# FIELD RESPONSE OF KOHLRABI VARIETIES AGAINST MAJOR FUNGAL AND VIRAL DISEASES

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# *CERTIFICATE*

*This is to certify that thesis entitled, "**FIELD RESPONSE OF KOHLRABI VARIETIES AGAINST MAJOR FUNGAL AND VIRAL DISEASES**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M. S.) IN PLANT PATHOLOGY**, embodies the result of a piece of bona fide research work carried out by **REGISTRATION NO. 19-10340** 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 this investigation has duly been acknowledged.*

**Dated:**

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DEDICATED

TO

MY BELOVED PARENTS

&

BEST FRIEND

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The author

# FIELD RESPONSE OF KOHLRABI VARIETIES AGAINST MAJOR FUNGAL AND VIRAL DISEASES


## ABSTRACT

A field experiment was conducted at central farm and plant pathology lab, Sher-e-Bangla Agricultural University, Dhaka-1207 from November 2020 to March 2022 to study the field response of selected kohlrabi varieties against major fungal and viral diseases and identification, isolation of causal organisms of fungal diseases. Five varieties were selected for this experiment viz- Challenger, Goliath, Bankim, OP Hybrid and Early star, which was collected from Siddik bazar, Dhaka. The field experiment was carried out in RCBD (Randomized Complete Block Design) with four replications of each variety in Robi season. During field response, three diseases were observed at field condition, where two fungal and one viral disease identified compared with international literature. They were- Wilt (caused by *Fusarium oxysporum*), Alternaria leaf spot (caused by *Alternaria brassicae*) and Mosaic disease (caused by Turnip Mosaic Virus). Wilt was observed at seedling condition where variety Bankim was the most susceptible (1.25%) and lowest incidence was recorded at OP and Early star variety (0.25%). In case of Alternaria leaf spot, among five varieties Challenger showed maximum infection (87.47%) and minimum was seen in Bankim variety (64.45%). In case of growth and yield character significant variation among all varieties were found. Maximum yield was observed in variety Bankim (9.80 t/ha) and minimum yield was recorded in variety Challenger (7.46 t/ha). Respectively, Yield loss was maximum in variety challenger (45%) and minimum in Bankim (20%). In case of viral disease, TuMV had the most impact on variety challenger (8.32%) and it greatly reduced its average fruit weight resulted as 45.12 gm and lowest disease incidence was observed in variety Bankim (1.09%) and their average fruit weight leads to 119.67 gm. Considering field response against all diseases among all varieties, variety Bankim has minimum percentage of incidence against all diseases as well as it gave highest yield in both fungal and viral infections. So Bankim reflects resistance against all disease response compared to other selected varieties.

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# ACRONYMS AND ABBREVIATIONS

| ACRONYMS | ABBREVIATIONS |
|---|---|
| AEZ | Agro-Ecological Zone |
| BBS | Bangladesh Bureau of Statistics |
| CM | Centimeters |
| CV | Coefficient of Variation |
| DAS | Days After Sowing |
| *et al.*, | And others |
| e. g. | exempli gratia (L), for example |
| etc. | Etcetera |
| FAO | Food and Agricultural Organization |
| i. e. | id est (L), that is |
| Kg | Kilogram (s) |
| LSD | Least Significant Difference |
| M. S. | Master of Science |
| No. | Number |
| SAU | Sher-e-Bangla Agricultural University |
| Var. | Variety |
| $^{o}$C | Degree Celsius |
| Entomology | *Entomol.* |
| International | *Int.* |
| Journal | *J.* |
| ANOVA | Analysis of Variance |
| Agricultural | *Agril.* |
| Biology | *Biol.* |
| Phytopathology | *Phytopathol.* |
| Mycology | *Mycol.* |
| Species | *Spp.* |
| Science | *Sci.* |
| % | Percentage |

# CHAPTER I

## INTRODUCTION

Kohlrabi (*Brassica oleracea* var. gongylodes) is one of the most popular vegetable crops among the cole crops belonging to the family Cruciferae. It has been under practiced by Romans since 600 B.C. (Bose, 2001). Kohlrabi originates from the North-European region. It has been spread all over the world including in South Asian countries (Singh, 2010). Kohlrabi is very widely used in the Northern state of Kashmir in India. It is also used popularly in many districts of Bangladesh. The botanical family to which kohlrabi belongs is the cruciferaceae (Rashid,1999). It is a winter-season crop and is also known as kohlrabi, German turnip, cabbage turnip, Navalkol, GunthGobhi, and Ganthgobhi. The name kohlrabi comes from the German word Kohl means "cabbage" plus Rübe ~ Rabi (Swiss German variant) means "turnip" because the swollen stem resembles the latter. The tuber-like swollen edible portion is a stem known as a knob, which arises from the thickening of stem tissues above the cotyledon. Leaves are attached like swollen structures on this knob. The edible part of kohlrabi is green or violet and generally, rope (Nagar 2016).

An excellent provider of nutrients is kohlrabi. From one cup (135 grams) of raw kohlrabi, consumers get the following benefits: 36 calories, 8 grams of carbs 5 grams of fiber, 2 grams of protein, 93% of the Daily Value (DV) for vitamin C, 12% of the DV for vitamin B6, 10% of the DV for potassium, 6% of the DV for magnesium, 8% of the DV for manganese, and 5% of the DV for folate (healthline.com). The vegetable is a great source of vitamin C, an antioxidant that defends body from free radical damage and aids in the production of collagen, the healing of wounds, the absorption of iron, and immune system function. It also contains a lot of vitamins B6, which is important for the synthesis of red blood cells, protein metabolism, and a healthy immune system. Kohlrabi is very nutritious and offers various health benefits. A variety of antioxidants, including vitamin C, anthocyanins, isothiocyanates, and glucosinolates, are present in kohlrabi. These plant-based chemicals safeguard cells from the disease-causing effects of free radicals. Consuming a lot of antioxidant-rich vegetables like kohlrabi is linked to a lower risk of developing diabetes, metabolic disease, and early mortality. Anthocyanins, a type of flavonoid that gives vegetables and fruit a red, purple, or blue color, are particularly abundant in the skin of purple kohlrabi. A high anthocyanin consumption may reduce the risk of heart disease and improve brain function. The potent antioxidants isothiocyanates and glucosinolates, which are present in high concentrations in all color variants of kohlrabi, are linked to a reduced risk of some malignancies, heart disease, and inflammation (healthline.com).

The average per hectare yield of kohlrabi in Bangladesh is very low as compared to that of other countries (Hoq, 2014). The lower yield potentiality of this crop is responsible for the lower yield attribute. This low yield may be attributed to a great extent to the low production management practices adopted by the farmers (Zhao, 2006). Farmers especially use poor quality seeds, maintenance of lower soil fertility, inadequate irrigation and time of sowing, and proper spacing which are potential for fungal and viral diseases and responsible for the performance of lower kohlrabi production (Sharma, 2002). It is quite easy to grow a successful crop of kohlrabi, as long as varieties suitable to the growing environment and ecology are selected and the proper cultural and pest management practices are followed. Cultivar selection is one of the critical decisions that the industrial grower must make each season (Olaniyi, 2011). Variety selection is a dynamic and sensitive process (Ricardson, 2012). Some varieties may remain favorable for many years while others might be supplanted by newer cultivars after a few seasons against pests and diseases (Greenland, 2002). Furthermore, the cultivar plays a great role in the higher production of the crop. Kohlrabi varieties have been bred to produce good yielding mature heads very early in the season (Cervenski *et al.*, 2011). For farmers growing kohlrabi in both tropical and temperate climates, varieties with a short growing season, or less numb of days to maturity with less susceptible to diseases and are more advantageous for meeting early market demands (Adeniji *et al.*, 2010).

Kohlrabi grows better in temperatures between (4˚C-24˚C) (harvesttotable.com). As the temperature fast to our country so it has become a great chance to cultivate Kohlrabi in a great amount. It requires 45 to 60 days to reach maturity (Mehwald, 1976). It is widely cultivated in Europe, America and Asia and has gained popularity around the world for its health benefits and culinary benefits (healthline.com). In Bangladesh, it has gained popularity as usual. The most common varieties cultivated in our country are Anupom, Express Mollica F-1, Early Mollica F-1, Bumper Harvest F-1, Nimjin F-1, Kranti F-1, and Unique Ball F-1. The light green cultivar is known as Early White Vienna and the purple cultivar is known as Early Purple Vienna. Various fungal and viral diseases are observed Kohlrabi field, and a major is considered in this research. The major three fungal diseases are Alternaria Leaf Spot of Kohlrabi (*Alternaria brassicicola),* Downy Mildew (*Peronospora parasitica),* and Pythium Damping off, and one major viral disease is Turnip Mosaic Virus (transmitted by Aphid) of Kohlrabi. The Alternaria leaf spot in kohlrabi is firstly observed in Egypt in the years 2004-05 (Mohamamedy, 2007). There is a wide scope of increasing kohlrabi production with the introduction of new suitable cultivars.

Alternaria leaf spot (ALS) is a fungal disease affecting in cultivated and wild *Brassica* spp., which impacts crop yield and seed production worldwide (Verma, 1994). The disease can be caused by several fungi in the genus Alternaria, but the most damaging species in the production of vegetable brassicas are *A. brassicae* and *A. brassicicola* (Degenhardt, 1982). Disease development is favored by cool temperatures and long periods of leaf wetness or high relative humidity, and ALS can be a limiting factor in the production of vegetable and seed crops in regions where these conditions are common. Infection can cause a reduction in crop quality and yield through damage to seedlings, leaves, and heads, and can also spread during the storage of vegetable crops like kohlrabi (Cucuzza,1994). The disease is a perennial problem for Bangladeshi growers and is of growing concern due to increasing disease severity and limited control by fungicides (Dixon, 2007).

Turnip Mosaic Virus (TuMV) has the largest host range of any potyvirus among plant genera and families (Walsh and Jenner, 2002). It was estimated to be the second most important virus infecting field-grown vegetables after Cucumber mosaic virus (Tomlinson, 1987). At least 318 species, in more than 43 dicot families, are known to be infected by TuMV as well as various monocot families (Walsh and Jenner, 2002). Conveniently, TuMV can infect *Arabidopsis thaliana*, which is considered the model system for genetic and host-pathogen interaction studies (Dangl, 1993). TuMV is particularly damaging for brassicas in areas of Asia, North America, and Europe (Walsh and Jenner, 2002). This virus also infects and causes damage to several non-brassica crops and ornamentals including lettuce, escarole, pea, endive, courgetti, and rhubarb (Walsh, 1997), making TuMV an important virus economically.

Wilt is a disease or condition, caused by *Fusarium oxysporum* that kill or weaken seeds or seedlings before or after they germinate (Snyder, W.C. and Hansen, H.N. 1940). It is most prevalent in wet and cool conditions. Wilt has a variety of symptoms that reflect the diversity of pathogenic organisms that can cause the illness (wiikipedia.org). But in every population, at least a few seedlings die because of every symptom. When seedlings die, they sometimes do so in roughly circular patches with stem lesions at the ground level. Additionally, the vitality of seedlings may be diminished if their stems develop into "wire-stems," which are thin and tough. Sometimes roots entirely decay or return to being only discolored stumps (wikipedia.org). Several soil and seed-borne fungus, such as *Rhizoctonia solani* and *Aphanomyces cochlioides*, are responsible for damping-off. Oomycetes and various fungi, such as *Pythium*, *Fusarium*, *Phytophthora*, *Botrytis*, *Cylindrocladium*, *Diplodia*, *Phoma*, and *Alternaria*, are also to blame. These pathogens produce wilt or damping off, which has a severe effect on plant species and can result in significant losses to economically significant food crops (vedantu.com).

The objective of this study was: -

- To evaluate the field response of selected kohlrabi varieties against different diseases,
- To determine the incidence of different diseases among varieties in field condition and
- To indicate the existence of significant variation for all traits (Growth and Yield) among different varieties.

# CHAPTER II

# REVIEW OF LITERATURE

Various fungal and viral diseases were observed in the Kohlrabi field, but the majors were considered in this research. The major two fungal diseases are Alternaria Leaf Spot of Kohlrabi (*Alternaria brassicae)* and Wilt disease (*Fusarium oxysporum*), and one major viral disease was Mosaic Virus (Turnip Mosaic virus) of Kohlrabi.

## Origin and Distribution of Kohlrabi

*Brasica oleracea* var. gongylodes L., known as knol-khol or Kohlrabi, is a winter crop that was first cultivated in the Mediterranean coastal nations (Choudhary, 1967).

Since 600 B.C., the Romans have been cultivating Kohlrabi. (Bose, 1986).

The edible stem, which grows totally above ground and has a variety of exquisite flavors and textures (Singh, 1989).

Kohlrabi is widely grown in northern, central Europe and America (Splittstoesser, 1990; Krug, 1991; Liebster,1991).

With a tall, leafy stem and a rounded bulb, kohlrabi is a cool-weather plant. Purple and pale green kohlrabi (PGK) are the two most popular cultivars (PK) (Park,2012).

The bulbous vegetable kohlrabi is accessible throughout the year and may be consumed raw or cooked; the root and leaves are both safe for human consumption because they are high in nutrients and low in calories (Caroling, 2015).

To prevent age-related macular degeneration, brassica vegetables are crucial because they contain large amounts of carotenoids like zeaxanthin and lutein, two essential elements of the macula lutea region of the retina (Thomas, 2015).

Because of its knobby, bulbous stem that resembles a bulb, kohlrabi is a cool-season temperature-sensitive crop. 15 to 25 $^{0}$C is the ideal temperature for its growth (Dhaliwal, 2017).

The Crusader family of plants, which includes the kohlrabi (*Brassica oleracea* var. gongylodes L.), is said to have its origins on the northern side of Europe. It can be cultivated in both the late and early seasons and can survive a wide variety of temperatures (Al-Shammari *et al*., 2020).

**Nutritional value of Kohlrabi**

The kohlrabi's edible portion is the larger stem above the soil's surface, and it has a high nutritional and medicinal value because of its significant concentration of vitamins including Vitamin A, B1, B2, and B5, minerals such Iron, Magnesium, including Zinc, and antioxidants which fight cancer (Bhandari, 2021).

Kohlrabi has secondary metabolites such glucosinolates, anthocyanins, carotenoids, as well as phenylpropanoids that are good for your health, just like other Brassicaceae members do. Particularly in kohlrabi, there are significant levels of carbohydrates, amino acids, organic acids, vitamins, and minerals (Park, 2017).

**Field response against wilt disease**

Fusarium wilt is caused by *Fusarium oxysporum* f. sp. *conglutinans*. Many crucifers (members of the cabbage family) are susceptible to Fusarium wilt (RPD,1988).

Haware *et al*., (1990) examined that the fungus *Fusarium oxysporum* is primarily a soilborne pathogen. However, few reports indicate that it can be transmitted through seeds.

Kubota and Abiko (1999) studied the ailments that affect cabbage seedlings in a vegetable seedling nursery in the Japanese prefecture of Mie. They discovered that seedling damage increased with rising temperatures, and that *Pythium megalacanthum*, which usually causes damping off, is sometimes linked to *Alternaria brassicicola*.

Hwang *et al*. (2001) indicated that Fusarium wilt causes damping-off, seedling blight, root rot, and reduces stand establishment, nitrogen fixation, root distribution, and root vigor.

Mui-Yun, (2003) found that at least 32 nations have reported experiencing fusarium wilt of tomatoes, which is serious in warm-climate countries including the United States, Australia, the United Kingdom, Netherlands, Brazil, Mexico, Nigeria, Morocco, Israel, Iraq, and Vietnam.

Egel and Martyn, (2007) stated that several vascular wilt diseases that affect the Cucurbitaceae plant family are brought on by several formae speciales of the fungus *F. oxysporum*, which are highly homologous but typically host-specific. The most economically significant of them attack cucumber, watermelon, or muskmelon. The most significant economic loss occurs from fusarium wilt of watermelon, one of the earliest Fusarium wilt illnesses ever documented. Every continent except Antarctica has it, and new strains of the disease continue to affect global output in many different regions.

Erskine *et al*., (2009) stated that globally, it is acknowledged that the primary cause of lentil production decline and limitation is fusarium wilt.

Elliot (2009) stated that the leaves of palms are firmly affixed to the crown. Fusarium wilt, a deadly condition that affects some types of palm trees, was first noticed in the United States in 1970 and in Australia in the early 1980s when palm trees at Centennial Park in Sydney started to die. It has also been reported in France, Greece, Italy and Japan.

Gunua (2010) after conducting an experiment fount that sweet potato tubers that an infected with Fusarium wilting have vascular tissues that are discolored and may decay when stored. Cuttings that are polluted are a popular way to infect fields. When in the field, the fungus enters healthy plants through wounds that are still open. Up to 50% of yield losses are possible, and warm temperatures and dry soils increase the likelihood of these events. Normally, plants succumb to disease within a few days of showing obvious symptoms.

Garkoti *et al*., (2013) found the most significant biological barrier to lentil productivity in the globe is fusarium wilt, which significantly reduces seed quality and severely damage leaves, stems, roots, and pods.

**Field response against Alternaria leaf spot disease**

Singh *et al*. (1990) reported that from the time of germination to harvest, as well as during storage and transportation, *Alternaria brassicae* severely damaged cauliflower. Symptoms included leaf spot, leaf blight, curd rot, seedling blight, stump rot, and damping-off.

Singh *et al.* (1990) shared that cauliflower was severely harmed by *Alternaria brassicae* from germination through harvest in the field, as well as during storage and transportation.

Some facts contributing to the rapid progression of *Alternaria* spp. Its short life cycle, and flexibility in terms of climatic situations (Strandberg, 1992). Humpherson-Jones & Phelps, (1989) and Strandberg, (1992) observed that the time between leaf infection and following spore production is usually 7 to 10 days, and spores can be produced from leaf lesions that have existed for several weeks in most *Alternaria* spp.

Cobb and Dillard (1998) observed, In August 1996, *T. arvense*, a cruciferous weed, developed a leaf spot for the first time. *A. brassicicola* was identified from diseased tissues, and pathogenicity was confirmed. They proposed that this weed might be an *A. brassicicola* source in cabbage farms.

Zhang *et al.* (1998) observed the principal pathogen responsible for Chinese cabbage black spot in Heilongjiang, China 1995–1996: *Alternaria brassicae*. They looked examined how 21 Chinese cabbage isolates responded to four hosts and seven different kinds. Despite being the least harmful, *Alternaria brassicae* (ABI) was the dominant type.

Kubota and Abiko (2000) found that in a commercial nursery in Japan from August to October, *Alternaria brassicicola* was the main pathogen affecting damping off on cabbage plug seedlings, especially during a stretch of consecutive rainy days. Additionally, they noted even though *A. brassicicola* caused sooty spot in adult plants, the disease frequently led to hypocotyl rot and caused seedlings to wet off because it develops grey lesions on cotyledons that eventually extend to the hypocotyl or stem.

Azevedo *et al.* (2000) stated that *Xanthomonas campestris* pv. *campestris* and *Alternaria brassicicola*, which cause black rot and Alternaria leaf spot, respectively, affect the production of cabbage, a very economically significant vegetable in the Agreste Region of the state of Pernambuco, Northeastern Brazil. They discovered a significant regional frequency of both illnesses and noted that, in 1997, black rot and Alternaria leaf spot symptoms were present in 100 and 95%, respectively, of the study locations. In 95% of the regions, both disorders were documented in 1998. They also noted that there were significant differences (P=0.05) in the prevalence and severity of black rot and Alternaria leaf spot across planting regions and seasons.

One of the most significant and harmful diseases affecting Kohlrabi and other brassicas in the globe is dark leaf spot, which is brought on by *Alternaria brassicicola* and *Alternaria brassicae* (Meah *et al*.,2002).

Lakshman and Karuna (2006**)** stated that poor seed quality and yield losses in cauliflower (*Brassica oleracea* var. *botrytis* subvar. *cauliflora*) seed yields are brought on by Alternaria blight, which is brought on by *Alternaria brassicae* and *A. brassicicola*.

Khan *et al.* (2010) reported that most common Indian mustard varieties that were inoculated with *Alternaria brassicicola* had necrotic lesions on 15–70% of their leaves, stems, and/or pods. In addition, on leaves, the fungus had the highest recorded number. Seeds were lowest, followed by stem and pods.

Michereff *et al*. (2012) stated that *Alternaria brassicicola* and *A. brassicae* are among the most important pathogens of Brassicaceae causing Alternaria leaf spot disease. They randomly picked 50 leaves showing at least five lesions from each of the ten Chinese cabbage, six cabbage, six cauliflower, and six broccoli farms they visited. They then identified isolated species based on the morphology of the conidia. They discovered that among the two *Alternaria* species, *A. brassicae* was present in every field of Chinese cabbage, whereas *A. brassicicola* was present in every field of broccoli, cauliflower, and cabbage. Additionally, they noted that *A. brassicicola* was more common than *A. brassicae* and that there was very little overlap between the two *Alternaria* species. The findings of this investigation also supported the idea that different species have prefered hosts.

Dharmendra *et al.*, (2014) stated that Alternaria leaf blight also known as Alternaria leaf spot is the most destructive disease of oilseed brassicas species in all the continents. This disease is known to be incited by *Alternaria brassicae*, *Alternaria brassicicola* and *Alternaria raphani* singly or by mixed infection.

Sharma *et al*. (2013) reported that *Alternaria brassicae,* which causes dark leaf spot, is one of the major diseases in crucifers are negatively impacting production quality and yield because to the pathogen's ability to spread through seeds.

**Field response against viral diseases**

Turnip mosaic virus (TuMV) belongs to the genus Potyvirus and was first described in 1921 in the USA in host plant Brassica rapa (Gardner and Kendrick, 1921; Schultz, 1921).

A mosaic disease of Chinese cabbage, turnip, and mustard occasionally caused 30 percent loss near Fukuoka, Japan, according to Takimoto (1930), The virus was transmitted by mechanical inoculation to cauliflower but not to cabbage or radish. Aphids were held responsible for natural transmission of the disease.

Tomlinson (1987) estimated that it to be the second most important virus infecting field-grown vegetables after cucumber mosaic virus.

Conveniently, Dangl (1993) revealed that TuMV can infect *Arabidopsis thaliana*, which is considered the model system for genetic and host-pathogen interaction studies.

Yoon *et al.*, (1993) examined that in some regions of Asia, Europe, and North America, TuMV is particularly harmful to brassicas. According to experts, TuMV is the most significant virus affecting brassicas in several Asian countries.

Shukla *et al.*, (1994) showed that the infection can also lead to severe stunting of young plants and an important reduction in yield. Malformations of leaf, stem, and fruit can also be observed as well as fruit drop and necrosis of different tissues.

Walsh (1997) noted that this virus also infects and causes damage to several non-brassica crops and ornamentals including lettuce, escarole, pea, endive, courgette, and rhubarb, making TuMV an important virus economically.

In 2002, Walsh and Jenner observed that TuMV has the largest host range of any potyvirus among plant genera and families. Walsh and Jenner experienced in 2002, At least 318 species, in more than 43 dicot families, are known to be infected by TuMV as well as various monocot families.

Walsh and Jenner (2002) showed that TuMV is particularly damaging for brassicas in areas of Asia, North America, and Europe.

Walsh and Jenner (2002) found that TuMV is transmitted to plant cells through the style of aphids in a non-persistent manner during aphid probing or feeding. The viral infection results in various symptoms depending on the plant such as mosaic, mottling, chlorotic rings, or color break on stems, foliage, flowers, and fruits.

Sánchez *et al.* (2003) stated that Turnip mosaic virus, also known as TuMV, is a rare phytovirus that has primarily adapted to the plant Arabidopsis thaliana. Due to its ability to infect the widest host range of any other viruses in the genus Potyvirus, infecting 318 species in 156 genera of 43 plant families, both dicots and monocots, this model Potyvirus, TuMV, is regarded as an economic pathogen internationally.

**Varietal reaction against Alternaria leaf spot disease**

Brassica crops (as Kohlrabi, cabbage, cauliflower, broccoli, turnip etc) contain many cultivars which are distributed around the world. Varietal resistance is one of the most important factors that reduce infection, reduce control cost and give fungicide free crop.

Pandey *et al*. (2014) noted that Hazipur 4, Deep Mallika, Suryamukhi, Kathmandu Local, and Aghani1 were found to be disease-resistant after 47 cauliflower cultivars were artificially screened for resistance to alternaria leaf blight caused by (*A. brassicae*). They continued by stating that based on the quantity, size, and progression of the disease, the cultivars Indian Express, Kunwari 4, and Kunwari 7 were recognised as slow-blighting cultivars.

Sharma *et al*. (2002) in light of the significant crop losses brought on by *Alternaria brassicae*, it is vital to produce leaf spot resistant mustard varieties.

They tested 38 species of *Brassica*, including cultivated and wild allies, from nine genera for two years in an epiphytic environment and discovered that only eight species (*Brassica desnottesii*, *Camelina sativa, Coincya pseuderucastrum, Diplotaxis berthautii, D. catholica, D. cretacea, D. erucoides*, and *Erucastrum gallicum*) were completely resistant, Since no resistance exists in the cultivated species, these eight resistant wild species could be utilised as donor parents to introduce resistance to the leaf spot disease in Indian mustard.

Khan *et al*. (2010) found that *Alternaria brassicicola* and *A. brassicae* were found to be present on the Indian mustard cultivars Mahyco Bold, Rohini, Alankar, Swarna, Varuna, Pusa Karishma, Pusa Bold, BS-2, Kalamoti, and Kranti. All cultivars are susceptible to *A. brassicicola*, they continued, as inoculation with the fungus caused a significant decline in yield across the board, with the Pusa Karishma cultivar showing the greatest yield loss (50%) followed by Kalamoti (46%) and Kranti (14%) when compared to the uninoculated control.

# CHAPTER III

# MATERIALS AND METHODS

In this study field response of five selected Kohlrabi varieties were considered and evaluated against major fungal and viral diseases under filed condition. Later, identification and isolation were done in lab. Materials used in this study and methods which are being followed are included in this chapter.

## 3.1. Experimental Site

The study was carried out at Sher-e-Bangla Agricultural University's (SAU) Central Farm at Sher-e-Bangla Nagar, Dhaka, 1207. The research site was 8.24 meters above the sea level and was located at 230 46' N latitude and 900 22' E longitude at the elevation of 8.6 m above the sea level (Appendix I).

## 3.2. Experimental Period

The field experiment was conducted in Rabi season (Mid November to Mid-February) 2020-2021.

## 3.3. Soil Characteristics

The experiment was conducted on a medium-high parcel of land in the Modhupur tract, which is in Agro Ecological Zone (AEZ) 28. The soil had a pH of 6.7 and had the silty loam, non-calcareous, dark grey texture of the Tejgaon soil series (Appendix II).

## 3.4. Climatic condition

The experimental site was under the sub-tropical winter climatic condition, which is characterized by cold winter during Rabi season (October-March). There was no rainfall during the month of December, January, and February. The average maximum temperature during the period of investigation was $19^0$C and the average minimum temperature was $10.5^0$ C. Details of the metrological data in respect of temperature, rainfall, and relative humidity the period of experiment were collected from Bangladesh Metrological Department, Agargaon, Dhaka (Appendix III).

### 3.5. Experiment

For achieving the objectives of the research, the experiment was conducted in field.

### 3.6. Details of Experiment

#### 3.6.1. Experimental period

The experiment was conducted during the period of November to March, 2020-2021in field.

#### 3.6.2. Planting materials

Five different kinds of Kohlrabi varieties were used for conducting this experiment. All seeds were collected from local seed market named Siddik bazar, Dhaka. They were:

| **Variety name** | **Amount of seed** |
|---|---|
| Challenger seed (V1) | 5gm |
| Goliath Variety (V2) | 5gm |
| Bankim seed (V3) | 5gm |
| OP Hybrid Variety (V4) | 5gm |
| Early Star Variety (V5) | 5gm |

**Figure 1: Variety of Kohlrabi used in this experiment**

### 3.6.3. Design and layout of the Experiment

The experiment was laid out following Randomized Complete Block Design (RCBD) with four replications. The layout of the experiment was prepared for distributing the variety combinations in each plot in each block. There were 20 units plot in the experiment. The total area was 210 $m^2$. The size of the plot was 2.4 m ×2.8 m. The distance between two blocks and two plots were 0.5 m and 0.5 m, respectively. 24 plants were incommoded in each lot.

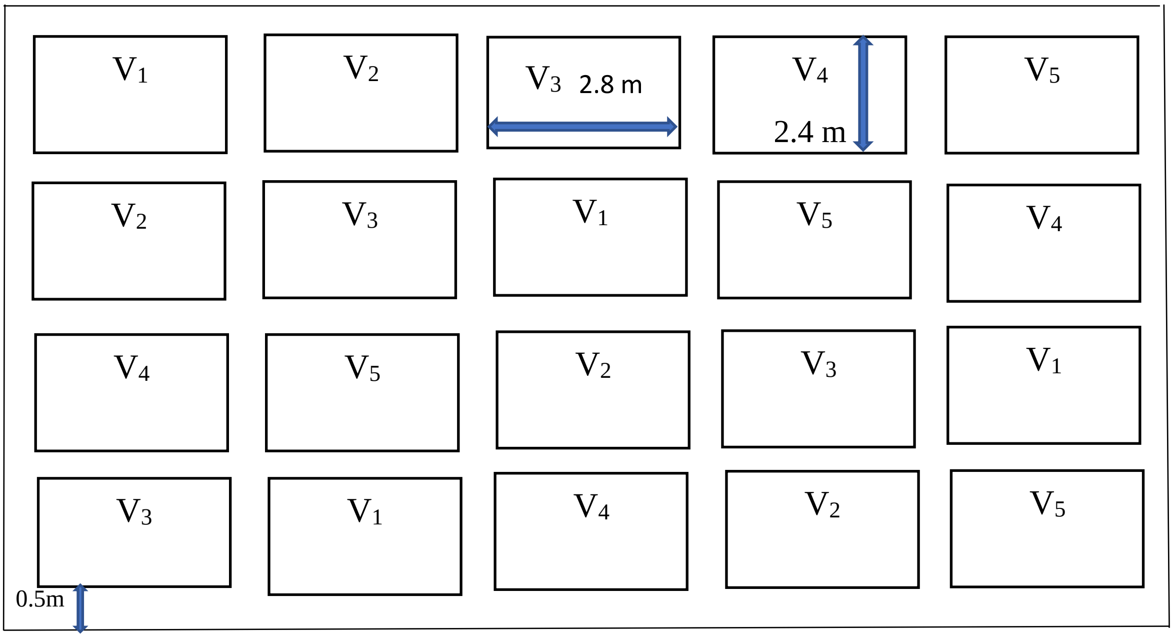



**Figure 2. Layout of the experimental plot**

Legend:

| | |
|---|---|
| 1. Width of the plot = 2.4 m | |
| 2. length of the plot = 2.8 m | |
| 3. Space around the land = 50 cm | 0.5 m |
| 4. Space between the block =50 cm | 0.5 m |
| 5. Space between the plot =50 cm | 0.5 m |

### 3.6.4. Land Preparation

The experiment's chosen plot was prepared by disc plough on November 28, 2020. Before the next ploughing, it was left in the sun for 7 days. After that, the soil was cross ploughed to achieve good tilth. To create a good tilth, deep ploughing was done to increase this crop production. Each ploughing was followed by laddering to break up the soil clods into smaller pieces. The experimental ground was cleared of all weeds and brambles.

### 3.6.5. Application of manure and fertilizer

The sources of fertilizer —triple superphosphate (TSP), muriate of potash (MOP), and boron—were applied at corresponding dosages of 3 kg, 3.6 kg, 1.8 kg, and 200 gm. On the last day of land preparation, the full volumes of TSP and MOP were applied respectively. When finishing off the field preparation, 200 kg of well-rotten cow manure was also used. After a month of the final land preparation urea (3 kg) was applied. Using a spade, each individual unit plot was levelled after fully integrating the fertilizers into the soil.

### 3.6.6. Seed bed preparation and seed sowing

Seed bed was prepared on 16 November 2020 by incorporating 250 gm of TSP and 250 gm of MOP. A good amount of cow dung (2 Kg) was also added in the seed bed.

Seeds were sown in the seed bed on 18 November 2020. Length of the seed bed was 1.5 meter and width were 1 meter. As well as in seed bed proper watering was also done for proper germination of the seeds and overall seedling health and growth.

### 3.6.7. Transplanting

The seedlings were always kept under careful observation. Twenty days old seedlings were transplanted in the main field on 08 December 2020. Each pit contained one seedling.

### 3.6.8. Gap Filling

Gap filling was done whenever it was necessary.

### 3.6.9. Intercultural operation

Necessary intercultural operations were done throughout the growing season for proper growth and development of the experimental plants. As earthing up and weeding was done to the experimental field.

**A** **B**


**Plate 1: Experimental plot: A. Overview of whole experimental plot; B. Weed free plot**

#### 3.6.9.1. Irrigation

Required irrigation was given in the experimental field several times after transplanting of the plants

#### 3.6.9.2. Weeding

Weeding was done two times in the experimental plot. First weeding was done after one month of transplanting and second one was followed by another with 20 days interval.

### 3.6.9.3. Tagging

Five plants of each plot were tagged according to variety and disease symptoms. Tagging was done in three categories as 5 plants for wilting, 5 plants for Alternaria leaf spot and 5 plants for TuMV from 24 plants in each plot.

### 3.6.10. Disease Observation

Three diseases were recorded at field condition. Each disease was identified by their typical symptom shown at field condition. Fungal diseases were identified by observing their typical symptoms at field and preparing slide from infected plant and pure culture.

**1.Identification of Wilt disease**

**Visual Symptoms**

Yellowing of older leaves, wilting of seedlings, damping off leaves and dark spot-on stem.

**A** **B** **C**

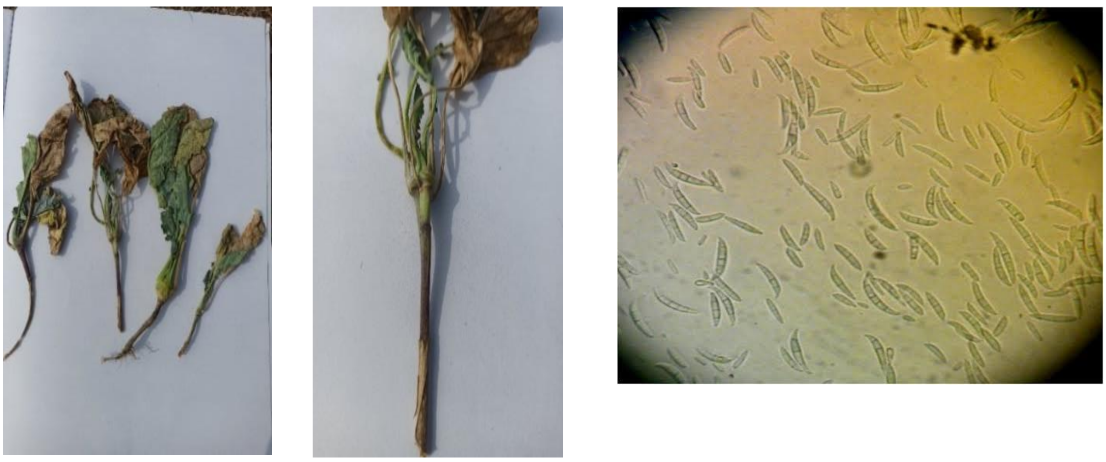


**Plate 2. Wilt disease of Kholrabi : A. Wilt symptom on seedling; B.Close view of wilted seedling; C. Conidia of *Fusarium oxysporum* under compund microscope (10X)**

## 2.Identification of Alternaria leaf spot disease

### Visual Symptoms

Appearance of leaf symptoms include round, brown spots with concentric rings.Spots often have a yellow halo, and can crack through the middle. Spots often occur first on older leaves. As the disease spreads, leaves can develop enough spots that they begin to meld together to create large necrotic areas on leaves(ag.umass.edu).

**A** **B**

**C** **D**

**Plate 3: Alternaria leaf spot of kohlrabi (in field): A. Whole experiment plot (showing Alternaria leaf spot disease); B. Symptoms on leaf of Kohlrabi; C. Conidia of *Alternaria brassicae* under compound microscope (10X); D. Pure culture of Alternaria leaf spot of *Alternaria brassicae***

**3.Identification of TuMV disease**

Viral disease was identified by observing their typical symptoms at field Zitter (1996).

**Visual symptoms**

Chlorotic local lesions, mosaic on leaves.

**Figure 3: Kohlrabi plant showing Turnip Mosaic Virus (TuMV) symptoms on leaf**

### 3.6.11. Harvesting

The crop was 1st harvested at early maturity on 11 February,2021. The second and final harvesting was done on 01 March,2021. Total yield was calculated in Kg.

### 3.6.12. Crop sampling and data collection

During the growing period, the plots of Kohlrabi were inspected regularly to record the occurrence of several diseases and to measure different parameter. Data was collected on three diseases as- two fungal disease, viz: Alternaria leaf spot, wilt and one viral disease Turnip Mosaic. Dead plants were removed from the field after counting. Number of infected leaves, number of leaf spots was obtained from randomly selected five plants and marked with sample sticks and following data were recorded.

- No of healthy plants
- No of infected plants
- No of infected leaves per plant
- No of spots per plant (Alternaria leaf spot disease)
- No of plants died (Wilt disease)
- Modified stem diameter (cm) (For Alternaria leaf spot & Viral disease)
- Modified stem length (cm) (For Alternaria leaf spot & Viral disease)
- Modified stem weight (gm) (For Alternaria leaf spot & Viral disease)
- Yield (t/ha)

**3.6.12.1. Number of healthy plants**

Number of healthy plants from each plot was recorded at 40, 45, 50, 55, 60, 65, 70 and 75 days after transplanting (DAT).

**3.6.12.2. Number of infected plants**

Number of Infected plants was counted by visual observation and data were recorded from each plot at 35, 45, 55 and 65 days after transplanting (DAT).

**3.6.12.3. Number of infected leaves per plants**

Infected leaf number was measured from five randomly selected plants at 30, 40, 50, 60 and 70 days after transplanting (DAT). The data was recorded calculating the average number of infected leaves.

**3.6.12.4. Number of spots per leaf (For Alternaria leaf spot disease)**

Number of leaf spot per leaf was counted from five randomly selected plants at 40, 50, 60 and 70 days after transplanting (DAT). The data was recorded calculating the average number of infected leaves.

**3.6.12.5. Number of plants died (Wilt disease)**

Number of plants died of wilting was counted by visual observation and data were recorded from each plot at 30, 40 and 50 days after transplanting (DAT).

### 3.6.12.6. Modified stem diameter (cm) (Infected with Alternaria leaf spot)

Modified stems harvested from selected plants of each plot were measured. 10 stems were taken from each plot and their mean diameter was taken as the granted value for that plot. Diameter was calculated in the unit of centimeter.

### 3.6.12.7. Modified stem length (cm) (Infected with Alternaria leaf spot)

Modified stems harvested from selected plants of each plot were measured. 10 stems were taken from each plot and their mean length was taken as the granted value for that plot. Length was calculated in the unit of centimeter.

### 3.6.12.8. Modified stem weight (gm) (Infected with Alternaria leaf spot)

Modified stems harvested from selected plants of each plot were measured. 10 stems were taken from each plot and their mean weight was taken as the granted value for that plot. Weight was calculated in the unit of gram.

### 3.6.12.9. Modified stem diameter (cm) (Infected with Turnip Mosaic Virus)

Modified stems harvested from virus infected plants of each infected plot were measured. Stems were taken from each infected plot and their mean diameter was taken as the granted value for that plot. Diameter was calculated in the unit of centimeter.

### 3.6.12.10. Modified stem length (cm) (Infected with Turnip Mosaic Virus)

Modified stems harvested from virus infected plants of each infected plot were measured. Stems were taken from each infected plot and their mean length was taken as the granted value for that plot. Length was calculated in the unit of centimeter.

### 3.6.12.11. Modified stem weight (gm) (Infected with Turnip Mosaic Virus)

Modified stems harvested from virus infected plants of each infected plot were measured. Stems were taken from each infected plot and their mean weight was taken as the granted value for that plot. Weight was calculated in the unit of gram.

### 3.6.12.12. Yield from Alternaria infected plant (t/ha)

A yield was recorded from all Alternaria infected plants by calculating each fruit weight. Average yield was recorded by dividing Total yield by no of Alternaria infected plants.

### 3.6.12.13. Yield from Virus infected plant (t/ha)

A yield was recorded from all TuMV Virus infected plants by calculating each fruit weight. Average yield was recorded by dividing Total yield by no of virus infected plants.

### 3.6.12.14. Total yield per plot (Kg)

Total yield of Kohlrabi per plot was recorded by adding the yield of different harvesting time and it was included weight of fruits at different harvesting time and was expressed in kilogram.

### 3.6.12.15. Yield per hectare

Yield/hectare was computed by converted total yield per plot into yield per hectare and was expressed in ton. It included weight of fruits at final harvesting time from 80 days after transplanting (DAT) and continued.

### 3.6.13. Assessment of disease incidence

The experimental plots were examined at 10 days interval for the appearance of fungal symptoms. The incidence of Alternaria leaf spot was recorded five times. The first counting was made at 35 DAT and the following counting was made at 10 days interval. The Alternaria leaf spot were identified by visual observation as dark brown spots on Kohlrabi leaves coalesced to form larger concentric rings that develops into a dark brownish concentric ring; eventually the entire leaf could turn brown. Disease incidence data were calculated following formulae (Nutter et al., 2006; Agrios, 2005; Kranz, 1988; James, 1974; Large, 1966):

$$\text{Disease incidence (\%)} = \frac{\text{Numbers of infected plants / leaf}}{\text{Numbers of inspected plants / leaf}} \times 100$$

### 3.6.14. Assessment of disease severity

Alternaria Leaf Spot severity was recorded at 35, 45, 55, 65 and 75 DAT. For scoring the severity (0-4 scale) of the disease, ten infected plants were selected randomly from each replicate plot. Five leaves were selected from each selected plant for scoring the disease severity data. The per cent disease index (PDI) was calculated by using the formula given by Townsend and Heuberger (1943). Disease severity was determined by calculating the PDI as follows:

$$\text{Percent Disease Index (PDI):} \frac{\text{Sum of total ratting} \times 100}{\text{Total number of observations} \times \text{Highest grade in the scale}}$$

Percent disease intensity (severity) was calculated as per 0 to 4 disease scale developed by Bhattiprolu (2018).

**Table 1: Alternaria leaf spot disease rating scale**

| Rating scale (RS) | Per cent leaf area covered (%) | Disease reaction |
|---|---|---|
| 0 | 0 | Immune (I) |
| 1 | 0-10 | Resistant (R) |
| 2 | 11-20 | Moderately resistant (MR) |
| 3 | 21-40 | Moderately susceptible (MS) |
| 4 | More than 40 | Susceptible (S) |

**RS-0**

**RS-1**

**RS-2**

**RS-3**

**RS-4**

**Plate 4: Alternaria Disease Rating Scale (RS): Grade 0 = 0%; Grade 1= 0-10%; Grade 2=11-20%; Grade 3 = 21-40%; Grade 4 = >40%; RS= Rating Scale**

### 3.7 Laboratory experiment

The experiment was conducted at the Plant Pathology Laboratory of the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka from March 2022 to May 2022.

### 3.7.1 Collection of leaf samples

Kohlrabi leaves having typical leaf spot symptoms were collected from 5 different varieties namely Challenger seed, Goliath variety, Bankim seed, OP Variety, Early star Variety. A brown paper envelope was filled with the diseased leaves which had been removed from the plants that had been cultivated in the field. The brown paper envelopes from each collection were then brought to the laboratory at the Sher-e Bangla Agricultural University in Dhaka for isolation.

### 3.7.2. Preparation of culture medium and culture plates

For these experiments, Potato Dextrose Agar (PDA) was used. The dehydrated PDA was rehydrated with distilled water at a rate of 39 gL-1 in a conical flask (250 ml), and it was then autoclaved at $121^0$C under 15 pressure for 30 minutes. After being autoclaved, the media was allowed to cool for a little while then 25–30 drops of lactic acid were added before being put into sterile petri plates. This culture media was then used for pathogen isolation and pure culture preparation.

**Figure 4: Preparation of cultural media**

### 3.7.3 Isolation and identification of the pathogens

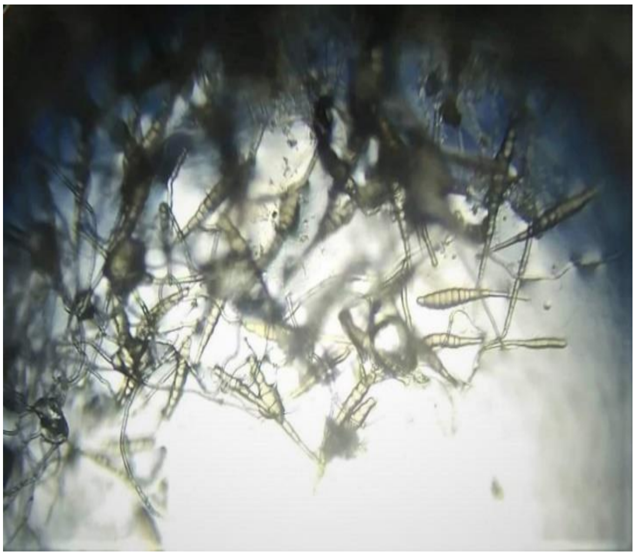
The pathogen was isolated by tissue planting method (Hasan, 2008). Using ethanol at a 70% concentration, the working clean bench's surface was sterilized. The infected Kohlrabi leaf sample was then brought to a clean bench, cut into little pieces (0.5-1.5 cm), sterilized in 10% ethanol solution for 1 minute, removed with the use of sterile forceps, and washed with sterile distilled water. This washing process was done three times.

Following ISTA guidelines, the cut pieces were washed, placed on sterile blotter paper (Whatman No. 1) on Petri plates, as well as onto the PDA plates, and then incubated at $25^0$C under near ultraviolet light (ISTA, 1996). The fungal culture was examined five to seven days after incubation to identify the target pathogen using a stereoscope (Model: Motic, SMZ-168) and compound microscope (Model: Omano, OMTM-85).

A B

**Plate 5: Isolation and identification of *Fusarium oxysporum*: 1. Close view of *Fusarium oxysporum* conidia under compund microscope (10X); 2. Isolation of *Fusarium oxysporum* on culture media**

C D



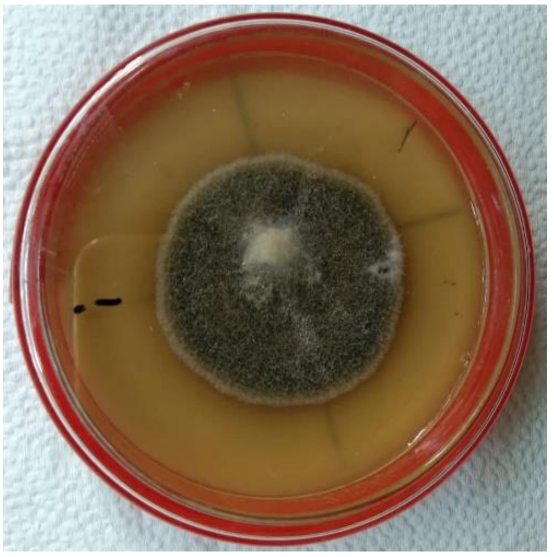


**Plate 6: Isolation and identification of *Alternaria brassicae*: A. *Alternaria brassicae* conidia under compound microscope (10X); B. Isolation of *Alternaria brassicae* on culture media**

# CHAPTER IV

# RESULTS

During field evaluation three diseases were found in field condition. Among them two were fungal diseases viz- Wilt disease (caused by *Fusarium oxysporum*) and Alternaria leaf spot disease (caused by *Alternaria brassicae),* and viral disease was identified viz- Mosaic disease (caused by Turnip Mosaic Virus, TuMV). Findings from all of these diseases are describe below under specific headings.

## 4.1 Field response of kohlrabi varieties against wilt disease of different DAT

The findings of Wilt disease caused by *Fusarium oxysporum* of the present study was revealed non-significant effect on varieties of Kohlrabi at different DAT. The data was recorded at 30 ,40 and 50 DAT. The results of wilt disease incidence (%) are presented in table 2.

At 30 DAT, variety Bankim was recorded numerically the highest (1.25%) wilt disease incidence and the lowest was found in Challenger (0.25%).

At 40 DAT, numerically maximum (1.75%) disease incidence was found in Goliath and minimum (0.05%) was found in both Challenger and OP variety, respectively.

At 50 DAT, results also showed non-significant effects. Variety Bankim had maximum (2.00%) wilting and Challenger had minimum (0.5%) wilt.

Table 2: Disease incidence (%) of different varieties against wilt disease at different DAT

| Variety | % Wilt Disease Incidence | | |
|---|---|---|---|
| | 30 DAT | 40 DAT | 50 DAT |
| Challenger | 0.25 | 0.50 | 0.50 |
| Goliath | 1.00 | 1.75 | 1.75 |
| Bankim | 1.25 | 2.00 | 2.00 |
| OP (Hybrid) | 0.25 | 0.50 | 0.50 |
| Early star | 1.00 | 1.50 | 1.50 |
| Significance Level | NS | NS | NS |
| P value | 0.32 | 0.43 | 0.43 |
| CV (%) | 13.43 | 12.76 | 12.76 |

NS = Not Significant

From this above Table 2 it was showed that variety Challenger and OP (Hybrid variety) showed best performance against wilt disease compared to other varieties.

### 4.2. Field response of kohlrabi varieties against Alternaria leaf spot disease caused by *Alternaria brassicae*

There was significant variation found in disease incidence (%) and Percent disease index among five varieties of Kohlrabi against Alternaria leaf spot disease caused by *Alternaria beassicae.* The result of Disease incidence and PDI is showed in table 3.

#### 4.2.1 Alternaria leaf spot incidence (%)

Disease incidence (%) was recorded at 35, 45, 55 and 65 DAT. The findings of the present study revealed significant effect of Alternaria leaf spot on varieties of Kohlrabi at 35, 45, 55 and 65 DAT at 5% level of probability.

At 35 and 45 DAT, variety Bankim was recorded the highest (2.08%) incidence whereas no disease (0.00 %) was found in rest varieties such as Challenger, Goliath, OP and Early star at 35 DAT. At 45 DAT, disease incidence ranges from 4.16 % to 13.52 %. Maximum (13.52 %) disease incidence was found in Bankim variety which was statistically similar with OP Variety (10.39 %) and Early star variety (8.33 %), respectively and minimum (4.16 %) was found in both Goliath and Challenger variety.

At 55 and 65 DAT, disease incidence ranges from 32.30 % to 42.68 %. Variety Challenger revealed maximum (42.68 %) disease incidence and minimum (32.30%) was recorded in variety Early star at 55 DAT. At 65 DAT, disease incidence ranges from 68.75% to 87.47 %. Variety Challenger repeatedly showed maximum (87.47 %) incidence and minimum (68.75 %) was recorded in variety Bankim.

Table 3: Effect of different varieties on Disease Incidence by Alternaria leaf spot at different DAT

| Variety | Disease incidence (%) | | | |
|---|---|---|---|---|
| | 35 DAT | 45 DAT | 55 DAT | 65 DAT |
| Challenger | 0.00 b | 4.16 b | 42.68 a | 87.47 a |
| Goliath | 0.00 b | 4.16 b | 34.38 bc | 74.97 bc |
| Bankim | 2.08 a | 13.52 a | 37.50 b | 68.75 c |
| OP | 0.00 b | 10.39 ab | 40.58 ab | 78.10 a-c |
| Early star | 0.00 b | 8.33 ab | 32.30 c | 81.25 ab |
| Significance Level | * | * | * | * |
| P value | 0.050 | 0.042 | 0.034 | 0.022 |
| CV (%) | 7.79 | 7.38 | 24.95 | 11.46 |

* Significant at 5 level of probability

### 4.2.2 Percent disease index (PDI) of Alternaria leaf spot

Percent disease index (%) was recorded at 35, 45, 55 and 65 DAT. The findings of the present study revealed significant variation effect of Alternaria leaf spot on varieties of Kohlrabi at 35, 45, 55 and 65 DAT. Results showed significant variations at 5% and 1% level of probability, the results of Alternaria leaf spot percent disease index (%) are presented in table 4.

At 35 DAT, percent disease index ranges from 26.66 to 28.71. There was no significance variation on verities of Kohlrabi. Variety Challenger was recorded maximum (28.71) percent disease index and minimum (26.66) was recorded in Bankim.

At 45 DAT, percent disease index ranges from 42.22 to 55.30. The highest (55.30) percent disease index was found in Challenger which was statistically differ with other varieties. On the other hand, the lowest PDI (42.22) was found in Early star which was statistically similar with Bankim (42.75), OP (42.75) and Goliath (44.25), respectively.

At 55 DAT, percent disease index ranges from 45.92 to 62.77. Results also showed significant effects. Variety Challenger showed maximum (62.77) percent disease index which was statistically similar with Early Star (54.72), whereas minimum (45.90) was recorded in variety OP which was statistically similar with Goliath (50.70), Bankim (51.42) and Early star (54.72), respectively.

Similar trend also found at 65 and 75 DAT, percent disease index ranges from 52.42 to 71.37 from 65 DAT. For 75 DAT, percent disease index ranges from 64.45 to 77.97. Here Challenger showed the highest percent disease index at 65 DAT (71.37) and at 75 DAT (77.97), respectively which was statistically similar with Early star at both DAT. Besides, minimum (52.42) and (64.45) PDI was found in case of Bankim variety at 65 and 75 DAT, respectively. Rest varieties showed minimum result which was statistically similar with Bankim at both 65 and 75 DAT.

Table 4: Effect of different varieties on percent disease index by Alternaria leaf spot at different DAT

| Variety | Percent disease index | | | | |
| --- | --- | --- | --- | --- | --- |
| | 35 DAT | 45 DAT | 55 DAT | 65 DAT | 75 DAT |
| Challenger | 28.71 | 55.30 a | 62.77 a | 71.37 a | 77.97 a |
| Goliath | 28.00 | 44.25 b | 50.70 b | 53.65 b | 66.10 b |
| Bankim | 26.66 | 42.75 b | 51.42 b | 52.42 b | 64.45 b |
| OP | 28.18 | 42.75 b | 45.92 b | 64.25 ab | 75.25 ab |
| Early star | 27.73 | 42.22 b | 54.72 ab | 66.12 ab | 77.82 a |
| Significance Level | NS | ** | * | * | * |
| P value | 0.900 | 0.001 | 0.010 | 0.040 | 0.040 |
| CV (%) | 10.14 | 11.93 | 15.45 | 18.15 | 12.22 |

* Significant at 5 level of probability, ** Significant at 1 level of probability and NS = Not Significant

**4.2.2.1 Comparison between % Disease incidence and Percent disease index of different Kohlrabi varieties against Alternaria leaf spot disease at 65 DAT**

Comparison between disease incidence and percent disease index of different kohlrabi varieties against Alternaria leaf spot at 65 DAT are showed in figure 5. In both cases variety Challenger showed highest infection compared to other varieties whereas variety Bankim showed lowest infection. Next to challenger variety Early star and OP Hybrid shower much disease incidence and disease severity compared to variety Goliath.

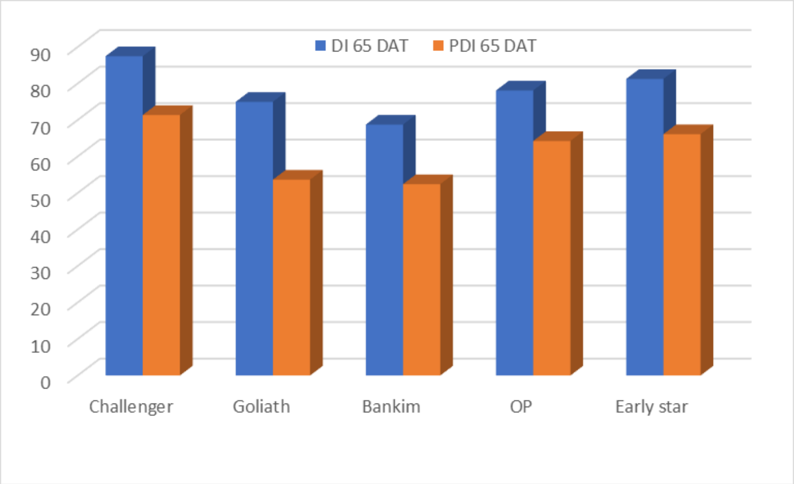



Figure 5: Comparison between Disease Incidence and Percent Disease Index of different Kohlrabi varieties against Alternaria leaf spot at 65 DAT

### 4.2.3 Effect of different Kohlrabi Varieties against Alternaria leaf spot

Performance of five Kohlrabi varieties were evaluated against Alternaria leaf spot disease, showed significant variation in case of different parameters as no of infected leaves per plant and no of spot per leaf. The results are showed in Table 5.

#### 4.2.3.1 Number of infected leaves per plant

Number of infected leaves per plant was recorded at 45, 55, 65 and 75 DAT. The findings (No of infected leaves per plant) of the present study revealed significant effect on varieties of kohlrabi at 55, 65 and 75 DAT while 45 DAT showed non-significance value. Results showed significant variations at 5% and 1% level of probability, are presented in table 5.

At 45 and 55 DAT, variety Goliath was recorded numerically maximum (1.28) no. of infected leaves and minimum (0.93) was recorded in variety Bankim in 45 DAT. Besides, at 55 DAT, results showed maximum (3.08) no. of infected leaves was found in Challenger which is statistically different with other varieties and minimum (2.05) was found in Goliath which is statistically similar with other varieties named as Early star (2.53), OP (2.30) and Bankim (2.70), respectively.

At 65 and 75 DAT, also showed the highest infected leaves per plant in Challenger (5.05) which was statistically similar with Early star (4.30) and Bankim (4.25), respectively. On the other hand, the lowest (3.65) was recorded in variety Goliath which was statistically similar with other rest varieties except Challenger in 65 DAT. At later stage 75 DAT, results also showed significant effects. Variety Challenger recorded maximum (7.05) no. of infected leaves per plant which was statistically similar with Early star (6.20) and OP (6.00) followed by Goliath (5.80). Bankim (5.00), respectively whereas minimum was recorded.

### 4.2.4 Number of spots per leaf

Number of spots per leaf was recorded at 35, 45, 55, 65, and 75 DAT. The findings of the present study revealed significant effect of varieties on no. of spot per leaf at 35, 45, 55, 65, and 75 DAT. Results showed significant variations at 1% level of probability, the results of Alternaria spots per leaf are presents in table 5.

At 35 DAT, variety Challenger was recorded maximum (4.52) no. of spot per leaf which was statistically similar with Bankim (3.25) and minimum (2.62) was recorded in variety Early star which was statistically similar with Goliath (2.67), OP (2.85) and Bankim (3.25), respectively.

Besides, at 45 and 55 DAT, maximum (13.3) and (26.72) no. of spot per leaf was found in Challenger, respectively which was statistically different with other varieties. However, minimum no of spot per leaf was (6.75) in Early star and (12.67) in OP was found at 45 and 55 DAT respectively, which was statistically similar with all varieties except Challenger.

At 65 DAT highest spot per leaf was found in Bankim (38.15) which was statistically similar with Challenger (38.08) and Early star (36.55), respectively. On the other hand, the lowest spot per leaf was found in (26.65) in OP Variety which was statistically similar with Goliath (30.30).

At 75 DAT highest OP Variety (41.95) no of spot per leaf was observed which was statistically similar with Challenger (40.95) and Early Star (38.42), respectively. Besides the lowest no of spot per leaf was observed in Bankim (30.22) which was statistically similar with Goliath (33.17)

Table 5: Effect of different varieties on number of infected leaves per plant and number of spots per leaf in case of Alternaria leaf spot at different DAT

| Variety | No. of infected leaves | | | | No. of spot per leaf | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 45 DAT | 55 DAT | 65 DAT | 75 DAT | 35 DAT | 45 DAT | 55 DAT | 65 DAT | 75 DAT |
| Challenger | 1.23 | 3.08 a | 5.05 a | 7.05 a | 4.52 a | 13.30 a | 26.72 a | 38.08 a | 40.95 ab |
| Goliath | 1.28 | 2.05 b | 3.65 b | 5.80 b | 2.67 b | 6.90 b | 13.55 b | 30.30 bc | 33.17 bc |
| Bankim | 0.93 | 2.70 b | 4.25 ab | 5.0 c | 3.25 ab | 8.42 b | 16.37 b | 38.15 a | 30.22 c |
| OP | 0.95 | 2.30 b | 3.90 b | 6.0 ab | 2.85 b | 7.00 b | 12.67 b | 26.65 c | 41.95 a |
| Early star | 1.18 | 2.53 b | 4.30 ab | 6.2 ab | 2.62 b | 6.75 b | 14.97 b | 36.55 ab | 38.42 ab |
| Significance Level | NS | * | ** | * | ** | ** | ** | ** | ** |
| P value | 0.260 | 0.030 | 0.004 | 0.040 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 |
| CV (%) | 15.30 | 10.52 | 14.74 | 16.57 | 18.68 | 14.57 | 12.93 | 16.80 | 15.39 |

* Significant at 5 level of probability,

** Significant at 1 level of probability and NS = Not Significant

### 4.2.5 Mean Yield performance of Kohlrabi varieties against Alternaria Leaf Spot

Performance of five Kohlrabi varieties were evaluated against Alternaria leaf spot disease, showed significant variation in case of different parameters as Modified stem diameter (cm), modified stem length (cm), modified stem weight (cm), yield (t/ha). Their harvested yield was calculated in ton/h. Yield loss is calculated by comparing with expected yield. The results of mean yield performance are showed in table 6.

#### 4.2.5.1 Modified stem diameter (cm)

In the case of diameter (cm), there were significance effect on five Kohlrabi varieties due to Alternaria leaf spot disease. Variety Bankim showed maximum modified stem diameter (33.95 cm) while Goliath (32.93 cm) were also statistically similar variety followed by Early star (29.33 cm) and Challenger (29.03 cm), respectively. Minimum was found in OP (26.88 cm) which is similar with Early star (30.32cm).

#### 4.2.5.2 Modified stem length (cm)

In case of length (cm), there were significance effect on five Kohlrabi varieties due to Alternaria leaf spot disease. Variety Bankim showed maximum stem length (14.98 cm) which is statistically similar with Goliath (14.40 cm) followed by OP (13.75 cm). On the other hand, minimum result was recorded at Challenger (12.05 cm) which is statistically similar with Early star (12.40 cm).

#### 4.2.5.3 Modified stem weight (gm)

In case of weight (gm), there were significance effect among five Kohlrabi varieties due to Alternaria leaf spot disease. Maximum modified stem weight (430.43 gm) was found in Goliath which was statistically similar with Bankim (428.90 gm) followed by OP (369.58 gm) and Early star (346.98 gm), respectively. Both were statistically similar. Challenger showed minimum (326.280 gm) weight which was statistically similar with Early star 9346.98 gm) and OP (369.58 gm).

#### 4.2.5.4. Yield (t/ha)

There was significance effect among five Kohlrabi varieties due to Alternaria leaf spot disease. Maximum yield (9.84 ton/ha) was showed in Goliath which was statistically similar with Bankim (9.80) followed by OP (8.45 ton/ha) and Early star (7.93ton/ha), respectively. Among all variety Challenger showed minimum (7.46 ton/ha) yield.

Table 6: Effect of modified stem performance on Alternaria Leaf Spot infected plant of kohlrabi

| Variety | Modified stem diameter (cm) | Modified stem length (cm) | Average modified stem weight (gm) | Yield (t/ha) |
|---|---|---|---|---|
| Challenger | 29.03b | 12.05 c | 326.28 c | 7.46c |
| Goliath | 32.93a | 14.40 a | 430.43 a | 9.84a |
| Bankim | 33.95a | 14.98 a | 428.90 a | 9.80a |
| OP | 26.88c | 13.75 bc | 369.58 bc | 8.45b |
| Early star | 29.33b | 12.40 c | 346.98 bc | 7.93bc |
| Significance Level | * | * | * | ** |
| P value | 0.020 | 0.018 | 0.012 | <0.01 |
| CV (%) | 6.47 | 11.18 | 14.90 | 9.45 |

* Significant at 5 level of probability, ** Significant at 1 level of probability and NS = Not Significant

### 4.2.6. Effect of yield performance against Alternaria Leaf Spot disease of Kohlrabi varieties

To find out the loss due to disease, yield loss was calculated by comparing between expected yield and harvested yield. Their value is being showed in table 7 and figure 8.

The highest yield loss was found in variety OP Variety (3.55 t/ha) which was statistically similar with Challenger (3.36 t/ha). Besides lowest yield loss was found in variety Bankim (1.96 ton/ha) preceded by variety Goliath (2.16 ton/ha). In case of % yield loss maximum 45% yield loss was found in variety Challenger and minimum 20% was found in variety Bankim.

Table 7: Effect of yield performance on Alternaria Leaf Spot infected plant of Kohlrabi

| Varieties | Expected yield (t/ha) | Harvested yield (t/ha) | Yield loss (t/ha) | % Yield loss |
|---|---|---|---|---|
| Challenger | 10.81b | 7.46 c | 3.36 a | 45a |
| Goliath | 12.00 a | 9.84 a | 2.16 c | 22c |
| Bankim | 11.76 a | 9.80 a | 1.96 c | 20c |
| OP | 12.00 a | 8.45 b | 3.55 a | 42a |
| Early star | 11.02 ab | 7.93 bc | 3.09 b | 39ab |
| Significance Level | * | ** | ** | * |
| P value | 0.03 | <0.01 | <0.01 | 0.04 |
| CV (%) | 14.12 | 9.45 | 13.22 | 18.25 |

* Significant at 5 level of probability, ** Significant at 1 level of probability and NS = Not Significant

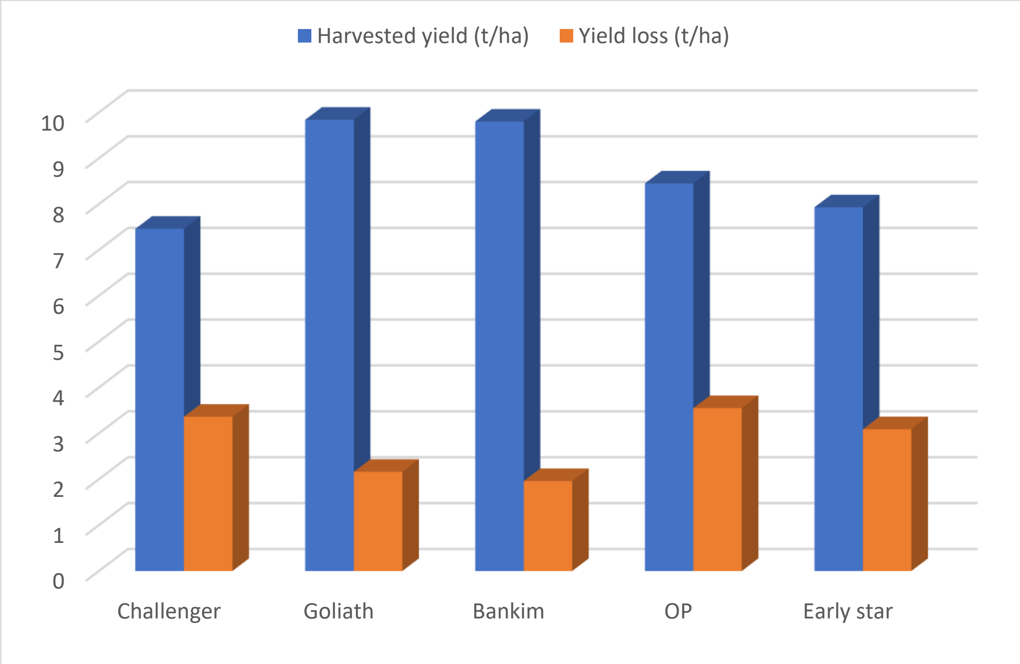



Figure 6. Comparison between Harvested yield (t/ha) and Yield loss (t/ha) due to Alternaria leaf spot of Kohlrabi

### 4.3 Field response of kohlrabi varieties against Turnip Mosaic Virus (TuMV) Disease

Turnip Mosaic Virus usually known as TuMV symptom was recorded at field condition. During field response, the disease incidence and yield performance was recorded at different DAT.

#### 4.3.1 Disease incidence (%) of TuMV

TuMV incidence (%) was recorded at 40, 50 and 60 DAT. The findings of the present study revealed significant effect on varieties of Kohlrabi at 5% level of probability. Finding’s data are given in Table 8.

At 40 DAT, variety Challenger was recorded the highest (3.12%) incidence followed by Early star (0.92%) and OP (0.90%) whereas, Bankim (0.20%) and Goliath (0.30%) varieties showed minimum incidence, respectively.

In case of 50 DAT, maximum (5.20 %) TuMV incidence was found in Challenger which is statistically similar with Early star (3.12 %) and minimum (0.45%) was found in Bankim which was statistically similar with Goliath (1.05 %).

At 60 DAT, results showed significant variation among varieties. Variety Challenger showed maximum (8.32%) TuMV incidence followed by Early star (4.15%), and (3.10 %) in OP Variety, respectively. On the other hand, Bankim showed minimum TuMV incidence (1.09%) which was statistically similar with Goliath (1.12 %).

Table 8: Effect of % Disease Incidence of turnip mosaic virus on different varieties of Kohlrabi at different DAT

| Variety | Disease incidence (%) | | |
|---|---|---|---|
| | 40 DAT | 50 DAT | 60 DAT |
| Challenger | 3.12 a | 5.20 a | 8.32 a |
| Goliath | 0.30 c | 1.05 bc | 1.12 c |
| Bankim | 0.20 c | 0.45 c | 1.09 c |
| OP | 0.90 b | 2.05 b | 3.10 b |
| Early star | 0.92 b | 3.12 ab | 4.15 b |
| Significance Level | ** | ** | ** |
| P value | <0.01 | <0.01 | <0.01 |
| CV (%) | 17.54 | 15.36 | 13.78 |

* Significant at 5 level of probability, ** Significant at 1 level of probability and NS = Not Significant

### 4.3.2 Modified stem performance of infected kohlrabi plant by turnip mosaic virus

TuMV infected modified stems were analyzed, and their diameter and length were calculated in cm. Their weight is calculated in gm. These valued are shown in table 9.

#### 4.3.2.1 Modified stem diameter (cm)

In the case of modified stem diameter (cm), there were significance effect on five Kohlrabi varieties due to TuMV disease. Variety Bankim showed maximum diameter (13.52 cm) which was statistically similar with variety Goliath (13.15 cm) followed by OP (8.2 cm). While Challenger (5.8 cm) showed minimum result.

#### 4.3.2.2 Modified stem length (cm)

In case of modified stem length (cm), there were significance effect on five Kohlrabi varieties due to TuMV disease. Variety Bankim showed maximum length (6.75 cm) which was statistically similar with Goliath (6.52 cm) followed by OP (3.34 cm) and Early star (3.17cm). On the other hand, minimum result was recorded at Challenger (2.75 cm).

#### 4.3.2.3 Modified stem weight (gm)

In case of modified stem weight (gm), there were significance effect among five Kohlrabi varieties due to TuMV disease. Maximum weight (119.67 gm) was found in Bankim which was statistically similar with Goliath (110.72 gm) followed by OP (65.23 gm) and Early star (58.85 gm), respectively. Both were statistically similar. Challenger showed minimum (45.15 gm) stem weight which was statistically similar with Early star (58.85 gm) and OP (65.23 gm).

Table 9: Effect of modified stem performance in the case of turnip mosaic virus on kohlrabi plant

| Variety | Modified stem diameter (cm) | Modified stem length (cm) | Modified stem weight (gm) |
|---|---|---|---|
| Challenger | 5.80 c | 2.75 c | 45.12 b |
| Goliath | 13.15 a | 6.52 a | 110.72 a |
| Bankim | 13.52 a | 6.75 a | 119.67 a |
| OP | 8.20 b | 3.34 b | 65.23 b |
| Early star | 6.70 bc | 3.17 b | 58.85 b |
| Significance Level | * | * | * |
| P value | 0.03 | 0.01 | 0.04 |
| CV (%) | 17.06 | 11.33 | 15.88 |

* Significant at 5 level of probability, ** Significant at 1 level of probability and NS = Not Significant

## DISCUSSION

The Cruciferae family of Cole crops incorporates the kohlrabi (*Brassica oleracea* var. gongylodes), one of the most widely grown vegetable crops. Since 600 B.C., the Romans have been practicing it and it is native to north Europe. Kohlrabi contains several antioxidants, namely as vitamin C, anthocyanins, isothiocyanates, and glucosinolates. These organic compounds from plants shield cells from the harmful consequences of free radicals. A lower risk of acquiring diabetes, metabolic disease, and early mortality is associated with consuming many antioxidant-rich vegetables like kohlrabi. Kohlrabi is susceptible of various kinds of diseases but among some are major as Alternaria leaf spot, wilting disease, Turnip mosaic virus etc. The present experiment was undertaken to evaluate the response of selected kohlrabi varieties against different disease and to determine the disease incidence of different diseases among varieties in field condition. Also determined the existence of significant variation for all traits (Yield) among different varieties.

During evaluation, three diseases were identified in field. Among them two fungal diseases viz- Wilt caused by *Fusarium oxysporum*, Alternaria leaf spot caused by *Alternaria brassicae* and one viral disease caused by *Turnip mosaic virus*. Fungal and viral diseases were identified according to symptoms shown.

### Wilt disease

In case of wilt disease, disease incidence (%) of wilting was calculated at 30 ,40 and 50 DAT. Field evaluation showed significant variation. Variety Bankim showed highest infection 1.25% highest disease incidence. On the other hand, two variety challenger and OP (Hybrid variety) showed lowest disease incidence (0.25%). Pathogen identified for wilt disease was *Fusarium oxysporum,* which was later isolated and identified. Similar work was done by Dubey *et al*. (2010). They surveyed chickpea at different states of India and found Fusarium wilt incidence of chickpea varied from 14.5 to 20.2 %, also said that it is prevalent in almost all chickpea growing areas of the world. Disease incidence was equal to stand loss (%) because the infected plants did not recover, and diseased plants died and bring no use for the community for any purpose.

**Alternaria leaf spot disease**

One of the most devastated diseases for Kohlrabi is Alternaria leaf spot. The major disease observed during conducting this experiment was Alternaria leaf spot. Among five selected kohlrabi varieties, they showed different level of disease incidence at 35, 45, 55 and 65 DAT. At 35 DAT, variety Bankim showed maximum disease incidence 2.08 %, where there was 0.00% incidence at rest four varieties. At 45 DAT, variety Bankim revealed maximum disease incidence 13.52% and minimum 4.16% was recorded at both variety Challenger and Goliath. At 55 DAT, variety challenger reflected the highest disease incidence of 42.68% where the lowest was observed 32.30% in variety Early star. At 65 DAT, Variety Challenger revealed maximum (87.47 %) incidence and minimum disease incidence was recorded (68.75 %) in variety Bankim. In case of disease incidence variety challenger reputedly showed maximum disease incidence in all DAT but growing with days Bankim showed the lowest disease incidence among five varieties. Similar work was also done by Azevedo *et al.*, 2000; they worked on cabbage and revealed that although cabbage is a very economically important vegetable in Northeast of Brazil, but its production is impaired by the occurrence of diseases, Alternaria leaf spot caused respectively by *Alternaria brassicicola*. They found high prevalence of diseases and observed the symptoms of Alternaria leaf spot was in 95% of the studied areas, in 1997. They added that the data for incidence and severity of Alternaria leaf spot varied significantly (P=0.05) among planting areas inside seasons. Kubota and Abiko (2000) carried out a resembling experiment and found that although *A. brassicicola* caused sooty spot in adult plants, the pathogen often gave rise to hypocotyl rot and cause wilt as it causes grey lesions on cotyledons which later spread to the hypocotyl or shoot, the seedlings then damped-off.

Percent disease index (PDI), among five selected kohlrabi varieties PDI was recorded at 35, 45, 55 and 65 DAT and results showed different with a significant value. At 35 DAT, there was no significance variation on verities of Kohlrabi, but variety Challenger was recorded maximum (28.71) percent disease index and minimum (26.66) was recorded in variety Bankim. At 45 and 55 DAT, variety challenger shower highest disease severity respectively 55.30% and 62.77%, where variety early star showed minimum PDI 42.22% at 45 DAT and OP Hybrid variety showed 45.92% at 55 DAT. At 65 and 75 DAT variety challenger repeatedly showed maximum disease severity with a value of 71.37% and 77.97% respectively, whereas variety Bankim showed minimum disease severity 52.42% and 64.45%, respectively. Recorded value of PDI was significant for all 45,55,65 and 75 DAT. An experiment conducted by Singh *et al*., 2018 during Rabi season 2012-13 and findings recorded that maximum percent incidence (34.78) and minimum yield (196.2 kg/100m$^2$) and maximum yield loss (34.6%) in Udaipur district.

Effect of different kohlrabi varieties was calculated at different parameters as no of infected leaves and no of spot per leaf for Alternaria leaf spot. Data was recorded at 45, 55, 65 and 75 DAT. At 45 DAT, variety Goliath showed 1.28 which contains maximum number of infected leaves and variety Bankim showed 0.93 which is minimum among all counted at field condition. At 55 and 65 DAT, variety challenger recorded the highest no of infected leaves of 3.08 and 5.05 respectively and variety Goliath presented minimum no of infected leaves 2.05 and 3.65 respectively. At the later stage,75 DAT, still variety challenger showed maximum number of infected leaves with 7.05 and variety Bankim showed minimum 5 infected leaves. Calculated data was significant at 55, 65 and 75 DAT. Considering number of spots per leaf, data was recorded at 35, 45, 55, 65 and 75 DAT. AT 35 and 45 DAT, variety challenger showed 4.52 and 13.30 which indicated maximum number of spots per leaf and minimum was recorded 2.62 and 6.75 in variety Early star, respectively. At 55 and 65 DAT, variety OP Hybrid reflects the lowest no of leaf spots 12.67 and 26.65, respectively and variety challenger showed the highest 26.72 leaf spot at 55 DAT while Bankim showed the highest 38.15 at 65 DAT. Later, at 75 DAT, variety OP Hybrid showed maximum no of spots with 41.95% and minimum was showed in variety Bankim 32.22%. Similar study conducted by Marraiki *et al*., 2012; Czajka *et al.*, 2015; Aslam *et al*., 2019 reported that symptoms manifested on spinach start as small and circular spots with concentric rings at first which later became irregular lesions appearing on the upper surface of the lower and middle leaves. These circular spots appear as dark black colored along the margins which encircle the necrotic region. With the spread of the disease, these necrotic spots turn to appear as blight. Each spot was surrounded by a chlorotic halo and as the disease progressed, lesions enlarged; covering the entire leaf surface (Aslam *et al*., 2019; Gilardi *et al*., 2019). Other effects on the plant include extensive defoliation, reduced photosynthetic leaf area, loss of plant vigor, loss of reproductive capacity and loss of seed or plant death (Humaira, 2015).

Yield performance was calculated by considering fruit weight (gm), diameter (cm), and length (cm). Maximum average yield of fruit was obtained in variety Goliath (430.43 gm) and yield recorded as 9.84 ton/ha. Variety Bankim showed a quite similar performance in yield with 9.80 ton/ha. Minimum fruit weight was observed 326.28 gm in variety challenger which leads 7.46 ton/ha. Yield performance is significant in all parameters. The highest percentage of yield loss was recorded 45% in variety challenger and lowest was found 20% in variety Bankim and very closely second lowest 22% was recorded in variety Goliath. A similar experiment conducted by Sharma *et al*. (2013), reported that Dark leaf spot caused by *Alternaria brassicae* is one of the important diseases in crucifers causing serious yield and quality loss in production. Singh *et al*., 2018 surveyed to carry out during Rabi season 2012-13 and recorded minimum yield (196.2 kg/100m$^2$) and maximum yield loss (34.6%) in Udaipur district. An experiment carried out by Dharmendra *et al*., (2014) reported that Alternaria leaf spot pathogens (*Alternaria brassicae, Alternaria brassicicola* and *Alternaria raphani*) affecting oilseed brassicas species, are necrotrophs and produces lesions surrounded by chlorotic areas on leaves, stems and siliquae causing reduction in the photosynthetic areas, defoliation, and early induction of senescence. They added that, Alternaria blight causes considerable reduction in quantity and quality of harvested brassica products. A similar work carried out by Tamayo *et al*. (2001) on cauliflower revealed that *Alternaria brassicae* was identified as the causal agent of cauliflower head rot causing losses of about 30%, in Colombia. An experiment was done on Brussels sprout by Kohl *et al*. (2011) recorded that *Alternaria brassicicola* and *A. brassicae* can infect leaves of Brussels sprouts resulting in dark leaf spot and yield losses.

**Turnip mosaic virus (TuMV) disease**

In case of Turnip mosaic virus (TuMV) disease, among five selected varieties TuMV showed a different disease incidence with a significant result. Data was recorded at 40,50 and 60 DAT. At 40 and 50 DAT, Variety Challenger showed maximum viral disease incidence of 3.12% and 5.20 % respectively, where variety Bankim showed minimum viral disease incidence with 0.20% and 0.45%, respectively. Later, 60 DAT, still variety challenger recorded maximum disease incidence of 8.32% and minimum was recorded in variety Bankim with 1.09% of disease incidence. Similar experiment carried out by Gram, (1925) found a mosaic disease of turnip in eight localities in Denmark in 1921. Plants susceptible to natural infection included swedes or rutabaga (*Brassica campestris* L. var. napo-brassica DC), radish, and charlock (*Sinapsis arvensis* L.). In a brief report given by Thatcher, (1927), showed that mustard, rutabaga, flat turnip, and Chinese cabbage are very susceptible to mosaic whereas Rape was less susceptible.

Yield performance is calculated by considering fruit diameter, length, and weight. Among five selected kohlrabi varieties variety Bankim showed maximum average fruit weight of 119.67 gm and minimum fruit weight is recorded in variety challenger 45.12 gm. Maximum fruit diameter and fruit length was found in variety Bankim as 13.52 cm and 6.75 cm, respectively. On the other hand, minimum fruit diameter and fruit length was found in variety Challenger as 5.80 cm and 2.75 cm. A similar experiment conducted by Takimoto, (1930) revealed that mosaic disease of Chinese cabbage, turnip, and mustard occasionally caused 30 percent loss near Fukuoka, Japan. The virus was transmitted by mechanical inoculation to cauliflower but not to cabbage or radish. Aphids were held responsible for natural transmission of the disease.

According to Pape, (1935) surveyed, losses caused by turnip mosaic in Germany, may vary from 1 to 90 percent. Some varieties of turnip were found to be much more susceptible to infection than others.

# CHAPTER V

# SUMMARY AND CONCLUSION

Kohlrabi (*Brassica oleracea* var. gongylodes), a biennial vegetable, a low, stout cultivar of wild cabbage. Its unique name is derived from the German word for cabbage (kohl) and turnip (rabi). The kohlrabi originates from the northeast of Europe. Its consumption has stayed mainly in this area, while in others it is hardly known. Typically planted as a cool-season annual, kohlrabi is a biennial plant. From the enlarged stem, waxy lobed or wavy leaves with long petioles emerge (leaf stems). The slender fruits are referred to as siliques, and if the plant is allowed to reach maturity, it will produce clusters of tiny yellow flowers with four petals. The vegetable is a terrific source of vitamin C, an antioxidant which aids the body to fight off free radicals and is important for wound healing, collagen production, iron absorption, and immunological function. Additionally, it's an excellent source of vitamin B6, which promotes the creation of red blood cells, protein metabolism, and a healthy immune system. Additionally, potassium, an electrolyte and mineral crucial to fluid balance and heart function, is a good source of it. Additionally, 1 cup (135 grams) of kohlrabi delivers 17% of your daily fiber requirements. Dietary fiber supports the regulation of blood sugar and intestinal health. The present experiment carried out to study the evaluate the response of selected kohlrabi varieties against different diseases. The main objective of this study is to determine the disease incidence of different diseases among varieties in field condition and also to indicate the existence of significant variation for all traits (Yield) among different varieties.

The experiment was carried in Central Farm and Plant Pathology Lab, Sher-e-Bangla Agricultural University. The experiment was conducted using RCBD (Randomized Complete Block Design). A total of five different Kohlrabi varieties viz- Challenger, Goliath, Bankim, OP (Hybrid) and Early star were selected for this experiment and each variety had four replications. The entire experimental plot was divided into 20 plots.

Three major diseases on Kohlrabi were recorded while conducting field evaluation. They were wilt disease caused by *Fusarium oxysporum*, Alternaria leaf spot caused by *Alternaria brassicae* and Mosaic caused by Turnip Mosaic virus.

In case of Wilt disease, Variety Bankim showed highest infection 1.25% which is called highest disease incidence. On the other hand, both two variety challenger and OP (Hybrid variety) showed lowest disease incidence was (0.25%).

In case of Alternaria leaf spot disease, among five selected kohlrabi varieties, variety challenger reputedly showed maximum disease incidence (87.47%) and Bankim showed the lowest disease incidence (68.75%). Percent disease index (PDI) showed significant value where variety challenger repeatedly showed maximum disease severity with a value of (77.97%) and variety Bankim showed minimum disease severity of (64.45%).

In case of growth parameters, infected leaves per plant, variety challenger showed maximum number 7.05 and variety Bankim showed minimum 5 infected leaves. Considering number of spots per leaf, variety OP Hybrid showed maximum no of spots with (41.95) per leaf where minimum was showed in variety Bankim (32.22) spots per leaf.

Yield performance was significant among all varieties. Maximum average yield was obtained in two variety Goliath recorded average fruit weight (430.43 gm) which leads a yield of 9.84 ton/ha and variety Bankim recorded average fruit weight (428.90 gm) yield with 9.80 ton/ha. Minimum fruit weight was observed 326.28 gm in variety challenger which leads 7.46 ton/ha.

The highest percentage of yield loss was recorded 45% in variety challenger as they contained maximum percentage of infection and lowest was found 20% in variety Bankim.

The viral disease examined in this experiment was Mosaic disease caused by TuMV. Among five selected varieties, TuMV showed a a significant result.

Variety challenger recorded maximum disease incidence (8.32%) and minimum was recorded in variety Bankim with (1.09%).

Among five selected kohlrabi varieties, variety Bankim showed maximum average fruit weight (119.67 gm) and minimum fruit weight is recorded in variety challenger (45.12 gm).

Considering all the facts we can conclude at a point that

- Field response was observed with three diseases at field condition where two fungal diseases and one viral disease had been identified from five selected kohlrabi varieties.
- Disease incidence (%) has recorded for all three diseases. In case of Wilt highest DI was observed in variety Bankim (1.25%) and lowest found in Challenger and OP Hybrid (0.25%). In Alternaria leaf spot, maximum disease incidence was obtained in Challenger (87.47%) and minimum was obtained in Bankim (68.75%). In Mosaic disease, variety challenger showed maximum incidence (8.32%) and Bankim recorded minimum disease incidence (1.09%).
- Among selected five kohlrabi varieties significant result was found regarding all Yield traits. Variety Bankim recorded highest yield for all diseases and variety Challenger recorded the minimum yield.

# RECOMMENDATIONS

- Among five varieties disease incidence was minimum in variety Bankim and it leads highest yield, whereas variety challenger recorded maximum disease incidence and lowest yield.
- During this experiment only five varieties were used to evaluate three diseases in filed condition in only one AEZ. So further research needs to be done in additional AEZ considering other varieties.
- Also consider other diseases of kohlrabi at field condition.

# CHAPTER VI

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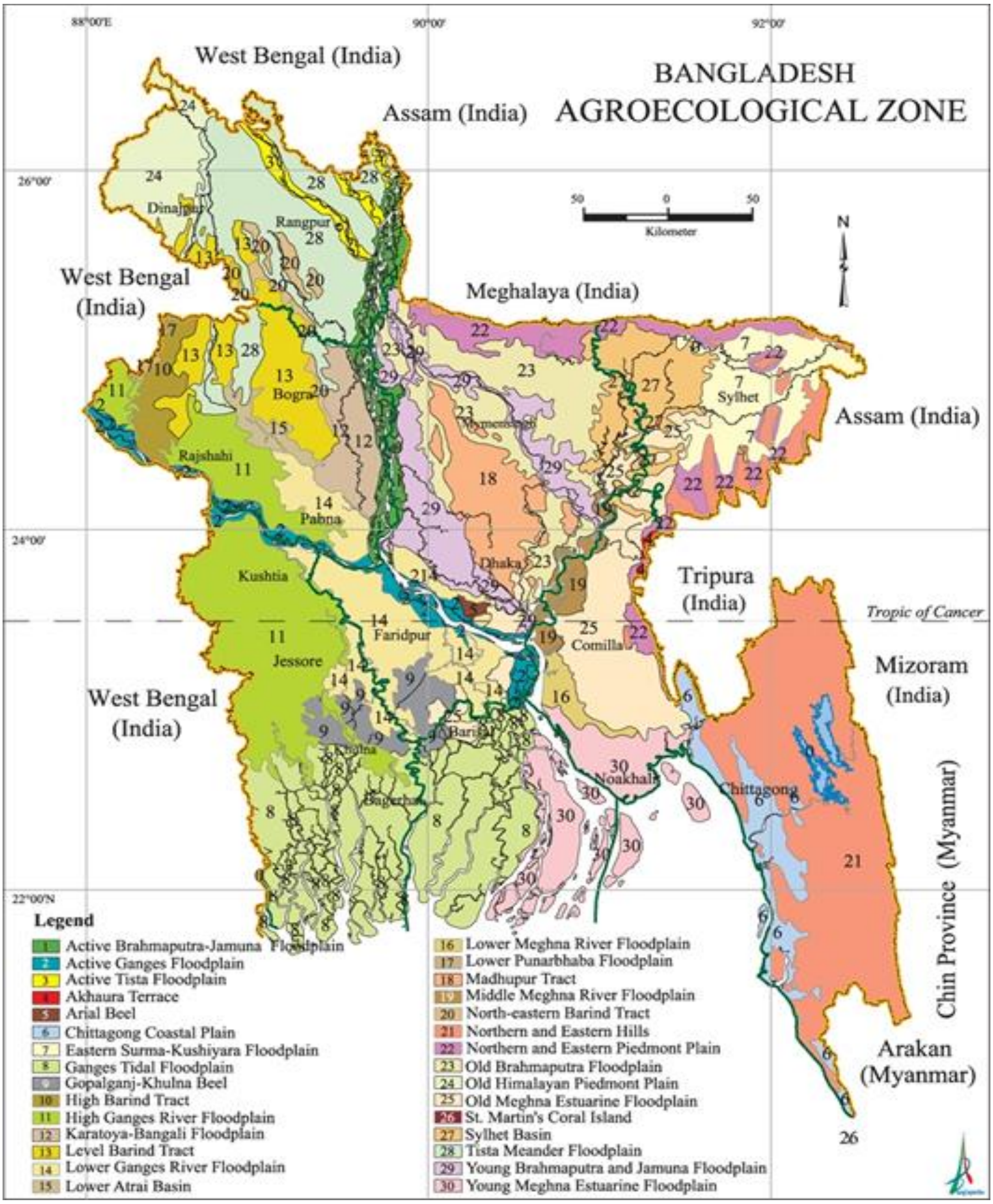
## APPENDICES

## Appendix I: Map showing the experimental site



**Appendix II: Soil characteristics of experimental farm of Sher-e-Bangla Agricultural University are analyzed by soil Resources Development Institute (SRDI) Farmgate, Dhaka.**

**A. Characteristics of the experimental field**

| **Morphological features** | **Characteristics** |
|---|---|
| Location | Farm, SAU, Dhaka |
| AEZ | Modhupur tract (28) |
| General soil type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |
| Drainage | Well drained |
| Cropping pattern | **N/A** |

**B. Physical and chemical properties of the initial soil**

| **B. Physical and chemical properties of the initial soil Characteristics** | **Value** |
|---|---|
| Practical size analysis | |
| Sand (%) | 16 |
| Silt (%) | 56 |
| Clay (%) | 28 |
| Silt + Clay (%) | 84 |
| Textural class | Silty clay loam |
| pH | 5.56 |
| Organic matter (%) | 1.00 |
| Total N (%) | 0.06 |
| Available P (µgm/gm soil) | 42.64 |
| Available K (me/100g soil) | 0.13 |

Source: SRDI

**Appendix III. Monthly average relative humidity, average temperature (ºC) and rainfall (mm) of the experimental period (November 2020 to March 2021).**

| Month | Average RH (%) | Average Temperature (ºC) | Rainfall (mm) |
|---|---|---|---|
| November | 79 | 27 | 32 |
| December | 73 | 24 | 15 |
| January | 65 | 20 | 8 |
| February | 69 | 21 | 30 |

**Source: Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka-1207.**