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**A study of fungal diseases of onion (*Allium cepa* L.)
with special reference to purple blotch**



Thesis

**Submitted for the Degree of
Master of Philosophy
in
Botany**

**By
Md. Tauhiduzzaman**

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April 2003

*Dedicated
to
my parents*

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DECLARATION

I hereby declare that the whole of the work now submitted as a thesis entitled “**A study of fungal diseases of onion (*Allium cepa* L.) with special reference to purple blotch**” for the degree of Master of Philosophy in Botany of the University of Rajshahi is the results of my own investigation. The thesis has not been concurrently submitted in substance for any other degree.

(Md.Tauhiduzzaman)

Candidate



CERTIFICATE

This is to certify that the thesis entitled “**A study of fungal diseases of onion (*Allium cepa* L.) with special reference to purple blotch**” is an original work done by Mr. Md. Tauhiduzzaman for the degree of Master of Philosophy in Botany. The references cited in it have duly been acknowledged. The style and contents of the thesis have been approved and recommended for submission.

M.A. Alam.

3. 5. 2003

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(Md.Tauhiduzzaman)

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ACRONYMS, ABBREVIATIONS AND SYMBOLS

a.m. = Antimeridium	N = Nitrogen
a.i. = Active ingredient	P = Phosphorus
°C = Degree celsius	PDI = Per cent Disease Index
cv. = Cultivar	pH = A symbol for the degree of acidity or alkalinity of a solution
cm = centimetre	RH = Relative humidity
Codex = Coefficient of disease index	P ₂ O ₅ = Phosphorus penta-oxide
DAP = Days after planting	ppm = Parts per million
D = Date of planting	RCBD = Randomized complete Block Design
DMRT = Duncan's Multiple Ranga Test	S = Sulphur
EC = Emulsifiable concentrate	t = Ton
FYM = Farm yard manure	temp. = Temperature
g = Gramme	V = Variety
μg = Microgramme	WP = Wettable powder
ha = Hectare	/ = Per
MP = Muriate of potash	% = Per cent
mt = Metric tonnes	

CHAPTER - 1

CHAPTER ONE

INTRODUCTION

Onion (*Allium cepa* L.) belonging to the family Alliaceae is one of the most important spice as well as vegetable crops of the world. Its origin is in Iran, Pakistan and the mountaineous region to the north of these countries (Purseglove, 1972). The primary center of origin of onion is central Asia and a secondary center for larger types of onion is Mediterranean regions (Mc Collum, 1976). Its use is neither limited to any climate nor associated with any nationality and it is probably as widely grown as any cultivated crop. The leading onion producing countries, in order of production are the United States of America, Japan, Spain, Egypt, Turkey and Italy (Jones & Mann, 1963). Onion is relatively high in food energy and is rich in calcium and riboflavin. It can be used as medicine.

This crop can be grown over a wide range of conditions from sea level up to the elevation of about 1828 metre and from warm summer temperature of plains to cold weather down to a temperature of about 16°C. However it is not suited to heavy rainfall and the rainfall should not exceed 762 mm during cultivating season (Aiyer, 1980).

Onion grows in almost all districts of Bangladesh but widely cultivated in the greater districts of Faridpur, Dhaka, Rajshahi, Comilla. The onion cultivating area of Bangladesh covers 33000 ha. of land, total production 1,31,000 mt and total yield 3948 kg/ha (FAO, 2000). The local cultivars namely, Taherpuri, Jhitka, Salta, Kalasnagari and Faridpur bhati are mainly grown in the country (Rahim and Siddique, 1991).

The crop suffers from many diseases (Meah and Khan, 1987; Ahmed and Hossain, 1985; Munoz *et. al.*, 1984). Various kinds of diseases are found in the field as well as in the storage. About 45 different fungal and 5 bacterial species are reported to

cause diseases of onion in the field. Five viral entities are also responsible for onion diseases in the field conditions, the percentage of infection and/or the extent of loss due to diseases may vary from 0-100% (Harrison, 1954 and Vovk, 1959).

A variety of disease and disorders affect onions and related crops in Ontario. Most of the diseases are caused by fungi or bacteria whereas disorders may be caused by adverse weather, air pollutions, soil conditions, nutritional imbalances and pest control products, sometimes several diseases and/or disorders can be present at the same time (J. Chaput, 1995).

Purple blotch is one of the field disease caused by *Alternaria porri* (Ellis) Cif. is noted as the major disease in many onion growing countries including Bangladesh (Castellanos-Linares *et. al.*, 1988; Rahman *et. al.*, 1984; Ashrafuzzaman, 1977). Ahmed and Goyal (1988) mentioned that purple blotch, incited by *A. porri* is a major problem of onion (*A. cepa*) in India. The disease is a serious problem for seed production in tropical countries like Bangladesh (Rahman *et. al.*, 1988; Anonymous, 1985). Initially symptoms appear on leaves or seed stalk as small water-soaked lesion that quickly develops white centers. As lesions enlarge, they become zonate and brown to purple, and are surrounded by a yellow zone. The lesion may be covered with brown to dark grey fruiting structures of the fungus. A few large or seed stalk and tissues distal to the lesions will die (Schwartz and Mohan, 1994). Purple blotch of onion causes breaking of floral stalks and thus the seed production is seriously affected. Damage of foliage and breaking of floral stalks due to the disease resulting in failure of seed production are common (Munoz *et. al.*, 1984; Asrafuzzaman and Ahmed, 1976). The infected seed stalks break at the point where the lesion is developed (Singh, 1987). Under favorable environmental conditions for the disease complete failure of the crop may take place if appropriate control measures are not followed (Sharma, 1986). Bulb and seed yields of onions cv. 'Nasik Red' were significantly reduced as a result of

purple blotch caused by *A. porri* (Gupta and Pathak, 1988). About 20 to 25% losses in seed yield has been recorded in India (Thind and Jhooty, 1982) and 41-44% in Bangladesh (Hossain *et. al.*, 1993). Two onion cultivars, Taherpuri and Faridpur bhati are widely grown in Bangladesh but both of them are susceptible to purple blotch (Rahman *et. al.*, 1988) in the cultivation area of onion and its rate of production per unit area in Bangladesh are gradually decreasing due to this disease (Anonymous, 1992). As a result Bangladesh has to import a large quantity of onion every year to fulfill the national demand in exchange of foreign currency.

Onion (*A. cepa*) crops in Western Australia were surveyed for the presence of *Sclerotium cepivorum* (the cause of white rot), *Puccinia porri* [*P. allii*] (the cause of rust) and *Urocystis cepulae* (the cause of American onion smut) (Mackie-AE; McKirdy-SJ, 2002).

Nine fields direct-seeded with onion were surveyed in central Washington during the spring and summer of 2001 for *Botrytis* spp. associated with onion seed crops (Toit-LJ-du; Derie-ML; Hsiang-T; Pelter-GQ; du-Toit-LJ, 2002).

In the summer of 1999, typical yellows-type symptoms were observed on garlic and green onion plants in a number of gardens and plots around Edmonton, Alberta Canada (Khadhair-AH; Evans-IR; Choban-B, 2002).

A new disease was found in September 2001 on greenhouse-grown onion transplants of cv. Colorado 6 transplanted in a field in Larimer County, northern Colorado, USA. Symptoms included straw-coloured, dry, tan, spindle- or diamond-shaped lesions on the leaves and scapes of onion plants. Infected plants were scattered (less than 5% incidence) throughout the outer perimeter of the sprinkler-irrigated field (Schwartz-HF; Brown-WM Jr.; Blunt-T; Gent-DH, 2002).

Allium white rot (AWR), caused by the soil-borne fungus *Sclerotium cepivorum*, is the most devastating disease in onion crops worldwide (Hunger-SA; Mclean-KL; Eady-CC; Stewart-A; Zydenbos-SM, 2002).

A trial was established to study the effect of three temperatures (15, 21 and 28°C) and relative humidity (80, 90 and 100%) on onion leaf blight, caused by *Stemphylium botryosum* [*Pleospora herbarum*] and *Alternaria alternata* (Cova-J; Rodriguez-D, 2001).

A survey identified viruses infecting garlic, leek and onion crops and wild *Allium* species in Greece. Samples of cultivated *Allium* species were collected from five districts, whereas samples of twenty-seven wild *Allium* species were also collected from all over Greece (Dovas, C. I.; Hatziloukas, E.; Salmon, R.; Barg, E.; Shibolet, Y. and Katis, N. I., 2001).

Twenty-two onion cultivars were inoculated with *F. oxysporum* f.sp. *cepa* (at 101-1010) either through planting in soil infested with the pathogen, or puncturing the basal plate followed by plantlet immersion in a conidial suspension (Apaza-WE; Mattos-L, 2000).

In June of 1998, a new bacterial disease was observed on Welsh onion in Okinawa Prefecture, Japan. Infected plants in nursery boxes were stunted with tip dieback, and heavily infected plants died. In fields, the disease appeared on leaves as irregular gray spots or elliptical spots with creases in the center. These spots enlarged and spread rapidly in continued cloudy or rainy weather, and formed blight lesions on outer leaves. Yellow mucoid bacterial colonies were consistently isolated from these lesions. The causal bacterium was identified as a pathovar of *Xanthomonas campestris* on the basis of bacteriological properties (Kadota-I; Uehara-K; Shinohara-H; Nishiyama-K, 2000).

In February 1999 a disease of onions was observed in Georgia, USA. The causal organism was isolated and identified as *P. destructor*. This is the first report of *P. destructor* in Georgia (Langston-DB Jr.; Sumner-DR, 2000).

Symptoms of *Botrytis squamosa* [*Sclerotinia squamosa*], *Peronospora destructor*, *Urocystis cepulae*, *Sclerotium cepivorum*, *Pseudomonas* spp., *Alternaria porri*, *Stemphylium vesicarium*, and onion yellow dwarf potyvirus in onions and shallots are described, as well as chemical and cultural control methods (Monnet-Y; Thibault-J, 2000).

In March 1998 a leaf blight of onion was detected in Weslaco, Texas, USA. The causal organism was isolated and identified as *X. campestris* and its pathogenicity was confirmed. This is the first report of this pathogen on onion in the continental USA (Isakeit-T; Miller-ME; Barnes-LW; Dickstein-ER; Jones-JB, 2000).

Foliar anthracnose, caused by *C. gloeosporioides* [*Glomerella cingulata*] is one of the main disease occurring in the onion-producing S. Francisco River region in Brazil (Assuncao-IP; Coelho-RSB; Lima-GS-de-A; Lima-JAS; Tavares-SCC-de-H; de-A-Lima-GS; de-H-Tavares-SCC, 1999).

Surveys between 1989 and 1993 in the major garlic production areas of Spain identified a new leaf spot disease, characterized by white and purple lesions followed by extensive necrosis. Isolation and pathogenicity tests with fungal isolates taken from these spots indicated that *S. vesicarium* was the causal agent (Basallote-Ureba-MJ; Prados-Ligero-AM; Melero-Vara-JM, 1999).

In 1990, onion leaf blotch was observed for the first time in the Lower Rio Colorado Valley (Province of Buenos Aires), the most important onion-producing region of Argentina. Since then, the disease has been found in other production areas of this country. Infections on shallot have also been recorded. The causal agent, *Mycosphaerella allii-cepae*, was identified on the basis of symptoms,

fungus morphology (as anamorph *Cladosporium allium-cepae*) and successful artificial inoculations on onion plants. Although the disease has been present in all seasons since 1990, epidemics of any importance have not been observed in the main crop of dry onions. This is the first record of onion leaf blotch for Argentina (M. Kiehr, F. Anderson, A. Azpilicueta and R. Delhey, 1997).

The name yellows streak is proposed for a severe disease caused by mixed infection with garlic latent virus (GLV) and onion yellow dwarf potyvirus (OYDV). This is the first report of OYDV in *Allium chinense*. Incidence of the disease was low (1.0-3.5%) and symptoms included yellow streaks of the basal part of newly developed leaves, which were thin and curled, while infected leaf tips turned white. Symptoms were most distinct from spring to autumn and were masked over the winter (Sako, I.; Nakasone, W.; Okada, K.; Ohki, S. T.; Osaki, T.; and Inouye, T., 1991).

Diseased leaves showing yellowing and stunting with fasciation were associated with MLO in the sieve tubes. Bulbs of diseased plants showed hypertrophy and sprouted earlier than healthy ones after storage. In transmission tests with 5 spp. of planthopper and leafhoppers only *Macrostes orientalis* transmitted the disease to onion seedlings. Typical symptoms were expressed 20-28 days after transmission. The transmission rate by natural infection was 3.3-30%. The name onion yellows is proposed for the disease (Miyahara, K.; Matsuzaki, M.; Tanaka, K. and Sako, N., 1982).

Many factors influence the storage life of onion. In the tropics, onion bulbs are usually stored in shelters under ambient conditions resulting in severe storage losses (Ko-SweeSuak; Chang - WooNang; Wang - JawFen; Cherng - ShinJiun; Shanmugasundaram-S; Ko-SS; Chang-WN; Wang-JF; Cherng-SJ, 2002).

A new disease of onion in Rajasthan, India is presented. The causal organism is *S. rolfsii* [*Corticium rolfsii*], and the symptoms are briefly discussed (Kamlesh-Mathur; Sharma-SN; Mathur-K, 2002).

The effect of EM on onion and seed production on a commercial organic farm in New Zealand are reported, and the problems of broad acre application of EM are discussed. In a trial in 1995, the effect of EM and organic fertilizers on onion production was investigated. The highest percentage of first grade onions and the second highest yield were observed in the EM treatment. In 1996, 1.3 ha of onions were intensively sprayed with EM from 6 weeks post emergence to 4 weeks before lifting. Such a treatment induced high yields (53 tonnes/ha). Fungal diseases were a major problem in storage causing loss of 50% of the crop (a potential loss of US \$ 15thn000) (Chamberlain-TP; Daly-MJ; Merfield-CN; Senanayake-YDA (ed.); Sangakkara-UR, 1999).

Among the fungal diseases the most important and damaging ones are seed borne. In Bangladesh, 9 different fungal diseases were reported to be seed borne of which 7 were major and 2 were minor (Akanda, 1994; Fakir, 1998). *Aspergillus* sp., *Penicillium* sp. and *Fusarium* sp. can cause storage losses of onion (Gupta and Srivastava, 1992).

Under storage conditions, onion bulbs lose its weight due to continuous loss of water and dry matter. But the most serious loss rises from storage rots due to various diseases caused by bulb rotting micro organisms and also from sprouting and rooting (Jones *et. al.*, 1963). About 15 different fungal and 5 bacterial species are responsible for the onion diseases in the storage and transit all over the world. The loss due to these diseases is considerable and may go up to 40% (Aiyer, 1980).

FARMER'S BOOKSHELF

An information system of crops in Hawaii

Department of Horticulture

University of Hawaii at Manoa

Onion 1

Climate

Day Length Requirements of Bulb Onions and Background Information on Green Onions

In Hawaii, special attention needs to be placed on day-length when growing bulb onions. Bulb onions differ as to the photoperiod (length of day) required to produce bulbing at favorable temperatures (60 - 80 degrees F.). The longest day never exceeds 13 .83 hours (13 hours, 50 minutes) and varieties, which require photoperiods of 13.5 or more hours for bulbing should not be planted. Ripening of bulb onions (drying of the neck and tops falling over) generally requires just as long days as bulbing or longer and higher temperatures (70 - 80 degrees F.) together with dryness of both soil and atmosphere.

Bulb onions grow best under cool conditions (50 - 70 degrees F.) with plenty of moisture during the early stages. The best adapted varieties for Hawaii are those that bulb at 12 - 13 hours day length and ripen at 13 - 13.5 hours day length.

Localities for Bulb Onion Production

Group I bulb onions can be grown almost anywhere in the state where rainfall is very low during the maturing, ripening and harvesting phase of the production cycle. There is no one place with the ideal natural climatic requirements in the state. Ideally , bulb onions prefer moist conditions and about 45 - 60 degrees F.

during the growing phase and 60 - 80 degrees F. for the bulbing and ripening phase with dry conditions during the ripening phase.

Most of the bulb onions are grown in Kula on the island of Maui, it has good growing conditions, 60 - 65 degrees F. with sufficient rainfall but may lack dryness and higher temperatures during the maturing and ripening phases (April - August). Onions grown at the higher elevations can be properly cured by harvesting and transporting it to some hot dry locality for about a week. The leaves and roots should be untrimmed. To prevent sunburning, the onions should be set out to cure with overlapping tops. Localities that approach the ideal for bulb onion production are the Kualapuu and Maunaloa districts on Molokai and Lanai. Onions grown at lower elevations are generally smaller, more pungent and have a better shelf-life than those grown in higher elevations because of the warmer growing conditions during bulbing and ripening.

Culture

Soil Preparation

Fertile, well-drained soil, which can retain some moisture and is reasonably free from weed seeds, is ideal for onion production. The soil should be plowed to a depth of at least ten inches, preplant fertilizers and amendments incorporated, harrowed or rot ovated, leveled and left in good tilth.

Irrigation

The shallow root system requires frequent irrigations. Plantings in Hawaii are almost all sprinkler irrigated. A general guideline to keep in mind is that after planting, the soil should not be allowed to dry out below one inch from the surface. Onions at the bulbing stage utilize substantial amounts of water. If the onion is set back by lack of water during its growth, the new growth may, upon irrigation cause splits or double bulbs. Lack of water also causes slowing down of

growth and increases the amount of bloom on the leaves, giving the plants a greyer or bluer-green color. Over irrigation would cause the leaves to take on a yellowish-green color and results in reduced yields and bulbs with very poor shelf life.

When the plants/bulbs start to mature, irrigation should be reduced and when the plants start to ripen (tops topple over at the neck), irrigation should be discontinued and the soil allowed to dry out. If moisture remains in the ground, adventitious roots may regenerate from the stem and this may complicate the curing process of the mature bulbs.

Weed Control

Onions are not good competitors with weeds. Early cultivation may be employed for weed control, but once direct seeded onions reach the four or five-leaf stage, fields should not be cultivated because root damage would be unavoidable.

Common preemergent herbicides used are DCPA or Goal and postemergent Poast or a 3 - 5% sulfuric acid solution may be tried. It is important to control weeds as soon as possible.

Soil Amendment and Fertilization

Start with a soil test, if the soil pH is less than 6.0 or the available calcium is less than 2,000 lbs. per acre, applied and incorporated agricultural lime at the rate of 2,000 pounds per acre (4.5 lbs./100 square feet) about 8 - 12 weeks before planting. The lime requires some time moisture to chemically react with acid soil to raise the pH.

Soils low in phosphorus, applied and incorporated about 1,000 lbs./acre (2.25 lbs./100 square feet) of triple super phosphate or its equivalent. It is suggested that the phosphate be banded 2-1/2 - 3-1/2 inches below and to both sides of the row where

onion will be planted. Soils low in magnesium (less than 500 lbs./acre), applied magnesium sulfate (epsom salt, 9.8% Mg.) at the rate of 200 lbs. per acre as a soil application at planting.

Soils low in potassium, applied murate of potash (0-0-61) at the rate of 300 - 350 lbs./acre (0.7 - 0.8 lbs./100 square feet). Applied half (150 - 175 lbs.) at time of planting together with the epsom salt and or the complete fertilizer. The remaining half may be combined with the nitrogen and applied 4 - 6 weeks later as side dress.

For bulb onions, after adjusting for pH, P, K, Ca and Mg, and for soils within the moderate range of available nutrients, about 1,500 - 2,000 lbs. of 4-12-8 or 5-10-10 and about 200 - 400 lbs. of sulfate of ammonia should be sufficient for an acre of bulb onions. All the complete fertilizer is usually banded preplant below the row to be planted.

Bulb onion has only a single primary root, continuous plant growth depends almost entirely upon the adventitious roots which are continually dying and must be continually replaced by new adventitious roots arising from the stem (or stem plate). Most onion roots are in a six inch radius from the stem and therefore are shallow feeders.

Studies have determined that it is best to apply banded pre-plant fertilizers 2-1/2-3-1/2 inches below the seeded or transplanted row for best growth. Several applications of fertilizers containing nitrogen and possibly potassium should be applied especially in sandy, well drained soils because earlier applications may leach from the root zone because of all the watering during the early growth period. Normally a side dressing of 200 lbs. of sulfate of ammonia (21-0-0-) per acre when the plants are about 1/4 inch thick at the base is given to the seeded and

set propagated plants. A second application of 200 lbs. of sulfate of ammonia is given about a month after the first.

For transplanted crops, one side dressing of 200 lbs. sulfate of ammonia per acre a month after transplanting may be sufficient. The nitrogen may be injected into the irrigation water and applied in several applications.

For green onions, after adjusting for pH, P, K, Ca and Mg and for soils within the moderate range of available nutrients, about 800 - 1,200 lbs. of 10-10-10 fertilizer or equivalent should be sufficient for a one acre crop. Green onion roots are similar to bulb onions and therefore are shallow feeders. Applied half of the 10-10-10 fertilizer banded 4 - 5 inches below the row to be planted (transplant divisions 1 - 1-1/2 inches deep) and the remaining half 4 - 5 weeks later side dressed. In sandy areas it may be necessary to supplement the side dressing with about 200 lbs. of sulfate of ammonia.

Handling

Storage of Bulb Onions

Storage of the types of bulb onions grown in Hawaii is usually of minimum concern. It is a fact that the granex, grano, Bermuda and early harvest types are not good storage onions; therefore, the production and marketing are done accordingly to minimize the necessity for storage. If storage is desired, cured well and gradually brought temperature down to 32 degrees F with relative humidity at 65 - 70 percent.

To prevent disease from spreading in stored onions, a relative humidity of 70 percent must not be surpassed. Above 70 percent, bulbs tend to root more readily, however, above 70 percent scale color for the yellow and brown types may be enhanced.

Harvesting and Postharvest Storage of Green Onions

Shallot Types - If harvesting for the small mature bulbs that cluster at the base, one has to wait at least till leaves start to turn yellowish or may harvest when the tops eventually dry off. Stored like bulb onions. If harvesting for the young bulbs with green leaves, it should be pulled, older leaves stripped and washed before leaves start to turn yellowish.

Multiplier Types - The locally grown types mature approximately 70 - 85 days after planting. The whole cluster of divisions (usually 6 - 12 divisions) is pulled washed and discolored/damaged leaves stripped/topped. Many wholesalers prefer packing in ten-pound bundles or boxed.

Non-multiplier Types - These are generally white bulb cultivars harvested at the immature/miniature bulb stage. The local or Asian non-multiplier green onions are not of the bulbing type but flowers very readily year round and need to be harvested before flowering (70 - 90 days). In harvesting, entire planted areas are pulled, plants and roots washed, discolored/damaged leaves stripped if necessary. Like the multiplier types, wholesalers prefer packing in ten-pound bundles or boxed. Storage conditions for green onions are 32 degrees F and 90 - 95 percent relative humidity.

Planting to harvest

a. Bulb onions

Seed to harvest, 160 - 180 days

Sets to harvest, 90 - 120 days

b. Shallot, multiplier and non-multiplier green onion seed to harvest, 75 - 120 days

Sets/division to harvest, 50 - 75 days

c. Futo-negi seed to harvest, 160 - 200 days

Estimated Yield

Bulb Onions - 15,000 lbs. per acre (300 bags)

Non-multiplier green onion - 12,000 lbs. per acre

Multiplier green onions - 10,000 lbs. per acre

Futo-negi - 6,000 - 9,000 lbs. per acre

Harvesting and Curing Bulb Onions

Bulb onions should be harvested when or after the necks weaken and the tops fall over --- when elongation of new leaves into the neck stops. However, the nutrients from the tops continue to increase the weight and dry matter content of the bulbs. This is an advantage when growers pull onions and do not trim tops off immediately.

Curing is the drying of neck, roots and outer scale tissue. Curing is essential to prevent disease infection, particularly neck rot.

Generally, growers start to harvest when 25 - 50 percent of the tops have fallen over. Many growers pull the crop when the bulbs have reached its maximum size and place it in windrows and allowed to cure, some growers clip the tops off as they pull, bag bulbs immediately and cure bulbs in the bags under shelter. If pulled crop is windrowed, bulbs should be protected from sunscald. The tops should be clipped to leave a short neck; cutting too close to the bulb is undesirable as a large open wound does not dry as well and decay organisms may enter. The roots are trimmed close to the stem or base.

The length of curing depends on temperature, humidity, wind or air movement and neck moisture at topping. If the onions are mature, humidity low and air movement good, couple of days may be sufficient. The use of forced air in artificial drying systems can be advantageous if rapid curing is desirable, if large bulbs are harvested before natural curing is complete, or if weather is too damp. If artificial curing system is employed, using 90 to 95 degree s F (32 to 35 degrees C) air moving through onions at the rate of 1 - 2 cubic feet of air per minute per cubic foot of onions should be sufficient. If temperatures that high cannot be achieved, higher airflow rates can compensate. Relative humidity of 60 - 70 percent is desirable. Lower humidity allows faster drying but gives poorer scale color and greater loss of outer scales, whereas higher humidity slows drying and creates a more suitable environment for disease establishment.

In Bangladesh onion bulbs reharvested when dry weather along with higher temperature prevails in the atmosphere. The harvested bulbs are usually stored in room conditions both for consumption throughout the year and also for using as planting materials for seed production in the next year. Onions in such type of storage usually sustain heavy losses due to higher weight loss, rooting and sprouting (Mondal and Pramanik, 1992). Storage methods and conditions have great impact on the storage life of onion (Rahim *et. al.*, 1983; Rahim and Farooque, 1984). High temperatures reduce the storage life of onion causing severe weight loss, disease infection and rooting. So, studies are also needed to see whether or not different planting time and planting methods have any significant effect on storage life of onion.

In Bangladesh onion bulbs are produced in winter season when short day length prevails. So, introduction and cultivation of high yielding varieties of developed countries is not possible in Bangladesh. Therefore, emphasis must be given to increase the per hectare yield of onion by adopting improved methods of

cultivation such as planting geometry, planting/sowing time, fertilization and other cultural measures. Planting time has a pronounced effect on yield of onion.

Researchers in different countries have shown that time of planting has a profound effect on yield of onion.

During the last several years, onion supply in the market could not satisfy the demand of consumers. Its price was always high except few months after harvest. This shortage of onion is largely attributed to the scarcity of good quality seeds. Late planting of crops resulting in poor yields and damage of bulbs due to spoilage in storage. Farmers in general except few in several districts do not know which method of raising crops and which optimum time of planting should be followed for production of bulbs and seeds. They do not have much idea of post harvest losses of onion in storage either.

The information regarding planting time and planting methods of onion are meagre and found scattered in few journals in Bangladesh. Farmers produce onion bulbs and seeds on the basis of traditional hearsay information. So, more systematic worthy research needed to be carried out to provide the farmers with accurate information on these aspects.

Trials were carried out in San Carlos Department, Mendoza, Argentina, in 1994-95 and 1995-96 to determine the possibility of obtaining 2 onion seed production cycles. In both years, bulbs of the long-day onion cv. Valcatorce INTA were planted on 4 dates between mid-March and early August. The morphological development of bulbs and scapes is described. The total number of bulbs produced/plant increased with later planting dates, resulting in greater regrowth in the second cycle and higher seed production at the second flowering. Planting between the end of June and early August gave the best results (Gaviola-JC; Planchuelo-AM; Oliva-RN, 1999).

Two trials carried out during 1997-98 and 1998-99 in Oman showed that final seed yield in onion cv. Omani was influenced by planting date of bulbs. Early planting (20 October) reduced seed yield by 42.9 and 13.5% compared with later planting (10 November) in 1997-98 and 1998-99, respectively. Considerable losses were recorded due to planting on 30 November and 20 December. Percentage seed germination was improved by early planting (20 October and 10 November). The number of days to flowering decreased significantly with delayed planting. Bulbs planted on 10 November 1997 had the longest flowering stalks. However, the length of the flowering stalk decreased with delayed planting in 1998-99 due to cold weather conditions prevailing during the experimental period. Differences recorded in the response of some parameters between the 2 trials were attributed to climatic conditions (El-Aweel-MAT; Ghobashi-AA, 1999).

In Bangladesh, report on impetus for successful production of onion seed is scanty (Rahim and Siddique, 1991; Rahman *et. al.*, 1988). Ashrafuzzaman and Ahmed (1976) tested some foliar fungicides against the disease. Little information is available in Bangladesh on the benefit of use of fertilizer, time of planting and protective sparing on onion seed production (Rahim and Siddique, 1991; Bokshi *et. al.*, 1989).

Our knowledge on the kinds of field and storage diseases of onion and the extent of loss due to these diseases in Bangladesh is scanty. The objective of the present piece of work is to have a preliminary survey of the kinds of diseases of onions in the field as well as in the storage and the extent of loss due to these diseases in some selected areas of the country. Date of planting had a vital role in severe attack of purple blotch disease on onion seed crop and seed yield decrease of onion.

CHAPTER - 2

CHAPTER TWO

REVIEW OF LITERATURE

Various fungal, bacterial and viral pathogens are responsible for different onion diseases all over the world. They cause considerable loss in the field as well as in the storage.

2.1 Field diseases

About 45 different fungal and 5 different bacterial species are responsible for various field diseases of onions. Five different viral entities are also responsible for onion diseases in field condition. The percentage of infection and/or the extent of loss vary from trace to about cent per cent.

Purple blotch of onion caused by *A. porri* (Ellis) Cif. is a major disease under tropical conditions. The disease is a limiting factor for bulb and seed production. Gupta *et al.* (1991) reported that purple blotch of onion is an important, widespread disease and is prevalent in almost all the onion-growing areas of India. According to them the characteristic feature of the disease are the small, whitish, sunken lesions with purple centres which rapidly enlarge and eventually girdle the leaf or seed stalk of onion. Usually the affected leaves or seed stalks fall down and die within 3 or 4 weeks if the environment favours the disease. Ahmed and Hossain (1985) recorded purple blotch of onion from all onion growing regions of Bangladesh. Ashrafuzzaman and Ahmed (1976) reported that the damage of foliage and breaking of floral stalks due to the disease resulting in failure of seed production are common. Hossain *et al.* (1993) reported 41-44% loss of seed crop in Bangladesh. Under favourable environmental conditions for the disease complete failure of onion seed crop takes place and there is no pod formation and seed set (Sharma, 1986). The disease causes 20-25 per cent loss in seed yield in India (Thind and Jhooty, 1982).

Srivastava *et al.* (1994) reported the high incidence (2.5-87.8%) of purple blotch (*A. porri*) in both the kharif and rabi onions, when high humidity prevailed, during the 5 years of the survey (1998-93).

In India the most serious diseases, which can result in 100% crop losses were reported by Daljeet *et al.* (1992) as purple blotch (*A. porri*), *Stemphylium vesicarium*, *Peronospora destructor* and *Botrytis* spp., as well as the insect pest *Thrips tabaci*.

In addition to purple blotch (*A. porri*), which usually occurs in the Indian Punjab, stalk rot (*Sclerotinia sclerotiorum*) has recently been recorded, and blight and blotch (*S. botryosum* [*Pleospora tarda*]) and Downy mildew (*Peronospora destructor*) are now causing major losses of the onion seed crop reported by Sharma *et al.* (1992).

Among the factors reducing yield and limiting the production of onion seed in Cuba were breaking of floral stalks due to injuries caused by *A. Porri* was reported by Munoz-de-Con *et al.* (1986).

In Cuba, Ariosa-Terry and Herrera-Isla (1986) measured the damage of onion due to purple blotch caused by *A. porri*. The first symptoms appeared 50 days after sowing and disease intensity was highest at 110 day. White onions were more affected than red onions.

Rao and Pavgi (1975) recorded another serious pathogen, *S. vesicarium* causing Stemphylium blight, which confined to leaves and inflorescence stalks. Brar *et al.* (1991) reported that *S. botryosum* grows over the downy mildew lesions and transformed them into large elliptical dark brown depressed spots. Bisht and Thomas (1992) in India did work on varietal screening of garlic against Stemphylium blight. They found out some resistant garlic lines against the disease.

Shi and Kuang (1991) studied the biological characteristics of *S. botryosum*, causing onion leaf blight. The optimum temperature for conidial germination

and hyphal growth of the fungus was 25°C. The pH range for growth was 3 to 11 and conidial formation was inhibited by light. The best medium for sporulation was PDA supplemented with 0.5% MgSO₄ and 0.5% CaCO₃. Tomaz and Lima (1988) reported from Portugal 80-85% losses caused by a disease (*S. vesicarium*) affecting leaves and inflorescence stalks.

Miller *et al.* (1978) reported Stemphylium blight of onion in South Texas, a previously unrecognized disease of onion caused significant damage during 1976, both alone and with *A. porri*. Lesions were nondelimited, light yellow to brown, water-soaked and from 1 cm in length to the entire leaf, compared with the purple lesions of *A. porri*. Isolations from light yellow areas of lesion invariably yielded *S. vesicarium*. Density of spores (244/cm²) and lesions were greater on the southeast side of leaves facing the prevailing wind, whereas fewer spores (14/cm²) were observed on the opposite green side of the leaf. Inoculations with *S. vesicarium* on the short day onion cultivars, White Granex, Ben Shamen and New Mexico Yellow Grano produced lesions identical to those in the field.

Shishkoff and Lorbeer (1989) isolated *S. vesicarium* from lesions on leaves of onion plants. In controlled inoculations the fungus caused lesions on leaves of all ages of onion plants, especially on older leaves. Rubbing leaves of greenhouse-grown onion plants with bleached, non-absorbent cotton to damage the cuticle increased the number of lesions/leaf.

Everts and Lacy (1996) studied the factors influencing infection of onion leaves by *A. porri* and subsequent lesion expansion. Conidia deposited on onion leaves formed one to several germination tubes and appressoria and often penetrated at more than one locus under conditions favorable for infection. After 3 h in the dew chamber at 24°C following inoculation of onion leaves, 73% of conidia had germinated and 5% had formed appressoria. Infection hyphae were not observed until 6 h following inoculation, at which time 2% of conidia had formed infection hyphae and 0.5% of conidia had caused visible

lesions. Length of dew period was significantly positively correlated with lesion numbers but not with lesion size. There were two types of lesions: expanding and nonexpanding (flecks of less than or equal to 2 mm in diameter). Expanding lesions resulted even when plants inoculated with dry conidia of *A. porri* were incubated in a growth chamber under conditions not conducive to infection for 4 days prior to being placed in a dew chamber for 24 h under conditions conducive to infection, indicating that conidia survived well under these conditions.

The intensity and dynamics of *A. porri* conidial germination were studied by Rodriguez *et al.* (1994) in Cuba with 5, 10, 15, 20, 25, 30, 35, 37.5 and 40°C and RH 76-100%. Conidia developed at 5-37.5°C, with an optimum temperature of 30°C. Germination started within 1 h of incubation at 20-35°C and in 4 h 50% of the conidia had germinated. The minimum threshold for RH at 20°C was between 76-78%.

Formation of conidia by *A. porri* was examined under variable dew duration and controlled relative humidity (RH) by Everts and Lacy (1990). Viable conidia produced on lesions increased from 26% after 9 hr of dew to 72, 91, 93, 96 and 96% after 12, 15, 18, 21 and 38 hr of dew, respectively. Conidia formed during dew duration of 12 hr caused flecks when used to inoculate healthy plants, and those formed during dew duration of 16 hr caused typical lesions. Conidia were formed at all RHs tested (75-100%); numbers were very low at 75-85% RH but increased with increasing RH. Conidia formed on lesions on senescent leaves when incubated in dew at 25°C. They formed repeatedly (up to eight cycles) on lesions exposed to alternating low (35-50%) and high (100%) RH in a dew chamber at 25°C.

Gupta and Pathak (1986) mentioned that sixty-day-old onion plants (cv. Nasik Red) were most susceptible to the purple blotch pathogen (*A. porri*). Inoculated plants to high RH (100%) for 120 hours resulted in maximum disease severity and shortest incubation period.

Attack by *T. tabaci* predisposed plants to infection by *A. porri* and severe purple blotch occurred on plants in which the insects were uncontrolled reported by Thind and Jhooty (1982).

Khare and Nema (1981) studied on purple blotch of onion-sporulation on host and dispersal of conidia. Maximum sporulation of *A. porri* in the field was at 8 a.m. and most occurred immediately after the rains. In the laboratory sporulation was best at 22°C and 90% RH. Most conidia were trapped at 12 noon and at least at 8 a.m. (mean temp. >18 °C).

A. porri and *S. botryosum* were reported by Wu (1979) to be seed-borne which reduced germination in onion. The occurrence of *A. porri* was not affected by irrigation as reported by Dematte *et al.* (1976).

Hunger-SA; Mclean-KL; Eady-CC; Stewart-A; Zydenbos-SM, (2002) reported that Allium white rot (AWR), caused by the soil-borne fungus *Sclerotium cepivorum*, is the most devastating disease in onion crops worldwide.

Wall-M; Corgan-J (2002) reported that NuMex Arthur is a low-pungency, high-yielding, pink root (caused by *Phoma terrestris*)-resistant, intermediate-day, open-pollinated, yellow onion cultivar for spring seeding or transplanting in southern New Mexico, USA. This cultivar, derived in 2000 from an intercross between NuMex BR 1, Ben Shemen, P1249538, and various sweet Spanish-type accessions, is ideal for fresh market consumption. NuMex Arthur matures in late July when planted during spring in Las Cruces. Results of replicated trials conducted in 1997 and 1999 comparing NuMex Arthur to NuMex Jose Fernandez, NuMex Luna, and Candy are presented.

Wall-M; Corgan-J (2002) reported that NuMex Freedom is a low-pungency, high-yielding, bolting-resistant, pink root (caused by *Phoma terrestris*)-resistant, intermediate-day, open-pollinated, yellow onion cultivar derived in 2000 from intercrossing yellow grano and sweet Spanish-type cultivars (NuMex Sunlite and other bolting-resistant selections from Texas Grano 502

PRR as parents) in New Mexico, USA. Results of replicated field trials in 1998-99, 1999-2000, and 2000-2001 comparing NuMex Freedom with NuMex Luna and Candy are presented.

Mackie-AE; McKirdy-SJ (2002) reported that Onion (*Allium cepa*) crops in Western Australia were surveyed for the presence of *Sclerotium cepivorum* (the cause of white rot), *Puccinia porri* [*P. allii*] (the cause of rust) and *Urocystis cepulae* (the cause of American onion smut).

Toit-LJ-du; Derie-ML; Hsiang-T; Pelter-GQ; du-Toit-LJ (2002) reported that nine fields direct-seeded with onion were surveyed in central Washington during the spring and summer of 2001 for *Botrytis* spp. associated with onion seed crops. Fungal isolates isolated from whole plants and seeds were identified as *B. porri* based on colony morphology, growth rate, spore and sclerotium characteristics, and nucleotide sequence analysis. This is thought to be the first report of the natural infection of onion by *B. porri* [*Botryotinia porri*], and the first report of seedborne *B. porri* on onion.

Thakur-RP; Kusum-Mathur; Mathur-K (2002) reported that the downy mildew diseases are caused by different fungus species in several genera in the class Oomycetes. They comprise a major group of diseases affecting a large number of crops. In India, downy mildews have been reported on several economically important crops, including maize, sorghum, pearl millet, onion, soyabean, cucurbits and grapes, causing severe economic losses in some regions and seasons.

Swift-CE; Wickliffe-ER; Schwartz-HF (2002) reported that nineteen isolates of *Fusarium oxysporum* f. sp. *cepae* recovered from diseased onions growing in the western, southern, and northern regions of Colorado were placed into vegetative compatibility groups (VCGs) based on pairing of complementary mutants. Pathogenic isolates from these regions were cultured on variations of potassium chlorate (1.5 or 3.0%) mutation media, potato dextrose agar (PDA), and minimal medium (MM) supplemented with L-asparagine and L-threonine.

Chlorate PDA and 3% chlorate MM with L-threonine did not generate the nitrate nonutilizing (nit) mutants required, while MM with L-asparagine (1.5 and 3% chlorate) and MM with L-threonine (1.5% chlorate) generated complementary nit mutants required for compatibility pairings. Five VCGs of *F. oxysporum cepae* were identified. One VCG was present in all three regions of Colorado examined. Four VCGs were restricted to either western or eastern Colorado. Additional sampling and evaluation of a more diverse collection of *F. oxysporum cepae* isolates from other regions of onion production is needed to determine the diversity of this pathogen. Such information could assist in breeding for resistance to *F. oxysporum cepae*.

A new disease was found in September 2001 on greenhouse-grown onion transplants of cv. Colorado 6 transplanted in a field in Larimer County, northern Colorado, USA. Symptoms included straw-coloured, dry, tan, spindle- or diamond-shaped lesions on the leaves and scapes of onion plants. Infected plants were scattered (less than 5% incidence) throughout the outer perimeter of the sprinkler-irrigated field (Schwartz-HF; Brown-WM Jr.; Blunt-T; Gent-DH, 2002).

In the summer of 1999, typical yellows-type symptoms were observed on garlic and green onion plants in a number of gardens and plots around Edmonton, Alberta, Canada (Khadhair-AH; Evans-IR; Choban-B, 2002).

Walker-J (2001) reported that seven smut species have been recorded on Liliales in Australia. Four are accepted as genuine Australian records. *Urocystis cepulae* on *Allium cepa*, *U. destruens* on *Wurmbea dioica* and *U. hypoxis* on *Hypoxis glabella* are authenticated from specimens examined and are described in detail. Evidence is presented to show that *U. colchici* and *U. gladiolicola* do not occur in Australia. *Ustilago allii* is excluded from the smuts, being based on onion bulbs infected by *Aspergillus niger*. A key to the accepted species is given.

Mohan-K; Ebenezer-EG; Seetharaman-K (2001) reported that field experiments were conducted in Tamil Nadu, India in the rabi seasons of 1998 and 1999 to investigate the effects of plant extracts (from *Pithecellobium dulce* and *Prosopis juliflora* leaves), plant oils (palmarosa oil at 0.1 and 0.05% and neem oil at 3%) and biological control agents (*Trichoderma viride*, *Pseudomonas fluorescens* and *Bacillus subtilis*) in controlling leaf blight in onion cv. Co 4 caused by *A. porri*. The lowest disease percentage was obtained with palmarosa oil at 0.1%, sprayed at the first appearance of disease symptoms and 15 days after the appearance of the disease. This treatment produced yield at 7650 kg/ha, which was higher than the control.

Cova-J; Rodriguez-D (2001) reported that a trial was established to study the effect of three temperatures (15, 21 and 28°C) and relative humidity (80, 90 and 100%) on onion leaf blight, caused by *Stemphylium botryosum* [*Pleospora herbarum*] and *Alternaria alternata*. Sixty-day-old onion plants were inoculated with the pathogens either individually or combined. Three replications (bags with three plants each) per treatment and a complete randomized design were used. Results for *S. botryosum* showed incubation and latency periods were shorter at 21°C and 80-100% RH. For *A. alternata*, 21 and 28°C, and 90-100% RH were more favourable for symptom development and sporulation started at 3.9 days. Results indicate a high influence of temperature and relative humidity on sporulation and disease development.

Velasquez-Valle-R (2001) reported that the spread of nematodes *Nacobbus aberrans* on beans, *Meloidogyne incognita* and *Meloidogyne* spp. on bean (*Phaseolus vulgaris*), pepper (*Capsicum annuum*), zucchini (*Cucurbita* sp.), onion, sunflower, lucerne and peach [*Prunus persica*] as well as on a weed (*Amaranthus graecizans*) in irrigated and drylands of the states of Aguascalientes, San Luis Potosi and Zacatecas, Mexico during 1998-2000.

Dovas, C. I.; Hatziloukas, E.; Salomon, R.; Barg, E.; Shibolet, Y.; Katis, N. I. (2001) reported that a survey identified viruses infecting garlic, leek and onion

crops and wild *Allium* species in Greece. Virus identification was based on ELISA, immunoelectron microscopy, and occasionally, on RT-PCR. Samples of cultivated *Allium* species were collected from five districts, whereas samples of twenty-seven wild *Allium* species were also collected from all over Greece.

In March 1998 a leaf blight of onion was detected in Weslaco, Texas, USA. The causal organism was isolated and identified as *X. campestris* and its pathogenicity was confirmed. This is the first report of this pathogen on onion in the continental USA (Isakeit-T; Miller-ME; Barnes-LW; Dickstein-ER; Jones-JB, 2000).

Monnet-Y; Thibault-J (2000) reported that symptoms of *Botrytis squamosa* [*Sclerotinia squamosa*], *Peronospora destructor*, *Urocystis cepulae*, *Sclerotium cepivorum*, *Pseudomonas* spp., *Alternaria porri*, *Stemphylium vesicarium*, and onion yellow dwarf potyvirus in onions and shallots are described, as well as chemical and cultural control methods.

In February 1999 a disease of onions was observed in Georgia, USA. The causal organism was isolated and identified as *P. destructor*. This is the first report of *P. destructor* in Georgia (Langston-DB Jr.; Sumner-DR, 2000).

Clarkson-JP; Kennedy-R; Phelps-K (2000) reported that the rate of conidiogenic germination of *Botrytis squamosa* [*Sclerotinia squamosa*] was highest at 16°C and the greatest numbers of conidia per sclerotium (up to 5×10^4) were produced at temperatures of 5-10°C. At temperatures above 20°C, the percentage of sclerotia producing conidia declined rapidly. Decreasing water potential reduced the rate at which conidia were produced and also resulted in fewer conidia produced per sclerotium. However, conidia were produced at water potentials as low as -2 MPa, at which sclerotial germination was at least 60%. A simulation model that included effects of both temperature and water potential was developed from laboratory and field data obtained for conidial production in sclerotia exposed for periods of 1, 2, 3 or 4 weeks during an entire year. There was good agreement between conidiogenic germination

predicted by the model and conidial production observed in onion plots artificially inoculated with sclerotia. Temperature and water potential were therefore considered to be the principal microclimatic factors affecting conidial production by *B. squamosa*. The role of sclerotia in the context of UK onion production is discussed.

Kadota-I; Uehara-K; Shinohara-H; Nishiyama-K, (2000) reported that in June of 1998, a new bacterial disease was observed on Welsh onion in Okinawa Prefecture, Japan. Infected plants in nursery boxes were stunted with tip dieback, and heavily infected plants died. In fields, the disease appeared on leaves as irregular gray spots or elliptical spots with creases in the center. These spots enlarged and spread rapidly continued cloudy or rainy weather, and formed blight lesions on outer leaves. Yellow mucoid bacterial colonies were consistently isolated from these lesions. The causal bacterium was identified as a pathovar of *Xanthomonas campestris* on the basis of bacteriological properties.

Apaza-WE; Mattos-L (2000) reported that twenty-two onion cultivars were inoculated with *F. oxysporum* f.sp. *cepae* (at 101-1010) either through planting in soil infested with the pathogen, or puncturing the basal plate followed by plantlet immersion in a conidial suspension. This last method was the best, with 105 conidia/ml giving the best result. Resistance was determined by disease severity and percentage of plantlets death. Only cultivar Atena was resistant and XPH6700 was moderately resistant to *F. oxysporum* f.sp. *cepae*.

Robak-J; Plucinska-M (2000) reported that the most important diseases causing losses of vegetable crops in Poland are fungal organisms belonging to Oomycetes class. Pathogenic fungi from this class causing major diseases are: *Pseudoperonospora cubensis* (a causal agent of cucumber downy mildew), *Peronospora destructor* (a causal agent of onion downy mildew) and *Phytophthora infestans* (a causal agent of late blight on tomato).

Surveys between 1989 and 1993 in the major garlic production areas of Spain identified a new leaf spot disease, characterized by white and purple lesions followed by extensive necrosis. Isolation and pathogenicity tests with fungal isolates taken from these spots indicated that *S. vesicarium* was the causal agent. Pseudothecia of the teleomorph stage, *Pleospora* sp., were found on leaf debris from affected plants. Inoculation of garlic and onion plants with residues carrying mature pseudothecia, or with ascospore suspensions obtained from the pseudothecia, resulted in the development of white and purple leaf spots. Wetness periods longer than 24 h were required for symptom development under controlled conditions. Isolates of *S. vesicarium* from garlic, onion and asparagus caused disease in all 3 hosts. In garlic, cv. Blanco de Vallelado was most susceptible, while lines B4P17 and B6P1, and cvs Iberose and Golourose were less susceptible to the disease (Basallote-Ureba-MJ; Prados-Ligero-AM; Melero-Vara-JM, 1999).

Assuncao-IP; Coelho-RSB; Lima-GS-de-A; Lima-JAS; Tavares-SCC-de-H; de-A-Lima-GS; de-H-Tavares-SCC (1999) reported that foliar anthracnose, caused by *C. gloeosporioides* [*Glomerella cingulata*] is one of the main diseases occurring in the onion-producing S. Francisco River region in Brazil.

H. F. Schwartz *et al.*, (1999) reported that Purple blotch of onion is caused by *Alternaria porri* (Ellis) Ciferri. This fungus is also a pathogen of leek, garlic and chive, and is present throughout the United States and Canada. Field and storage loss estimates from this onion disease have ranged from 30 to 50 percent, and up to 100 percent in Colorado. He also reported that Downy mildew of onion is caused by *Peronospora destructor* (Berk.) Casp. Ex Berk. This fungus is present throughout the world. Field loss estimates in the United States varies from 25 to 50 percent. *Alternaria porri* and *Peronospora destructor* spores develop in high humidity, rain or persistent dew with an optimum range of 77 to 85 degrees. Fungal activity of *Alternaria* is reduced by temperatures lower than 55 degrees.

The plant disease known as pink root rot of Welsh onion which occurs in the region of Guambia, Colombia, is thought to be caused by *Fusarium oxysporum* f.sp. *cepae* (Navia-E; Gomez-J, 1999).

H. F. Schwartz *et al.*, (1999) reported that Colorado is a major producer of onions. Approximately 14,000 acres are planted annually on the Western Slope, in the Arkansas Valley and throughout northeastern Colorado. Yields often average 350 to 400 hundredweight per acre unless constraints, such as soil-borne diseases, become widespread and serious enough to limit production. Plant survival, bulb size and quality can be reduced and thereby affect crop productivity (up to 60 percent yield loss recorded) and profitability. Soil-borne disease problems of seeded and transplanted onions include: damping-off (caused by *Pythium*, *Fusarium* and *Rhizoctonia* species), pink root (caused by *Pyrenochaeta* or *Phoma terrestris*), fusarium basal or plate rot (caused by *Fusarium oxysporum* f. sp. *cepae*), bloat or stem and bulb nematode (*Ditylenchus dipsaci*), and smut (caused by *Urocystis colchici*).

In 1990, onion leaf blotch was observed for the first time in the Lower Rio Colorado Valley (Province of Buenos Aires), the most important onion-producing region of Argentina. Since then, the disease has been found in other production areas of this country. Infections on shallot have also been recorded. The causal agent, *Mycosphaerella allii - cepae*, was identified on the basis of symptoms, fungus morphology (as its anamorph *Cladosporium allium – cepae*) and successful artificial inoculations on onion plants. Although the disease has been present in all seasons since 1990, epidemics of any importance have not been observed in the main crop of dry onions. This is the first record of onion leaf blotch for Argentina (M. Kiehr, F. Anderson, A. Azpilicueta and R. Delhey, 1997).

J. Chaput (1995) identified different diseases and disorders of onion. A variety of diseases and disorders affect onions and related crops in Ontario. Most of the diseases are caused by fungi or bacteria whereas disorders may be caused by

adverse weather, air pollutants, soil conditions, nutritional imbalances and pest control products. Sometimes several diseases and/or disorders can be present at the same time.

S.J. Kay and A. Stewart (1994) reported that four fungi (*Chaetomium globosum*, *Trichoderma viride*, *T. harzianum*, *Trichoderma* sp.) were capable of reducing the incidence of onion white rot relative to the untreated control in two soil box trials.

Onion white rot, caused by the soil-borne sclerotial fungus, *Sclerotium cepivorum*, is a serious problem throughout all the main onion growing countries of the world (Adams, 1981; Coley-Smith, 1987), including New Zealand (Fullerton *et al.*, 1986).

Bhardwaj, B. S.; Gupta, R. P.; Singh, J. B. (1992) reported that Nymphs of Thrips tabaci were released on one-month-old onion plants at 0, 5, 10, 20, 40, 60, 80 and 100/plant in Haryana, India, in 1985-88. Data on damage and yield loss showed increases as the pest populations increased, with a significant yield loss even at an initial nymph density of 5/plant. This research was reported at a National Symposium on Onion and Garlic held at Dr Y. S. Parmar University of Horticulture and Forestry, Himachal Pradesh, on 2-3 June, 1990.

Mc. Keen (1950) studied Pythium root rot of Spanish onion caused by *Pythium irregulare*. The organism caused both pre and post emergence damping off. Post - emergence mortality was extensive (65%).

Leyendecker (1950) reported the leaf spot of onion (*Phyllosticta allii*) from New Mexico. Approximately 80 acres of the Yellow Grano variety was seriously affected during the year 1949. Walker (1950) reported that White rot disease (*Sclerotium cepivorum*) developed most rapidly in between 10°-20°C soil temperature and in fairly dry soil.

In Eastern France, Yellow streak of onion caused by Onion Yellow Dwarf Virus (OYDV) was a serious disease of seed onions. The loss was 50% or even

more (Anon., 1951). White rot (*Sclerotium cepivorum*) was responsible for extensive damage to field crops in Holland (Anon., 1951).

Harrison (1954) made a survey on the White rot (*Sclerotium cepivorum*) of onion in Victoria and showed that the onion acreage was reduced by about 50 percent during the past 10 to 15 years, largely owing to depredation by White rot. He further stated that in 1952-53, approximately 800 acres on 300 or more farms (about half of the farms) were affected by White rot, the degree of severity varied from a trace to 50%.

Bremer (1955) reported an outbreak of Smudge disease (*Colletotrichum circinans*) of white onions from a village in the Bonn district of Germany in the wet summer of 1954. Doepel *et al.*, (1955) reported that Downy mildew (*Peronospora destructor*) was widespread in Western Australia, often-attended epidemic form in market garden near North.

Abdullaev (1957) reported that in Azerbaijan, *Peronospora destructor* (Downy mildew) affected over 81% of onion plants in some fields in 1946-49. The infected plants yielding 46.7 - 94.7% less seed than the healthy plants. Woolliams (1957) reported that Downy mildew (*Peronospora destructor*) had damaged the crop in nearly every season in the semi arid interior of British Columbia. Treggi (1958) isolated the fungus *Pleospora herbarum* from onion crop in the Province of Messina, Italy, in which the fungus caused 20-50% loss.

Iren (1959) reported Onion Smudge (*Colletotrichum circinans*) from Turkey, where it was noted on White onion in 1956 at Ankara. Damage was confined to the surface and damp weather favoured the development of the disease. Vovk (1959) reported that the onion Mosaic Virus was very widespread in Poltava, Kharkov, Sumsk, Chernigev and Kirovograd regions of U.S.S.R. causing often 50 - 100% loss.

Segall *et al.*, (1960) reported that Blast (*Botrytis allii*) usually occurred in the field when the foliage area was maximum and before the bulbs had enlarged

appreciably. Khristodorov (1962) reported that all onion crops were attacked by *Peronospora destructor* (Downy mildew) in the Trnovo region, Bulgaria in 1959-61. Young and old plants were equally affected.

Pandotra (1964) recorded that *Alternaria porri* (Purple blotch) caused heavy damage in Punjab, India. Kazokova (1964) reported that Downy mildew (*Peronospora destructor*) and Neck rot (*Botrytis* sp.) are the two most harmful diseases on onion in Tashkent, USSR. No. Soviet varieties were found resistant. El-Helaly *et al.*, (1964) observed that White rot *Sclerotium cepivorum*) occurred in both upper and middle Egypt. Boelema *et al.*, (1967) reported that Purple blotch (*Alternaria porri*) was favoured by wet weather and temperature 21°-30°C. The sowing of seeds early in January and February expose the plants to conditions conducive to infection for a much longer period.

Felix (1968) reported that Pink root rot disease (*Pyrenochaeta terrestris*) was endemic and affected the local red variety in Mauritius. Venkata Rao *et al.*, (1969) described a new blight disease of onion caused by *Colletotrichum lindemuthianum*. The disease caused severe damage to crops in South India in 1966. Infected plants were stunted with poorly developed bulbs.

Patil *et al.*, (1976) evaluated different fungicides against leaf blotch of onion. In culture the fungus was inhibited by Kitazin, Cuman, Difolatan, Vitavax, Captan, Hinosan, Dutex, Miltox and Aureofungin. As a prophylatic spray Kitazin was proved to be superior to all other fungicides.

Talukdar (1974) listed two onion diseases from Bangladesh. The diseases were Downy mildew and White rot caused by *Peronospora destructor* and *Sclerotium cepivorum* respectively. Valdivia (1974) reported Pink root rot (*Pyrenochaeta terrestris*) disease in Peru causing heavy losses. Swarup *et al.*, (1974) recorded a new bacterial stalk rot of onion caused by *Pseudomonas alliicola* in India. Upto 90% of the affected plants of the cultivar Kalyanpur Red showed rolling in 14 - 50% of their flower stalks. Ponnappa (1974)

reported leaf blight of onion (*Alternaria cepulae*) caused severe damage to onions in Mysore, India. All 14 varieties tested were susceptible under laboratory and field conditions.

Los' *et al.*, (1974) reported that 22.7 - 83.1% onion plants were affected by *Peronospora destructor* (Downy mildew) in the Krasnodar region of USSR. Tsupkova (1976) reported that Downy mildew (*Peronospora destructor*) was particularly severe in districts of USSR with abundant rainfall where it caused loss upto 15 - 20%.

Entwistle *et al.*, (1977) estimated that the overall losses caused by *Sclerotium cepivorum* (White rot) was 1 - 2% in ware and pickling onion crops and 5% in salad crops. But in some sites loss reached over 70%.

Stefance (1977) observed Onion Yellow Dwarf Virus (OYDV) in several regions of Yugoslavia. He estimated that in some onion plots near Zagreb, more than 50% of the plants were infected. Zaman (1977) made a list of the onion diseases 'in and around Bangladesh Agricultural University'. The author recorded 4 diseases - Purple blotch (*Alternaria porri*), Blast (*Botrytis allii*), White rot (*Sclerotium cepivorum*) and Pink root rot (*Pyrenochaeta terrestris*).

Sako, I.; Nakasone, W.; Okada, K.; Ohki, S. T.; Osaki, T.; Inouye, T. (1991) reported that the name yellow streak is proposed for a severe disease caused by mixed infection with garlic latent virus (GLV) and onion yellow dwarf potyvirus (OYDV). This is the first report of OYDV in *Allium chinense*. Incidence of the disease was low (1.0-3.5%) and symptoms included yellow streaks of the basal part of newly developed leaves, which were thin and curled, while infected leaf tips turned white. Symptoms were most distinct from spring to autumn and were masked over the winter.

Gupta, R. P.; Pandey, U. B. (1986) reported that three surveys showed that onion yellow dwarf virus occurs commonly in bulb and seed crops. In some places aster yellows was also recorded in seed crops. The incidence of both

diseases was 0-2% in 1981-82, 0-4% in 1982-83 and 0-5% in 1983-84 in Haryana, Rajasthan, Uttar Pradesh and Maharashtra.

Miyahara, K.; Matsuzaki, M.; Tanaka, K.; Sako, N. (1982) reported that diseased leaves showing yellowing and stunting with fasciation were associated with MLO in the sieve tubes. Bulbs of diseased plants showed hypertrophy and sprouted earlier than healthy ones after storage. In transmission tests with 5 spp. of planthopper and leafhoppers only *Macrostelus orientalis* transmitted the disease to onion seedlings. Typical symptoms were expressed 20-28 days after transmission. The transmission rate by natural infection was 3.3-30%. The name onion yellows is proposed for the disease.

2.2 Storage and Transit diseases

About 15 different fungal and 5 bacterial species are responsible for different onion diseases in storage and transit all over the world. The disease cause considerable decay and loss of onion.

Kamlesh-Mathur; Sharma-SN; Mathur-K, (2002) reported that a new disease (Bulb rot) of onion in Rajasthan, India is presented. The causal organism is *S. rolfsii* [*Corticium rolfsii*].

Nielsen-K; Yohalem-DS; Jensen-DF (2002) reported that *Botrytis aclada* and other *Botrytis* spp. can cause neck rot on onions, a storage disease that normally is very difficult to detect at harvest using traditional isolation techniques. Sequence characterized amplified region primers (BA2f/BA1r) were designed based on a previously cloned and amplified DNA fragment for direct amplification of isolates of *Botrytis* spp. associated with neck rot of onions.

Roed (1950) reported that Grey neck rot (*Botrytis* spp.) is the common disease in Norway causing most damage on stored onions. Leyendecker (1950) reported that 5 - 10% of the bulbs were affected due to *Rhizopus stolonifer* (Neck bulb rot) of white grano onion.

Venkataraman *et al.*, (1951) estimated the loss of stored onions upto 30% in Bangalore, India, by *Aspergillus niger* (Black mold rot). This disease was for the first time reported in India and attacked both red and white varieties, the later is most susceptible.

At Newton Agricultural Station, Deighton (1952) reported that the fungus *Botryodiplodia theobromae* attack onion bulbs. In moist chamber, onions rapidly become covered from the neck downwards by *Aspergillus niger*.

In Denmark Neck rot (*Botrytis allii*) was largely responsible for storage losses of onions (Anon., 1955). In Finland stored onions suffered serious losses from *Botrytis allii* (Anon., 1956).

Ko-SweeSuak; Chang-WooNang; Wang-JawFen; Cherng-ShinJiun; Shanmugasundaram-S; Ko-SS; Chang-WN; Wang-JF; Cherng-SJ (2002) reported that onion bulbs are usually stored in shelters under ambient conditions resulting in severe storage losses. This study aimed at determining whether variation in bulb storability exists among short-day onion cultivars and whether the trait can be improved through conventional breeding. Twelve onion cultivars (Red Pinoy, Serrana/XP8403 (OP), Texas Grano 1025Y, Arad (H), Galil (H), Early Yellow Premium (H), Texas Early Grano 502 (OP), Early Supreme, Dehydrator No. 3, AC50, Granex 429 (H), and Torrens White) with different degrees of storability were selected from preliminary experiments. Bulbs of selected cultivars were grown and stored for 3 months under ambient conditions. Observations were made on disease incidence at harvest, percentage diseased bulbs, and storage disease incidence of bacterial soft rot (BR (*Pseudomonas gladioli* pv. *alliicola* [*Burkholderia gladioli* pv. *alliicola*])), black mould (BM (*Aspergillus niger*), and Fusarium basal rot (*Fusarium oxysporum* f.sp. *cepae*)) after 3 months of storage. Data on bulb characteristics such as bulb fresh weight (FW), dry matter (DM) content, total soluble solids (TSS), and pyruvic acid content were recorded at harvest. Mean storage losses of cultivars ranged from 21 to 99% over 3 years. Heavy rainfall during bulb

development in 1997 may have contributed to higher disease incidence at harvest, higher percentage of diseased bulbs during storage, and lower DM, and TSS of the cultivars. Disease incidences on 'Red Pinoy' and 'Serrana', both in the field and in storage, were significantly lower than in the other cultivars, indicating they are tolerant to major storage diseases and that they could be used as donor parents for genetic improvement of onion storability.

Fan-LH; Song-J; Hildebrand-PD; Forney-CF; Ben-Arie-R (ed.); Philosoph-Hadas-S (2001) reported that the effects of corona discharge on the control of decay in stored onions were investigated. The corona system was operated at 350 Hz and 2.5 kV, and the ozone concentration was controlled at set points of 50 ppb during the day and 250 ppb during the night. Onion quality was assessed after 2 and 4 weeks of storage under the corona system. Corona discharge treated onions had 2 times less mould and less weight loss compared to control onions. Airborne spores concentration was less in the storage room after corona discharge treatment compared to the initial concentration, resulting in low pathogen developments in onions.

Campacci (1962) reported that Anthracnose of onion (*Colletotrichum chardonianum*) caused rot of bulb in field and in storage. The pathogen is responsible for considerable damage in parts of St. Paul's State on local grown variety. Chandra *et al.*, (1964) first observed a Soft rot disease of stored onion bulbs in local markets of India caused by *Sclerotium rolfsii*. Dirty white spots on the outer scale gave a water soaked appearance to the affected area and the whole bulb became rotten.

Vitanov (1967) made a survey on the Soft rot of onion (*Pseudomonas alliicola*). He found that 50% of the onion were affected, the infection being favoured by severe mildew (*Peronospora destructor*) during the growing period. Anon.(1967) reported that Grey rot of onion (*Botrytis allii*) is a serious disease in stored onion in Iran.

Evtyushkin (1968) reported that *Erwinia carotovora* and *E. aroideae* attack onions during growth and storage. In the Krasnodar region of USSR the disease is particularly harmful to common onion. Late varieties are more affected than early. Lutynska (1968) recorded four species of *Botrytis*, (*B. allii*, *B. byssoidea*, *B. cinerea* and *B. squamosa*) and the incidence of rot in storage varied widely with rainfall, an average of 8.27% of the onions being attacked.

Hopper *et al.* (1971) showed that Mycoplasma like bodies (MLB) is associated with onion bulbs sprouting in storage. The authors had taken samples of stored onions randomly from 6 different storage and found that 4 - 8% of stored onions were sprouted. Cother (1974) reported that an internal brown rot caused by a *Pseudomonas* sp. causes heavy losses in stored onion bulbs of Cream Gold Variety in the Griffith district of Australia.

Hussein *et al.*, (1977) studied storage diseases of onions and their incidence in Upper Egypt. The authors collected bulbs from markets and store-houses. Results showed that locality had no effect on isolation frequency of pathogens. Fungi were more frequently isolated than bacteria.

Sharma and Roy (1978) recorded two new soft rot diseases of onion bulbs in storage from India. The diseases were caused by *Aspergillus niger* and *Cephalosporium curtipes*.

Bazzi (1979) isolated the bacterium *Pseudomonas cepacia* from stored onion bulbs with a serious soft rot in Bologna, Italy and its pathogenicity was confirmed.

Wilson *et al.*, (1978) isolated the pathogen *Penicillium cyclopium* causing watery rot of stored English onion in the Cambridge market in February 1977 and believed to be the first report of the disease from U.K. The fungus was also isolated from Spanish onion brought in London and Dutch onions purchased in Cambridge.

Chamberlain-TP; Daly-MJ; Merfield-CN; Senanayake-YDA (ed.); Sangakkara-UR (1999) reported that the effect of EM on onion and sheep production on a commercial organic farm in New Zealand are reported, and the problems of broad acre application of EM are discussed. In a trial in 1995, the effect of EM and organic fertilizers on onion production was investigated. The highest percentage of first grade onions and the second highest yield were observed in the EM treatment. In 1996, 1.3 ha of onions was intensively sprayed with EM from 6 weeks post emergence to 4 weeks before lifting. Such a treatment induced high yields (53 tonnes/ha). Fungal diseases were a major problem in storage causing loss of 50% of the crop (a potential loss of US \$ 15thn000). The growth rates of sheep and lambs grazing on EM treated pasture and drinking water was compared in a separate trial. EM lambs had higher live-weight gains for the first 3 and last weighing and has a higher overall live-weight gain. There was no significant difference between the ewe live-weights. Internal parasite faecal egg numbers were lower in EM-treated lambs.

H. F. Schwartz *et al.*, (1999) reported that Neck rot, gray mold, or leaf and flower blast of onions and garlic is caused by various species of the fungus *botrytis* including *B. allii*, *B. byssoidea*, and *B. squamosa*. *Botrytis cinerea* can infect onion seed heads and cause brown stain. These pathogens reportedly cause storage yield losses of 20 to 30 percent in Colorado, 50 percent in Idaho and 60 percent in Europe. Poor ventilation, high humidity and temperatures greater than 40 degrees can produce storage rot. Condensation on onions brought from cold storage into warm, moist air can increase rot losses during transportation.

Rahim-MA; Bashar-MA; Begum-A; Hakim-MA (1992) reported that the various methods and problems of onion storage in Bangladesh.

Mondal-MF; Pramanik-MHR (1992) reported that the effects of storage temperature and RH, bulb size, cultivar, harvesting date and chamilical treatment pre-and post harvest on storage life of onions are reviewed. It is suggested that

to prolong storage life and minimize storage losses, bulbs should be kept at low temperature ($<15^{\circ}\text{C}$) and low RH (50-70%). Smaller bulb size, application of maleic hydrazide 10 - 20 days before harvesting and application of maleic hydrazide or benomyl after harvest are also recommended.

Currah-L; Proctor-FJ (1990) reported the factors influencing the storage of onions. Preharvest cultural factors, treatment with sprout suppressant, time of harvesting, harvesting and handling damage; onion stores and management strategies are considered.

2.3 Time of Planting

Sidhu *et al.* (1994) produced 1100 kg/ha seed of Punjab Naroya variety using medium to large bulbs. In Sri Lanka Yazawa (1990) suggested from a preliminary trial that decreasing the plant spacing, shading of the roof, use of jungle bees as pollinators and the selection of fully mature bulbs as mother bulbs could improve seed yield.

Gupta and Pathak (1987) reported from India that three summer ploughings reduced the disease severity by 72%, with 24.4-29.8% higher bulb yield, compared with unploughed plots. The early sown crop had lower disease index and higher bulb yield, compared with the crop sown later than 15 September as reported by Munoz *et al.* (1986) studied on the effects on seed production of various factors including cultivar, bulb storage temperature and duration, planting date and bulb diameter. They reported that the seed yields of 300-400 kg/ha obtained from bulbs of cv. Red Creole stored for 70-120 days at $3-12^{\circ}\text{C}$ prior to planting out in the cooler months of October and November. Seed yields increased with bulb diameter. Bulb losses during storage and losses due to *A. porri* infection of the flowering seed stalks were high.

Sandhu *et al.* (1983) studied the incidence of *A. porri*. Onions grown for seed (cv. unspecified), the incidence of *A. porri* was appreciably higher (85.3%) in plants grown from sets than in those grown from seeds (29.5%). Disease

incidence was higher in closely spaced plants (45×30 cm) than in those spaced at 60×45 cm. The early sown crop (1 November) was always more susceptible to *A. porri* than the late sown crop (1 December).

Kumar-S; Ram-M; Giberti-G (ed.); Craker-L (ed.); Lorenz-M (ed.); Mathe-A (ed.); Giulietti-A (1999) reported that field experiments were conducted at Lucknow, India, during 1993-96, to determine the conditions for mint cultivation, after rice-vegetable(s), rice-potato, rice-legume and rice-wheat crop sequences, in the northern Indian plains. Cultivars, date of planting and density of 2-month-old nursery-raised plantlets, and N-fertilizer rates were the variables. A 90-day-old transplanted crop of the mint cv. Kalka obtained with 2.5 X 10⁵ plants and treated with 160 kg N/ha gave an essential oil yield of about 164 kg/ha (about 55% of that of the normal duration crop of the highest yielding cv. Himalaya). The late crop of cv. Gomti could be harvested twice. The leaf : stem ratio was observed to be a dependable morphological indicator of herbage maturity in the mint crops. The leaf : stem ratio for a minimum essential oil yield of about 130 kg/ha varied from 1.0 to 1.5 for different cultivars. It was concluded that the late transplanting schedule of mint cropping could save at least 3 months and thus allows food crops such as mustard, potato, grain legumes, onion, garlic and wheat to be grown in the same field prior to mint. Cultivation of one or more food crops in between rice and seedling-transplanted mint could benefit food production and bring to the farmer higher levels of profit/ha than those accruing from rice-sucker-planted mint.

Award *et al.*, (1978) reported that the onions transplanted on 1 December had the most *Alternaria porri* infection. Disease severity decreased significantly when plant density was reduced. Maude *et al.*, (1980) reported that in 1973-74 and 1974-75, *Botrytis cinerea* caused losses of 26% and 37% respectively in onion crops grown at Wellesbourne.

Gaviola-JC; Planchuelo-AM; Oliva-RN (1999) reported that trials were carried out in San Carlos Department, Mendoza, Argentina, in 1994-95 and 1995-96 to determine the possibility of obtaining 2 onion seed production cycles. In both years, bulbs of the long-day onion cv. Valcatorce INTA were planted on 4 dates between mid-March and early August. The morphological development of bulbs and scapes is described. The total number of bulbs produced/plant increased with later planting dates, resulting in greater regrowth in the second cycle and higher seed production at the second flowering. Planting between the end of June and early August gave the best results.

El-Aweel-MAT; Ghobashi-AA (1999) reported that two trials carried out during 1997-98 and 1998-99 in Oman showed that final seed yield in onion cv. Omani was influenced by planting date of bulbs. Early planting (20 October) reduced seed yield by 42.9 and 13.5% compared with later planting (10 November) in 1997-98 and 1998-99, respectively. Considerable losses were recorded due to planting on 30 November and 20 December. Percentage seed germination was improved by early planting (20 October and 10 November). The number of days to flowering decreased significantly with delayed planting. Bulbs planted on 10 November 1997 had the longest flowering stalks. However, the length of the flowering stalk decreased with delayed planting in 1998-99 due to cold weather conditions prevailing during the experimental period. Differences recorded in the response of some parameters between 2 trials were attributed to climatic conditions.

2.4 Onion Variety

Intensity of *A. porri* infection was recorded by Bhangale and Joi (1985) on 74 cultivars of onion grown under field conditions. No resistant cultivars were observed, but Gujarat and 1003 were classed as moderately susceptible to the disease.

Alves (1983) studied the incidence of purple spot (*A. porri* Ell. Cif.) on onion cultivars and hybrids in Manaus, Amazonia. Plants were divided into five

classes on the basis of natural infection in the field. Incidence was 30-50% (class III) in most cases, only the hybrid P×76 having plants in class I (0-10%).

Padule and Utikar (1982) tested 32 onion cultivars under field conditions against purple blotch and recorded all the cultivars to be susceptible.

CHAPTER - 3

CHAPTER THREE

SURVEY

3.1 Survey of Field Diseases

a) Selection of Location:

The survey was conducted in the farmers and in commercial field plots of three selected localities of Rajshahi during December 2001 to March 2002. These selected areas were:

- (1) In and around Rajshahi University Campus.
- (2) Taherpur village under Baghmara Thana and
- (3) Singa village under Durgapur Thana both in Rajshahi district.

(b) Method of Survey:

During the course of survey of field diseases, the above-mentioned localities were visited from time to time to find out the occurrence of each kind of disease. Records were taken on two stages of growth of plants, seedling stage and mature stage. Three and five replications were taken randomly from each field plot from No. I and No. II localities respectively. In each replication. 100 plants were counted for disease survey. In this way in each month a total number of 27,000 plants in 270 replications and 15,000 plants in 150 replications were counted from No. I and No. II localities respectively, to find out the percentage of infected plants.

During the survey, seven kinds of diseases were observed in all the selected localities under field conditions. These were Purple blotch (*Alternaria porri*), Leaf mold (*Stemphylium botryosum*), Blast (*Botrytis allii*), White rot (*Sclerotium cepivorum*), Downy mildew (*Peronospora destructor*), Smut (*Urocystis cepulae*) and Pink root rot (*Pyrenochaeta terrestris*) diseases.

It may be mentioned here that, out of seven kinds of diseases found in field condition, record on the prevalence of Pink root rot disease was discarded, because it was not possible to identify the Pink root rot infected plants without uprooting them.

3.2 Survey of the Storage and Transit Diseases

a) Selection of Location:

The survey was conducted in different 'Arots' (store house) of two-selected markets of Rajshahi Metropolitan City and one of Therpur village bazar market during the months of April to November, 2002. The different 'Arots' (store house) were:

- (i) Shaheb Bazar Market, Rajshahi.
- (ii) Katakhal Bazar Market, Rajshahi.
- (iii) Taherpur villge Bazar Market under Rajshahi District.

b) Selection of Varieties for Survey:

Two varieties of onions 'Deshi' and an 'Indian' variety were stored in these 'Arots' (store house).

- (i) The Deshi variety, often referred to as Taherpuri is smaller in size and has very strong pungent odour, and
- (ii) The Indian variety is larger in size, having fleshy scales and has very light pungent odour.

c) Method of Survey:

During the survey period, the different 'Arots' of the above mentioned markets were visited each month from April to November, 2002. Every month, 20 bags of onions were randomly selected from each variety of onion. From each bag, 12 seers (11.4 kg approximately) of onions were taken out randomly. In this way, in each month 5 mds (186.05 kg approximately) of onions of each variety

in each market were surveyed. The diseased bulbs were then sorted out and weighed separately. By this way, the amount of loss due to diseases in the storage in each month was calculated. The rotted bulbs, which were identified by visual symptoms, were recorded separately under each disease category.

During the course of survey 4 kinds of diseases found in storage condition like Grey neck rot (*Botrytis allii*), Soft rot (caused by Bacteria), Black mold rot (*Aspergillus niger*) and White rot (*Sclerotium cepivorum*).

In the field, different diseases were recognized by visual observation of the symptoms, and then the samples of diseased specimens were brought to the laboratory for isolation of the pathogen and confirmation of the disease.

d) Storage and Transit conditions affecting the development of diseases:

From the time of harvest of onions until they reach to the consumers, sufficient care should be taken during storing, packing, transporting, handling and distribution of onions.

Contamination during harvest and transit is very important for the development of diseases in storage and the extent of loss. Factors, which may be responsible for the development of diseases in storage and transit, are as follows:

i) Conditions of 'Arots' (store house):

Most of the 'Arots' are dirty inside. The floors as well as the wall remain damp. These conditions increase the chance of infection of healthy bulbs from the affected ones.

ii) Packing of Onions:

The packing of onion is considered necessary for convenient distribution of the product to the consumers. The onions are packed in gunny bags. During the 'Chalan' of onion the sellers use the old gunny bags and they use the same one without disinfection for several times. So, it is obvious that many of these bags

are contaminated from the diseased bulbs of the previous 'Chalan' and it increases the chances of contaminations of the unaffected healthy bulbs during the next 'Chalan' under suitable conditions.

iii) Transportation and Handling of Onions:

Transportation has also been referred to as storage as wheels. During transportation the bags are piled one upon another, which leads to contamination of the unaffected bulbs of one bag from the affected ones of other bags. During transportation and handling of onion bulbs, mechanical injuries such as cracking, bruising, splitting etc., occur which lead to infection of bulbs more easily by bulb-rotting microorganisms.

3.3 Survey of Date of Planting of Onion bulb for Data Collection

a) Selection of Location:

The survey was conducted at the Botanical Garden, Rajshahi University Campus, Rajshahi during 2001-02 and 2002-03. The crop period was from November to April.

b) Method of Survey:

During the course of survey, the fields were visited from time to time and records were taken on Seed stalk/hill, Seed stalk height, Umbell diameter, PDI (per cent disease index) and Seed yield (kg/ha). Three replications were taken randomly from each field plot from No. I and No. II localities respectively.

From this study it is evident that onion is an important crop, which is affected by different diseases caused by different pathogens, and detail studies are needed. Thorough and systemic surveys on the prevalence of the disease have not yet been carried out.

CHAPTER - 4

CHAPTER FOUR

MATERIALS AND METHODS

4.1. Isolation and identification of pathogen

4.1.1 Collection of diseased samples:

During the course of survey of field-diseases, different onion fields of selected localities were visited from time to time and different types of diseased symptoms were carefully observed and recorded. For storage diseases 'Arots' (store house) of these selected markets were visited from time to time during the period of survey. Diseases were first identified by visual symptoms and then samples were collected in plastic bags and brought to the laboratory for isolation and identification of the pathogens.

4.1.2 Methods of isolation:

Isolation and identification of various fungal pathogens were made in 3 ways:

- a) By direct observation;
- b) By blotter method; and
- c) By growing on Potato Dextrose Agar (PDA) medium.

a) Direct observation:

The diseased samples having the fruiting bodies were directly identified under a stereoscopic microscope. In case of Pink-root rot disease, the infected roots having minute fruiting bodies (pycnidia) were sectioned with the help of a new blade and were observed under the microscope. But in case of White rot disease; the infected bulbs were kept in plastic bags for the growth of mycelium and sclerotia. The bags were tied with a piece of thread putting only one bulb in each plastic bag. Within 3-4 days the plastic bags were covered with profusely branched, white, fluffy mycelium. After some days numerous

black spherical sclerotia formed which were embedded within the mycelium and the fungus was then identified.

b) Blotter method:

The petridishes were at first surface sterilized. Three layers of sterile filter papers were moistened by dipping them in sterile water and were placed on the bottom of each petridish. The diseased plant portions were cut into small pieces along with some healthy tissues and then kept on the laboratory desk for incubation at room temperature ($20^{\circ}\text{C} \pm 2^{\circ}\text{C}$) for the growth and sporulation of the fungus. The sporulating fungus which grew on the wet blotters, were identified under the stereoscopic microscope.

c) PDA medium:

From the necrotic areas of diseased leaves, small pieces of inocula along with a portion of healthy tissues were prepared and were surface sterilized with mercuric chloride (HgCl_2) solution for 1.0 - 1.5 minute. But in case of isolation of the diseased bulbs, they were washed first in tap - water to remove dusts or other inert matters attached to the surface of the bulbs. Then small pieces of diseased portions were cut out at the junction of the diseased and healthy tissues and then the inocula were subjected to surface sterilization as mentioned above. These inocula were then washed with sterile water for 3 - 4 times and then placed aseptically in the petridishes containing acidified PDA media. The petridishes were incubated at room temperature for several days. The plates were examined daily for any fungal growth on the media around the inocula. The fungi thus growing out from the inocula were transferred to fresh culture plates from where sub-cultures were made into PDA plates for identification of the organism.

In case of bacterial diseases isolations were not done. The disease was identified by visual symptoms only.

4.2. Incidence of Different Field Diseases of Onion

Survey of different field diseases of onion seed crop was conducted in three localities at Rajshahi District from December 2001 to March 2002. Most of the onion cultivars are local land races, grown in the country and named as Taherpuri, Jhitka, Faridpuri bhati etc. Disease samples were collected during the survey to identify the causal pathogen. Pathogenecity test of different fungi was tested on a local cultivar (Taherpuri) by inoculation tests. Incidence of different field diseases was recorded on a 0-5 scoring scale (Sharma, 1986) as follows:

0 = no disease symptoms

1 = a few spots towards the tip, covering less than 10% leaf area

2 = several dark purplish brown patches covering less than 20% leaf area

3 = several patches with paler outer zone, covering up to 40% leaf area

4 = long streaks covering up to 75% leaf area or breaking of leaves/ seed stalks from the centre

5 = complete drying of the leaves/seed stalks or breaking of the leaves/ seed stalks from the base

The per cent disease index (PDI) was calculated as below:

$$\text{PDI} = \frac{\text{Total sum of numerical ratings}}{\text{Number of observations}} \times \frac{100}{\text{Maximum disease rating}}$$

4.3. Measurement of Loss of Bulbs due to Storage and Transit Diseases of Onion in case of 'Deshi' and 'Indian' variety

Survey of different storage diseases of onion seed crop was conducted in different 'Arots' (store house) of three selected markets at Rajshahi District during the months of April to November 2002. From the time of harvest of onions until they reach to the consumers, sufficient care should be taken during storing, packing, transporting, handling and distribution of onions.

Contamination during harvest and transit is very important for the development of diseases in storage and the extent of loss.

4.4. Effect of Date of Planting and Onion Cultivars on the severity of purple blotch and seed yield of Onion

The experiment was conducted at the Botanical Garden, Rajshahi University Campus, Rajshahi during 2001-02 and 2002-03. The crop period was from November to April. The experiment was laid out in RCBD factorial. Two cultivars viz. 1st November (D_1), 15th November (D_2), 1st December (D_3) and 15th December (D_4) for the second factor. The treatments were replicated three times. Plant spacing was maintained as row to row 30 cm and plant to plant 15 cm. A raised bed (3m $\times$ 2m) was considered for each unit plot. There was 50 cm space in between blocks plots and 1 m in between blocks.

Farmyard manure (FYM) and fertilizers- N, P_2O_5 , K_2O and S were applied @ 10 tons, 200 kg, 150 kg, 80 kg per hector respectively (Bokshi *et al.*, 1989). Urea, tripple super phosphate, muriate of potash and gypsum were applied as sources of N, P, K and S respectively. The entire quantity of FYM, TSP (tripplesuper phosphate) and gypsum were applied at the time of final land preparation. Urea and MP (muriate of potash) were applied in four and two equal installments respectively during the cropping season. Urea was applied for the first time at final land preparation, and 45, 65 and 85 days after planting. MP was applied at final land preparation and 45 days after planting. Adequate moisture was maintained by proper irrigation in the field. The experimental plots were kept free of weeds by periodical weeding. Data were recorded on the number of seed stalk per hill, seed stalk height, umbel diameter, incidence of purple blotch and seed yield (g) per plot. Yield of seed per plot was converted to yield (ton) per hector. The incidence of disease was recorded on a 0-5 scoring scale (Sharma, 1986). The data of various parameter recorded in the experiment were analyzed statistically following the methods of Gomez and Gomez (1984). Mean of different parameters were compared by DMRT. In

case of PDI, analysis was done after arcsine transformation. The experiment was repeated in the next rabi season using the same treatments and following the same design during November 2002 to April 2003.

Preparation of Lactophenol:

Lactophenol solution used as a mounting medium consisted of the following composition (Ainsworth, 1963):

Phenol crystals	20 gm
Lactic acid	20 ml
Glycerol	40 ml
Distilled water	20 ml

After weighting the constituents were taken in a conical flask to which distilled water was added. The flask was shaken well till a homogenous solution was obtained.

Preparation of Lactophenol - Cotton Blue Stain:

One gram of cotton blue added to 100 ml of lactophenol and shaken well till it was dissolved. The solution of lactophenol and lactophenol cotton blue were stored in a cool dark place.

Preparation of Slides:

A suitable portion of culture of pathogens, either from host tissue, or from PDA plate was selected under a stereoscopic binocular microscope and was taken out with the help of forceps and needles and put in 1 or 2 drops of lactophenol on clean slide. It was then gently warmed by heating and cooling over a low flame of spirit lamp for 6 to 8 times, but was never allowed to boil. Whenever needed, the material was stained with small quantity of cotton blue. A clean cover glass was then placed over the material, excess fluid was removed by soaking with blotting paper and examined under compound microscope.

Preparation of Clearing Reagent:

Throughout the present investigation corning glasswares and chemicals supplied by E. Mark and BDH were used. All glasswares were cleaned with a solution of Potassium dichromate and Sulphuric acid in the following proportions (Ricker and Ricker, 1936).

Potassium dichromate	60 gm
Sulphuric acid	60 ml
Water	1000 ml

Petridish and other glasswares were sterilized for three hours in hot air oven at 160°C.

Preparation of 0.1% Mercuric Chloride Solution:

Mercuric chloride solution is used for surface sterilization of the diseased sample.

Mercuric chloride	100 mg
Distilled water	100 ml

Shaken well till it was dissolved.

Preparation of Culture Media:

The following culture media were used:

Potato Dextrose Agar (PDA) Medium:

Peeled and sliced potatoes	200 gm
Dextrose	15 gm
Agar	20 gm
Distilled water	1000 ml

Garrett's (1936) agar disc method was used for inoculation, except where otherwise stated. The inoculum was taken from 14-15 days old culture and size of the inoculum was the same in all cases. After inoculation the culture was incubated at $28 \pm 2^{\circ}\text{C}$ for 15 days for mycelial growth and conidial formation.

CHAPTER - 5

CHAPTER FIVE

RESULTS

In the present study, survey was undertaken to have a preliminary knowledge about the field diseases, storage diseases of onion and effect of date of planting and onion cultivars on the severity of purple blotch and seed yield of onion.

The study was undertaken to identify seven kinds of field diseases and four kinds of storage diseases of onion. These diseases were caused by different fungi and bacteria.

5.1 Experiment 1: Incidence of Different Field Diseases of Onion and Pathogenecity Test of Different Fungal Pathogen

The survey of the field diseases of onion in three selected localities of Rajshahi revealed that onions suffered from seven different diseases. The survey was conducted during the growing season of onion from December 2001 to March 2002.

The causal fungi *Alternaria porri* (Ellis) Cif. was identified on the disease samples collected from different locations. *A. porri* was reported by many workers to be the causal pathogen of Purple blotch of onion (Linares *et al.*, 1988; Bose and Som, 1986; Anonymous, 1985, Munoz *et al.*, 1984). During the present study the incidence of Purple blotch (*A. porri*) was more severe from the beginning of the growing season till harvest than other diseases.

In the selected localities the incidence of Purple blotch (*Alternaria porri*), Leaf mold (*Stremphylium botryosum*), Blast (*Botrytis allii*), Smut (*Urocystis cepulae*), and Downy mildew (*Peronespora destructor*) was more or less same and caused severe leaf damages. Purple blotch (*A. porri*) was severe from the beginning of the growing season till harvest but Blast (*B. allii*) was severe only in mature stage and not in seedling stage (Tables 1 & 2). The higher incidence of Purple blotch (99.98%) was recorded in March at Rajshahi University

Campus (Botanical Garden) than in Singa village under Durgapur Thana (99.57%).

The incidence of Leaf mold (*Stemphylium botryosum*) was severe in mature stage than seedling stage in both localities (Tables 1 & 2). The higher incidence of Leaf mold (99.87%) was recorded in March at Rajshahi University Campus (Botanical Garden) than in Singa village under Durgapur Thana (99.28%). Leaf mold disease was also severe from the beginning of the growing season till harvest.

The incidence of Blast (*Botrytis allii*) was absent in seedling stage at Rajshahi University Campus but it was present at Taherpur village under Baghmara Thana in the month of December (Tables 1 & 2). The higher incidence of Blast (99.24%) was recorded in March at Rajshahi University Campus (Botanical Garden) than in Singa village under Durgapur Thana (99.14%).

The incidence of White rot (*Sclerotium cepivorum*) was nonsignificant in mature stage and was absent in seedling stage (Tables 1 & 2).

The incidence of Smut (*Urocystis cepulae*) was also severe in mature stage. The higher incidence of Smut (99.18%) was recorded in March at Rajshahi University Campus (Botanical Garden) than in Singa village under Durgapur Thana (99.10%). Smut disease was less severe from the beginning of the growing season.

The incidence of Downy mildew (*Peronospora destructor*) was more severe in mature stage but less than these diseases. Downy mildew disease also showed from the seedling stage in both the localities (Tables 1 & 2). The higher incidence of Downy mildew (88.52%) was recorded in March at Rajshahi University Campus (Botanical Garden) than in Singa village under Durgapur Thana (85.12%). Downy mildew disease was less severe from the beginning of the growing season.

Pink root rot (*Pyrenochaeta terrestris*) disease was observed only in one location (in and around Rajshahi University Campus specially Botanical Garden) but was absent in the other (Taherpur and Singa villages).

It may be mentioned here that the Pink root rot was not recorded because it is not possible to recognize the affected plants without uprooting the plants.

Table 1. Occurrence of Field Diseases of Onion in Botanical Garden, Rajshahi University Campus, Rajshahi in the growing season of 2001 – 02.

Stages of growth	Locality	Months	Percentage of infected plants					
			Purple blotch	Leaf mold	Blast	White rot	Smut	Downy mildew
Seedling stage	Botanical Garden	December	89.72	31.10	0	0	15.60	23.36
	Botanical Garden	January	98.83	63.93	16.20	0	42.92	36.82
Mature stage	Botanical Garden	February	99.34	95.43	94.17	3.42	93.53	76.42
	Botanical Garden	March	99.98	99.87	99.24	5.27	99.18	88.52

Table 2. Occurrence of Field Diseases of Onion in Taherpur village under Baghmara Thana and Singa village under Durgapur Thana both in Rajshahi District in the growing Season of 2001- 02.

Stages of growth	Locality	Month	Percentage of infected plants					
			Purple blotch	Leaf mold	Blast	White rot	Smut	Downy mildew
Seedling stage	Taherpur	December	91.53	28.91	0.45	0	9.96	15.32
	Taherpur	January	96.75	56.98	28.67	0	31.63	38.23
Mature stage	Singa	February	97.98	95.21	93.18	1.18	86.54	59.92
	Singa	March	99.57	99.28	99.14	2.24	99.10	85.12

5.2 Experiment 2: Incidence of Different Storage and Transit Diseases of Onion and Pathogenecity Test of Different Pathogens

A preliminary survey of the storage & transit diseases of onions in three selected markets in Rajshahi revealed that onions suffer from four kinds of diseases namely, Grey neck rot (*Botrytis allii*), Soft rot (caused by bacteria), Black mold rot (*Aspergillus niger*) and White rot (*Sclerotium cepivorum*). In different 'Arots' (store house) the loss of Indian variety due to diseases was about 5 times more than the Deshi variety (Tables 6 & 7). The results of the survey of storage diseases of onions are shown in Tables 3, 4, 5, 6 & 7.

Among the three selected localities, incidence of diseases was more in Katakhal bazar market and in Taherpur village bazar market compared to Shaheb bazar market (Table 5). Comparative loss in Shaheb bazar market was less which may be due to the fact that the 'Arots' (store house) in this bazar are clean, well ventilated and dry.

The content of loss in both the varieties was found to be greater in the first four months (April-July) of survey.

The highest loss in Deshi variety (1.83%) was observed in Taherpur bazar and that for Indian variety it was observed to be (9.23%) in Taherpur bazar in the month of July (Tables 3 & 4). In both Deshi and Indian varieties highest loss was caused by Grey neck rot during the period of survey (Tables 6 & 7).

Grey neck rot was observed throughout the whole period of survey (Tables 3, 4, 6 & 7). Grey neck rot disease inflicted much more damage in Indian variety than in the Deshi onion (Tables 6 & 7). Soft rot loss also caused considerable loss during transit and storage. The disease became more prevalent in April both in Deshi (0.42%) and Indian (3.54%) varieties and gradually declined in the following months. Disease incidence was much higher in Indian variety (Tables 6 & 7).

Black mold rot was found throughout the whole period of survey and the loss was more or less the same in all the months in both Deshi and Indian varieties (Tables 6 & 7).

White rot disease was found at the beginning of survey and the incidence was somewhat higher in Indian variety (0.66%) than the Deshi variety in April. In case of Deshi variety the disease was not observed from June to October (Table 6). The disease reappeared in November when the temperature is low.

Table 3: Loss of bulbs due to diseases in Deshi variety of onions in different 'Arots' (store house) of three localities during storage season of 2002.

Months	Locality	Percentage of loss*	Nature of diseases
April	Shaheb bazar	1.21	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	1.28	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	1.35	Grey neck rot, Soft rot, Black mold rot, White rot
May	Shaheb bazar	1.26	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	1.36	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	1.52	Grey neck rot, Soft rot, Black mold rot, White rot
June	Shaheb bazar	1.45	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	1.54	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	1.75	Grey neck rot, Soft rot, Black mold rot, White rot
July	Shaheb bazar	1.43	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	1.58	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	1.83	Grey neck rot, Soft rot, Black mold rot, White rot
August	Shaheb bazar	0.87	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	0.93	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	1.12	Grey neck rot, Soft rot, Black mold rot, White rot
September	Shaheb bazar	0.38	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	0.45	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	0.57	Grey neck rot, Soft rot, Black mold rot, White rot
October	Shaheb bazar	0.28	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	0.36	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	0.82	Grey neck rot, Soft rot, Black mold rot, White rot
November	Shaheb bazar	0.25	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	0.39	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	0.95	Grey neck rot, Soft rot, Black mold rot, White rot

*Percentage was calculated on the basis of 5 mds (186.05 kg approximately) of onions examined during survey in each month in each bazar.

Table 4: Loss of bulbs due to diseases in Indian variety of onions in different 'Arots' (store house) of three localities during storage season of 2002.

Months	Locality	Percentage of loss*	Nature of diseases
April	Shaheb bazar	3.32	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	4.2	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	5.34	Grey neck rot, Soft rot, Black mold rot, White rot
May	Shaheb bazar	3.38	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	4.26	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	6.38	Grey neck rot, Soft rot, Black mold rot, White rot
June	Shaheb bazar	4.25	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	5.62	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	8.28	Grey neck rot, Soft rot, Black mold rot, White rot
July	Shaheb bazar	5.53	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	7.89	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	9.23	Grey neck rot, Soft rot, Black mold rot, White rot
August	Shaheb bazar	2.28	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	3.21	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	4.26	Grey neck rot, Soft rot, Black mold rot, White rot
September	Shaheb bazar	1.25	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	2.27	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	4.1	Grey neck rot, Soft rot, Black mold rot, White rot
October	Shaheb bazar	1.12	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	2.03	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	3.39	Grey neck rot, Soft rot, Black mold rot, White rot
November	Shaheb bazar	1.01	Grey neck rot, Soft rot, Black mold rot, White rot
	Katakhali	2	Grey neck rot, Soft rot, Black mold rot, White rot
	Taherpur	2.89	Grey neck rot, Soft rot, Black mold rot, White rot

*Percentage was calculated on the basis of 5 mds (186.05 kg approximately) of onions examined during survey in each month in each bazar.

Table 5: Mean loss of bulbs due to diseases in ‘Deshi’ and ‘Indian’ varieties of onions during storage season of 2002.

Variety	Locality	Mean percentage of loss
Deshi	Shaheb bazar	0.8913
	Khatakhali	0.9863
	Taherpur	1.2388
Indian	Shaheb bazar	2.7675
	Khatakhali	3.935
	Taherpur	5.4838

Table 6: Loss of Deshi variety of onions due to different diseases in the storage season of 2002.

Months	Loss in percentage				Total percentage of loss (month wise)
	Grey neck rot	Soft rot	Black mold rot	White rot	
April	0.75	0.42	0.22	0.08	1.47
May	1.03	0.18	0.17	0.07	1.45
June	1.43	0.09	0.15	0	1.67
July	1.57	0.03	0.14	0	1.74
August	0.75	0	0.17	0	0.92
September	0.28	0	0.18	0	0.46
October	0.08	0	0.24	0	0.32
November	0.06	0	0.23	0.05	0.34
Total percentage of loss (disease wise)	0.74375	0.09	0.1875	0.025	1.04625

Table 7: Loss of Indian variety of onions due to different diseases in the storage season of 2002.

Months	Loss in percentage				Total percentage of loss (month wise)
	Grey neck rot	Soft rot	Black mold rot	White rot	
April	1.72	3.54	0.19	0.66	6.11
May	2.65	3.06	0.18	0.33	6.22
June	3.53	2.86	0.15	0.06	6.6
July	3.56	2.56	0.12	0	6.24
August	2.21	0.72	0.14	0	3.07
September	1.15	0.05	0.17	0	1.37
October	1.13	0.03	0.19	0	1.35
November	1.1	0.02	0.19	0	1.31
Total percentage of loss (disease wise)	2.13	1.6	0.17	0.13	4.03

5.3 Experiment 3: Effect of Date of Planting and Onion Cultivars on the Severity of Purple Blotch and Seed Yield of Onion

5.3.1 Crop season 2001- 02

Four dates of planting used in the study during 2001-02 showed significant difference among themselves in all parameters (Table 8). The highest seed stalk/ hill was observed in November 1 planting followed by November 15 planting and they were statistically similar. The lowest number of seed stalk/hill was recorded in December 15 planting and it was significantly different as compared to December 1 planting. Seed stalk height varied from 61.05 to 74.22 cm. The maximum seed stalk height was observed in November 1 planting followed by December 1 planting and the minimum was found in December 15 planting. Umbel diameter was maximum in November 1 planting followed by December 1 planting and the smaller size of umbel was observed in December 15 planting. The highest PDI was recorded in December 15 planting (81.82%) followed by December 1 planting (73%). The lowest PDI was recorded in November 15 planting (44.82%) followed by November 1 planting (56%). The highest seed yield was recorded in November 15 planting (688.72 kg/ha) followed by November 1 planting (623.45 kg/ha). The lowest seed yield was recorded in December 15 planting (219.28 kg/ha).

In case of onion cultivar, the highest seed stalk/hill, umbel diameter and yield/ha were recorded 2.94, 5.31 cm and 515.34 kg, respectively in Taherpuri. The highest PDI was recorded in Jhitka cultivar as compared to Taherpuri.

Interaction effect of date of planting and variety on different parameters was significant. The highest number of seed stalk/hill was recorded in $V_1 \times D_1$ followed by $V_1 \times D_2$ and $V_2 \times D_1$. The minimum number of seed stalk/hill was recorded in $V_2 \times D_4$. The maximum seed stalk height was recorded in $V_1 \times D_1$ followed by $V_2 \times D_1$ and $V_2 \times D_3$. The lowest seed stalk height was recorded in $V_1 \times D_4$. The treatment $V_1 \times D_1$ produced the highest umbel diameter. The smallest size of umbel was observed in $V_2 \times D_4$ followed by $V_2 \times D_3$ and $V_1 \times$

D₄. The lowest PDI was recorded in V₁ X D₂ followed by V₂ X D₂. On the other hand, the highest PDI was recorded in V₁ X D₄. The maximum seed yield/ha was found in V₁ X D₂ followed by V₂ X D₂ and V₁ X D₁. The lowest yield of onion seed/ha was recorded in V₂ X D₄ (Table 8).

The number of seed stalk/hill was significantly different from rest of the treatment combinations except V₁ X D₂. The seed stalk number among V₁ X D₂, V₂ X D₁ and V₂ X D₂ was statistically similar. The seed stalk/hill in V₂ X D₄ was also statistically similar to those of V₁ X D₃, V₁ X D₄ and V₂ X D₃. The seed stalk height in V₁ X D₁ did not differ significantly as compared to V₁ X D₃, V₂ X D₁, V₂ X D₂ and V₂ X D₃. The umbel diameter was significantly higher in V₁ X D₁ as compared to rest of the treatment combinations except V₁ X D₃ and V₂ X D₁. Considering the PDI value, it appeared that V₂ X D₂ expressed significantly the best combination in reducing disease severity as compared to rest of the treatment combinations except V₁ X D₁ and V₁ X D₂. The treatment combination V₂ X D₄ was statistically similar to V₁ X D₄ in respect of PDI. In respect of seed yield/ha, V₁ X D₂ was statistically similar to V₂ X D₂ and V₁ X D₁ but differed significantly from rest of the treatment combinations. The seed yield from V₂ X D₄ was not statistically different from V₁ X D₄ (Table 8).

Table 8: Effect of date of planting and variety on plant growth, purple blotch severity and seed yield of onion in Botanical Garden, Rajshahi University Campus during 2001-02.

Treatment	Seed stalk/hill	Seed stalk height (cm)	Umbel diameter (cm)	PDI	Seed yield (kg/ha)
D ₁ (November 1)	3.34 a	74.22 a	7.43 a	56.00 b	623.45 a
D ₂ (November (15)	3.18 a	65.6 b	5.92 b	44.82 a	688.72 a
D ₃ (December 1)	2.48 b	71.08 ab	6.02 b	73.00 c	456.63 b
D ₄ (December (15)	2.31 b	61.05 c	5.44 c	81.82 d	219.28 c
Variety					
V ₁ (Taherpuri)	2.94 a	68.91 a	5.31 a	65.93 a	515.34 a
V ₂ (Jhitka)	2.72 a	71.41 a	4.66 b	67.91 a	475.26 a
Interaction					
V ₁ x D ₁	3.61 a	75.15 a	6.68 a	54.58 b	639.21 ab
V ₁ x D ₂	3.35 ab	66.36 bcd	6.14 bc	43.52 a	695.15 a
V ₁ x D ₃	2.32 d	70.54 abc	6.45 ab	73.01 c	456.82 bc
V ₁ x D ₄	2.35 d	61.85 d	5.75 c	82.28 d	214.15 d
V ₂ x D ₁	3.02 bc	73.42 a	6.28 ab	55.32 b	619.23 ab
V ₂ x D ₂	2.91 bc	70.86 ab	5.75 c	45.25 a	682.92 a
V ₂ x D ₃	2.62 cd	72.58 a	5.68 cd	75.01 c	412.82 c
V ₂ x D ₄	2.24 d	64.19 cd	5.25 d	83.31 d	208.27 d

Means in a column under planting date or variety or their interaction followed by same letter are not significantly different ($P = 0.05$) according to DMRT (in case of PDI analysis was done after arcsine transformation).

5.3.2 Crop season 2002-03

The results on the effects of date of planting and onion cultivar on plant growth, purple blotch and seed yield during 2002-03 are presented in Table 9. The effect of date of planting on seed stalk/hill was not significant. The seed stalk height of plants and umbel diameter of November 1 planting were statistically similar to those planted in November 15 but significantly different from those planted in December 15. The PDI values of purple blotch of onion seed crop were significantly different among the dates of planting having maximum severity at November 15 followed by November 1, December 1 and December 15. The highest severity was recorded in December 15 planting and the lowest in November 15 planting. The highest yield of onion seed/ha was observed in November 15 planting followed by November 1 and December 1 plantings.

In case of Taherpuri, The seed stalk height; umbel diameter and yield/ha were higher as compared to Jhitka. The lowest PDI was recorded in Taherpuri, as a result the highest yield of seed were recorded in Taherpuri as compared to Jhitka.

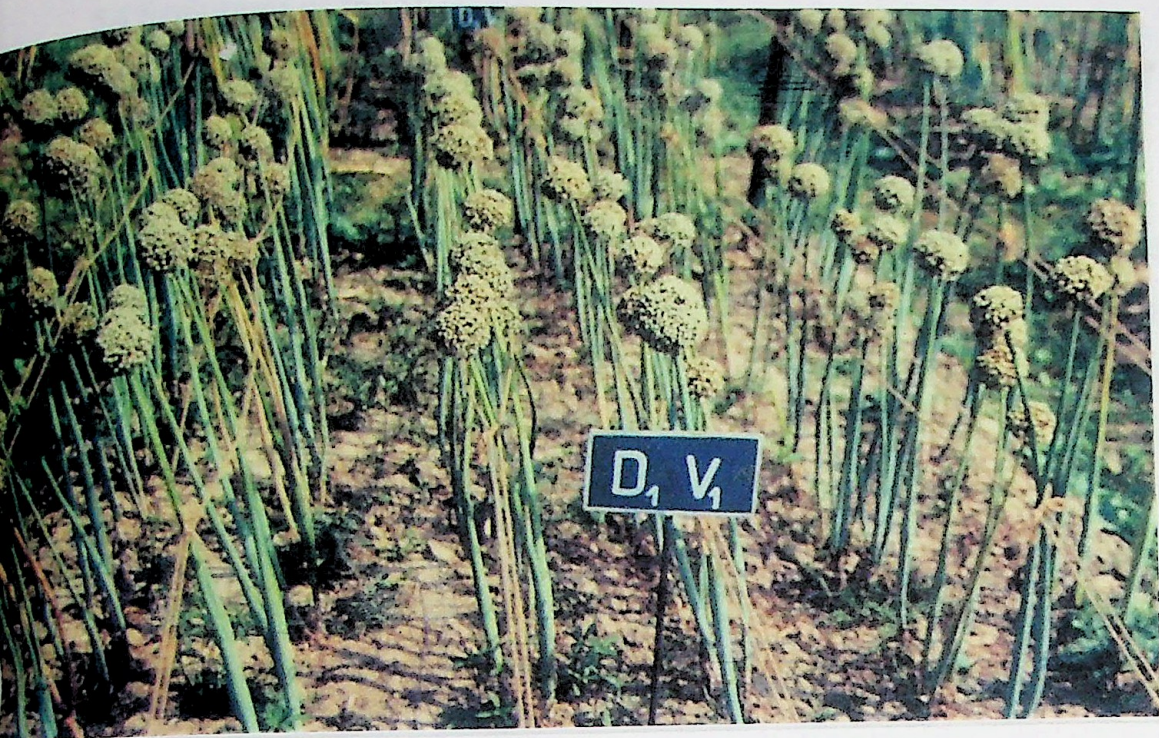
Interaction effects of date of planting in reducing purple blotch of onion seed crop and seed yield are presented in Table 9. In case of seed stalk/hill, the highest number was recorded in $V_2 \times D_2$ followed by $V_1 \times D_3$ and $V_1 \times D_1$. The lowest number of seed stalk/ hill was recorded in $V_1 \times D_4$. The highest seed stalk height was recorded in $V_1 \times D_1$ and the lowest in $V_2 \times D_4$ (Plate A). Large umbel diameter was observed in $V_1 \times D_1$ followed by $V_1 \times D_2$, $V_1 \times D_3$ and $V_2 \times D_2$. The lowest diameter of umbel was recorded in $V_2 \times D_4$. The lowest PDI was of purple blotch recorded in $V_1 \times D_2$ and the highest in $V_2 \times D_4$. The highest yield was obtained in $V_1 \times D_2$. The lowest yield of seed was recorded in $V_2 \times D_4$ followed by $V_1 \times D_4$ and $V_2 \times D_3$. In 2002-03 crop season, significant effect of all the attributes was observed in interaction effect. Although higher number of seed stalk/hill was recorded by $V_2 \times D_2$

numerically, but it was statistically insignificant with all treatment combinations except $V_1 \times D_4$. Significantly maximum plant height was measured in $V_1 \times D_1$ and it did not differ significantly from the under $V_1 \times D_2$, $V_1 \times D_3$, $V_2 \times D_1$, $V_2 \times D_2$ and $V_2 \times D_3$. In case of umbel diameter, there was no significant difference among the treatments, $V_1 \times D_1$, $V_1 \times D_2$ and $V_2 \times D_2$, but other treatments differed significantly. The significantly lowest umbel diameter was computed by $V_2 \times D_4$, which clearly differed significantly with rest treatments. Regarding PDI, significantly the lower PDI value was calculated in $V_1 \times D_2$, which was statistically similar with $V_1 \times D_1$ and $V_2 \times D_2$. The maximum yield was computed in $V_1 \times D_2$, which differed significantly with all other combinations. The treatment, $V_2 \times D_2$ exhibited second in increasing yield but it was statistically similar to $V_2 \times D_1$ and $V_1 \times D_1$. The treatment $V_2 \times D_4$ appeared to be the least yielder and it was statistically similar to $V_1 \times D_4$.

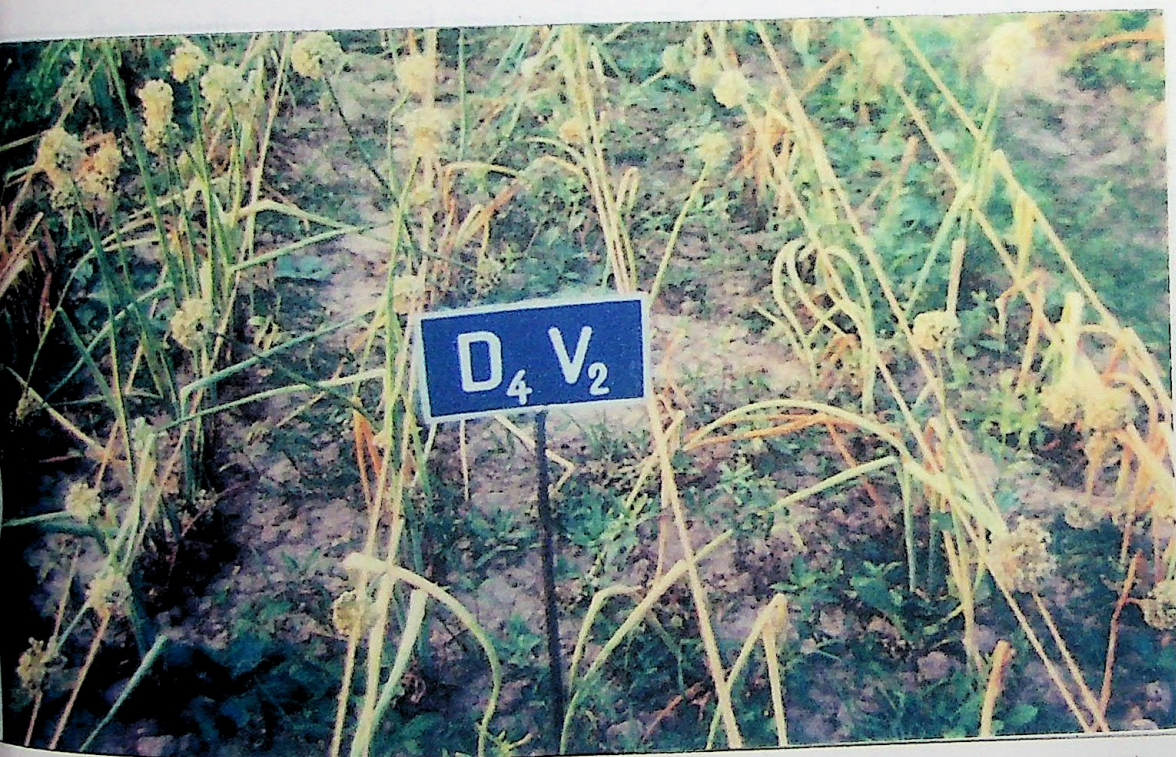
Table 9: Effect of date of planting and variety on plant growth, seed yield and severity of purple blotch of onion seed-crop in Botanical Garden, Rajshahi University Campus during 2002-03.

Treatment	Seed stalk/hill	Seed stalk height (cm)	Umbel diameter (cm)	PDI	yield (kg/ha)
D ₁ (November 1)	3.28 a	75.31 a	6.95 a	43.31 b	730.31 b
D ₂ (November 15)	3.34 a	73.82 a	6.93 a	39.37 a	842.56 a
D ₃ (December 1)	3.17 a	70.45 a	6.59 a	51.16 c	526.43 c
D ₄ (December 15)	2.94 a	56.26 b	5.21 b	83.09 d	193.51 d
Variety					
V ₁ (Taherpuri)	3.15 a	71.13 a	6.72 a	51.52 a	582.03 a
V ₂ (Jhitka)	3.22 a	68.82 a	6.15 a	54.75 a	553.29 a
Interaction					
V ₁ x D ₁	3.35 ab	78.43 a	7.30 a	42.51 ab	700.65 b
V ₁ x D ₂	3.18 ab	76.15 a	7.16 ab	39.12 a	874.00 a
V ₁ x D ₃	3.44 a	73.08 a	6.72 bc	52.00 c	531.48 c
V ₁ x D ₄	2.64 b	60.12 b	5.62 d	76.00 d	221.00 d
V ₂ x D ₁	3.21 ab	75.28 a	6.63 bc	46.23 b	735.74 b
V ₂ x D ₂	3.50 a	74.43 a	6.74 abc	41.68 ab	778.59 b
V ₂ x D ₃	2.92 ab	71.03 a	6.40 c	54.13 c	518.43 c
V ₂ x D ₄	3.28 ab	54.58 b	4.88 e	81.19 e	172.37 d

Means in a column under planting date or variety or their interaction followed by same letter are not significantly different ($P = 0.05$) according to DMRT (in case of PDI analysis was done after arcsine transformation).



a



b

Plate A. onion seed-crop planted at: a) November 1 cv. Taherpuri (D_1V_1) and b)
December 15 cv. Jhitka (D_4V_2).

5.4 Symptoms of the Diseases

Field diseases:

Purple Blotch

Purple blotch is a disease of leaves, seed stems, and bulbs. It has been confused with leaf mold because the leaf mold organism commonly follows the purple blotch fungus as a secondary invader. However, unlike the leaf mold organism, the purple blotch fungus is capable of invading the onion plant quite independently of any forerunner. The disease is of some importance on the seed crop and sometimes causes appreciable losses as a bulb rot. The causal organism appears to be rather widespread in occurrence (Tables 1 & 2).

Characteristics

The disease appears first as small, whitish, sunken lesions with purple centers that rapidly enlarge and eventually girdle the leaf or seed stem. About 2 or 3 weeks after its first appearance, darkened zones, consisting of superficial masses of fungus spores, appear on the lesion. Usually the affected leaves or stems fall over and die within 3 or 4 weeks after lesions appear if the environment is favorable for disease development. Purple blotch requires less humid weather than downy mildew; thus it is much less limited in geographic distribution.

The bulbs are attacked at harvest time. The fungus invades most commonly through the neck, but it may invade wounds on the fleshy scales. The decay is at first semiwatery and is especially conspicuous because of the color associated with it. The parasite secretes in abundance a pigment which diffuses through the scale tissues somewhat in advance of the fungus threads. Affected tissue is deep yellow at first, but it turns gradually to a wine red. With the profuse development of dark colored fungus threads, the older decayed tissue eventually becomes dark brown to black. As the tissue becomes desiccated, the diseased scales eventually dry down to a papery texture. Often only one or two

outer scales are affected; in other instances, notably with white bottom sets, the entire bulb may be destroyed.

Causal Organism

The causal fungus (*Alternaria porri* (Ell.) Cif.) is closely related to that associated with early blight of potato and tomato. It is confined, however, to onion and possibly such closely related plants as leek and chive. The spores, which are produced on short fruiting branches on the surface of the decayed leaves, stems, and scales, are many celled, dark colored, and capable of withstanding unfavorable environment; thus they carry the fungus through northern winters or hot southern summers. They germinate to produce fungus threads (mycelium) that invade the stomatas of leaves and stems and wounds on the bulbs (Fig. A).

Leaf Mold

Lesions are initially light yellow to brown and water-soaked. They elongate, often reaching the leaf tips, and become dark brown to black. The disease can become serious following periods of more than 24 hours of rainy weather. In midseason or later, dying back from the tips of the leaves commonly occurs. While this injury may be due in part to insufficient soil moisture, the trouble is often increased by *Stemphylium botryosum* Wallr., a secondary fungus, which attacks the dying parts and later produces a black mold on the dead tissues. This fungus also commonly follows downy mildew or purple blotch on the seed stems (Fig. B).

Blast

Blast disease is a field disease which is caused by (*Botrytis allii*) and it was found in three localities under Rajshahi District (Tables 1 & 2). It was also found to occur extensively. It was severe at the mature stage of growth. At first tiny water-skoaked yellowish spots were evident on the leaves. Within 10-12 days the tiny spots increased in size to form white lesions, devoid of

chlorophyll, leaving only the white or bleached membranous areas (epidermis) on the leaves (Fig. C) with heavy infection, the leaf tip died and turned brown.

White Rot

White rot, a serious disease of onion in Rajshahi University Campus and Singa village under Durgapur Thana (Tables 1 & 2), but the severity of infection was very low as compared to the former five diseases.

Usually white rot appears first during the cool, moist weather in the spring and fall. The first signs are yellowing and wilting of the leaves, followed later by a total collapse of the top. The causal fungus (*Sclerotium cepivorum* Berk.), which inhabits the soil, actually invades the roots and the basal parts of the bulb scales (Fig. D). If diseased plants are gently pulled, they will come up very readily, because the roots have been almost entirely destroyed. The diseased bulb is commonly covered with a white fluffy mass of fungal threads. Somewhat later this fungus mass takes on the appearance of a closely fitting weft in which are embedded numerous black spherical bodies, or comes shrunken and dried up.

In the later stages white rot may be mistaken for neck rot, in which black sclerotia are commonly formed. The neck rot sclerotia, however, are several times as large as those of the white rot fungus; moreover, a gray mold is commonly associated with neck rot, while the mold associated with white rot is distinctly white. Neck rot almost always appears after harvest and starts in most cases at the neck. White rot commonly appears on the growing crop, and infection occurs in the roots and bases of the scales.

The fungus that causes white rot is disseminated chiefly by bulbs that have come from diseased soil. Once established, the parasite may persist in the soil indefinitely and is known to survive northern winters. Bulbs from a diseased field should never be used for propagation, and soil once infested should not be used again for onions or closely related plants without being first steam sterilized.

The disease is favored by relatively cool soil temperature, and in soil at 73° F. or above plants tend to outgrow it.

Smut

Smut is a disease caused by a fungus, which remains viable in the soil for many years. Smut-infested soil is therefore likely to remain infested indefinitely and is found usually in areas where onions have been grown intensively for a long time. This disease is found in Rajshahi University Campus and Taherpur & Singa villages (Tables 1 & 2).

Characteristics

The disease appears soon after the seedlings emerge above ground. Brown to black elongated blisters form within the scales or leaves; the latter usually are slightly thickened and often curved downward abnormally. These blisters often break open and expose black powdery masses made up of the spores of the causal fungus. A majority of the infected seedlings die within 3 to 5 weeks after germination. Such thinning of the stand is thus an early and important feature of smut injury, although a small percentage of infected seedlings outgrow the disease. Some diseased plants survive until midseason or harvest, new leaves and scales becoming infected as they develop. Figure E shows half grown infected plant, which has survived the seedling stage. Such plants usually produce bulbs so small and imperfect that they are thrown out at harvest.

Occasionally, infected bulbs are large enough and so slightly affected as to escape notice and reach the warehouse and market. Such specimens are characterized by slightly raised brown to black pustules most prevalent near the base of the outer fleshy scale and occurring as deeply as the third or fourth scale. Smut does not cause storage rot, but smutted bulbs shrink more rapidly and are more subject to the attack of other organisms than healthy ones.

Causal Organism

The fungus parasite (*Urocystic cepulae* Frost) associated with onion smut infects only the onion and certain closely related species of plants, such as leek. Most varieties of the onion are resistant to this disease. The black powdery masses exposed upon the splitting of the blisters, or pustules, in the onion leaf consist of myriads of spores, or seed bodies, which propagate the fungus. These spores are highly resistant to environmental changes; as they become incorporated in the soil, they remain viable for many years. This is the reason that continuous cropping is favorable to the accumulation of the fungus and that soil once infested remains so indefinitely.

The spores germinate by sending out fungus threads, which permeate the soil and often break up into many secondary spores. These stages of the fungus are sensitive to cold and drought and survive for short periods only. The threads penetrate young onion seedlings, take nourishment from the plant, and form the characteristic blisters within the tissue; finally more dark spores develop.

Important to the understanding of onion smut and its control is the fact that the fungus can invade the onion plant only in the early seedling stage. If the outer seedling leaf (cotyledon) escapes infection until it is mature (about 3 weeks from germination), no further invasion occurs even in very heavily infested soil. This is the reason why smut is not a disease factor when the crop is started from sets or transplants, even though they are set in smutty land. When the mean soil temperature is 84° F. or above during the period of the seedlings' susceptibility, no infection occurs, because the fungus is inactive at this high temperature. At slightly lower temperatures the seedlings tend to outgrow the disease more effectively than in cool soil.

Smut spores are spread locally by farm implements, by the feet of men and animals, by surface drainage water, and by air borne soil. The transfer from locality to locality is rarely made through the medium of seed, but commonly by means of onion sets grown on smutty soil.

Downy Mildew

Downy mildew has been reported from most areas where onions are grown. Its destructiveness varies widely with locality and season. Relatively cool, moist weather is most favorable for its development. Losses are most severe on the bulb crop in Rajshahi University Campus, Taherpur & Singa villages (Tables 1 & 2). In Rajshahi district losses in the seed crop during the winter and spring are sometimes heavy, since the foggy weather is especially favorable for the mildew; it attacks the seed stems and causes them to fall over before the seed is mature.

The first symptoms are found most readily by examining leaves closely in the early morning while the dew is still present. The violet furry growth on the surface of the leaf or seed stem is characteristic. The affected leaves gradually become pale green and later yellowish, and the diseased parts collapse. The furry growth becomes more widespread if the humidity remains high, but the advance and spread are very dependent on favorable weather. The disease commonly starts in spots in the field and spreads to surrounding areas. If the weather remains dry after an outbreak, plants send out new leaves and partially recover; but on the return of humid conditions the fungus revives and the new growth becomes blighted. Repeated killing of leaves in this manner reduces growth, and the bulbs remain small while the necks are unduly succulent and subject to attack by storage decay organisms. Lesions on seed stems are circular or elongate, often affecting only one side of the stalk; they weaken the stalk and cause it to break over from the weight of the seed umbel. This causes shriveling of the seeds. The fungus may infect the flower parts as well, and there is circumstantial evidence that it is carried with the seed.

Causal Organism

The causal organism (*Peronospora destructor* (Berk.) Casp.) is closely related to those associated with potato late blight, grape downy mildew, and cucumber downy mildew. The furry masses (Fig. F) on the affected parts of the plant are

made up of branches of the fungus, which extend above the surface and bear numerous microscopic spores. These spores are thin walled and light; they are easily detached and transported by air currents, and this is the chief means whereby the fungus is disseminated locally. They are short-lived, however, and very sensitive to drying.

When damp weather prevails, the spores germinate promptly. If germination occurs on the leaf surface, the germ tube growing into a thread enters through a breathing pore (stomate) into the internal tissue. As the fungus absorbs food from the onion the cells of the latter gradually succumb; as a result the leaves turn yellow, shrivel, and die. The fungus sends fruiting branches to the surface, where they produce more spores.

Another type of spore, the resting spore (oospore), is formed in the dying plant tissues. Because this spore has a thick wall and a concentrated food supply, it is suited to withstand unfavorable environment. The internal threads (mycelium) also survive for long periods, especially when they get into the bulb before it matures. Oospores and mycelium may be carried with the seed, but the evidence that seed is an important carrier of the organism is very meager. Thus, the fungus lives over unfavorable periods chiefly as oospores or as mycelium in bulbs and sets and may be transported long distances in this way.

Pink Root Rot

Pink root rot (*Pyrenochaeta terrestris*) is serious in the Rajshahi University Campus. Affected roots shrivel and die, meanwhile taking on a distinctly pink color. Abnormal yellowing of the roots is commonly associated with pink root, but it may be due to other factors and is not necessarily a stage of this disease. As the plant sends out new roots, they in turn eventually become diseased and functionless. This procedure continues throughout the growing season, and although the affected plants are commonly not killed by the disease, the reduced food supply results in the formation of mere scallions, or small bulbs. During the growing season there are often few outward symptoms of the

disease. It becomes most apparent at harvest time in the small size of the bulbs; the size varies with the severity of the attack.

The fungus which causes Pink root rot (*Phoma terrestris* Hansen) lives and multiplies in the soil; consequently, it becomes more destructive the longer the onions are grown in the same field. It is disseminated on diseased green or bottom sets, on tools, and by natural agencies, such as surface drainage water. It attacks all varieties of onions, as well as shallot and garlic, and a large number of unrelated economic plants. There is considerable difference in susceptibility of varieties of onions (Fig. G).

When pink root rot becomes very serious in a given area the best procedure is not to plant onions there. Transplants or sets from soil infested with the pink root fungus should not be used. Good cultural practices and high fertility are helpful. Efforts are being made to develop satisfactorily resistant varieties.

Storage diseases:

Grey Neck Rot

Neck rot is a destructive and widespread disease of onions in storage and in transit in Rajshahi District (Tables 3 & 4). During certain seasons many growers have lost 50 percent or more of their crop on account of this trouble.

Characteristics

Usually there is little or no evidence of neck rot up to or at the time of harvest, but after the onions are topped and have lain in crates for a few days the early signs appear. A softening of the scales begins usually at the neck and more rarely at the base or at a wound.

There is a definite margin between the healthy and diseased tissue, the latter taking on a sunken, water soaked appearance. A gray, felt like growth later forms on the rotting scales, which may be accompanied by a gray to brownish mold, consisting of the spores (seeds) of the causal fungus, and by brown to black kernel like bodies (sclerotia) one-eighth to one-fourth inch in diameter

(Fig. H). The disease may progress rather slowly unless conditions are very moist, several months often elapsing before the entire bulb has destroyed.

Causal Organisms

Neck rot is caused by *Botrytis allii*. The fungus is not vigorous parasite and seldom seriously attack actively growing onion plants. It does not ordinarily penetrate the outer scale of the onion but require wounds in order to gain entrance to the plant tissues. The gray to brown moldy growth on the rooted scales consists chiefly of the spores of the causal fungi, which are especially adapted to dissemination by air currents. It carried to the healthy bulbs, where it germinate and send fungus threads into the necks, either through the dead tops or through wounds left by the removal of tops. These threads then kill the tissue slightly in advance of their progress through the scale. The black sclerotia are compact masses of fungus threads, which, being resistant to cold and drought, carry the organisms over winter.

Bacterial Soft Rot

Bacterial soft rot usually begins at the neck of the bulb, and advances down one or more scales (Fig. I). It sometimes starts in bulbs in the field slightly before harvest. At first the tissue is water soaked; later it disintegrates into a soft, slimy mass. An offensive sulfurous odor is usually given off; this characteristic distinguishes bacterial soft wounds on the scales and commonly follows in tissue injured by freezing. When the rot affects only one or two inner scales, as is often the case, the only external sign of the disease is the lack of firmness of the bulb and often the appearance of a watery exudate through the neck when pressure is applied to the upper part of the surface of the bulb.

The organism enters only through wounds and in moist environment (Tables 3 & 4). Onion maggots may carry the bacteria and through their feeding on bulbs provide the necessary wounds for infection. The bacteria may persist in the intestinal tract of the larvae and the adult fly and thus be carried from place to place. The eggs may be contaminated when laid by the fly, and thus the soft rot

bacteria become identified closely with the life history of the maggot, depending upon the latter for its perpetuation and dissemination.

Black Mold

Black mold occurs in three markets at Rajshahi District (Tables 3 & 4). It is one of the most important storage and transit disease.

Because of its resemblance in appearance to onion smut, black mold is often confused with it by growers and dealers. The chief distinguishing characteristic is the fact that the black powdery masses of spores in the case of black mold are borne on the exterior of the scales and can be rubbed off readily (Fig. J). It is true that the disease is not confined to the exterior of the bulb, but as the inner scales are separated the black powder will be found to exist on the exterior of the individual scales. Black mold causes a slow shriveling of the affected scale, which assumes a brittle texture. Moist conditions favor the disease, while a cool, dry environment seems to check it. Black mold is caused by *Aspergillus niger*. The organism is a very common saprophyte, living on almost any dead or dying vegetable matter. When it is most serious on onions it undoubtedly grows and multiplies throughout the year in the soil or in dead refuse. It is present to a slight extent on the dead outer scales of the bulb before harvest, but it is noticeable until the onions are pulled. Rainy weather at this critical period will result in widespread infection, which continues to develop storage and transit.

The old Black mold in check, general initial measures and protection from moisture after harvest are essential. Bulbs should be throughout dry before being shipped, since moisture in the pack favors development of the disease in transit.

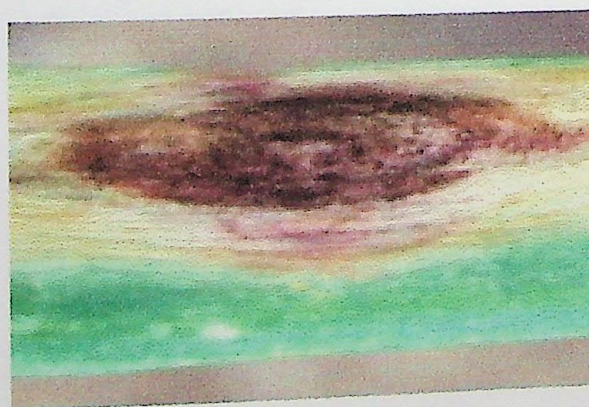
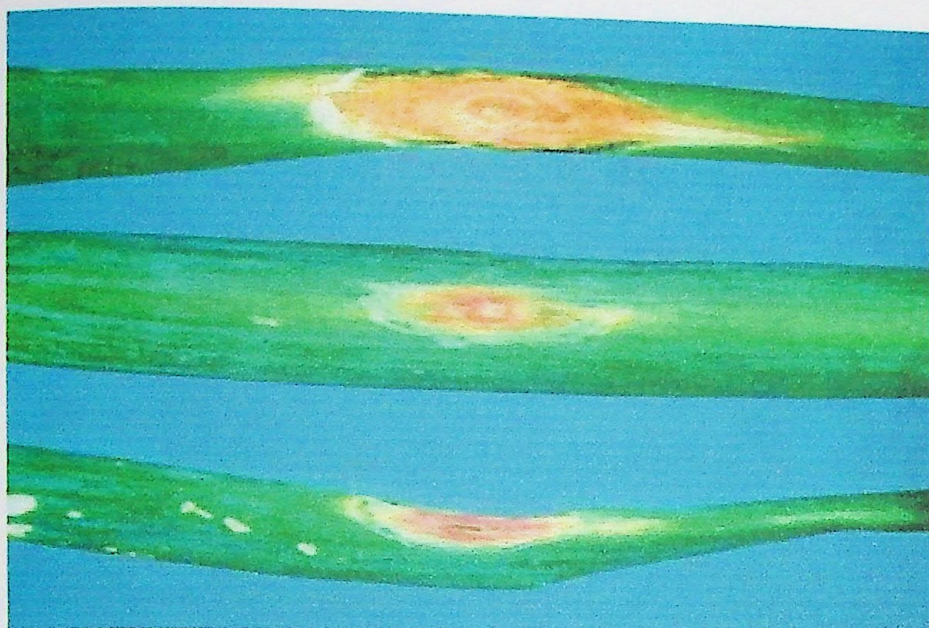


Fig. A: Purple Blotch



Fig. B: Leaf mold.



Fig. C: Blast



Fig. D: White rot



Fig. E: Smut

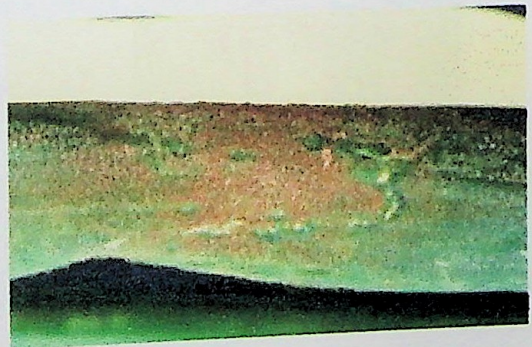
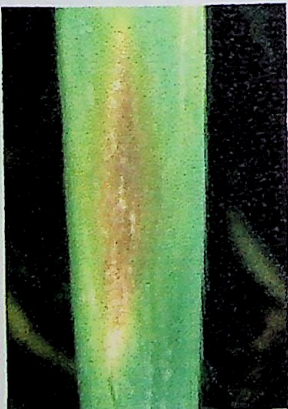
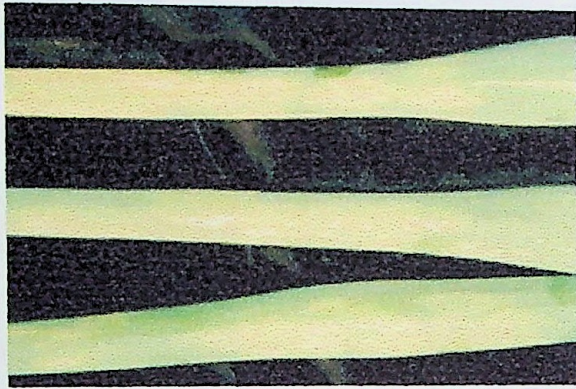


Fig. F: Downy mildew



Fig. G: Pink root rot

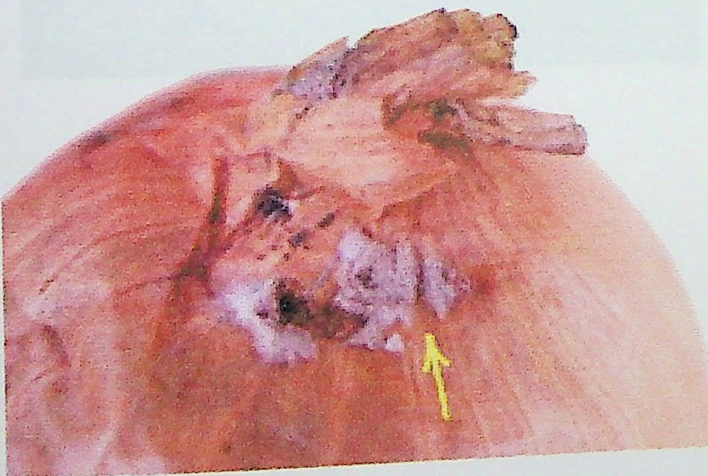
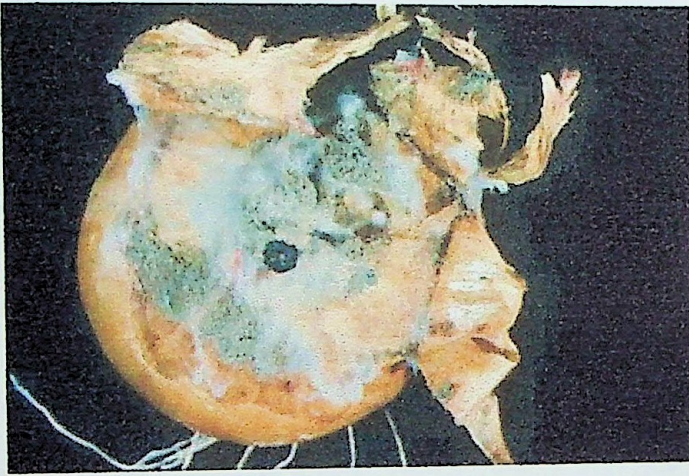
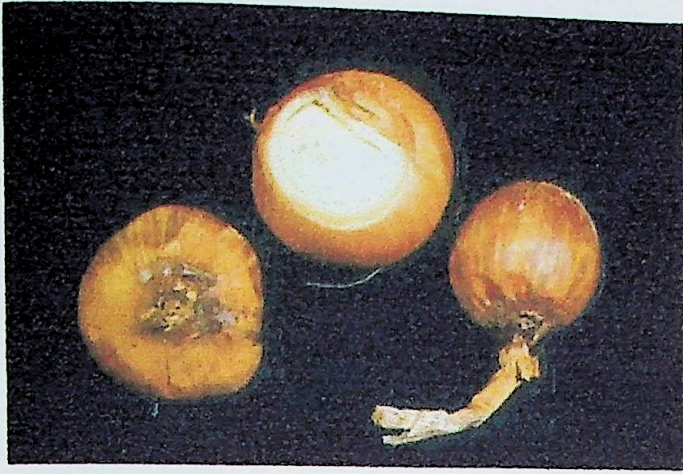


Fig. H: Neck rot



Fig. I: Soft rot

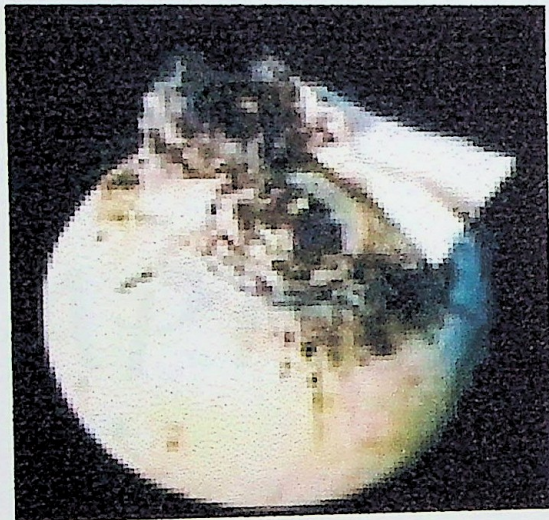


Fig. J: Black Mold

CHAPTER - 6

CHAPTER SIX

DISCUSSION

The crop suffers from many diseases like field diseases and storage diseases. Most of the field diseases and storage diseases caused by fungi and bacteria are among the various factors responsible for declining onion seed production in Bangladesh.

Discussion on Field Diseases

The survey was conducted in the farmer's and in commercial field plots of three selected localities of Rajshahi District from December 2001 to March 2002.

In the present study seven types of field diseases of onion, caused by different fungal pathogen have been reported.

In the selected localities the incidence of Purple blotch (*Alternaria porri*), Leaf mold (*Stemphylium botryosum*), Blast (*Botrytis allii*), Smut (*Urocystis cepulae*) and Downy mildew (*Peronospora destructor*) was more or less same and caused severe leaf damage.

Purple blotch (*Alternaria porri*) was severe from the beginning of the growing season till harvest but Blast (*Botrytis allii*) was severe only at mature stage and not in seedling stage (Tables 1 & 2).

The severity of Leaf mold (*S. botryosum*) disease had similarity with Purple blotch in both localities (Tables 1 & 2).

Smut (*Urocystis cepulae*) and Downey mildew (*Peronospora destructor*) were severe only at mature stage and were less severe in seedling stage (Tables 1 & 2).

The incidence of White rot (*Sclerotium cepivorum*) was nonsignificant in mature stage and was absent in seedling stage in all the selected locations (Tables 1 & 2).

Pink root rot (*Pyrenochaeta terrestris*) disease was observed only in one location (in and around Rajshahi University Campus) but was absent in the other (Taherpur village under Baghmara Thana & Singa village under Durgapur Thana). The absence of this disease in the above-mentioned locality is due to the fact that the disease is endemic (Felix, 1968) and soil-borne; so it might happened that the soil of that locality was free from Pink-root rot pathogen. Navia-E; Gomez-J (1999) reported that Pink root rot disease of welsh onion which occurs in the region of Guambia, Colombia, is thought to be caused by *Fusarium oxysporum* f. sp. *cepae*. The symptoms of the disease agree with the description given by J.Chaput (1995).

Among the various factors responsible for decline of onion seed production in Bangladesh, Purple blotch, a serious disease which was caused by *Alternaria porri* (Ellis) Cif., but under the present investigation, Leaf mold (*Stemphylium botryosum*), Blast (*Botrytis allii*), Smut (*Urocystis cepulae*) and Downy mildew (*Peronospora destructor*) was also found to be frequently associated in the diseased specimens. The disease (Purple blotch) causes 20 to 25 per cent loss of seed yield in India (Thind and Jhooty, 1982) and 41-44% in Bangladesh (Hossain *et al.*, 1993). Purple blotch is one of the field diseases, which caused by *A. porri* (Ellis) Cif. is noted as the major disease in many onion growing countries including Bangladesh (Castellanos-Linares *et. al.*, 1988; Rahman *et. al.*, 1984; Ashrafuzzaman, 1977). Ahmed and Goyal (1988) mentioned that Purple blotch, incited by *A. porri* is a major problem of onion (*Allium cepa*) in India. Ahmed and Hossain (1985) recorded Purple blotch of onion from all onion growing regions of Bangladesh. Ashrafuzzaman and Ahmed (1976) reported that the damage of foliage and breaking of floral stalks due to the disease resulting in failure of seed production are common. Srivastava *et al.* (1994) reported the high incidence (2.5-87.8%) of Purple blotch (*A. porri*) in

both the kharif and rabi onions, when high humidity prevailed, during the 5 years of the survey (1998-93). The symptoms of the disease agree with the description given by Mohan-K; Ebenezer-EG; Seetharaman-K (2001), J. Chaput (1995), Gupta *et al.*, (1991), Jones and Mann (1963), Brandes *et al.*, (1959). H. F. Schwartz *et al.*, (1999) reported that Purple blotch of onion is caused by *Alternaria porri* (Ellis) Cif.. This fungus is also a pathogen of leek, garlic and chive, and is present throughout the United States and Canada. Field and storage loss estimates from this onion disease have ranged from 30 to 50 percent, and up to 100 percent in Colorado. *Alternaria porri* and *Peronospora destructor* spores develop in high humidity, rain or persistent dew with an optimum range of 77 to 85 degrees. Fungal activity of *Alternaria* is reduced by temperatures lower than 55 degrees. Pandotra (1964) also recorded that the fungi caused heavy damage in Punjab, India. The highest infection was observed in the month of March, both in Rajshahi University Camus (Botanical Garden) (99.98%) and Singa village under Durgapur Thana (99.15%) and the lowest was in December (Tables 1 & 2). The occurrence and severity of disease gradually increased in the subsequent months with the maturity of plants. This continuous increase may be due to the fact that the sowing of seeds early in the season is conducive to infection for a much longer period (Boelema *et al.*, 1967). Boelema *et al.*, (1967) reported that the disease is favored in wet-weather and in a wide range of temperature from 21°-30°C. Everts and Lacy (1996) studied the factors influencing infection of onion leaves by *A. porri* and subsequent lesion expansion. Bock (1964) reported that high relative humidity favored the appearance of typical Purple blotches while low relative humidity resulted in white flecks. The continuous foggy weather and dew fall in every morning during winter and small amount of precipitation in December, probably favored the development of disease from the beginning of growing season (Table 1). This may be true in case of Taherpur & Singa villages (Table 2).

Leaf mold (*Stemphylium botryosum*) was extensive from the seedling stage (December) to mature stage (March) in all locations and caused severe leaf damage (Tables 1 & 2). Highest percentage of infection was observed in the month of March both in R. U. Campus (99.87%) and Singa village (99.28%). A trial was established to study the effect of three temperatures (15, 21 and 28°C) and relative humidity (80, 90 and 100%) on onion leaf blight, caused by *Stemphylium botryosum* [*Pleospora herbarum*] and *Alternaria alternata* (Cova-J; Rodriguez-D, 2001). Shi and Kuang (1991) studied the biological characters of *S. botriosum*, causing onion leaf blight. The optimum temperature for conidial germination and hyphal growth of the fungus was 25°C. The pH ranged for growth was 3 to 11 and conidial formation was inhibited by light. The best medium for sporulation was PDA supplemented with 0.5% MgSO₄ and 0.5% CaCO₃. Thomaz and Lima (1998) reported from Portugal 80-85% losses caused by a disease (*S. vesicarium*) affecting leaves and inflorescence stalks. The symptoms of the disease agree with the description given by Miller *et al.*, (1978).

Blast (*B. allii*) was also found to occur extensively in the mature stage of growth when the foliage area was maximum. Segall *et al.*, (1960) reported that Blast (*B. allii*) usually occurs in the field when the foliage area is maximum and before the bulbs have enlarged appreciably. The symptoms of the disease agree with the description given by Brandes *et al.*, (1959) and Segall (1960). Highest percentage of infection was observed in the month of March both in R. U. Campus (99.24%) and Singa village (99.14%), (Tables 1 & 2). The disease is favored by moist condition (Jones *et al.*, 1963) and low soil temperature (Mc. Keen, 1951). Though in January and February there was no precipitation and in March only in small quantity and mean air temperature was around $21.5^{\circ} \pm 2^{\circ}\text{C}$ in R. U. Campus but the disease occurred. This was probably due to the fact that the continuous foggy weather and dew fall every morning during winter season favored the disease incidence.

White rot (*S. cepivorum*) was observed at the time of bulb formation when the plants were mature. Onion white rot caused by the soil-borne sclerotial fungus, *Sclerotium cepivorum* is a serious problem throughout all the main onion growing countries of the world (Adams, 1981; Coley-smith, 1987), including New Zealand (Fullerton *et al.*, 1986). In New Zealand, White rot disease has resulted in a decrease in profitable onion growing land and a reduction in the productivity of some commercial fields of up to 40%. The symptoms of the disease agree with the description by Mackie-AE; McKirdy-SJ (2002); Hunger-SA; Mclean-KL; Eady-CC; Stewart-A; Zydenbos-SM (2002); Jones and Mann (1963); Walker (1950). Highest percentage of infection was observed in the March. J. Chaput (1995) reported that White rot, caused by the soil-borne fungus *Sclerotium cepivorum*, is a very destructive disease that begins in the field and carry over the storage. Walker (1950) reported that the disease develop most rapidly in between 10°-20°C soil - temperature and in fairly dry soil. Sirry *et al.*, (1974) observed that the most infections occurred when the crop was irrigated 4 times but under 1 or 2 irrigations infection was low. White rot is a soil-borne disease, so it may happen that the disease probably occurred in those places where suitable soil-temperature and moisture were present.

Smut (*Urocystis cepulae*) was observed extensively in all the localities and caused severe leaf damage in mature stage. Highest percentage of infection was observed in the month of March both in R. U. Campus (99.18%) and Singa village (99.10%), (Tables 1 & 2). The symptoms of the disease agree with the description by Walker-J (2001). J. Chaput (1995) reported that Onion smut is caused by the soil-borne fungus *Urocystis cepulae* and infects the flag leaf (cotyledon) as it grows through the soil. Often the seedling survives this initial infection and the characteristic black streaks and blisters appear in the leaves and small bulbs later in the growing season as the fungus moves from the infected flag leaf to younger leaves. Some seedlings will be killed by the disease in most years. A cool, wet spring increases the incidence of smut infection because the onion seedlings grow slowly and the flag leaf is in the

soil for a longer period. Similarly, planting onion seeds too deep will also make them more likely to be infected. Smut spores survive in the soil for many years, and even long crop rotations may not reduce disease incidence.

Downy mildew (*Peronospora destructor*) was observed from the seedling stage to mature stage but it caused severe leaf damage in mature stage in both localities. Highest percentage of infection was observed in the month of March both in R. U. Campus (88.52%) and Singa village (85.12%), (Tables 1 & 2). H. F. Schwartz *et al.*, (1999) reported that Downy mildew of onion is caused by *Peronospora destructor* (Berk.) Casp. Ex Berk. This fungus is present throughout the world. Field loss estimates in the United States vary from 25 to 50 percent. The symptoms of the disease agree with the description given by Thakur-RP *et al.*, (2002); Robak-J *et al.*, (2000); Langston-DB Jr *et al.*, (2000). J. Chaput (1995) reported that Downy mildew of onions is caused by the air-borne fungus *Peronospora destructor*. The first sign of downy mildew is a purple-grey, velvety growth on otherwise green leaves (most easily seen in the early morning). The disease often starts in patches and is favored by cool, (less than 22°C) humid weather. Diseased leaves quickly turn pale-green, then yellow, and collapse and die.

2. Discussion on Storage and Transit Diseases

The survey was conducted in the three selected markets (Shaheb bazar, Katakhalī bazar and Taherpur village bazar) of Rajshahi District from April to November, 2002.

In the present study four types of storage diseases of onion were caused by different fungal pathogens. These were Grey neck rot (*Botrytis allii*), Soft rot (caused by Bacteria), Black mold rot (*Aspergillus niger*) and White rot (*Sclerotium cepivorum*). The incidence of disease was more in Katakhalī bazar market and in Taherpur village bazar market than in Shaheb bazar market (Table 5).

The content of loss in both the varieties was found to be greater in the first four months (April - July) of survey. This was probably due to the fact that high humidity (Van-de-pol *et al.*, 1949 and Roed, 1950) and moist conditions (Walker, 1950 and Jones *et al.*, 1963) favored the disease incidence.

The highest loss in Deshi variety (1.83%) was observed in Taherpur bazar market and that for Indian variety (9.23%) in the month of July (Tables 3 & 4). In both Deshi and Indian varieties highest loss was caused by Grey neck rot during the month of April to November (Tables 6 & 7).

Grey neck rot (*Botrytis allii*) was found more or less throughout the whole survey period and caused higher loss of onions than the other diseases observed (Tables 3, 4, 6 & 7). The disease usually begins at the neck. Grey neck rot disease inflicted much more damage in Indian variety than in the Deshi onion (Tables 6 & 7). The total percentage of loss (month wise) of this disease of deshi variety is lower (0.74%) than Indian variety (2.13%). It is the pungency of onions which is important in giving resistant to neck rot (Jones and Mann, 1963). Walker (1950) reported that the mildly pungent varieties are significantly more affected than the strongly pungent ones. H.F. Schwartz *et al.*, (1999) reported that Neck rot, Gray mold, or leaf and flower Blast of onions and garlic is caused by various species of the fungus *Botrytis* including *B. allii*, *B. byssoidea*, and *B. squamosa*. *Botrytis cinerea* can infect onion seed heads and cause brown stain. These pathogens reportedly cause storage yield losses of 20 to 30 percent in Colorado, 50 percent in Idaho and 60 percent in Europe. The symptoms of the disease agree with the description given by Nielsen-K; yohalem-DS; Jensen-DF (2002), J. Chaput (1995), Walker (1950), Jones and Mann (1963). The high incidence of Grey neck rot is due to high humidity in the storage (Van-de-pol, 1949 and Roed, 1950). Walker (1950) reported that highest epidemic development of Grey neck rot occurring when cool, moist weather prevails for some days previous to and more or less frequently after harvest. Lutynska (1968) reported that the incidence of Grey neck rot in storage varied widely with rainfall.

Soft rot (caused by Bacteria) loss also caused considerable loss during transit and storage. The disease became more prevalent in April both in Deshi (0.42%) and Indian (3.54%) varieties and gradually declined in the following months. The incidence of disease was much higher in Indian variety (Tables 6 & 8). In case of deshi variety the disease was absent in June to October but in case of Indian variety was present in April to November. The total percentage of loss (month wise) of this disease of deshi variety is lower (0.09%) than Indian variety (1.6%). The high incidence at the beginning of storage may be attributed to heavy rainfall and moist conditions prevailing at the time of harvest and the green necks of the bulbs, which does not cure well, favored the infection (Jones and Mann, 1963). Though humid and moist conditions prevailed in the following months in Bangladesh, the extent of loss was less, which was probably due to the fact that the rotted bulbs are easily identified by their offensive odour which are sorted out by the growers' and are not found in the storage bags.

Black mold rot (*Aspergillus niger*) was found throughout the whole period of survey and the loss was more or less the same in all the months and in both deshi and Indian varieties (Tables 6 & 7). The total percentage of loss (month wise) of this disease of deshi variety is higher (0.19%) than Indian variety (0.17%). The extent of loss in both the varieties does not vary because the pungency of onions is not thought to be important in infection (Jones and Mann, 1963).

White rot (*Sclerotium cepivorum*) disease was found in the beginning of survey and the incidence was somewhat higher in Indian variety (0.66%) than the deshi variety in the month of April. The total percentage of loss (month wise) of this disease of deshi variety is lower (0.025%) than Indian variety (0.13%), Tables 6 & 7. In case of Deshi variety the disease was not observed from June to October (Table 6) but In case of Indian variety it was not observed July to November (Table 7). In case of deshi variety the disease reappeared in November when the temperature is low. The absence of white rot in those

months may be due to high temperature (24°C or above) that inhibited the growth of white rot fungus (Walker, 1950).

3. Discussion on Effect of Date of Planting and Onion Cultivars on the Severity of Purple Blotch and Seed Yield of Onion

The survey was conducted at the Botanical Garden, Rajshahi University Campus, Rajshahi during 2001-02 and 2002-03.

The effect of date of Planting on the seed yielding of onion implied that the November 15 planting reduced PDI and gave the highest seed yield of onion. December 1 and December 15 plantings increased PDI and reduced seed yield. The highest PDI was recorded in December 15 planting (81.82%) followed by December 1 planting (73%). The lowest PDI was recorded in November 15 planting (44.82%) followed by November 1 planting (56%). The highest seed yield was recorded in November 15 planting (688.72 kg/ha) followed by November 1 planting (623.45 kg/ha). The lowest seed yield was recorded in December 15 planting (219.28 kg/ha). Munoz *et al.*, (1986) reported that the early sown crop had lower disease index compared with the crop sown later than 15 September. Award *et al.*, (1978) reported that the onions transplanted on 1st December had the most *A. porri* infection. El-Aweel-MAT and Ghobashi-AA studied that the (1999) early planting (20 October) reduced seed yield by 42.9 and 13.5% compared with later planting (10 November) in 1997-98 and 1998-99, respectively. The number of days to flowering decreased significantly with delayed planting. However, the length of the flowering stalk decreased with delayed planting in 1998-99 due to cold weather conditions prevailing during the experimental period. On the contrary, Sandhu *et al.*, (1983) mentioned the early sown crop (November 1) was always more susceptible to *A. porri* than the late sown crop. The present investigation showed that November 15 planted crop had lower disease severity (Tables 8 & 9).

It was found that there was no varietal differences regarding PDI as well as seed yield of onion per unit area of land which might be due to the fact that the two cultivars used in the present investigation were of same origin with similar genetic trait. The local onion cultivars, Taherpuri and jhitka were found to be susceptible to purple blotch. Bhangale and Joi (1985) screened 74 onion cultivars against *A. porri*, but they observed no resistant cultivar among them.

Regarding the combined effect of planting time and variety, it has been reflected that both the varieties when planted on November 15 performed better in respect of PDI and seed yield of onion. It led to conclude that around November 15 planting of onion seed crop is congenial for avoiding purple blotch disease of onion seed crop with consequent higher seed yield

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SUMMARY

A survey of the field diseases of onion was conducted in three localities at Rajshahi district during the growing season of onion from December 2001 to March 2002. This survey revealed that the onions suffer from seven kinds of diseases namely, Purple blotch (*Alternaria porri*), Leaf mold (*Stemphylium botryosum*), Blast (*Botrytis allii*), White rot (*Sclerotium cepivorum*), Smut (*Urocystis cepulae*), Downy mildew (*Peronospora destructor*) and Pink root rot (*Pyrenochaeta terrestris*) in these localities. The occurrence and severity of the first six diseases were highest in the month of March.

Purple blotch (*A. porri*) was observed extensively in all the localities and caused severe scorching of leaves from the beginning of growing season till harvest. The infection was observed in the month of March, both in Rajshahi University Campus (Botanical Garden) (99.98%) and in Singa village under Durgapur Thana (99.57%) and the lowest were in December. The occurrence and severity of the disease gradually increased in subsequent months with the maturity of plants.

Leaf mold (*S. botryosum*) was extensively prevalent from the seedling stage (December) to mature stage (March) in all locations and caused severe leaf damage. Highest percentage of infection was observed in the month of March both in R. U. Campus (99.87%) and in Singa village (99.28%).

Blast (*B. allii*) was also found to occur extensively in the mature stage of growth when the foliage area was maximum. Blast (*B. allii*) was severe only at mature stage and not in seedling stage. Highest percentage of infection was observed in the month of March both in R. U. Campus (99.24%) and in Singa village (99.14%).

The incidence of white rot (*S. cepivorum*) was a mere trace in the mature stage and was absent in seedling stage. Pink root (*Pyrenochaeta terrestris*) was observed only in one location (in and around Rajshahi University Campus) and was absent in the other (Taherpur & Singa villages).

Smut (*Urocystis cepulae*) was observed extensively in all the localities and caused severe leaf damage in mature stage. Highest percentage of infection was observed in the month of March both in R. U. Campus (99.18%) and in Singa village (99.10%).

Downy mildew (*Peronospora destructor*) was observed from the seedling stage to mature stage but it caused severe leaf damage in mature stage in both localities. Highest percentage of infection was observed in the month of March both in R. U. Campus (88.52%) and in Singa village (85.12%),

A preliminary survey of the storage and transit diseases of onions was also conducted in different 'Arots' (store house) of three selected markets namely, Shaheb bazar market, Katakhalī bazar market and Taherpur village bazar market under Rajshahi District during the month of April to November 2002. Two varieties of onions 'Deshi' and 'Indian' were stored in these 'Arots' (store house). The survey revealed that the bulbs suffer from several kinds of diseases namely, Grey neck rot (*Botrytis allii*), Soft rot (bacterial rot), Black mold rot (*Aspergillus niger*) and White rot (*Sclerotium cepivorum*) in these 'Arots' (store house). The extent of loss due to diseases in both the varieties was maximum in the first four months (April-July) of survey. The loss of Indian variety was about 5 times more than that of 'Deshi' variety. Grey neck rot was observed throughout the whole period of survey and inflicted highest loss in both 'Deshi' (0.74%) and 'Indian' ((2.13%) varieties. Soft rot disease became more prevalent in April in both 'Deshi' and 'Indian' varieties and declined in the subsequent months. Black mold rot was found throughout the whole period of survey and the loss was more or less the same in all the months and in both the varieties. White rot disease was found at the beginning of survey and the

loss was somewhat higher in 'Indian' variety. This disease was not observed from June to October in 'Deshi' variety and reappeared in November, when the temperature was low.

Studies conducted on the effect of date of planting on the severity of purple blotch and seed yield of onion showed that November 15 was the best planting time to reduce PDI of purple blotch and producing the highest seed yield of onion. The lowest PDI was recorded in November 15 planting (44.82%) followed by November 1 planting (56%). The highest seed yield was recorded in November 15 planting (688.72 kg/ha) followed by November 1 planting (623.45 kg/ha). On December 1 and December 15 plantings PDI values varied from 73.00 to 81.82 and seed yield from 456.63 to 219.28 kg/ha. There were no differences between two onion cultivars, Taherpuri and Jhitka regarding PDI as well as seed yield.

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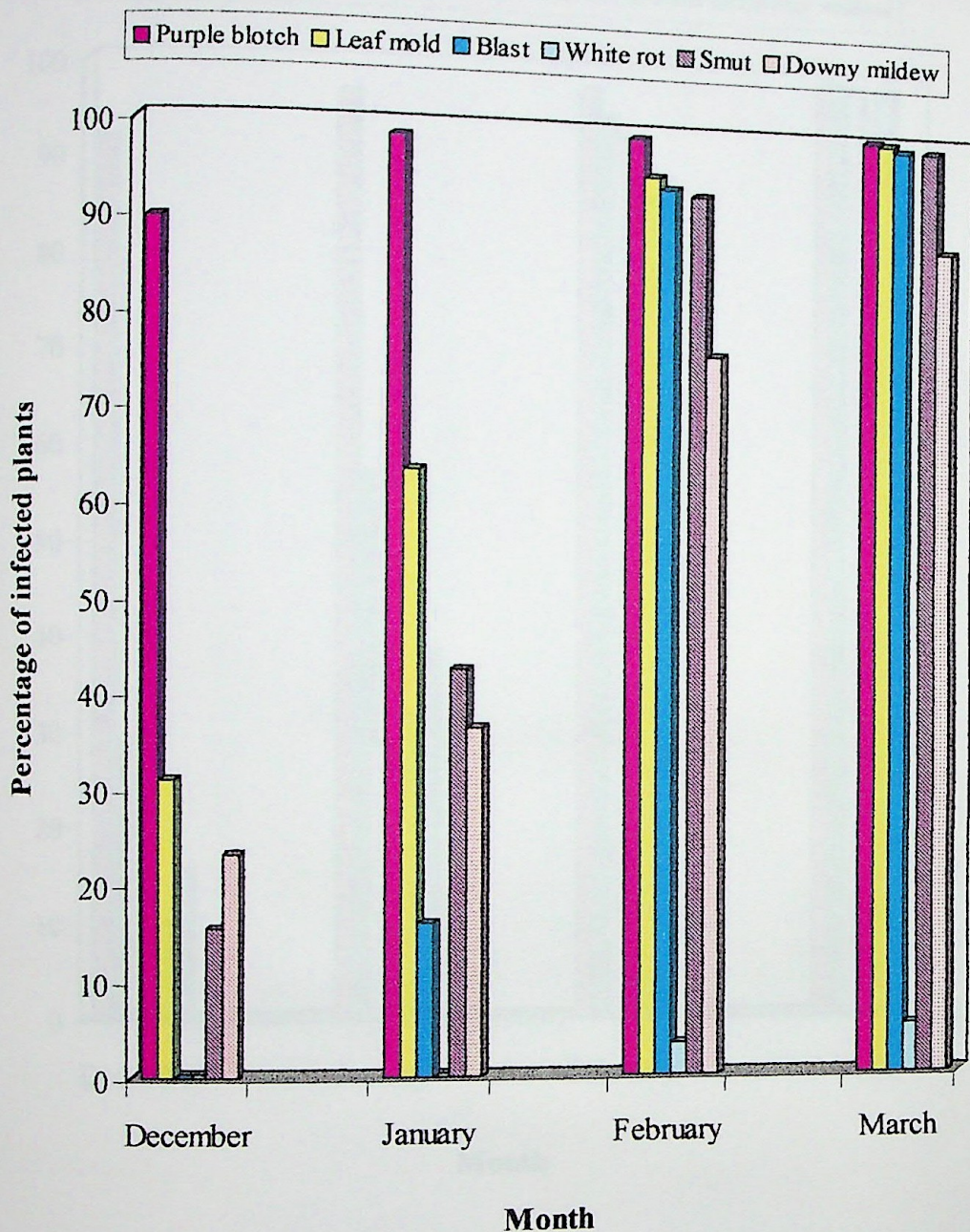
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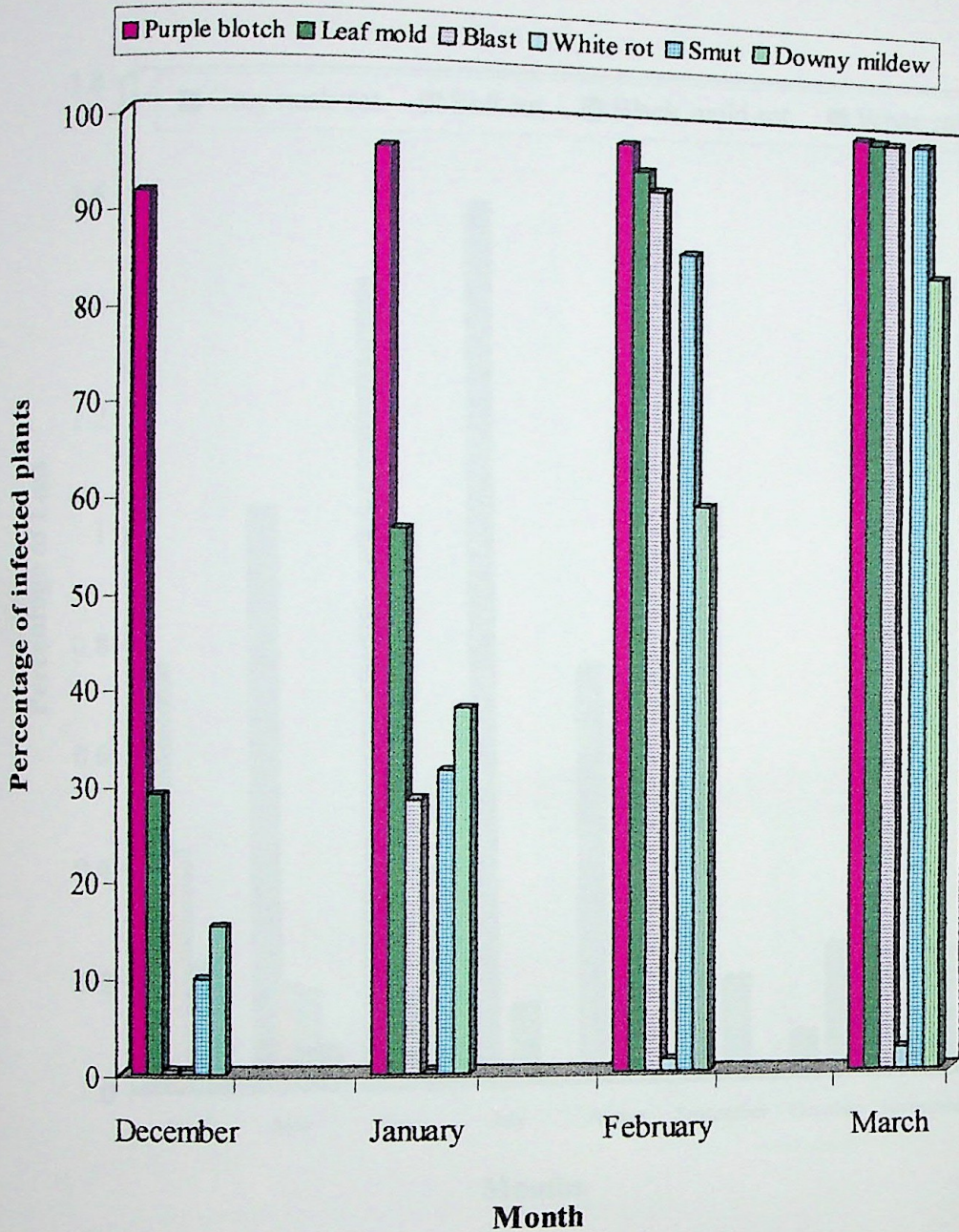
CHAPTER - 9



Seedling Stage: December and January

Mature Stage: February and March

Fig.1. Occurrence of Field Diseases of Onion in Botanical Garden, Rajshahi University Campus, Rajshahi in the growing season of 2001 – 02



Seedling Stage: December and January

Mature Stage: February and March

Fig. 2. Occurrence of Field Diseases of Onion in Taherpur village under Baghmara Thana and Singa village under Durgapur Thana both in Rajshahi District in the growing Season of 2001- 02.

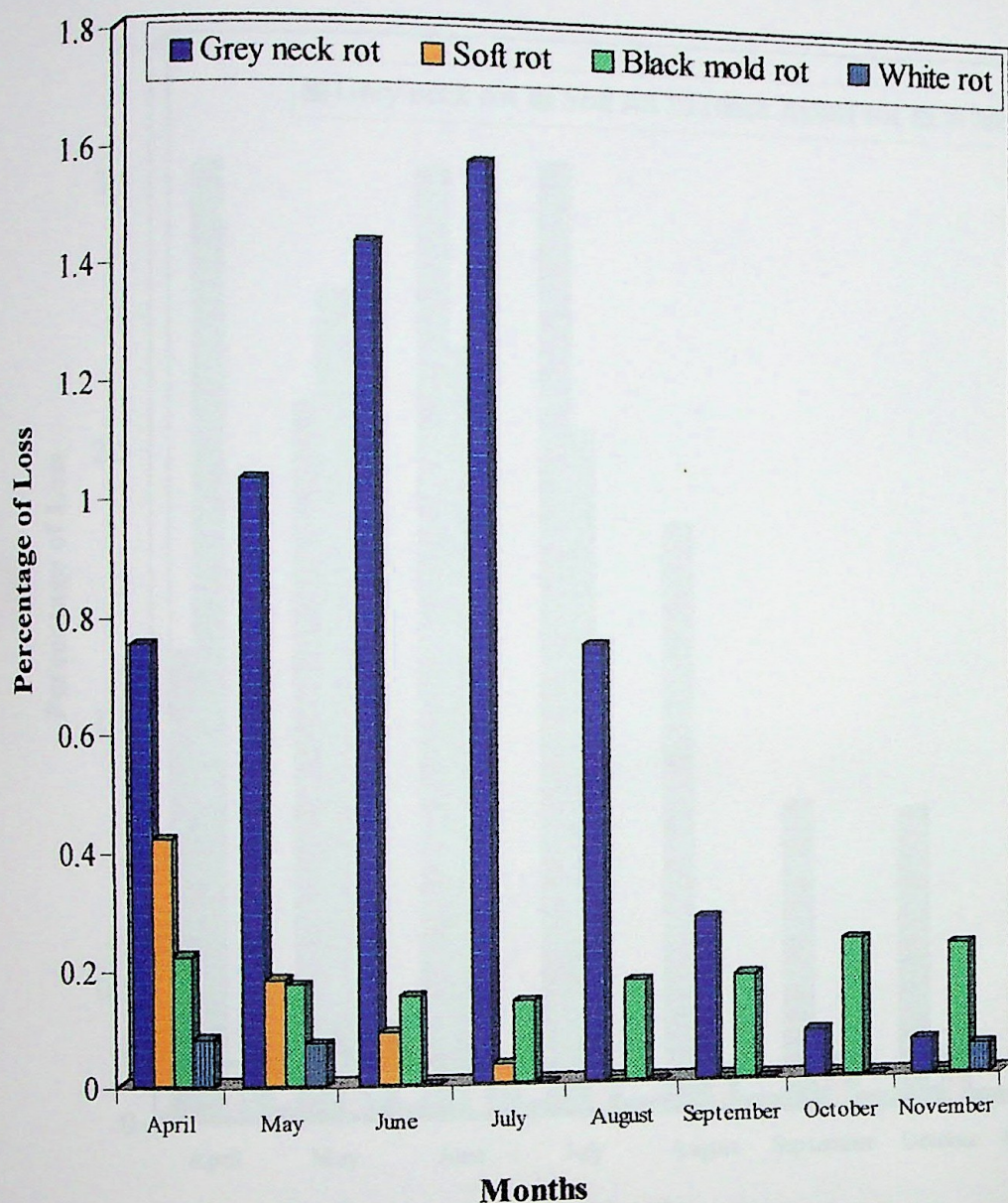


Fig. 3. Loss of bulbs due to diseases in Deshi variety of onions in different 'Arots' (store house) of three localities during storage season of 2002.

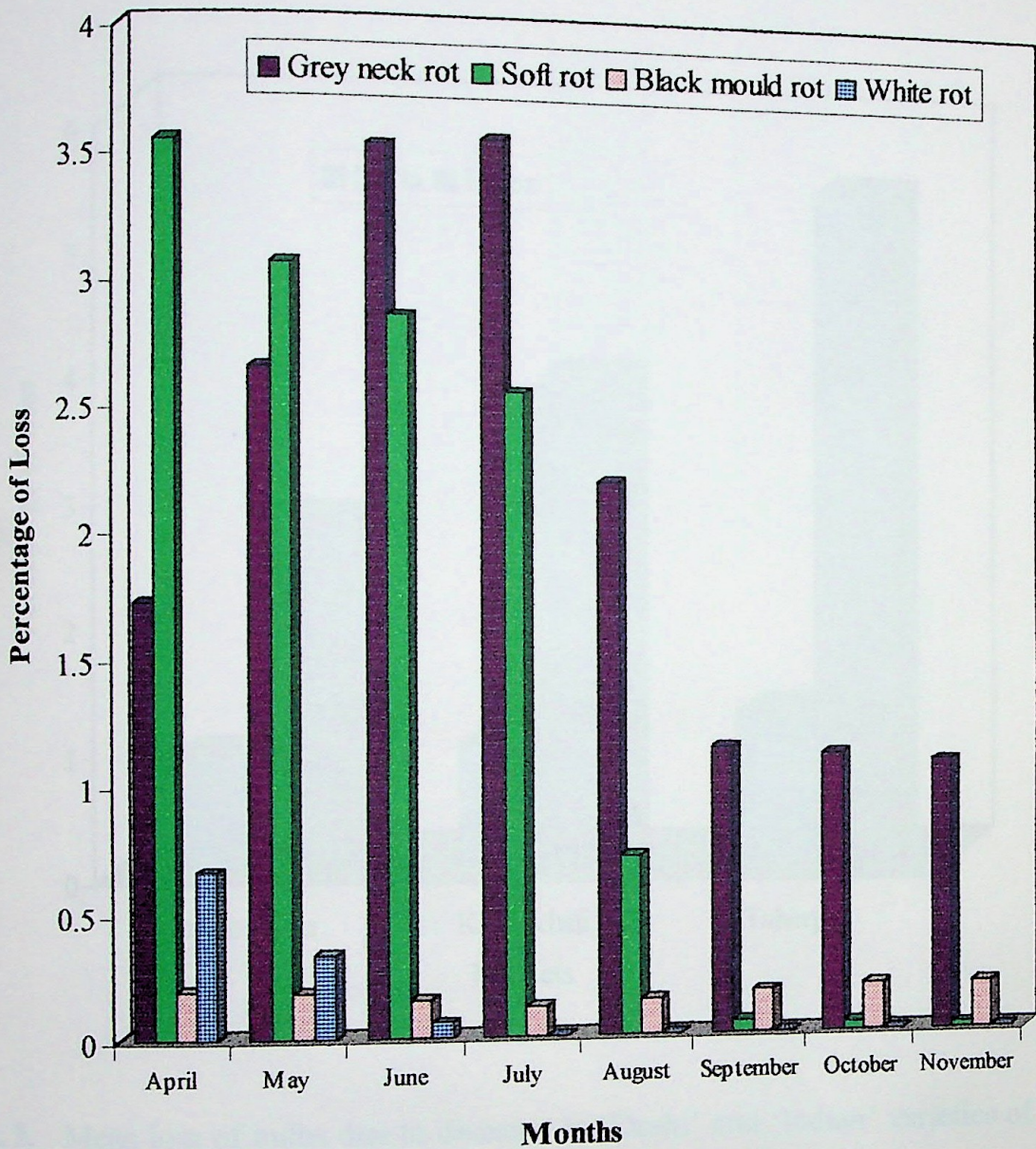


Fig. 4. Loss of bulbs due to diseases in Indian variety of onions in different 'Arots' (store house) of three localities during storage season of 2002.

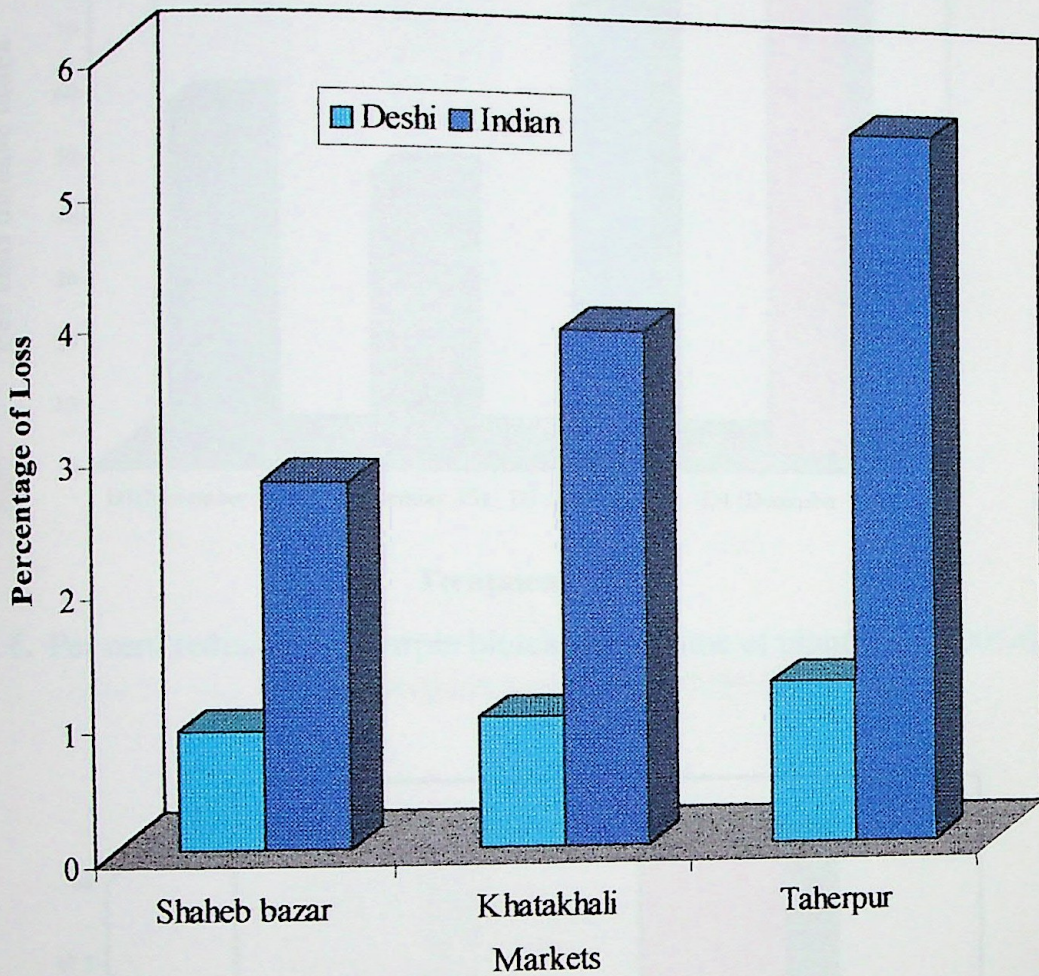


Fig. 5. Mean loss of bulbs due to diseases in 'Deshi' and 'Indian' varieties of onions during storage season of 2002.

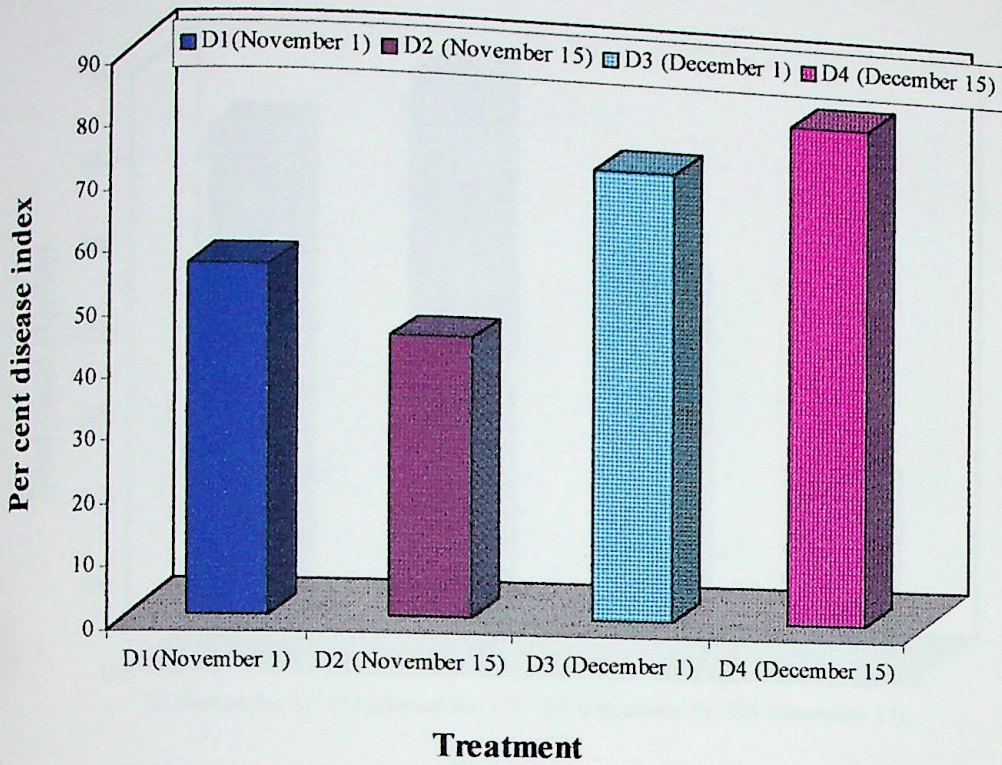


Fig. 6. Per cent reduction of purple blotch due to time of planting in 2001-02

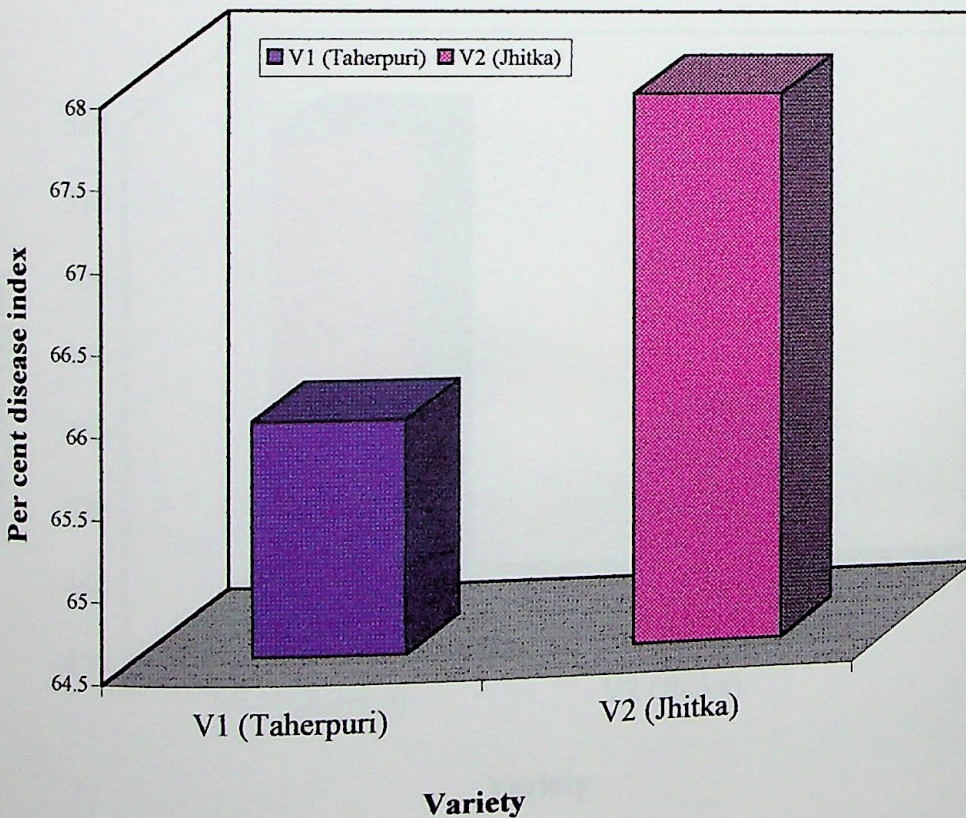


Fig. 7. Per cent reduction of purple blotch in two varieties due to time of planting in 2001-02.

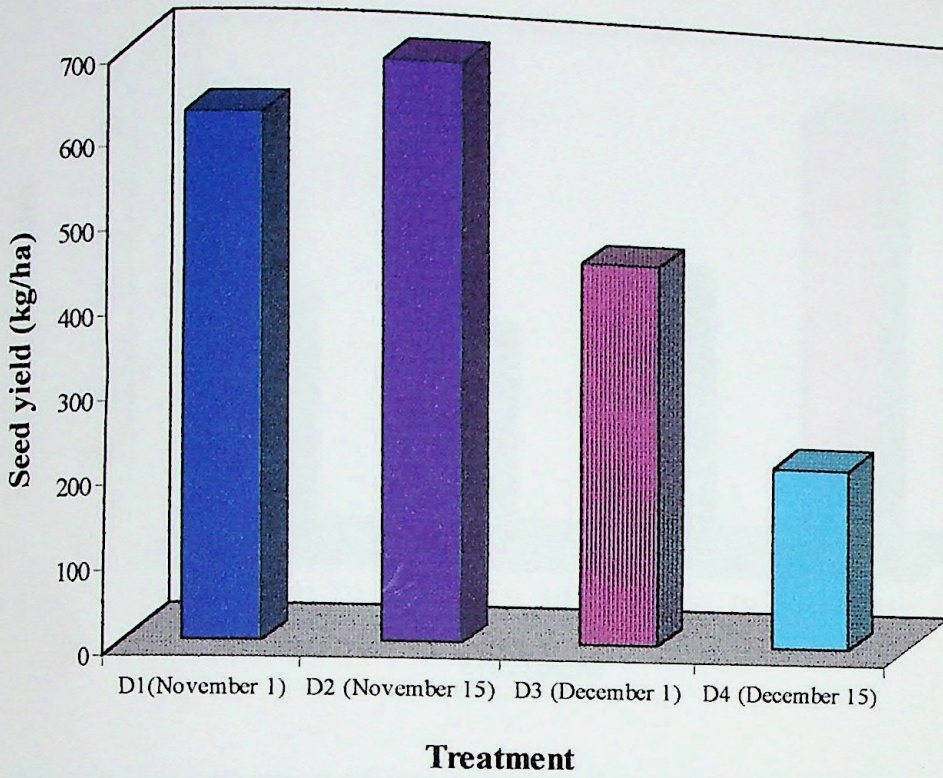


Fig. 8. Per cent yield increase of onion seeds due to time of planting in 2001-02.

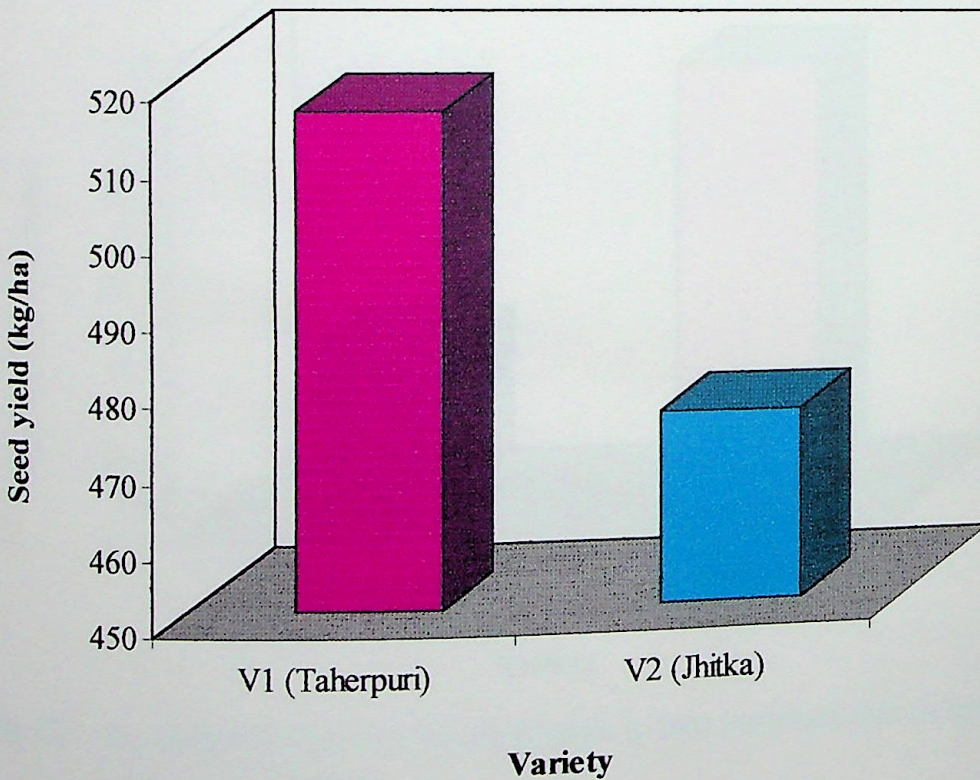


Fig. 9. Per cent yield increase of onion seeds in two varieties due to time of planting in 2001-02.

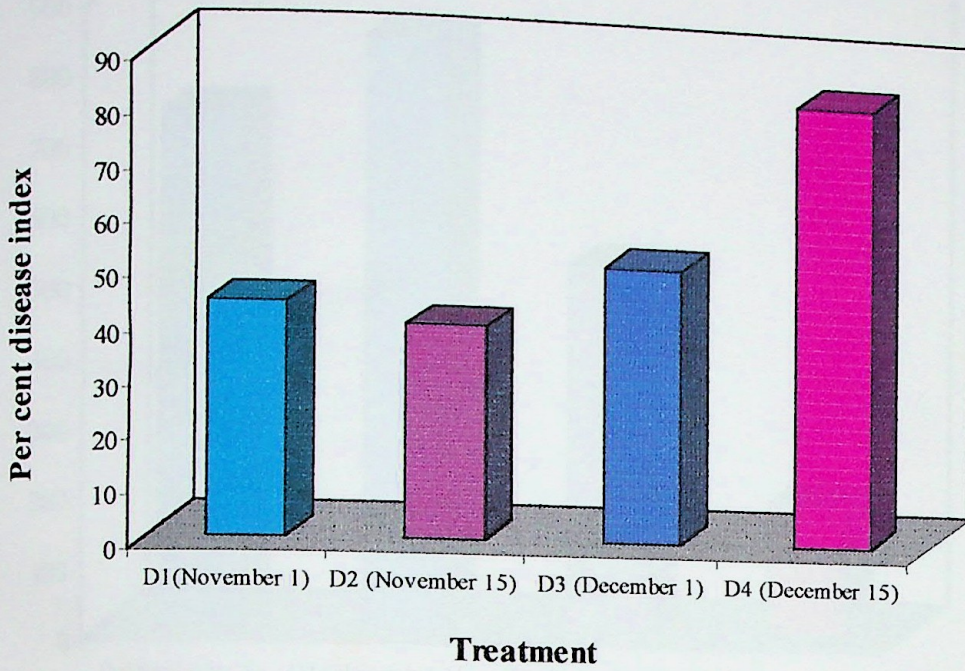


Fig. 10. Per cent reduction of purple blotch due to time of planting in 2002-03.

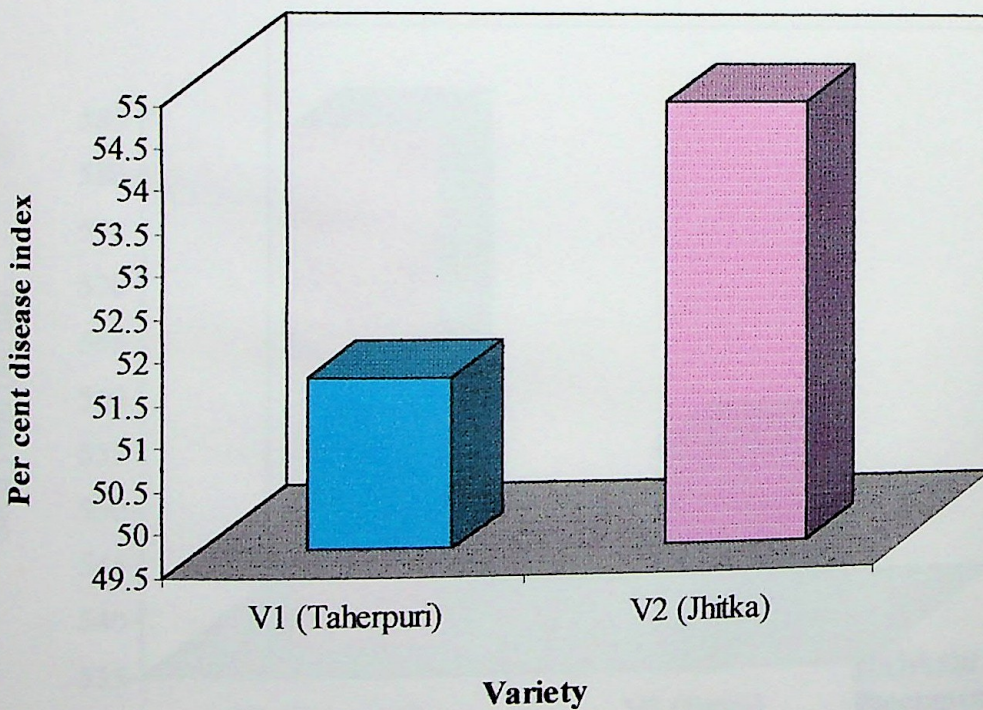


Fig. 11. Per cent reduction of purple blotch in two varieties due to time of planting in 2002-03.

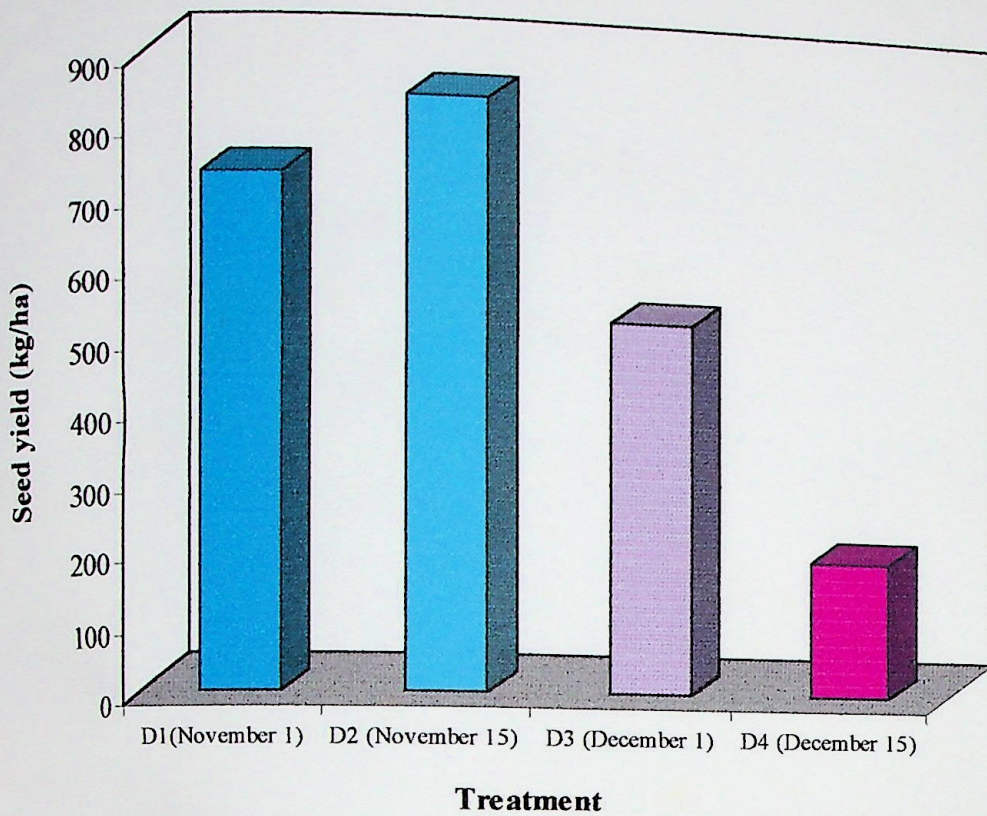
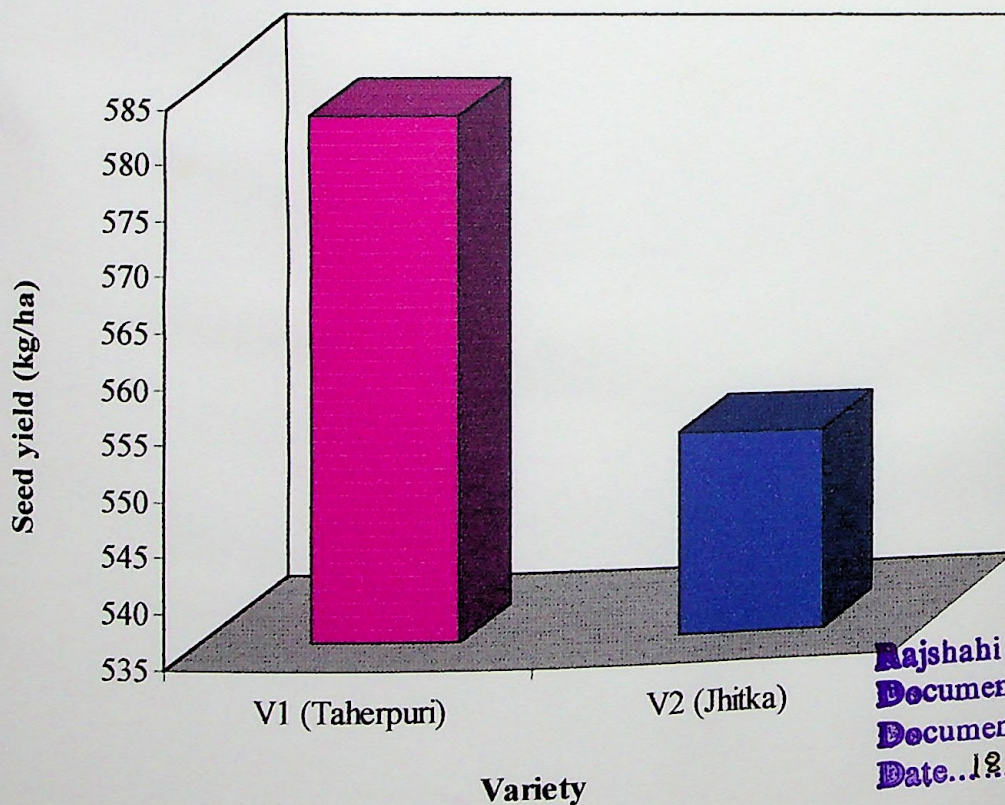


Fig. 12. Per cent yield increase of onion seeds due to time of planting in 2002-03.



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Fig. 13. Per cent yield increase of onion seeds in two varieties due to time of planting in 2002-03.