable condition for the vigorous growth of young seedlings. Weeds, stubbles and dead roots of the previous crop were removed. The seedbed was dried in the sun to destroy the soil insect and protect the young seedling from the attack of damping off disease. Sevin insecticide was used to control ant or other soil borne insect. Decomposed cow dung, Urea, TSP, MP were applied to the prepared seed bed. Five gram of each vegetable (broccoli, chinese cabbage, capsicum, squash and lettuce) seeds were sown in each seedbed on October 25, 2013. After sowing, the seeds were covered with finished soil. At the end of germination shading was done by polythene sheet with bamboo frame over the seedbed to protect the young seedlings from scorching of sunshine and heavy rainfall. Light watering, weeding done as and when necessary to provide seedlings with ideal condition for better growth.

Figure 2. Seedlings of different vareities of exotic vegetables

3.8 Layout and design of the experiment

The experiment was designed to screen out of seed borne pathogens and field diseases of some selected exotic vegetable (broccoli, chinese cabbage, capsicum, squash and lettuce) in Bangladesh. The laboratory experiment was conducted using Completely Randomized Design (CRD) and the field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were three blocks and each block consisted of five unit plots and the numbers of total plots were fifteen. Each unit plot size was 2m x 1m, plot to plot distance was 0.5m. For broccoli, chinese cabbage, and capsicum, the spacing between plant to plant and row to row was same 20 cm x 15 cm. Each unit plot had 2 rows and each with 5 plants. In squash, spacing between plant to plant and row to row was 50 cm x 45 cm with 2 rows and each row contained of 4 plants. In case of lettuce, plant to plant distance was 25 cm x 30 cm with 3 rows and each row consist 8 plants.

3.9 Preparation of the main field

The main field was ploughed thoroughly by and cross ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil for planting of seedlings. Cowdung, Urea, TSP, MP as per recommended dose were mixed with the soil of each unit plot.

3.10 Transplanting of seedlings in the main field

Healthy and uniform sized seedlings were transplanted in the main field. The seedlings were uprooted carefully from the seedbed to avoid any damage to the root system. To minimize the roots damage of the seedlings the seedbed was watered one hour before uprooting the seedlings. Transplanting was done in the afternoon. Broccoli and Chinese cabbage was transferred to the main field when the seedlings was 30 days old, lettuce transferred at the age of 20 days, squash at the age of 15 days and capsicum was transferred after 45 days. During

transplanting spacing between plant to plant and row to row according to each crops were maintained. The seedlings were watered immediately after transplanting. A number of seedlings were also planted in the border of the experimental plots for gap filling if necessary later on.

3.11 Fertilizer application

Different fertilizers were applied as per recommended dose. The quantity of different fertilizers for respective amount of N, P, K and cow dung are presented in Table 2 (Rashid, 1993).

Table 2. Doses of fertilizers used in the experiment

Crops	Cowdung (ton/ha)	Urea (Kg/ha)	TSP (Kg/ha)	MOP (Kg/ha)
Broccoli	15-20	250-300	150-200	200-250
Chinese cabbage	5-10	250-300	150-200	200-250s
Capsicum	10	250	350	250
Lettuce	10	200	75	---
Squash	0.3	23	23	20

3.12 Intercultural operation

When the seedlings started to emerge in the bed various intercultural operation were accomplished for better growth and development of the seedlings.

3.12.1 Irrigation

Light watering was given by a watering can at every morning and afternoon following transplanting and continued for a week for rapid and well establishment of the transplanted seedlings.

3.12.2 Gap filling

Dead, injured and week seedlings were replaced by healthy one from the stock kept on the border line of the experimental plot.

3.12.3 Weeding

Weed was found in the plots and weeding was done three times in these plots considering the optimum time for removal of weed.

3.13 Harvesting

The crops were harvested depending upon the maturity of each crop. Harvesting was done manually.

3.14 Data collection

The data were collected from the inner rows of plants of each crop to avoid the border effect. In each unit plot, 3 plants were selected at random for data collection. Data were collected in respect of the disease incidence, disease severity, plant growth characters and yield of these crops. Data on disease incidence and severity were counted at 10 days interval for 3 times from the beginning of disease attack and yield at harvest. The following parameters were set up for recording data and for the interpretation of the results. Data were recorded on the following parameters.

3.14.1 Disease incidence

Disease incidences were calculated by using the following formula:

Diseases incidence (%) = X1/X2 x 100

Where,

X1= No. of infected plants

X2= Total plants

3.14.2 Disease severity

Disease severities were calculated by using the following formula:

Disease severity (%) = = X1/X2 x 100

Where,

X1= Leaf area infected

X2= Total leaf area

3.14.3 Fresh weight of fruits

The fresh weight of fruits or unfolded leaves was taken which was collected at the harvest time and expressed in gram and mean value for a unit plant was recorded.

3.15 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance disease incidence and severity and yield contributing characters of these exotic vegetables. The mean values of all the characters were evaluated and analysis of variance was performing by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER

RESULTS

The main objectives of this research were to screen out of seed borne pathogens and field diseases of some selected exotic vegetables in Bangladesh. To achieve this goal, the disease incidence and severity was estimated at different days after transplanting (DAT). In this study, the effect of these diseases on the yield and yield contributing characters of the selected exotic vegetables was also determined.

4.1 Determination of prevalence of seed borne fungi of some selected exotic vegetables by blotter method of seed health testing

Prevalence of seed borne fungi of five selected exotic vegetables (Broccoli, Chinese cabbage, Capsicum, Lettuce and Squash) was done through blotter paper method. Significant variations among the varieties in respect of percent seed germination were observed (Table 3 and Figure 3-10).

In broccoli, the highest (92.75%) seed germination was observed in Green Magic and the lowest (86.5%) was found in Imperial Sakata and both were statistically different to other variety. In Chinese cabbage the highest (92%) seed germination was recorded in Bigking and the lowest (85%) was found in Summer Emperor and both were also statistically different from another variety Blues (88.5%). In case of lettuce, the highest (91%) seed germination was recorded in Ky Grand Rapid and the lowest (84.75%) was found in Grand Rapid and both were also statistically different from another variety.

In case of capsicum, the highest (91.25%) seed germination was observed in Sweet Pepper and the lowest (85.25%) was recorded in Capsicum First 104.

Moreover, in squash the highest seed germination percentage was recorded in Squash F_1 (92.00%) and the lowest was found in Hybrid Squash (84.75%).

In broccoli, three types of fungus viz. *Aspergillus flavus, Aspergillus niger* and *Chaetomium* sp. were identified by blotter method (Table 3, Figure 3-8). The highest (13.5%) incidence of *Aspergillus niger* was observed in Premium Crop and the lowest (7.75%) was found in Green Magic. Moreover, the highest (6%) incidence of *Aspergillus flavus* was recorded in Imperial Sakata followed by Premium crop (5%) and the lowest (2.5%) was found in Green Magic. The highest incidence of *Chaetomium* sp. was observed in Premium Crop (2.5%) followed by Green Magic (1.75%) and the lowest was found in Imperial Sakata (1.25%) followed by Green Magic (1.75%).

In Chinese cabbage, two fungal genera was observed viz. *Aspergillus niger* and *Chaetomium* sp. (Table 3).The highest incidence of *Aspergillus niger* was observed in Summer Emperor (3.75%) and the lowest was found in Blues (1%) followed by Bigking (1.5%). The highest incidence of *Chaetomium* sp. was identified in Blues (10.25%) followed by Summer Emperor (7.5%) and the lowest was noticed in Bigking (2.75%).

In lettuce, three fungi were identified (Table 3). They are *Bipolaris* sp., *Chaetomium* sp. and *Curvularia* sp. (Figure 7-10). The highest incidence of *Bipolaris* sp. was recorded in Grand Rapid (1.5%) and the lowest was found in Ky Grand Rapid (1%). The highest incidence of *Chaetomium* sp. was identified in Green Wave (5%) and the lowest incidence was found in Ky Grand Rapid (1.25%). The highest incidence of *Curvularia* sp. was recorded in Green Wave (1.75%) the lowest incidence was found in Ky Grand Rapid (1.00%).

In capsicum, two fungal genera viz. *Aspergillus niger* and *Chaetomium* sp. were observed (Table 3). The highest incidence of *Aspergillus niger* was recorded in Sweet Pepper (2.25%) and the lowest incidence was found in two varieties California Wonder and Capsicum First 104 (1.25%). The highest incidence of *Chaetomium* sp. was identified in Capsicum First 104 (4%) and the lowest incidence was also found in two varieties California Wonder and Sweet Pepper (3%).

In Squash, only one type of fungal genera was identified and that was *Chaetomium* sp. (Table 3). The highest incidence of *Chaetomium* sp. was identified in Squash F_1 Barbuda (4.25%) followed by Squash F_1 (3.5%) and the lowest incidence was found in Hybrid Squash (1.5%).

Table 3. Prevalence of seed borne fungi of some selected exotic vegetables by blotter method

Variety		Germination (%)	Fungal incidence (%)				
			Aspergillus niger (%)	*Aspergillus flavus* (%)	*Bipolaris* (%)	*Chaetomium* (%)	*Curvularia* (%)
Broccoli	Premium Crop	90.75 b	13.50 a	5.00 a	-	2.50 a	-
	Imperial Sakata	86.50 c	10.50 b	6.00 a	-	1.25 b	-
	Green Magic	92.75 a	7.75 c	2.50 b	-	1.75 ab	-
	LSD(0.050)	1.995	2.66	2.22	-	0.973	-
	CV (%)	1.20		12.71	-	8.75	-
Chinese cabbage	Bigking	92.00 a	1.50 b	-	-	2.75 b	-
	Blues	88.50 b	1.00 b	-	-	10.25 a	-
	Summer Emperor	85.00 c	3.75 a	-	-	7.50 a	-
	LSD(0.050)	2.22	1.476	-	-	2.788	
	CV (%)	1.36	8.37	-	-	12.09	
Lettuce	Ky Grand Rapid	91.00 a	-	-	1.00 a	1.25 c	1.00 a
	Green Wave	88.50 b	-	-	1.25 a	5.00 a	1.75 a
	Grand Rapid	84.75 c	-	-	1.50 a	3.00 b	1.25 a
	LSD(0.050)	1.92	-	-	0.81	1.34	1.15
	CV (%)	1.18	-	-	12.28	13.56	11.57
Capsicum	California Wonder	88.50 b	1.25 a	-	-	3.00 a	-
	Capsicum First 104	85.25 c	1.25 a	-	-	4.00 a	-
	Sweet Pepper	91.25 a	2.25 b	-	-	3.00 a	-
	LSD(0.050)	1.995	1.539			3.139	
	CV (%)	1.22	12.63			10.99	
Squash	Hybrid Squash	84.75 c	-	-	-	1.50 a	-
	Squash F_1	92.00 a	-	-	-	3.50 a	-
	Squash F_1 Barbuda	88.25 b	-	-	-	4.250 a	-
	LSD(0.050)	2.088				3.184	-
	CV (%)	1.28				5.91	-

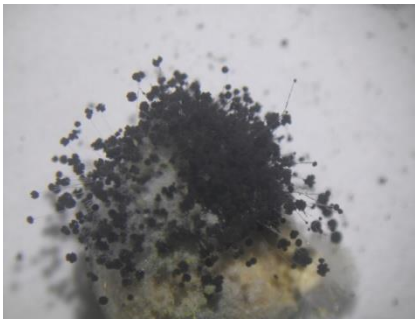

Fig. 3 *Aspergillus niger* under stereomicroscope

Fig. 4 *Aspergillus niger* under compound microscope

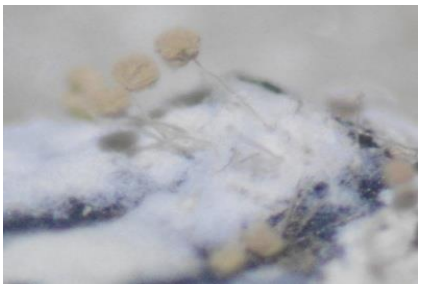

Fig. 5 *Aspergillus flavus* under stereomicroscope

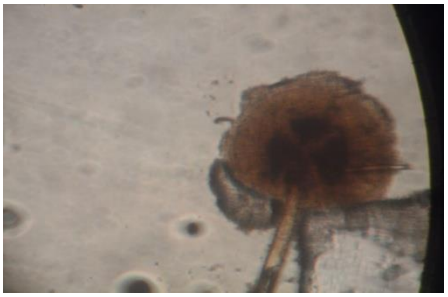

Fig. 6 *Aspergillus flavus* under compound microscope

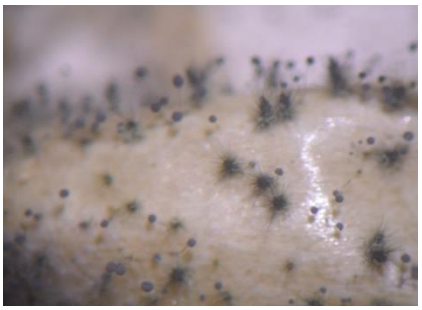

Fig. 7 *Chaetomium* sp. under stereomicroscope

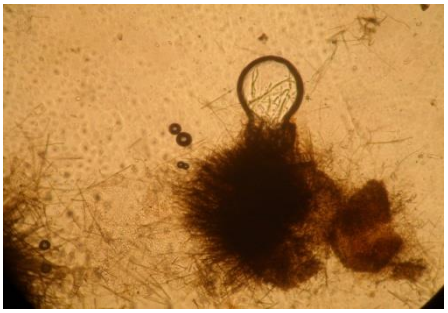

Fig. 8 *Chaetomium* sp. under compound microscope

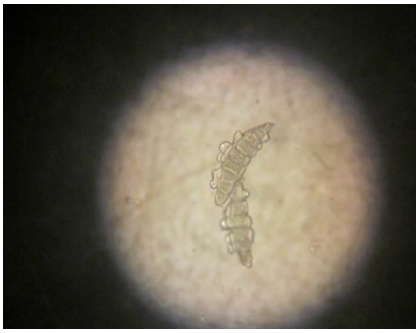

Fig. 9 *Bipolaris* sp. under compound microscope

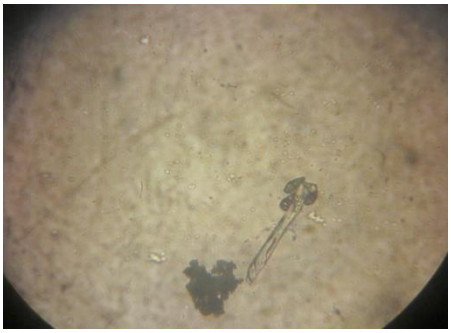

Fig. 10 *Curvularia* sp. under compound microscope

4.2 Disease incidence of some selected exotic vegetables (Broccoli, Chinese cabbage, Capsicum, Lettuce and Squash) in seed bed

Disease incidence of some selected exotic vegetable (Broccoli, Chinese cabbage, Capsicum, Lettuce and Squash) in seed bed were recorded from 10 days after germination of seeds (Table 4).

In broccoli, the highest germination (90.67%) was found in Green Magic which was statistically similar to Premium Crop variety (88.67%) and the lowest germination (84%) was recorded in Imperial Sakata. In broccoli, the incidence of Alternaria leaf blight showed significant variation among the varieties. The highest incidence (14.67%) was recorded in Premium Crop variety which was statistically different to other varieties and the lowest incidence (8%) was found in Imperial Sakata. In case of damping off disease, the highest disease incidence (7.66%) was recorded in Imperial Sakata that was statistically different to other varieties and the lowest incidence was found in Green Magic (3.66%) which was statistically similar to Premium Crop (5%).

In Chinese cabbage, the highest germination (90.67%) was recorded in Bigking which was statistically different to other varieties and the lowest germination (84.67%) was found in Summer Emperor. The highest incidence of Alternaria leaf

spot in Chinese cabbage was recorded in Bigking (15.33%) which was statistically different to other varieties and the lowest incidence was found in Blues (8.33%) that was also statistically different from other varieties.

In case of lettuce varieties, the highest germination (89%) was found in Ky Grand Rapid which was statistically different to other varieties and the lowest germination (83%) was recorded in Grand Rapid. The highest incidence (14.33%) of Alternaria leaf spot in lettuce was recorded in Ky Grand Rapid variety and the lowest incidence was found in Green Wave (7.67%) and both of them were statistically different to another variety. The highest incidence (17%) of damping off in lettuce was recorded in Ky Grand Rapid and the lowest incidence (11%) was found in Grand Rapid and both of them were statistically different from other varieties.

In capsicum, the highest germination (89%) was found in Sweet Pepper and the lowest germination (83.67%) was recorded in Capsicum First 104 and both of them were statistically different to other varieties. The highest incidence of Mosaic was recorded in California Wonder (4.67%) which was statistically similar to Capsicum First 104 (3.67%) and the lowest incidence was found in Sweet Pepper (2.67%) which was also statistically similar to Capsicum First 104 (3.67%) but different from California Wonder (4.67%).

In Squash, the highest germination (90.67%) was found in Squash F_1 and the lowest germination (84%) was recorded in Hybrid Squash and both of them were statistically different to others. The highest incidence of Mosaic in Squash was recorded in Hybrid Squash (10.33%) and the lowest incidence was found in Squash F_1 Barbuda (5.33%) and both of them were statistically dissimilar to other varieties. In case of Powdery mildew of squash, the highest incidence was

recorded in Squash F_1 Barbuda (5.33%) and the lowest was recorded in Hybrid Squash (2.33%) and both the varieties were different to another variety (Table 4).

Table 4. Disease incidence of some selected exotic vegetables (Broccoli, Chinese cabbage, lettuce, capsicum and Squash) in seedbed

Variety		Germination (%)	Disease incidence (%)			
			Alternaria leaf spot	Mosaic disease	Powdery mildew	Damping off
Broccoli	Premium Crop	88.67 a	14.67 a	-	-	5.00 b
	Imperial Sakata	84.00 b	8.00 c	-	-	7.66 a
	Green Magic	90.67 a	12.00 b	-	-	3.66 b
	LSD (0.050)	2.20	1.76	-	-	1.49
	CV (%)	1.26	7.63	-	-	13.69
Chinese cabbage	Bigking	90.67 a	15.33 a	-	-	-
	Blues	87.33 b	8.33 c	-	-	-
	Summer Emperor	84.67 c	11.67 b	-	-	-
	LSD (0.050)	1.99	1.15	-	-	-
	CV (%)	1.14	4.90	-	-	-
Lettuce	Ky Grand Rapid	89.00 a	14.33 a	-	-	17.00 a
	Greenwave	86.33 b	7.67 c	-	-	14.00 b
	Grand rapid	83.00 c	11.67 b	-	-	11.00 c
	LSD (0.050)	2.40	1.15	-	-	1.99
	CV (%)	1.40	5.14	-	-	7.14
Capsicum	California Wonder	86.33 b	-	4.67 a	-	-
	Capsicum First 104	83.67 c	-	3.67 ab	-	-
	Sweet Pepper	89.00 a	-	2.67 b	-	-
	LSD (0.050)	2.20	-	1.15	-	-
	CV (%)	1.28	-	15.75	-	-
Squash	Hybrid Squash	84.00 c	-	10.33 a	2.33 c	-
	Squash F_1	90.67 a	-	7.67 b	4.33 b	-
	Squash F_1 Barbuda	87.00 b	-	5.33 c	5.67 a	-
	LSD (0.050)	2.40	-	1.15	1.15	-
	CV (%)	1.38	-	7.42	14.04	-

4.3 Effect of different varieties on incidence and severity of Alternaria leaf blight disease of Broccoli at different days after transplanting (DAT)

The incidence and severity of Alternaria leaf spot of in different varieties of Broccoli (Figure 11-12) was recorded at 20, 40 and 60 days after transplanting (DAT) and the results are presented in Table 5. The incidence of Alternaria leaf blight was showed significant variation among the varieties at 20 DAT and ranged from 4.67-7.33% where the highest incidence was found in Premium Crop (7.33%) which was statistically different from other varieties and the lowest (4.67%) incidence was recorded in Imperial Sakata which was statistically similar to Green magic. After 40 DAT, the highest (13.67%) incidence was found in Premium Crop that was statistically similar to Green Magic (11.67%) and the lowest (7.67%) incidence was recorded in Imperial Sakata which was statistically different to other varieties. At 60 DAT, the highest incidence was also found in Premium Crop (19%) and the lowest (11%) incidence was also recorded in Imperial Sakata. It was noted that the disease incidence was gradually increased with the increase of the age of the plant.

The severity of Alternaria leaf blight was showed significant variation among the varieties at 20 DAT and ranged from 1.67-4.33%. The highest (4.33%) severity was found in Premium Crop which was statistically different from other varieties and the lowest (1.67%) severity was found in Imperial Sakata followed by Green Magic (2%). After 40 DAT, the highest (6%) severity was found in Premium Crop which was statistically different from Imperial Sakata (3.33%) but statistically similar to Green magic (4.67%) and the lowest (3.33%) severity was found in Imperial sakata that was statistically different from Premium Crop (6%) but preceeded to Green magic (4.67%) varieties. After 60 DAT, the highest severity was found in Premium Crop (8%) and the lowest (5.33%) severity was also recorded in Imperial Sakata which was statistically different from other varieties.

It was noted that, the disease severity was gradually increased with the increase of the age of the plant.

Table 5. Disease incidence and severity Alternaria leaf blight of Broccoli at different days after transplanting

Varieties	% Disease incidence			% Disease severity		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
Premium Crop	7.33 a	13.67 a	19.00 a	4.33 a	6.00 a	8.00 a
Imperial Sakata	4.67 b	7.667 b	11.00 c	1.67 b	3.33 b	5.33 c
Green Magic	5.67 b	11.67 a	15.00 b	2.00 b	4.67 ab	6.67 b
LSD (0.050)	1.511	3.463	2.617	0.926	1.85	0.926
CV (%)	11.32	12.89	7.70	9.31	12.50	6.12

*DAT= Days after transplanting

Figure 11. Healthy plant of Broccoli

Figure 12. Broccoli leaf showing Alternaria leaf blight disease

4.4 Effect of different varieties on incidence and severity of Alternaria leaf spot of Chinese cabbage at different days after transplanting (DAT)

The effect of different varieties on incidence of Alternaria leaf spot of Chinese cabbage in leaf was recorded at 20, 40 and 60 days after transplanting (DAT) (Table 6, Figure 13-15). The incidence of Alternaria leaf spot was showed significant variation among the varieties at 20 DAT and ranged from 5.33-9.33%. Among the varieties, the highest incidence (9.33%) was found in Bigking which was statistically similar to Summer Emperor (9%) and the lowest incidence (5.33%) was recorded in Blues which was statistically different from rest two varieties. After 40 DAT, the highest incidence (15.33%) was found in Bigking which was statistically similar to Summer Emperor (13.33%) and the lowest incidence (10.33%) was recorded in Blues that was also statistically similar to Summer Emperor (13.33%). After 60 DAT, the highest incidence was also found in Bigking (24%) that was statistically different from other varieties and the lowest incidence was also recorded in Blues with 15%.

The effect of different varieties on severity of Alternaria leaf spot of Chinese cabbage in leaf was recorded at 20, 40 and 60 days after transplanting (DAT) (Table 6). The severity of Alternaria leaf spot was showed significant variation among the varieties at 20 DAT and ranged from 1-1.83%. The highest severity was found in Summer Emperor (1.83%) followed by Bigking (1.67%) and the lowest severity was recorded in Blues (1%). After 40 DAT, the highest severity was found in Bigking (3.33%) that was statistically similar to Summer Emperor (2.97%) variety and the lowest severity was recorded in Blues (1.67%) that was statistically different from other varieties. After 60 DAT, the highest severity was also found in Bigking (6.67%) that was statistically different from other varieties and the lowest severity was also recorded in Blues (2.5%) and that was also

statistically different to other varieties. It was noted that, the disease incidence was gradually increased with the increase of the age of the plant.

Table 6. Disease incidence and severity of Alternaria leaf spot of Chinese cabbage at different days after transplanting

Varieties	% Disease incidence			% Disease severity		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
Bigking	9.33 a	15.33 a	24.00 a	1.67 a	3.33 a	6.67 a
Blues	5.33 b	10.33 b	15.00 c	1.00 a	1.67 b	2.50 c
Summer Emperor	9.00 a	13.33 ab	20.00 b	1.83 a	2.97 a	4.67 b
LSD (0.050)	2.203	3.069	2.617	0.926	0.903	1.362
CV (%)	12.32	10.42	5.87	11.22	9.04	7.03

*DAT= Days after transplanting

Figure 13. Chinese cabbage leaf showing Alternaria leaf spot symptom

Figure 14. Healthy plant of Chinese cabbage

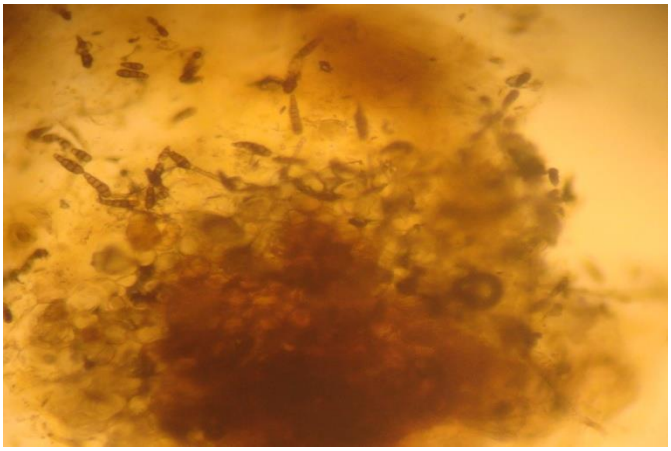

Figure 15. *Alternaria* sp. under compound microscope

4.5 Effect of different varieties on the incidence of foot rot of lettuce caused by *Sclerotium rolfsii* at different days after transplanting (DAT)

The effect of different varieties on incidence of foot rot of lettuce caused by *Sclerotium rolfsii* was recorded at 10, 20 and 30 days after transplanting (Table 7 and Figure 16-19). The incidence of foot rot at 10 DAT showed significant variations among the varieties and ranged from 6-14.33%. The highest incidence (14.33%) was recorded in Green Wave and the lowest incidence (6%) was found in Ky Grand Rapid. At 20 DAT, the incidence of foot rot disease ranged from 12.33 to 21.67% and the highest incidence (21.67%) was recorded in Green Wave variety that was statistically different from other varieties and the lowest incidence (12.33%) was found in Ky Grand Rapid variety. After 30 DAT, the highest incidence (32.67%) was also recorded in Green Wave and the lowest incidence (21%) was found in Grand Rapid variety those were also statistically different to other variety.

Table 7. Diseases incidence of foot rot of lettuce caused by *Sclerotium rolfsii* at different days after transplanting

Varieties	% Disease incidence		
	10 DAT	20 DAT	30 DAT
Ky Grand Rapid	6.00 b	12.33 b	26.33 b
Green Wave	14.33 a	21.67 a	32.67 a
Grand Rapid	8.333 b	14.00 b	21.00 c
LSD (0.050)	4.308	4.341	2.927
CV (%)	8.39	11.97	4.84

*DAT= Days after transplanting

Figure 16. Healthy Lettuce plant

Figure 17. Mycelia of *Sclerotium* sp. around the collar region of lettuce

Figure 18. Lettuce plant infected by *Sclerotium* rolfsii

Figure 19. Pure culture of *Sclerotium rolfsii* on PDA medium

4.6 Effect of different varieties on incidence and severity of Alternaria leaf spot of lettuce at different days after transplanting (DAT)

The effect of different varieties on incidence and severity of Alternaria leaf spot of lettuce was recorded at 10, 20 and 30 days after transplanting (Table 8 and Figure 20-21). The incidence of Alternaria leaf spot was showed significant variation among the varieties at 10 DAT and ranged from 1 to 4%. The highest incidence was recorded in Green Wave (4%) and the lowest incidence was recorded in Ky Grand Rapid (1%). Similar results also found at 20 and 30 days after transplanting. At 20 DAT, the highest incidence was found in Green Wave (9%) and the lowest incidence was in Ky Grand Rapid (2.33%). At 30 DAT, the highest incidence was observed in Green Wave (13.67%) and the lowest incidence was recorded in Ky Grand Rapid (4%).

The effect of different varieties on severity of Alternaria leaf spot of lettuce also studied at 10, 20 and 30 days after transplanting (Table 8). At 10 DAT, all the varieties showed same severity (1%). At 20 DAT, the highest (2.33%) severity

was recorded in Green Wave and the lowest (1.33%) severity was found in Grand Rapid (1%) preceeded by Ky Grand Rapid. At 30 DAT, the highest (4%) severity was recorded in Green Wave and the lowest (1.66%) severity was found in Grand Rapid variety.

Table 8. Disease incidence and severity of Alternaria leaf spot of lettuce at different days after transplanting.

Variety	% Disease incidence			% Disease severity		
	10 DAT	20 DAT	30 DAT	10 DAT	20 DAT	30 DAT
Ky Grand Rapid	1.00 b	2.33 c	4.00 b	1.00 a	1.33 b	2.33 b
Green wave	4.00 a	9.00 a	13.67 a	1.00 a	2.33 a	4.00 a
Grand Rapid	1.66 b	4.33 b	6.00 b	1.00 a	1.00 b	1.66 b
LSD (0.05)	1.331	1.490	2.401	0.6686	0.9431	1.490
CV (%)	12.01	10.39	8.32	4.84	10.30	7.95

*DAT= Days after transplanting

Figure 20. Alternaria leaf spot in lettuce plant

Figure 21. Conidium of *Alternaria brassicae* under compound microscope at 40x

4.7 Effect of different varieties on incidence of leaf curl and mosaic diseases of capsicum at different days after transplanting (DAT)

The effect of different varieties on incidence of leaf curl and mosaic diseases of Capsicum was recorded at 40, 60 and 80 days after transplanting (Table 9 and Figure 22-24). At 40 DAT, leaf curl incidence ranged from 9.66-13%, where the highest (13%) incidence was recorded in Sweet Pepper and the lowest value counted from Capsicum First 104 (9.66%). At 60 and 80 days after transplanting, there was no significant variation among the varieties regarding leaf curl incidence. At 60 DAT, the highest (21.67%) incidence was recorded in Sweet Pepper and the lowest (19.33%) incidence was recorded in Capsicum First 104. At 80 DAT, the highest incidence was recorded in Sweet Pepper (31.67%) and the lowest incidence was observed in Capsicum First 104 (28%). It was noted that the disease incidence was gradually increased with the increased of the age of plant.

The incidence of mosaic disease was not showed significant variation among the varieties at 40 DAT and ranged from 10 to 13%. The highest incidence was recorded in Capsicum First 104 (13%) and the lowest incidence was found in California Wonder (10%). At 60 and 80 days after transplanting, mosaic incidence showed statistically significant variations among the varieties. At 60 DAT, the highest incidence was recorded in Capsicum First 104 (25%) and the lowest incidence was found in California Wonder (16.33%) variety. Moreover, at 80 DAT, the highest incidence was recorded in Capsicum First 104 (36.33%) and the lowest incidence found from California Wonder (21.33%).

Table 9. Disease incidence of leaf curls and mosaic disease of Capsicum at different days after transplanting (DAT)

Variety	% Disease incidence of leaf curl			% Disease incidence of mosaic		
	40 DAT	60 DAT	80 DAT	40 DAT	60 DAT	80 DAT
California Wonder	11.00 ab	20.00 a	29.00 a	10.00 a	16.33 c	21.33 c
Capsicum First 104	9.66 b	19.33 a	28.00 a	13.00 a	25.00 a	36.33 a
Sweet Pepper (hybrid F_1)	13.00 a	21.67 a	31.67 a	11.00 a	20.00 b	29.00 b
LSD (0.050)	3.330	9.131	13.02	3.460	2.664	6.985
CV (%)	4.85	10.48	12.04	10.28	6.52	12.10

*DAT= Days after transplanting

Figure 22. Healthy plant of Capsicum

Figure 23. Capsicum leaves showing leaf curl disease

Figure 24. Leaves of capsicum showing mosaic symptoms

4.8 Effect of different varieties on incidence and severity of powdery mildew of squash at different days after transplanting (DAT)

The effect of different varieties on incidence of powdery mildew of squash in leaf was recorded at 20, 40 and 60 days after transplanting (Table 10 and Figure 25-27). The incidence of powdery mildew showed significant variation among the varieties at 20 DAT and ranged from 10.67-16%. The highest incidence (16%) was recorded in Squash F_1 Barbuda which was statistically similar to Squash F_1 (12.67%). The lowest incidence (10.67%) was found in Hybrid Squash followed by Squash F_1 (12.67%). Similar results also found at 40 and 60 days after transplanting. After 40 DAT, the highest incidence (28%) was recorded in Squash F_1 Barbuda and the lowest incidence (14%) was recorded in Hybrid Squash. At 60 DAT, the highest incidence (42.33%) was also recorded in Squash F_1 Barbuda and the lowest incidence (19.33%) was also recorded in Hybrid squash.

The effect of different varieties on severity of powdery mildew of Squash in leaf was recorded at 20, 40 and 60 DAT (Table 10). At 20 DAT, the highest incidence (4.33%) was recorded in Squash F_1 Barbuda and the lowest incidence (1.66%) was recorded in Hybrid Squash followed by Squash F_1 (2.66%). However, at 40 DAT, the highest incidence (10.33%) was recorded in Squash F_1 Barbuda and the lowest incidence (5%) was found in Hybrid squash. At 60 DAT, the highest incidence was also found in Squash F_1 Barbuda (18%) and the lowest incidence was recorded in Hybrid Squash (7.66%). It was noted that the disease incidence and severity was gradually increased with the increased of the age of plant.

Table10. Disease incidence and severity of Powdery mildew of Squash at different days after transplanting.

Variety	% Disease incidence			% Disease severity		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
Hybrid Squash	10.67 b	14.00 c	19.33 c	1.66 b	5.00 c	7.66 c
Squash F_1	12.67 ab	21.00 b	31.00 b	2.66 b	7.00 b	10.67 b
Squash F_1Barbuda	16.00 a	28.00 a	42.33 a	4.33 a	10.33 a	18.00 a
LSD (0.050)	3.940	5.159	5.612	1.153	1.762	1.490
CV (%)	11.31	10.74	5.35	9.43	10.36	11.77

*DAT= Days after transplanting

Figure 25. Healthy squash plant

Figure 26. Squash leaf showing powdery mildew disease

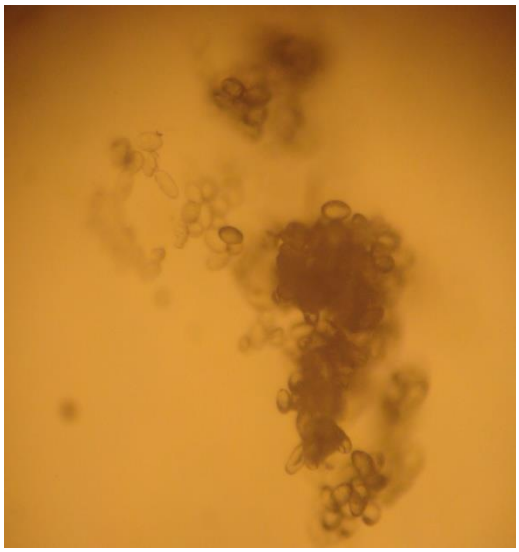

Figure 27. Conidia of powdery mildew pathogen observed under compound microscope

4.9 Effect of different varieties on incidence of mosaic of Squash at different days after transplanting (DAT)

The effect of different varieties on incidence of mosaic of squash was recorded at 20, 40 and 60 days after transplanting (Table 11 and Figure 28). At 20 DAT, among the varieties, the highest incidence of mosaic of Squash was recorded in Hybrid Squash (10.67%) that was statistically similar to Squash F_1 Barbuda (9%) and the lowest incidence was recorded in Squash F_1 (5.33%), which was statistically different to other varieties. After 40 DAT, the highest incidence was recorded in Hybrid Squash (16.67%) that was statistically different to other varieties and the lowest incidence was found in Squash F_1 (12.67%). After 60 DAT, the highest incidence was recorded in Hybrid Squash (28.33%) that was statistically different to other varieties and the lowest incidence was also found in Squash F_1(19%) followed by Squash F_1 Barbuda (20%).

Table 11. Disease incidence of mosaic of Squash at different days after transplanting

Variety	% Disease incidence		
	20 DAT	40 DAT	60 DAT
Hybrid Squash	10.67 a	16.67 a	28.33 a
Squash F_1	5.33 b	12.67 b	19.00 b
Squash F_1 Barbuda	9.00 a	13.33 b	20.00 b
LSD (0.050)	1.884	3.052	2.401
CV (%)	11.04	12.30	9..09

*DAT= Days after transplanting

Figure 28. Mosaic disease in Squash plant

4.10 Yield of selected exotic vegetable

The yield performance of different varieties of selected exotic vegetables was recorded after harvesting (Table 12). Among the Broccoli, the highest plant yield was recorded in Imperial Sakata (433.3g/plant) and the lowest yield performance was recorded in Green Magic (191.7g/plant) followed by Premium Crop (213.3g/plant). In case of Chinese cabbage the highest plant yield was recorded in Summer Emperor (1523 g/plant) and the lowest yield was recorded in Blues (1473g/plant) where both of them were similar to other varieties. In case of lettuce, the highest yield performance was recorded in Grand Rapid (280.3 g/plant) and the lowest was found in Green Wave (240 g/plant) where all variety gave statistically similar result. Among the Capsicum varieties, the highest plant yield was recorded in California Wonder (104.3 g/plant) followed by Capsicum First 104 (94 g/plant) and the lowest plant yield was found in Sweet Pepper (60.3 g/plant). In case of Squash, the highest plant yield was recorded in Hybrid Squash (210 g/plant) and the lowest plant yield was recorded in Squash F_1 Barbuda (166.7 g/plant) which was statistically similar to Squash F_1 (170 g/plant).

Table 12. Yield of some selected exotic vegetable

Crop	Variety	Yield/Plant(g)	Yield (kg/Plot)	Yield (t/ha)
Broccoli	Premium Crop	213.3 b	2.6	13
	Imperial Sakata	433.3 a	4.15	20.75
	Green Magic	191.7 b	1.8	9
	LSD (0.050)	150.7		
	CV (%)	7.00		
Chinese cabbage	Bigking	1503 a	15	75
	Blues	1473 a	14.5	72.5
	Summer Emperor	1523 a	15.2	76
	LSD (0.050)	0.209		
	CV (%)	7.08		
Lettuce	Ky Grand Rapid	258.3 a	6.19	30.95
	Green wave	240.3 a	5.76	57.6
	Grand Rapid	280.3 a	6.27	31.35
	LSD (0.050)	60.44		
	CV (%)	11.66		
Capsicum	California Wonder	104.3 a	12.5	6.25
	Capsicum First 104	95 a	0.28	1.4
	Sweet Pepper	60.3 b	0.72	3.6
	LSD (0.050)	14.16		
	CV (%)	8.19		
Squash	Hybrid Squash	210 a	1.68	8.4
	Squash F1	170 b	1.36	6.8
	Squash F1 Barbuda	166.7 b	1.32	6.6
	LSD (0.050)	O.229		
	CV (%)	10.18		

CHAPTER 5

DISCUSSION

Bangladesh has a unique climate for vegetable production. Vegetables occupy a significant part of the total cultivated land area of Bangladesh (BBS, 2006). Exotic vegetables are those which are introduced to our country from abroad or foreign countries. Many exotic vegetables are recently introduced to our country due to very high demand in the city market. As the vegetables are recently adapted to our country they are highly susceptible to diseases and pest (Ahmed, 1980).

The present investigation had been conducted to screen out of seed borne pathogens and field diseases of some selected exotic vegetables in Bangladesh. Five exotic vegetable viz. broccoli, Chinese cabbage, lettuce, capsicum and squash were considered for this experiment. The experiment was conducted under field condition in Rabi season during the period 15 October 2013 to 15 March 2014. For this study, three varieties of each five exotic vegetables were evaluated against diseases in seed, seed bed and main field. Broccoli (Premium Crop, Imperial Sakata, Green Magic), Chinese cabbage (Bigking, Blues, Summer Emperor), Capsicum (California Wonder, Capsicum First 104, Sweet Pepper), Lettuce (Ky Grand Rapid, Green Wave, Grand Rapid) and Squash (Hybrid Squash, Squash F_1, Squash F_1 Barbuda) varieties were used in this experiment. The seeds were collected from the local market.

Seed health study revealed that, seeds of exotic vegetables had good germination but more or less affected by fungi. *Aspergillus niger*, *Aspergillus flavus*, *Chaetomium* sp. were found associated with broccoli seed. In case of Chinese cabbage, *Aspergillus niger* and *Chaetomium* sp. were observed. In lettuce seed, *Bipolaris* sp., *Chaetomium* sp. and *Curvularia* sp. were found. In case of

capsicum, *Aspergillus niger* and *Chaetomium* sp. were noticed. Moreover, in squash *Chaetomium* sp. was identified. The result supported Gupta and Choudhury (1995). They isolated *Alternaria, Aspergillus, Chaetomium, Colletotrichium, Drechslera, Fusarium, Rhizopus* from exotic vegetable seed.

In this experiment, some seedbed diseases were also examined. The selected exotic vegetables were infected through some seed borne or soil borne diseases such as broccoli infected by Alternaria leaf spot and damping off disease. Chinese cabbage was also affected by Alternaria leaf spot disease. Lettuce crop was suffered by Alternaria leaf spot and damping off diseases in seed bed. However, in capsicum, only mosaic disease and in squash, mosaic and powdery mildew diseases were observed.

From the results it was observed that, all the selected varieties were infected with fungal and viral diseases in the main field. Such as, Alternaria leaf blight (*Alternaria* sp.) in broccoli, Alternaria leaf spot in chinese cabbage and lettuce was observed. Sandhu (1992) stated that, Alternaria blight of cabbage is a serious problem in India. Saha and Singh (1993) supported these findings. They reported that application of balanced fertilizers reduce the incidence of leaf blight disease caused by *Alternaria* spp.

Besides this, Sclerotium foot rot (*Sclerotium rolfsii*) in lettuce, powdery mildew (*Oidium* sp.) in squash, mosaic in capsicum and squash and leaf curl in capsicum were detected. The result supported by Saifullah (2003) and Ali (2003) while they surveyed the prevalence of the viruses infecting cucurbits in the southern and northern district of Bangladesh. Moreover, the symptoms in infected capsicum plant seemed to be identical to mosaic and leaf curl as described by Bos (1969), Suzuki *et al*. (2003) and Smith (1972).

In case of broccoli varieties, the highest incidence and severity of Alternaria leaf spot was found in Premium Crop at different days after transplanting (20 DAT, 40 DAT and 60 DAT). The lowest incidence and severity of alternaria leaf spot was found in Imperial Sakata at different DAT. On the other hand, in Chinese cabbage the highest incidence and severity of alternaria leaf spot was found in Bigking at different days after transplanting (20 DAT, 40 DAT and 60 DAT). However the lowest incidence and severity of alternaria leaf spot was found in Blues at different days after transplanting and also in Summer Emperor at 40 DAT. In lettuce varieties the highest incidence and severity of alternaria leaf spot was found in Green Wave at different days after transplanting (10 DAT, 20 DAT and 30 DAT). However the lowest incidence and severity of Alternaria leaf spot was found in Ky Grand Rapid at different days after transplanting and in Grand Rapid at 30 DAT.

In case of Sclerotium foot rot of lettuce the highest incidence was found in Green Wave at different days after transplanting (10 DAT, 20 DAT and 30 DAT) and the lowest incidence was recorded in Ky Grand Rapid at different DAT and Grand Rapid at 30 DAT. On the other hand, the highest incidence of leaf curl in capsicum was recorded in Sweet Pepper and the lowest incidence was found in Capsicum First 104 at different days after transplanting (40 DAT, 60 DAT and 80 DAT). In case of mosaic of capsicum, the highest incidence was recorded in Capsicum First 104 and the lowest incidence was found in California Wonder at different days after transplanting (40 DAT, 60 DAT and 80 DAT). Moreover, in Squash varieties, the highest incidence and severity of powdery mildew was recorded in Squash F_1 Barbuda and the lowest incidence and severity was found in Hybrid Squash. The highest incidence of mosaic in squash was recorded in Hybrid Squash and the lowest incidence was found in Squash F_1.

The yield of these exotic vegetables varied significantly. Among the broccoli varieties, the highest yield was recorded in Imperial Sakata and the lowest yield

was recorded in Green Magic. In case of Chinese cabbage, the highest yield was recorded in Summer Emperor and the lowest yield was recorded in Blues. On the other hand, in lettuce the highest yield was recorded in Grand Rapid and the lowest yield was recorded in Green Wave. In capsicum varieties, the highest yield was recorded in California Wonder and the lowest yield was recorded in Sweet Pepper. In case of squash, the highest yield was recorded in Hybrid Squash and the lowest yield was found in Squash F_1 Barbuda.

From present study, it has been observed that Premium Crop (broccoli variety), Bigking (chinese cabbage variety) and Green Wave (lettuce variety) were more susceptible to Alternaria leaf spot disease. However, Imperial Sakata (broccoli variety), Blues (Chinese cabbage variety), Ky Grand Rapid (lettuce variety) were comperatively resistant to Alternaria leaf spot disease. On the other hand, Ky Grand Rapid (lettuce variety) was more resistant to *Sclerotium* foot rot disease; where Green Wave (lettuce variety) was more susceptible to *Sclerotium* foot rot disease. Besides this, Sweet Pepper (capsicum variety) was more susceptible to leaf curl and Capsicum First 104 was more resistant to leaf curl disease. In squash variety, Hybrid Squash was more resistant to powdery mildew and Squash F_1 Barbuda was more susceptible to powdery mildew. In this study, it also found that Capsicum First 104 (capsicum variety) and Hybrid Squash (squash variety) were more susceptible to mosaic disease where as California Wonder (capsicum variety) and Squash F_1 (squash variety) were more resistant to mosaic disease.

It was also found that the Green Magic (broccoli variety) and Grand rapid (lettuce variety) were moderately susceptible to Alternaria leaf spot disease where as Summer Emperor (chinese cabbage variety) was moderately resistant to Alternaria leaf spot disease. On the other hand, California Wonder (capsicum variety) was moderately resistant to leaf curl disease and Sweet Pepper (capsicum variety) and Squash F_1 Barbuda (squash variety) were moderately resistant to mosaic but

Squash F_1 (squash variety) was moderately susceptible to powdery mildew disease.

From the present investigation it has been found that the most cultivated exotic vegetables are naturally got infection by alternaria leaf spot, powdery mildew, leaf curl and also by mosaic disease. So, different measures should be taken to control the diseases.

CHAPTER 6

SUMMERY AND CONCLUSION

The experiments were conducted for screening of seed borne pathogens and field diseases of some selected exotic vegetables in Bangladesh. Five common and most popular exotic vegetable were grown in the field of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2013 to March 2014 under natural epiphytic condition with normal horticultural practices. These vegetables are broccoli, chinese cabbage, capsicum, lettuce and squash. Three varieties of each vegetable used in this experiment.

From the present study it has been observed that all the exotic crops were more or less affected by various diseases in seed, seedbed and main field.

Prevalence of seed borne fungi was done by blotter method of seed health testing. In broccoli, the highest (92.75%) seed germination was observed in Green Magic and three types of fungus were identified viz. *Aspergillus flavus, Aspergillus niger* and *Chaetomium* sp. In Chinese cabbage, the highest (92%) seed germination was recorded in Bigking and two fungal genera were observed viz. *Aspergillus niger* and *Chaetomium* sp. In case of lettuce, the highest (91%) seed germination was recorded in Ky Grand Rapid and three fungi were identified viz. *Bipolaris* sp. *Chaetomium* sp. and *Curvularia* sp. In case of capsicum, the highest (91.25%) seed germination was found in Sweet Pepper and two fungal genera viz. *Aspergillus niger, Chaetomium* sp. were found. Moreover, in squash the highest (92%) seed germination was recorded in Squash F_1 and only *Chaetomium* sp. was identified.

In seed bed, Alternaria leaf spot and damping off diseases were noticed in broccoli and lettuce. In broccoli, the highest disease incidence of Alternaria leaf spot and damping off was recorded in Premium Crop and Imperial Sakata varieties, respectively. However, in lettuce, highest disease incidence observed in Ky Grand Rapid variety. Only Alternaria leaf spot disease was recorded in Chinese cabbage in seed bed. However, Mosaic disease was observed in capsicum and squash in seed bed. The highest mosaic incidence of capsicum was found in California Wonder variety and the highest squash mosaic incidence was observed in Hybrid Squash variety. Moreover, powdery mildew disease was observed in squash at seed bed.

In mail field, among the crops, the highest incidence and severity of alternaria leaf spot was found in Premium Crop variety of broccoli, Bigking variety of chinese cabbage and Green wave variety of lettuce. The lowest incidence and severity of alternaria leaf spot was recorded in broccoli (Imperial sakata), chinese cabbage (Blues) and lettuce (Ky Grand Rapid). On the contrary, the highest incidence of mosaic disease was found in capsicum (Capsicum First 104) and squash (Hybrid Squash). However, the lowest incidence of mosaic disease was recorded in capsicum (California Wonder) and squash (Squash F_1). Besides this, the powdery mildew disease also found in Squash and the highest incidence and severity of this disease was recorded in Squash F_1 Barbuda and lowest in Hybrid squash variety. Leaf curl disease also found in capsicum and the highest incidence was recorded in Sweet Pepper and lowest was observed in Capsicum First 104variety. Moreover, foot rot disease was also noticed in lettuce and the highest incidence was recorded in Green Wave variety.

From this investigation, it was revealed that, the various diseases also affect crops yield. The highest yield of broccoli was recorded in Imperial Sakata and the lowest yield was recorded in Green Magic. The highest yield of Chinese cabbage was

recorded in Summer Emperor and the lowest yield was recorded in Blues. The highest yield of lettuce was observed in Grand Rapid and the lowest was found in Green Wave variety. In case of capsicum, the highest yield was recorded in California Wonder and the lowest yield was recorded in Sweet Pepper variety. On the other hand, in squash the highest yield was recorded in Hybrid Squash and the lowest yield was found in Squash F_1 Barbuda variety. It was noted that, each infected crops reduce it fruits or head or curd yield with the increase of disease incidence and severity.

In this experiment, many problems are observed in exotic vegetable cultivation. These are; high input cost, required skilled labour, crops failure due to seed borne disease, total crop failure often occurs when early variety planted at late and due to early infection of diseases. Bangladesh imports seeds of many exotic vegetables, almost all of which are hybrids. Often crops from such seeds totally or partially fail due to disease problems.

Considering the situation of the present investigation, further studies in the following areas may be suggested:

1) Such study is needed in different agro-ecological zones of Bangladesh for observing regional, environmental effects on diseases and yield performance.
2) The use of certified seed should be ensured.
3) Proper seed laws should be enacted and strictly applied.
4) Technical knowledge should be increased for the management of diseases.

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Appendices

Appendix I. Monthly average temperature, relative humidity and total annual rainfall of the experimental site during the period from 15 October 2013 to 15 March 2014

Month	Air temperature (º C)			Average RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
October 13	31.25	21.55	24.40	78.55	28.55
November 13	29.18	18.26	23.72	69.52	0
December 13	25.82	16.04	20.93	70.61	0
January 14	24.22	14.42	19.32	78.50	0
February 14	24.68	17.23	19.56	79.50	0
March 14	26.55	19.00	22.24	77.56	10.15

Appendix II. Composition of PDA medium.

Material	volume
Distilled water	500 ml
Potato	100 g
Dextrose	10 g
Agar	10 g