

DISEASES OF TULIPS

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Abstract. Diseases of tulips have been reviewed and observations given on the incidence of two of them on 5 varieties under storage conditions in Peshawar in 1978. The average incidence of rot was 90% among all the varieties. *Fusarium oxysporum* was found to be the most prevalent and destructive pathogen on stored bulbs.

Introduction. Tulips, the members of Liliaceae, have been prized as garden flowers for centuries. They were probably first brought to Austria as far back as 1554 from Turkey (Perry, 1973). Suddenly the curiosity for tulips increased and their cultivation spread across Europe to the Netherlands, where Dutch really took them to their hearts and established a tulip industry. Pakistan imported two thousands bulbs from Holland in 1976 and are under cultivation trials at Peshawar (Chima, 1977). This necessitated investigations on the diseases of the valuable bulb crop. Information on the subject was, therefore, reviewed and observations were recorded on the diseases of tulips stored in Peshawar.

Review of literature. Beaumont (1956) described grey bulb rot (*Sclerotium tuliparum*), shanking (*Phytophthora cryptogea* and *P. erythroseptica*), root rot (*Pythium debaryanum* and *P. ultimum*), fire (*Botrytis tulipae*), storage bulb rot (*Penicillium* spp.), rust (*Puccinia prostii*), breaking (Virus) and streak (tobacco necrosis virus) diseases of tulips and briefly discussed their control measures.

Yumaguchi (1961) carried out studies on the tulip mosaic and flower breaking type diseases in Japan. The inoculation experiments revealed that the pink varieties William Pitt and Clarm Butt, early in development, were the best for detecting the virus. It was established that colour changes in the flower were mostly determined by the age of the plants at infection. The studies also provided evidence to show that various types of flower breaking were probably due to the genetical characters of the varieties rather than to differences in the virus.

Shurtleff (1962) described various diseases of tulips alongwith their control measures. The notable diseases included: fire (*Botrytis* blight); bulb, crown and root rot; flower breaking mosaic; leaf, bulb and stem nematode and ring disease; stem rot; flower stalk collapse; flower and leaf smut; tobacco necrosis of tulip; anthracnose and blindness.

Yumaguchi and Matsui (1963) purified the tulip breaking virus and obtained a low yield of the virus by means of differential centrifugation.

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Valaskova (1963) studied the biology and effect of internal and external factors on the course of infection of tulips by *B. tulipae*. The fungus was found to assimilate glucose and saccharose more quickly and better than other sugars. It could also utilize starch and cellulose. The most suitable N sources were asparagin and glutamic acid. The amount of N in the nutrient medium effected growth of aerial mycelium and intensity of sportulation whereas a higher C content stimulated formation of sclerotia. Zn limited growth without inhibiting sporulation and sclerotial formation. The sclerotia germinated within pH 3.5-8.7. It was found that tulips could be inoculated equally well with spores, mycelia and sclerotia. At 100% R.H., infection spread equally between 5° and 25°C. Any injury to the plant tissue, when either temperature or moisture were not optimum, aggravated the symptoms. Infection was found to spread twice as fast over the old and upper part of the leaf blade as over the young and lower part. This also induced early sporulation. Spread of the disease was limited by higher K and Mg whereas P and Ca had less influence. Zn, though limiting infection, had a simultaneous harmful effect on yield.

Valaskova (1963) studied the effect of fertilization on the incidence of infection in tulips by *B. tulipae*. A number of fertilizers at normal (n) concs., 1/3n and 3n were applied to an artificially contaminated stand of Rose Copeland tulips, during a long term experiment. P and K increased the resistance and Mg and Ca were also found favourable. Excessive N increased susceptibility but the effect was outweighed by the improvement of growth of the plant.

Miller (1967) conducted trials to study the phytotoxic effect of certain mercurials used to control *Fusarium* basal rot of tulip bulbs. The best control of *F. oxysporum* f. *tulipae* was given by soaking bulbs in Hg fungicides within 7 days of harvest. The treatment occasionally caused flower deformation.

Bergman et al (1967) isolated and identified α -methylenebutyrolactone, a fungitoxic substance obtained from tulips. The substance, isolated from the white skin of the young tulip bulbs, was found effective in preventing penetration by *F. oxysporum* f. sp. *tulipae*. It was probably the same as that obtained from the flower pistils.

Bergman (1968) carried out studies on a disease caused by a strain of *F. oxysporum* in tulips. The presence of a fungitoxic lactone, in extracts from different parts of the tulip plant, was demonstrated. The role of non-toxic glycosides, from which lactone was probably derived by enzyme action, in the defence mechanism of the tulip was discussed.

Yumaguchi (1968) studied the susceptibility of Darwin hybrid tulips to tulip breaking virus. Yellow splashes and dark red stripes were found to develop on the flowers following natural and artificial infection. The variety Red Emperor was highly resistant in the field but could be infected mechanically.

Rooy and Vink (1969) tested the effectiveness of two fungicides against *Fusarium* rots in tulips pre-cooled at 5°C. Benlate at 0.2% a.i. was applied to Apeldoorn bulbs on 10 October and on 24 December (before forcing) and an organic Hg compound at 0.33%

was applied on 24 Dec. Inoculation with *F. oxysporum* on 23 Dec. caused symptoms before flowering, on 29 January. No infection occurred where benlate was used in Dec. and only 10% infection followed the earlier treatment. The Hg fungicide gave very little control of the rots.

Shumilenko (1969) carried out investigations on the diseases of tulip and their control. Symptoms were described for grey rot (*B. tulipae*), *Fusarium* wilt (*F. oxysporum* f.sp. *gladioli*+*B. tulipae*), *Verticillium alboatrum* and mosaic (tulip breaking virus) diseases. Bulb treatment with quinosol, phthaloxil and thiram was recommended against *Fusarium* wilt and grey rot diseases.

Saaltink and Gcesteranus (1969) recorded a new disease in tulip caused by *Corynebacterium oortii*. Leaf symptoms of silvery streaks and rough and discoloured areas were noticed on tulips in the field for many years. The yellow lesions on the first white bulb scales were seen, for the first time, in 1964 on the bulbs in storage rooms. Subsequently, the bacterium responsible for these symptoms was found to be an undescribed species serologically related to *C. betae* and some strains of *C. flaccumfaciens*. A detailed description of *C. cortii* was given and the pathogenicity to tulip was confirmed in inoculation tests.

Schenk and Bergman (1969) studied some uncommon disease symptoms caused by *F. oxysporum* in tulip forced in the glasshouse after pre-cooling at 5°C. Tulip bulbs which had been cooled for 9 to 12 weeks at 5°C, before planting, flowered in 5 to 8 weeks in the glasshouse under the conditions favouring rapid attack by *F. oxysporum* f.sp. *tulipae*. Growth retardation and leaf yellowing were evident in 2 to 3 weeks after planting and mortality frequently occurred before flowering. Mycelium was found present mainly in the parenchyma thereby indicating that the fungus was not a vascular parasite in tulips whereas the consequences of infection resembled those of vascular *Fusarium* spp. in other hosts.

Price (1970) carried out further studies on the spotting phase of tulip fire disease caused by *B. tulipae*. The results showed the importance of prolonged periods of high R.H. in the formation of aggressive lesions ('fire') whereas periods of 48 hours were found to cause non-aggressive lesions ('spot') only. The former increased with increasing inoculum and were numerous on leaves after the removal of surface wax. Sanitation and spraying were recommended to reduce the incidence of infection.

Briggs and Price (1970) tested the effectiveness of some chemicals against tulip fire. Mancozed and Zineb, separately as well as in combination, and dichlofluanid were found effective only against leaf infection. Dipping bulbs in methoxyethyl HgCl and thiabendazole reduced the incidence of attack but did not eliminate the pathogen. Early roguing of primary infections was, therefore, considered necessary to keep the incidence of the disease below the economic level.

Price et al (1971) studied the effect of fungicidal spraying on leaf spotting and yield of tulips infected with *B. tulipae*, the cause of tulip fire. Among the fungicides screened,

dithiocarbamate and dischlofluamid were the most effective when measured in terms of reduction of leaf spotting and increase in bulb yield. These two properties were found inversely related. Though no significant increase in yield could be attributed to frequency and formulation or rate of application yet spraying, at two-week intervals, reduced leaf spotting.

Doornik et al (1971) studied the factors influencing the infection of tulip sprouts by *B. tulipae*. Sprout infection was found to be influenced by the degree of bulb infection, the presence of the brown tunic around the bulbs, the length of growth period between planting and flowering and soil temperature. The heavily infected sprouts produced no flowers.

Munk (1971) carried out studies on bud necrosis, a storage disease of tulips and analysed the disease—promoting storage conditions. The observations suggested that ethylene, emanating from bulbs infected by *F. oxysporum* f.sp. *tulipae*, induced premature opening of the bulb tips allowing entry of mites and subsequent necrosis. In some cases, high storage temperature could be a contributory factor.

Munk and Beijer (1971) studied the symptoms and the influence of storage conditions on the development of bud necrosis, a storage disease of tulips. Symptoms of the disorder, which was found neither contagious nor hereditary and occurring more frequently and severely in certain cultivars (Red Champion and White Sail) than in others (Rose Copeland), were described. It was found to originate in the stamens of the flower producing main bud between lifting and planting and was promoted by storage under poor ventilation and at higher temperatures later in the period (after 1 Sept.). The studies indicated a combined effect of several pathogenic factors. Of these, probably the physiological was the most important.

Gigante (1971) studied the invasion of tulip bulbs by a species of *Penicillium*. The fungus was found to penetrate bulbs through wounds and was generally seen on the fleshy external leaves from where it was found to spread in the damaged areas. Fungal development was favoured by moisture, high temperature and limited air supply whereas bulbs in dry, cool and well aired rooms remained unaffected. Heavily infested bulbs gave rise to weak and stunted plants which often did not flower. The fungus, however, did not prove parasitic.

Matsunami and Suetsugu (1971) identified the tobacco rattle virus, detected from imported Dutch tulip, on the basis of host range, physical properties, particle shape and serological reactions. The infected leaves showed a pale yellow streak pattern.

Schroeder (1972) studied the significance of γ -hydroxylic acid on the host—parasite relationship of tulip and *Botrytis* spp. The inhibitory tuliposide and lactones from tulip were converted by *B. tulipae* into corresponding γ -hydroxylic acids of low biological activity. The tests of several γ -hydroxylic acids on *B. tulipae* and *B. cinerea* showed that growth of both species was stimulated by glutamic acid and inhibited by 2-methyl—DL-glutamic acid. The γ -hydroxylic acids split off from the tuliposides stimulated *B. tulipae*

and inhibited *B. cinerea*. Glutamine induced sporulation in *B. tulipae*. The significance of these acids, for the specialization of the latter on tulips, was discussed.

Lomidze (1972) studied the developmental characteristics of the causal agent of the grey rot of tulip (*B. tulipae*) in Alkhazia. A detailed account of the conditions of development, morphology, culture and pathogenicity of the fungus and symptoms of the disease was given.

Munk (1972) continued studies on bud necrosis, a storage disease of tulips. The production of ethylene by tulip bulbs, infected with *F. oxysporum* f.sp. *tulipae*, was measured and proved sufficiently high to cause open buds (liable to mite infestation and subsequent necrosis) in non-infected bulbs stored in the same room when ventilation was inadequate. Production of ethylene was found to be the highest at a storage temperature of 20°C.

Coley-Smith and Javed (1972) studied the germination of sclerotia of *B. tulipae*, the cause of tulip fire. Buried sclerotia were found to germinate in field soil in winter and early spring to produce conidiophores and conidia, usually in the season following burial and then decayed. In the laboratory, sclerotia germinated on water agar to form colourless mycelium without conidiophores and conidia. The rate of germination on agar was maximum at 25°C; on paper and soil it was maximum at 5°C. and enhanced by previous cold treatment whereas it remained unaffected by moisture and pH levels. Primary infections of tulips started from sclerotia in the soil but only when they were near the shoot tip or developing stem. It was concluded that owing to their limited survival, soil-borne sclerotia were important, only, when tulips were planted annually in succession.

Mowat (1972) studied necrotic disease of tulip caused by tomato bushy stunt virus. An isolate of the virus, obtained from an infected tulip plant, differed from the type strain of TBSV in virulence on some experimental hosts and serologically was more closely related to a pelargonium leaf curl strain. On transmitting manually to tulip both the tulip isolate and the type strain produced leaf symptoms indistinguishable from those caused by tobacco necrosis virus but the effect on the flowers was different.

Anonymous (1972) published an advisory leaflet on tulip fire disease caused by *B. tulipae*.

Bergman and Slogteren (1972) studied the effect of planting time on the incidence of sourness, rattle and Augusta disease of tulips. Planting, at a high soil temperature of 17°C, followed by warm (14-18°) spring, greatly increased the incidence of sourness (*F. oxysporum*) in var. Apeldoorn. No disease occurred on planting at 11°C followed by 10-14°C. In one trial, Augusta disease (tobacco necrosis virus A) developed in 27% of tulips planted in infested soil on 18 Sept. whereas no symptoms appeared when planting was delayed until 8 Nov. Tobacco rattle virus infection was also reduced with Nov. rather than Oct. planting.

Rooy (1972) tried some cultural and chemical control measures against the rots occurring in forced tulips. At soil temperature 11°C or below for the first 10-14 days, after

planting, soft rot (*Pythium* sp.) was found to develop. The infection between bulbs tended to spread more rapidly at high than at low temperatures. Dipping bulbs in 0.2% etridiazol (as aaterra), before planting, controlled soft rot. A combined dip of etridiazol and benomyl was found necessary where *Fusarium* sp. was also present. *Pythium* root rot could often be controlled completely by mixing 5-10 g/m² etridiazol with soil to a depth of 20 cm. A combined bulb dip for 15 minutes, immediately before planting, also gave reasonable control of root rot without bulb damage. Mixing soil with 5-8 g dexion/m² prevented infection when bulbs were forced in boxes. A repeat treatment, after 8 weeks, was found necessary if a second batch was forced in the same soil. The boxes should also be sterilized.

Bergman and Beijersbergen (1973) provided a possible explanation of variations in susceptibility of tulip bulbs to infection by *F. oxysporum*. Some evidence was obtained that varieties in susceptibility to *F. oxysporum* f.sp. *tulipae*, at different growth stages, were related to the conc. of the fugitoxic compound tulipalin (α -methylene butyrolactone) found in the outermost bulb scales.

Munk (1973) recorded observations on bud necrosis in tulips, a multifactorial disorder. The irregularly occurring disorder of unknown aetiology was found to begin in the stamens during storage and might spread to the whole flower and other organs before planting. In some cultivars, necrosis might have been induced by packing bulbs in poorly ventilated boxes when *Fusarium* infected bulbs were present. It might be due to the accumulation of ethylene causing morphological aberrations. Consequently, the blubs failed to close properly, mites penetrated them and decay resulted.

Yamamoto (1973) carried out inoculation studies on cucumber mosaic virus in relation to tulip bulb production. Inoculation of bulbs with the ordinary and yellow strains of CMV, before sprouting, reduced bulb production to 50-60% of normal whereas inoculation at the 2-leaf stage or later had a little effect.

Mowat (1973) recorded a new disease of tulips, resembling Augusta disease, from U.K.

Anonymous (1973) reported *F. oxysporum* and *Rhizoctonia* spp. as occurring on tulip and blub crops respectively, from Netherlands.

Lange (1973) made inoculation tests to study the infection caused by Augusta disease (tobacco necrosis virus). Sap inoculation, from leaves of tulips cvs. with Augusta disease and from symptoms free plants from the same field, induced typical TNV symptoms. Indicator plants reacted similarly to inoculation from plants with large and almost rectangular necrosis. No TNV particles were, however, seen and serological tests were negative. It was suggested that the unstable B strain of TNV might had been involved. The vector, *Olpidium brassicae*, was found infecting the roots. of several weed species in tulip fields and together with soil infestation might had been responsible for the spread of the disease.

Hoof (1973) studied the role of nematodes as transmitter of tobacco rattle virus in tulips and the effect of planting time on the incidence of disease. Transmission trials showed

that virus infection increased with rising nematode (*Trichodorus*) populations. Even low populations could cause 22% infection. Late planting (Nov.-Dec.) prevented infection.

Muller (1973) recorded observations on nose rot, a disease of big tulip bulbs associated with luxuriant growing conditions. The physiological disorder was found to occur mainly in larger bulbs. Storing in 0.3% ethylene reduced nose rot without causing gumming.

Bergman and Noordermeer (1973) carried out detailed investigations on the influence of soil temperature on field infection of tulip bulbs by *F. oxysporum*. Soil temperature was found to be an important factor in field infection of tulip bulbs by *F. oxysporum* f.sp. *tulipae* in both autumn and late spring. Three types of infection and the associated symptoms were discussed in relation to temperature. Infection was found to occur through the browning tunic at any place, in the outer scales, during the last few weeks before harvest. It was found to be the most common type of infection in the Netherlands. A basal rot, thought to be favoured by a relatively high temperature after planting in warm spring conditions, was found to cause premature death of plants. The symptoms were attributed to infection of the root plate immediately after planting. After a warm spring period and several weeks before normal lifting time, brown spots could be seen in the otherwise white tunic. These were found frequently accompanied by an infection of the scale below the spot. It was suggested that a high inoculum level built-up in the decaying scales of the planted bulbs, under warm conditions, might have weakened the tunic barrier by local reduction of the tuliposid concentration in the white tunic. Tuliposid was a precursor of the fungitoxin tulipalin. A semi-quantitative assay for estimation of the number of propagules in the old scales was also discussed.

Doornik and Bergman (1973) studied the factors influencing the out-growth of *B. tulipae*, from lesions on tulip bulbs after planting. *B. tulipae* lesions, on tulip bulbs, did not give rise to new infection during storage. The storage at 20°C and 95% R.H. tended to increase the rate of successful isolations from lesions during the storage period and the number of new infections after planting. The bulbs showed more new infections during growth in soil at 9°C than at 18°C.

Goodenough and Price (1973) developed a method of quantitative test for pathogenicity of *F. oxysporum* to tulips. In test using various isolates of *F. oxysporum*, the Apeldoorn tulip bulbs inoculated with any *F. oxysporum* isolate were found to lose more weight than wounded but uninoculated during incubation. Losses in weight from all inoculated bulbs were similar up to 4 days whereas those inoculated with pathogenic isolates lost weight more rapidly and were found severely rotted after 10 days. Field observations suggested that cvs. differed in susceptibility to *F. oxysporum* and the Darwin hybrid group (of which Apeldoorn is a member) was considered very susceptible. The test method provided an accurate, reproducible and quantitative method for assessing pathogenicity that could also be tried on a large scale. It was of particular use in estimating the potential infection present in soil populations. The method might also be notified to give rapid assessment of disease resistance in newly bred tulip hybrids.

Lemeni and Lemeni (1973) briefly described the incidence, symptoms and control of some virus and fungal diseases of tulip, hyacinth, narcissus and gladiolus occurring in Romania.

Asjes and Muller (1973) studied the effect of the factors effecting the incidence of tulip veinal streak, a viral disorder of forced tulips, in the glass-house under certain environmental conditions. In variety Luslige Witwe the disease, probably caused by tobacco ring spot virus, was found to increase by certain conditions prevailing in the glasshouse during forcing. The different factors either reinforced or counteracted one another. Certain heat treatments increased susceptibility of stored bulbs. Plants with a bright and dark green colour, after heat treatment or under certain glasshouse conditions, might be more susceptible than those with pale colour growing either very rapidly or too slowly and showing other inferior qualities. The factors such as soil type, structure, planting depth, water supply, salt contents and presence of soil fungi and nematodes as well as air temperature and R.H. were found to effect the symptoms. Control methods were also discussed.

Gould and Miller (1974) controlled *Fusarium* and *Penicillium* rots of tulip with thiazobenzazole and benomyl. Both fungicides were found to control *F. oxysporum* quite effectively. Best results were, however, obtained by soaking bulbs in at least 1000 ppm at 20°C for 30 minutes within 18 hours of lifting. Adjuvants were found to improve the control of the disease. Dusting bulbs was also effective. Proper storage conditions were important against *P. corymbiferum*.

Doornik and Rooy (1974) made new developments in the control of *B. tulipae* in tulips. The fungus was effectively controlled by bulb treatment with tecnazene and organic Hg compounds. Disease spread, after planting and infection of newly formed bulbs, was almost completely controlled by tecnazene. Experimental results with some new fungicides were also discussed.

Valaskova (1974) studied the interaction of temperature and fungicides during storage of tulip bulbs. The bulbs 7-12 cm in size when dipped in 0.25% germisan for one hour, before storage at 25.5°C, gave the best quality planting material whereas for bulbs measuring 8-10 cm preplanting application of 0.5% heryl (thiram), was found to be the best.

Kusaba et al (1974) carried out investigations on the growth stage of tulips and their susceptibility to tulip breaking virus.

Kobayashi and Obata (1974) reported the occurrence of *C. oortii* on tulips from Japan. A disorder of tulip called Bakurytsulyo or Kusha Kusha had been known for many years and had now been proved to be identical to the Dutch disease Gellepok or Helsvour. Detailed descriptions were also given of the symptoms, characteristics of the bacterium and mode of outbreak in the field. The disease was now found widespread in tulip growing areas and was of increasing concern to bulbs and cut flower producers. The name Kanyoyo (bacterial canker) was also recommended as a standard name for the disease in Japan.

Peterson (1974) carried out investigations on the methods of growing virus-free planting material of bulbous plants. A complete method for obtaining virus-free planting material of tulips was described.

Price and Briggs (1974) tried fungicidal dipping against *B. tulipae*, the cause of tulip fire. Immersion in benomyl suspension killed sclerotia of *B. tulipae* and considerably lessened amounts of infection. The infection was, however, found subsequently developing on dipped bulbs of cv. Apeldoorn. Extrapolating the results to a commercial sample suggested that the amount of disease remaining might be so small as to obviate foliar spraying.

Doornik and Bergman (1974) carried out studies on the infection of tulip bulbs by *B. tulipae*, originating from spores or contaminated soil. Bulbs could be infected after planting by *B. tulipae* present in the soil or by its spores on the bulb surface. The tunic around healthy bulbs might have given partial protection to the scales. In contaminated soil, infection did not occur when the distance between bulbs and inoculum was 4 cm or more. The percentage of infected bulbs was considerably lower in the second year after soil contamination.

Rasmussen (1974) made a comparative study on the disinfection of tulip bulbs by organic mercury and other fungicidal compounds. Higher yields were obtained with Orthocide 50, aapirol extra, aamangan and euparen than with Hg compounds. Benlate gave the most promising results.

Masago et al (1974) studied the growth inhibitory substances contained in tulip plant against *Phytophthora* spp. The results showed that *P. porii* invaded the tulip bulbs through the young bud and not through the scale leaf. On bulb decoction medium, *B. cinerea* grew well whereas *P. porii*, *P. capsici*, *P. citrophthora* and *P. melonis* were inhibited. Such inhibitory action was also shown by similar media made from garlic and lily but not those from onion and hyacinth. There were few differences between the inhibitory substances from 3 tulip varieties tested. The inhibitory action was found to decrease when bulbs were stored at comparatively high temperatures (35%45°C). The bulbs, planted early in winter, yielded low active substances which did not increase with bud emergence. Activity in the leaves gradually increased as they elongated and the substances synthesized in the leaves moved to the developing new bulbs in early spring. It was concluded that infection occurred while sprouts were emerging through soil and before the active substances appeared to inhibit fugal invasion.

Glits and Folk (1974) reported the appearance of fusariosis of tulips in Hungary. The disease (*F. oxysporum* f.sp. *tulipae*) was observed in 1970 in the open as well as in storage. Pathogenicity of the fungus was proved by inoculation of bulbs of the tulip var. Spring Song.

Snookeer and Dabush (1974) observed mycoplasma bodies in tulip. The bodies were found in the phloem sieve elements of petals of a single plant of the tulip var. Emmry Peach which was chlorotic, stunted and had a virescent flower. They were not found in the healthy tulips.

Makutenaite (1975) reported virus diseases of tulip from Lithuania. Tulip virus 1 (tulip breaking virus), necrotic leaf spot and dark flower spot were found to occur on tulips; the last two being newly described. Tulip dark flower spot virus remained active in vitro for 8 days; dilution end point was 1:106 and thermal inactivation point 80°C.

Vacinic (1975) recorded *B. tulipae* as a new parasite of tulip in Montenegro. The disease was observed in 1975 attacking stems, leaves, flowers and bulbs. Varieties Spring Song and Red Metador were found relatively resistant to the disease. Benlate, thiram, Zineb and Ziram were recommended for control.

Lomidze (1975) studied the effectiveness of chemical measures of control against grey rot of tulips. In trials against *B. tulipae*, the best results were obtained with thiram and ferbam.

Kusaba and Nahata (1975) studied the effect of mineral oil spray on the control of tulip breaking virus. TBV infection was markedly reduced by alko-oil sprays applied 7 times at weekly intervals from early May to mid-June whereas sprayed tulip plants died off 7 days earlier than unsprayed plants. The oil had no effect on virus activity. It was neither insecticidal nor repellent to the vectors. The rate of aphid transmission and the acquisition of virus was reduced from oil sprayed plants.

Doornik and Bengman (1975) made studies on the infection of off-spring tulip bulbs by *B. tulipae* during the growth period and after lifting. The young bulbs might become infected, during the growth season, via the lesions present on the scales of the planted bulbs and from plant stems or by conidia washed down from leaf spots. During storage, infection could only occur after wound inoculation and when bulbs were stored at 100% R.H., for some days, immediately after lifting. There were no perceptible variations in susceptibility or sensitivity of the bulb tunic (during growth) whereas the sensitivity of the outer scale was more pronounced during the first weeks after flowering. The sensitivity of the scale tissues, during storage, tended to increase in October and November.

Munk and Hoogeterp (1975) studied the effect of storage and glasshouse conditions on flower-bud blasting disease in tulip. The disorder in susceptible varieties was found to be promoted by certain storage and glasshouse conditions. Similar effects resulted from exposure of bulbs to 1-3 ppm ABA for 3 days or injection of the flower buds in the glasshouse with 0.5 ml of 20 mg/l sol. of the chemical. Injections of bulbs with 0.5 ml G^A3, G^A4/7 and Kinetin counteracted the conditions.

Bergman (1975) made a device for the incubation of Fusarium-inoculated tulip in a constant air stream. Inoculation experiment on tulip bulbs with *F. oxysporum* f.sp. *tulipae* frequently gave inconsistent results when performed in stagnant air as well as under strictly standardised conditions. This was thought to be due to the accumulation of ethylene produced in large quantities by the inoculum and infected bulbs. For this reason, a device was developed to incubate bulbs in a reproducibly constant and water saturated air stream which kept the ethylene concentration at an inactive level and without appreciable variable variation in O₂ pressure.

Marenkova and Neupokoeva (1975) described some diseases of tulips. The main diseases included: *B. tulipae*, *F. oxysporum* and tulip breaking virus.

Duineveld and Beijersbergen (1975) studied the resistance to benomyl of fungi, isolated from bulbs and corms. *Penicillium* isolates, obtained from lily, iris, tulip, gladiolus and *Erythronium* sp. grew rapidly on media containing 1250 ppm benomyl. Tolerance of fungicide was also exhibited by some isolates of *F. oxysporum* from tulip.

Gould and Miller (1975) studied the effect of time of digging on the incidence of *Fusarium* rot in tulip bulbs. The best production of flowers and healthy bulbs was obtained from bulbs harvested on 4 May and replanted on 29 August. Lower yield, at an earlier harvest date, was presumably caused by immaturity and at later dates by increasing spread of *F. oxysporum* f.sp. *tulipae* which was found to be favoured by warm soil.

Mescheryakova (1975) studied the causes of the death of tulips and possibility of their control. Bacterial soft rot, *Fusarium* spp., typhulosis (*Typhula idahoensis*) and grey mould (*B. cinerea*) were found to be the most harmful diseases of tulip. The diseases lead to death of infected bulbs which should have been destroyed. Soil treatment with thiram or euparen was found quite effective against sclerotial rot (*Sclerotium rolfsii*).

Muller (1975) reported the infection of tulip bulbs by *Aspergillus niger* and *Rhizopus arrhizus*, from Netherlands.

Asjes (1975) conducted control trials, with mineral oil sprays, against the spread of tulip breaking virus in tulips. The spread of TBV was considerably reduced with concentrated sprays prepared with summer oil, winter oil, albolineum and asepthion oil. Control was improved by the more concentrated albolineum sprays (2.5, 5, 10%) and spread reduced more effectively when available quantities of emulsions giving good leaf coverage were used (2.5, 5%). The weight ratio's of bulb yield of plots, given a 2.5% spray in all the year and 95% spray in 1972 and 1973, were near those of the untreated plots (within 0-6%) but then ratios dropped by 11-19% after more conc. sprays were used in 1971. Spraying was slightly more effective at weekly than at fortnightly intervals. Better control of TBV spread was given when sprays were applied from the beginning of May whereas sprays started in June were found ineffective. The efficacy of mineral oil sprays was discussed in relation to applications on tulips and lilies. Besides, their use in curtailing TBV spread in commercial tulip fields was discussed.

Price (1975) carried out studies on the pathogenesis of tulips by *F. oxysporum*. A random selection from several thousand isolates of *F. oxysporum*, from sites on Norfolk where tulips had been grown the previous year, was tested for pathogenicity on tulip by a method based on the loss in weight of the bulbs during 10 days after wound inoculation. There was no apparent threshold of loss to distinguish pathogenic from non-pathogenic isolates whereas c. 1/4 of those isolates causing a large weight loss were also found associated with the production of a larger globule of yellow gum at the point of inoculation. The

results suggested that either some pathogenic isolates did not produce ethylene, the cause of gumming in tulips or that the physiological state of the bulb at the time of infection played a part in ethylene production.

Derks and Asjes (1975) studied the transmission of lily symptomless virus in tulips and tested its pathogenicity on various host plants. The virus was found transmitted mechanically only to *Lilium formosanum* and the tulip cvs. Rose Copeland and the 53 plant spp. tested *Macrosiphum euphorbiae* transmitted it more efficiently than *Myzus persicae* and *Aphis gossypii* from Lily to Rose Copeland. Yields of tulip Peerless Pink were slightly reduced by infection. Natural infection were found to occur in commercial tulip stocks. The virus could be purified either from crude sap or sap treated with cholroform.

Saniewski and Urbanek (1975) studied the effect of cycloheximide on the infection of hyacinth and tulip bulbs by a species of *Penicillium*. Bulb treatment of hyacinth (cvs. Lady Derby, Pink Pearl, Delft Blue) and tulip (cv. Oxford) with cycloheximide strongly stimulated infection by *Penicillium* sp. The possible mechanism of the effect was also discussed.

Anonymous (1975) discussed the high incidence of tulip breaking virus in imported bulbs and its possible spread that caused concern. In unsprayed plots, 21 of 55 healthy indicator bulbs, planted among infected ones, were infected in one season whereas 4 of 57 in plots sprayed with 2% oil emulsion every 14 days, were infected. Incidence of tobacco yellow dwarf disease (mycoplasma?) was the lowest in plots given 200 ppm methonly in transplant water plus a soil drench 4 weeks later.

Bergman (1976) conducted an advisory drive on control measures against *Fusarium* disease of tulips in Netherlands.

Derks and Asjes (1976) studied the transmission of Lily symptomless virus in tulips. LSV could be transmitted mechanically to 1 out of 52 plant spp. tested and was found to be transmitted by 3 aphids, in a non-persistent manner, from lily to tulip. The virus had very little effect on tulip yield and symptoms were mild.

Humphreys et al (1976) controlled *Pythium* root rot (*P. ultimum*) in five-degree tulips through soil treatment with etridiazole.

Selochnik (1976) carried out studies on dynamics and character of susceptibility to diseases of tulips. Root rot caused by a species of *Pythium* was a new record for Soviet Union. *Pectobacterium carotovorum* (*Erwinia carotovora* var. *Carotovora*) was found to develop on plants weakened by unfavourable wintering conditions. Prolonged cultivation of tulips on the same plot caused considerable spread of sclerotial diseases. With low temperature in winter and early spring, *Typhula borealis* (*T. idahoensis*) was the most prevalent disease. Excessive moisture also favoured the disease in spring. High air and soil temperatures enabled the development of *F. oxysporum*. The decisive factor in its spread

was unfavourable storage conditions. Early lifting of the plants provided the effective control of the disease.

Lomidze (1976) described the main diseases of tulip and their control. Diseases included: grey mould (*B. tulipae*), *Fusarium* sp., *Rhizoctonia* sp., *Penicillium* sp., bacteriosis and tulip breaking virus. Treatment of bulbs with thiram (8-15 g/Kg) and spraying plant with 1% thiram, 0.5% Ziram and 0.3% benlate were recommended against *B. tulipae*

Anonymous (1976) reported the resistance to benzimidazole in *B. cinerea* on tulip. The disease was found to occur more frequently than in the previous year. Resistance was also found in *F. oxysporum* on one stock of gladiolus but not in *F. oxysporum* on tulips. Treatment of tulip bulbs with benomyl was quite effective in preventing penetration by *F. oxysporum* even after 24 weeks. Hell fire symptoms caused by *C. oortii* on tulip leaves were reduced in inoculated stock by formaldehyde treatment of planting material. Some isolates of *Pythium* were found to cause root rot. Besides, *Rhizoctonia solani* isolates appeared to survive partially during storage of tulip bulbs and surviving propagules might act as a new source of infection after planting. Arabis mosaic virus was isolated from tulips and the factor like symptoms and disease development were studied.

Kamerman (1976) recorded observations on symptoms, cv. susceptibility and conducive factors of the foliar scorch disease of tulips caused by *C. oortii*. Disease incidence could be prevented by reducing damage by late night frost and by removing infected bulbs and plants. Cure could only be achieved by destroying the bacterium inside the bulb whereas heat and chemical treatments had so far proved unsuccessful.

Fujii (1976) recorded symptomatological and epidemiological observations on the tulip disease caused by *C. oortii*. Diseased plants were found in 45% of tulip fields in Toyama Province. Infection was found to be the most severe on cvs. grown for forcing.

Kudo and Kobayashi (1976) carried out studies on bacterial disease of tulip (*C. oortii*). Five bacteriophages, isolated and characterized, were found specific to *C. oortii*.

Rooy (1976) reported some strains of *B. tulipae* as resistant to systemic fungicides on tulip in the Netherlands. Limited use of systemic fungicides and combined with or replaced by mixed carbamates was recommended.

Kusaba and Nahata (1976) studied the distribution of pathogenic viruses of tulip plants in Toyama prefecture in Japan. Of 51 samples of viruses, isolated from diseased tulip plants in commercial fields, 50 were identified as tulip breaking virus and one as cucumber mosaic virus.

Hoof and Silver (1976) carried out investigations on the natural elimination of tobacco rattle virus in tulip 'Apeldoorn'. The studies confirmed the experience of tulip growers that infected bulbs often produced virus free plants when grown repeatedly in uninfected soil.

Putnaergle (1976) studied some properties of tobacco necrosis virus, the pathogen of Augusta disease of tulip. The virus was observed on tulip in Latvia in 1972, sometimes infecting 50-60% of plants, mainly early varieties. The thermal inactivation point was 78-80° and in vitro survival upto 15 days. *Chenopodium quinoa*, *Gomphera globosa* and *Phaseolus vulgaris* were found to be the best indicators.

Asjes (1976) briefly reported the symptoms associated with Arabis mosaic virus in tulip in primarily as well as secondarily infected field and glasshouse plants. The studies on the diagnosis and control of the infection were also reported.

Chima (1977) recorded nematodes as damaging agents to the tulip and daffodil bulbs, for the first time, from Peshawar, Pakistan. The varieties were, however, found to differ in their reaction towards the attack of nematodes.

Bulukova and Likha chev (1977) tested the effectiveness of some new fungicides against fungus diseases of tulips. Under natural infection by *B. tulipae* in the field, benlate followed by euparen and uzgen gave the best control. Infection was reduced 10-fold with benlate. Yield was found to increase and health of the bulbs during storage was improved. It was recommended that bulbs should be treated 2-4 weeks before planting.

Makutenajte (1977) studied internal symptoms caused by tobacco ring spot virus on ornamental plants in Luthuavia. In inoculation tests carried out on 22 species of plants with isolates of ring spot virus, obtained from *Dicentra spectabilis*, gladiolus and tulips, 11 were found infected showing typical symptoms. Electron microscope indicated spherical particles in infected tobacco var. Samsun.

Bulukova and Likha chev (1977) carried out further studies on the effectiveness of new fungicides against fungus diseases of tulips. Benlate, uzgen and fundazol were found to control *B. cinerea* and storage fungi such as *Penicillium*, *Alternaria*, *Aspergillus* and *Typhula* spp., quite effectively.

Rooy (1977) found a new chemical for the control of *Botrytis* in flower bulb crops. Roniban had proved satisfactory for controlling *B. tulipae* on a wide range of flower bulbs. It could also be used as a disinfectant for planting stock and as a field spray, applied 2 or 5 times at 500 g/ha, around flowering time.

Lomidze (1977) studied the effect of *B. tulipae* on the structure of tulip leaves and stems and on some physiological processes. Pathological changes in the infected tissues of tulip leaves and stem were also noted. Infected tissues became necrotic. The contents of pigments, chlorophyll, carotene and vitamin C in infected leaves decreased markedly. Respiration was found to increase whereas photosynthesis decreased.

Price and Briggs (1977) carried out trials to study the effect of chemical sterilants on tulip and narcissus growth, flower production and disease control in re-used forcing soil. Repeated application of bromomethane, dazomet and etridiazole on the same soil for three

years had no adverse effect on growth, flower production and flower quality as compared with other treatments such as untreated soil, steam sterilization and fresh soil each year. It also did not result in any improvement when compared with untreated soil used for the same period. Bulbs grown in steam sterilized soil and those in fresh soil annually were found no better than those in soil treated with the chemicals. No obvious pattern of disease was found to emerge after growing bulbs in the same soil for 4 seasons. It was suggested that there was little risk in using soil for forcing for several seasons without treatments provided the bulb stock was healthy. However, there might be a risk in not sterilizing soil, thought to be infested with disease. The experience with other crops showed that any of the chemicals treated would be suitable.

Swart and Kamerbeek (1977) carried out studies on ethylene production and mycelium growth of the tulip strain of *F. oxysporum* as influenced by shaking of and oxygen supply to the culture medium. Ethylene was produced abundantly by *F. oxysporum* f.sp. *tulipae* in liquid medium with glucose as the only organic substrate. Production started after a long phase of c. 4 days and reached at its peak coinciding with maximum mycelium weight. The rate of ethylene production was found to be more or less linearly dependent on Po_2 for several days. Total production also depended on oxygen con. whereas pure oxygen inhibited it by c. 50% as compared with 21% oxygen. The higher production in shake cultures than in stagnant cultures was probably due to better oxygen supply in the medium. Mycelium weight, however, did not provide a valid referential basis for the production of ethylene.

Sutton and Garrett (1978) studied the epidemiology and control of tulip breaking virus in Victoria. Rapid spread of TBV was found to be associated with aphid flights during the main tulip growing season (July-November). Attempts at control, by using chemical sprays and barrier crops, were unsuccessful whereas aphid-proof cages over tulips were found successful in preventing spread of the virus. Intensive roguing, under the cages, eliminated tulips infected with TBV. Healthy tulips grown 275 m from infected ones, but unprotected from migrating aphids, did not become re-infected during 2 seasons.

Peters et al (1978) tried some direct control measures against virus and mycoplasma diseases of crop plants. Oil sprays were reported being used to control the spread of tulip breaking virus in lilies and cucumber mosaic virus and potato virus y in *Capsicum*. Application of oils to potatoes reduced the spread of virus but caused a reduction in tuber weight and burning of the tubers. The hypothesis was advanced that the action of oil was due to its transference on the labium of the transmitting insect to the infection site with the virus, where the oil interfered with the development of infection. It was suggested that comparative studies on different types of oil and their effects should be made in order to expand the possibilities of use in the field.

Observations. The tulip bulbs were lifted in April from 5 varieties: Glacier, Sweet Harmony, Oxford, General Eisenhower and Aureola grown at the Pakistan Forest Institute's campus, Peshawar. The stored bulbs were examined for the diseases, at regular intervals, till November, 1978. The data on the incidence of lots, causal organisms and associated

symptoms were recorded. The incidence of rot varied from 49.4% in General Eisenhower to 98% in Aureola. The average incidence was 89.9%. Of the 2 fungal pathogens i.e. *Fusarium oxysporum* and *Aspergillus niger*, the former was found to be the most common and damaging to bulbs. The latter occurred only in combination with the former, on Sweet Harmony and Aureola as follows:

Variety	Number of bulbs available in		Bulbs lost due to rots		Causal fungi
	November	April	No.	%	
Glacier	13	292	279	95.5	<i>F. oxysporum</i>
Sweet Harmony	19	92	73	79.3	<i>F. oxysporum</i> + <i>A. niger</i>
Oxford	90	437	347	79.6	<i>F. oxysporum</i>
General Eisenhower	49	97	48	49.4	<i>F. oxysporum</i>
Aureola	19	967	948	98.0	<i>F. oxysporum</i> + <i>A. niger</i>
Total:	190	1885	1695	..	
Average (all varieties)	89.9	

Fusarium rot was seen as a white mycelium enveloping the bulbs after becoming evident on them and between their scales. The infected bulbs become light weight and soft. The decayed ones were almost rendered unfit for planting. The microscopic examination of the fungus revealed that the mycelial threads are septate and hyaline, stroma brownish-white to violet, plectenchymatic, smooth, sclerotia hard bodies, 0.5-3 mm in thickness, later forming sporodochia, more seldom pionnotes, with 3-sepate spindle to sickle-shaped conidia, curved or almost straight and weakly pedicellate ($19-45 \times 2.5-5 \mu$). Smaller conidia, one or two-celled, oval to reniform, numerous in aerial mycelium, measuring $5-26 \times 2-4.5 \mu$. The fungus appeared closely related to *Fusarium oxysporum* Schlechtendahl (Gilman, 1959).

Aspergillus rot was a soft and spongy type. More or less yellow coloured hyphae were seen with scanty aerial mycelium. Conidiophores mainly arising directly from the substratum, smooth, septate or non-septate, varying greatly in length and diameter ($200-400 \times 7-10 \mu$). Conidial heads fuscous, blackish brown to carbonous black, varying from small conidial chains to the more common globose heads measuring $300-500 \times 20-50 \mu$.

Phiallides typically in two series. Conidia globose, at first smooth, but later spinulose with colouring substance, mostly 2.5-4 μ , less frequently 5 μ . The characters were in close agreement with those of *Aspergillus niger* van. Tieghem (Gilman, 1959).

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