CHAPTER 6

INTEGRATED DISEASE MANAGEMENT OF ONION IN SRI LANKA

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Abstract

The importance of onion in Sri Lankan diet needs no over emphasis. National agriculture policy has also emphasised on improvement of onion. In spite of the rapid expansion of onion cultivation, considerable losses are reported to occur throughout the production process. Onion diseases account for a major share of total yield losses. Among important diseases in Sri Lanka, bulb rot (fungal bulb rot and bacterial bulb rot), leaf twister disease (anthracnose) and purple blotch continue to cause significant damage to both seed and bulb onion crops throughout the onion growing areas in Sri Lanka. The Department of Agriculture, Sri Lanka have carried out many investigations to find out effective management practices to control these diseases. Used alone, an individual management practice may not reduce the level of disease to an economic threshold level, hence the additive effect of several practices are experimented. Integrated disease management practices are being implemented for the management of onion diseases in Sri Lanka.

Introduction

Two general types of onion have been traditionally known to Sri Lankan consumers, called red onion (shallots) and big onion. They are distinguished by size rather than colour of bulbs. Red onion produces small bulbs whereas, big onion produces larger bulbs. In spite of the rapid expansion of red onion and big onion cultivations, considerable losses occur throughout the production process and onion diseases account for a major share of the total yield loss. Seed production in onion in Sri Lanka requires two different seasons *viz.*, one season for bulb production (bulb crop) and another season for seed production (seed crop). The big onion and red onion are affected by many diseases at different crop growth stages and they account for considerable losses in bulb and seed yield. Apart from reduction in crop yield, the diseases also cause harmful effects during harvesting, post harvesting, storage and marketing stages, causing significant losses in quality, which lead to heavy economic losses. The disease alters the cropping pattern and also consistent use of chemicals to control plant diseases not only poses a threat to the environment and mankind but also help in building up of resistance in pathogens. Among more important diseases in Sri Lanka, bulb rot (fungal bulb rot and bacterial bulb rot), leaf twister disease (anthracnose) and purple blotch contribute to cause significant damage in both seed and bulb onion crops throughout the onion growing areas in the country (Plates 1-3).

This article reviews the information on onion diseases recorded since 1970. The primary objective of this article is to summarize the coordinated and collaborative research program that was intended to improve the disease management strategies; outreach implementation and to overcome or minimize damage due to diseases of onion.

Damping Off

Early studies on onion diseases were mainly focused on management of nursery diseases. Two types of diseases *i.e.* pre emergence and post emergence seedling deaths (Plate 1) have been reported (Wimalajeewa and Wijewardana, 1971; Priyantha, 2014). Soil treatments with benlate, captan and cerasan have shown significant control of nursery diseases. Covering of nurseries during night with cadjan leaves was also found to be effective in controlling nursery diseases (Wimalajeewa and Wijewardana, 1971). However, the Integrated Disease Management (IDM) practices are recommended for the management of nursery diseases which comprises of soil solarization, seed treatment, cultural practices and fungicide treatment (Priyantha, 2014). Soil solarization of nursery beds has been found to be very effective in reducing damping off in onion. To minimize the risk of infection from soil borne diseases, nursery beds have been sterilized by burning straw and paddy husk on beds.

Sterilization of nursery beds help to destroy the pathogens in the upper layers of soil. Crop rotation in nursery beds for 2-3 year periods is recommended for raising healthy seedlings. Seed treatment with fungicides like captan, thiram, thiophanate methyl+thiram reduces the both phases of the disease *i.e.* pre-emergence and post emergence. Infected soils in the nursery beds can be drenched with fungicides like captan, thiram, thiophanatemethyl+thiram during the nursery stage for better control of disease.

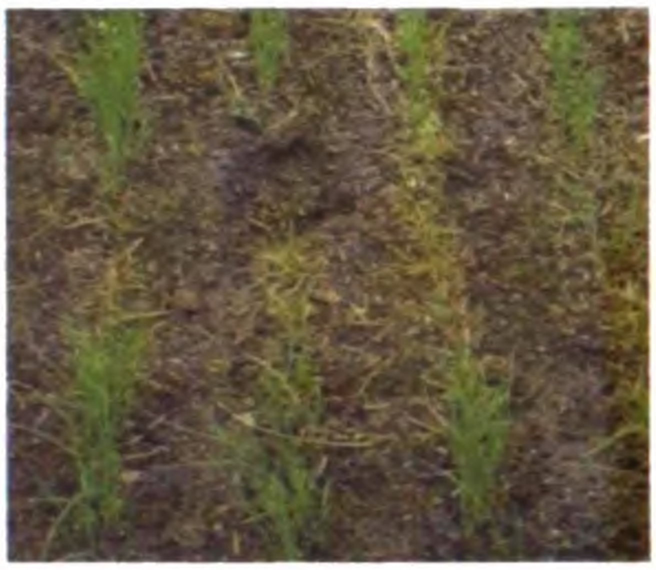

Plate 1: Pre and post emerging seedling death of onion.

Leaf Twister Disease – Anthracnose (*Colletotrichum gloeosporioides* and *Fusarium oxysporum*)

Leaf twister disease has been reported at various crop growth stages of onion from different parts of the island. The disease is locally named "*disco*" by farmers (Plate 2). The disease was first reported in shallots (red onion) from the Trincomalee district in 1970's, and from Puttalam district in 1987 (Anon, 1992). Similar symptoms were reported in big onion from Matale district in 1996 (Weerarathne, 1996; 1997). It was subsequently reported from Kalpitiya area in red onion (Rajapaksha *et al.*, 2001). During the *maha* 1995/96, a severe outbreak of the disease was observed.

Initially, the possible causes of disease symptoms were suspected as nematodes. However, Nugaliyadda and Ekanayake (1986) reported that parasitic nematodes were not associated with infected plants. Fungus named as *Fusarium oxysporum* was isolated from infected shallot plants. Thrips, mites, nematodes and other fungi could also cause similar symptoms (Kuruppu, 1992). Mithrasena (1994) isolated the fungus *Colletotrichum* spp. from infected samples collected from Ratnapura and suggested that it could be due to a soil borne pathogen. Both

Colletotrichum gloeosporioides and *Fusarium oxysporum* f. sp. *cepae* were isolated from the infected plants collected at Kalpitiya (Wijesinghe, 1994). It was subsequently reported in big onion cultivation and causal organism was identified as *Colletotrichum gloeosporioides* (Penz). Sacc. the perfect stage of *Gomerella cingulata* (Stonem) (Weerarathne, 1996; 1997). In 2002, Rajapaksha *et al.* (2001) also reported that leaf burning of red onion known as "acid disease" also caused by a fungus, *C. gloeosporioides.* According to the latest report, the causal agent of leaf twister disease of shallot in Kolonna area has been identified as *C. gloeosporioides* and *F. oxysporum. Colletotrichum gloeosporioides* causes twisting of above ground parts and *F. oxysporum* causes bulb rot. The both fungi were involved in the development of typical leaf twisted disease symptoms observed in Kolonna area. Morphological characters of *C. gloeosporioides* and *F. oxysporum* pathogens are given in Table 1.

Plate 2: Leaf twister disease symptoms (left) and decayed flower head on bulb crop (right).

It was reported that *C. gloeosporioides* quickly differentiates on leaf surfaces of onion varieties, Rampur and Pusa Red. Small, about 2-3 mm size brown lesions initiated on inoculated sites of leaves within 6 days under induced moisture conditions (Rajapaksha *et al.*, 2001; Priyantha *et al.*, 2002). Understanding the mode of anthracnose development in different varieties under different conditions could be used as a guide to identify suitable control measures for anthracnose disease of onion.

Table 1: Characters of *Colletotrichum gloeosporioides* and *Fusarium oxysporum* collected from leaf twister disease affected shallot plants.

Characters	Isolates	
	C. gloeosporioides	*F. oxysporum*
Colony colour	Gray, turn gray-black when older	White, turn brown-purple when older
Reverse colony colour	Black	Purple
Acervuli	Conidia produced in black acervuli as conidia masses, individually smaller size	Setae absent, conidia produced openly within hyphae and exposed to the air
Setae	Brown	Absent
Conidia	Straight rounded ends, unicellular	Two types; Macro conidia- Sickle shaped and pointed at ends, 3-5 cells, larger. Micro conidia- Abundant, cylindrical, 1-2 cells, smaller.

Source: Rajapaksha *et al.*, 2001.

Leaf twister disease can be recognized by typical symptoms on the host plant. Symptoms observed in the seed crop and bulb crop vary while the disease spread sporadically in the field. In the bulb crop, appearance of leaf curling, twisting, chlorosis and abnormal elongation of the pseudo stem could be observed. White sunken oval lesions appear mainly in lower leaves. However, a few lesions could also be observed in some young leaves. These lesions enlarge with time and spread all over the leaf. Black, minute, slightly raised acervuli (fruiting bodies) with pink masses of conidia could be seen scattered on the surface of lesions (Plate 2, left). Affected leaves wither and became detached. Bulbs produced from these plants were small and eventually rotted. Most of the affected bulbs rotted before harvesting while the others rotted during storage (Weeraratna, 1996; 1997).

Seed crop did not show symptoms of leaf curling, twisting, chlorosis or abnormal elongation of the pseudo stem. Lesions on seed crop consisting of dense black acervuli with pink masses of conidia were observed on flower stalks. These lesions increased in size and several lesions coalesced to form large infected areas on flower stalks. When the lesions reached the base of the flower head, young flowers decayed prematurely (Plate 2, right). At early flowering stage, flower stalks collapsed at the lesions and as a result the upper portion of the flower stem drooped and dried up prematurely with no seeds produced in the flower. Rajapaksha *et al.* (2002) described certain other characteristic symptoms like leaf burning.

Transmission studies showed that typical disease symptoms could be observed on seedlings raised on infected soil and on autoclaved soil incorporated with crop debris within 7-10 days and within 4-5 days after planting, respectively. But no symptoms were observed in seedlings raised on autoclaved and uninfected soil (Weerarathne, 1996; 1997). This suggests that the disease can be transmitted through soil and crop debris and the fungus could be inactivated by autoclaving. The same author further demonstrated that disease could also be transmitted through water and infected seeds. The inoculum sources were identified as infected planting materials and soil for both *C. gloeosporioides* and *F. oxysporum* pathogens (Rajapaksha *et al.*, 2001).

Environmental factors influence the occurrence of leaf twister disease. High relative humidity (RH nearly 100%) and moderate temperature changing from 20 to 31 °C with rainfall (5-31 mm) appeared to be very conductive for the infection and development of leaf twister disease (Weerarathne, 1996; 1997). Such environmental conditions are found during later part of *maha* season (January-February). It occurs rarely during the *yala* season (dry period). The results revealed that the disease may appear in the field at any stage of growth depending on the weather conditions and presence of inoculum.

Variety screening studies using locally available cultivars and exotic germplasm against leaf twister disease have been carried out in collaboration with plant breeders (Weerarathne, 1996). It was reported that all locally available big onion cultivars were susceptible to leaf twister disease whilst exotic varieties Red Grano, Hybrid Rojo and Primero showed resistance under field conditions.

However, all available shallot cultivars were susceptible to leaf twister disease (Rajapaksha *et al.*, 2001).

Use of fungicide is a common practice for management of diseases in crop cultivation. Field studies conducted by Rajapaksha *et al.* (2001) reported that application of homai (thiophanate methyl 50% + thiram 30% WP) as soil and bulb treatment and alternate spraying of thiophanate methyl 70% wp and chlorothalonil 70% WP or bulb treatment and spraying or spraying only with respective fungicides resulted a reduction in leaf twister disease incidence and an increase in bulb yield in the field. However, foliar spray was less effective in controlling leaf twister disease under severe epidemic and favourable weather conditions (Weeraratne and Yapa, 1999). Rajapaksha *et al.* (2002) reported that seed treatment with thiophanate methyl 80% + thiram 30% and solarization of soil for two weeks prior to planting significantly reduced the incidence of the disease and enhanced yield of onion.

Thiophanate methyl is a widely used fungicide for onion anthracnose control in Sri Lanka. In recent years, losses due to anthracnose in onion have been severe despite the use of thiophanate methyl (Priyantha *et al.*, 2011). Although the chemical fungicides effectively suppress and control the disease, continuous use of systemic fungicides can reduce their effectiveness due to the development of resistance. *C. gloeosporioides* isolates collected from Matale district showed to have developed resistance against thiophanate methyl (Priyantha *et al.*, 2011). The occurrence of thiophanate methyl resistant isolate in Matale district may be due to frequent cultivation of onion and widespread use of thiophanate methyl in the district. No other reports, except from Matale, on the failure of thiophanate methyl fungicides for controlling the disease have been reported. Hence, thiophanate methyl still provides excellent control of anthracnose in onion in other parts of Sri Lanka. Effective alternative fungicides for the control of anthracnose have also been identified as trifloxystrobin + tebuconazole 75 wg, pyraclostrobin + metiram 60 wg and fluzinam 500 g/l sc. (Priyantha *et al.*, 2010).

Accordingly, it can be stated that used alone, an individual management practice may not reduce the level of disease to an acceptable level, whereas the additive effect of several practices will be desirable. Therefore, the following integrated disease management practices are being implemented for the management of leaf twister disease of onion in Sri Lanka. Among the regulatory measures, use of healthy bulbs and seeds and removal of infected bulbs from the storage has been recommended. In epidemic areas, farmers are advised to collect infected materials and either burn or bury deep to minimize the initial inoculum content. Such practices reduce the initial inoculum and reduce spread to new areas. Fungicides thiophanate methyl 70% WP (20 g/10 l water) and thiophanate methyl + thiram 80% WP (18 g/10 l water) have been recommended to treat bulbs and seedlings and seed treatment with fungicides like thiram, captan, thiophanate methyl + thiram have been recommended. Some other fungicides have also been found effective against onion leaf twister disease, such as chlorothalonil, mancozeb, fluzinam, thiophanate methyl and pyraclostrobin + metiram.

Purple Blotch (*Alternaria porri*)

Purple blotch disease caused by *Alternaria porri* (Ellis) Cif. is one of the most important diseases of onions (Wickramaarachi *et al.*, 2004). Development and spread of the disease is highly correlated with warm weather and humid conditions. The disease reaches epidemic proportions every year during the wet (*maha*) season. The fungus can cause a reduction in yield from 90-100% in the low country dry zone during wet seasons if the disease is left uncontrolled. Major constrains in onion seed production in *maha* season are crop damage due to high rainfall and severe development of purple blotch. Hence, the production of onion is limited to *yala* season due to purple blotch disease. Proper management of this disease is the key determinant factor in true seed production during wet (*maha*) season (Sumanarathne, 2000). Big onion and shallot cannot be grown from October to January due to high incidence of this disease (Wijewardana, 1972).

Purple blotch disease is mainly a leaf disease and spreads to flower stalks. The initial symptoms are small, water-soaked lesions with white centres that appear usually on older leaves. As the disease progresses, the lesions enlarge and become purplish with light yellow concentric rings on margins (Plate 3, left). As the severity increases, leaves turn yellow brown, lose erectness and wilt. Lesions may also form on seed stalks and floral parts (Plate 3, right). In severe cases the seed stalks may be girdled, destroying the stalks before seeds get matured (Priyantha, 2014).

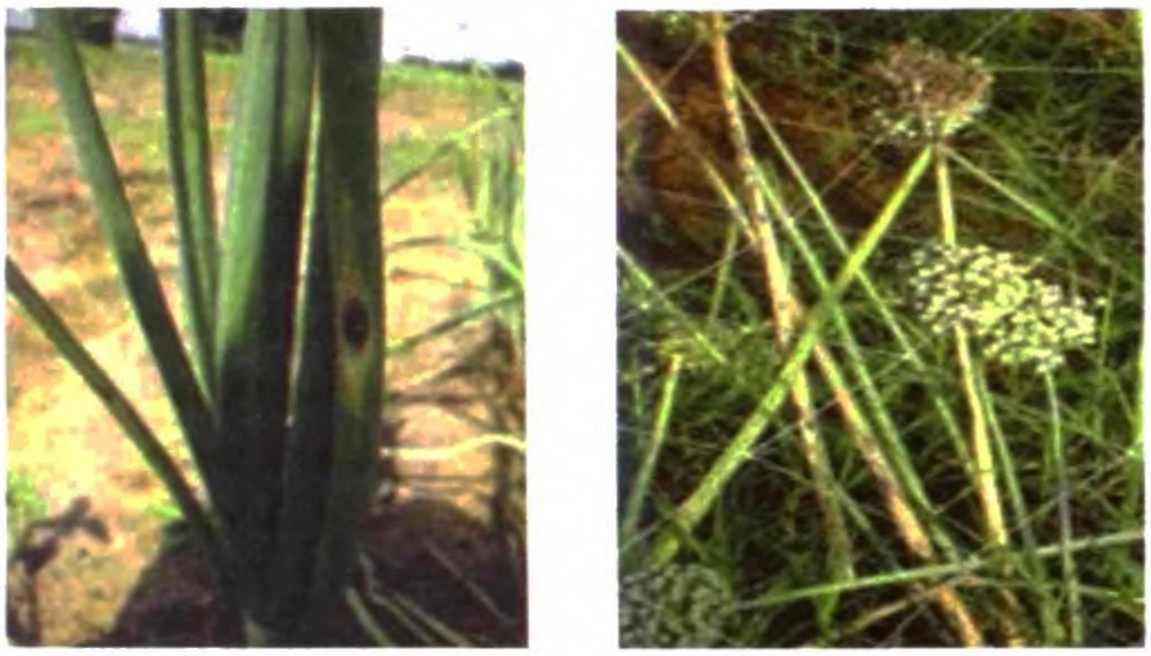

Plate 3: Purple blotch symptoms on leaves (left) and flowers (right).

Persistent rains and heavy dew are factors that favour the development of purple blotch disease during *maha* season. Wind borne conidia from previous crop debris initiate infection, which is favoured by high temperatures and humid conditions. Prolonged leaf wetness increases the probability of further infection. Continuous rain over 6 hours, high RH (70-90%) and air temperature of about 20-33 ^{0}C are favourable environmental conditions for purple blotch (Priyantha, 2014). Twelve big onion varieties have been screened to determine resistance and the genetic base of purple blotch resistance in Sri Lanka. The results showed that all varieties available were not resistant to purple blotch disease (Weeraratne, 1996). On the contrary, Mettananda (1998; 1999) reported that the variety Red Creole shows low susceptibility to purple blotch.

Foliar application of fungicides can effectively be used for the management of purple blotch disease of small onion. Wickramaarachchi *et al.* (2004) suggested that foliar application of pyraclostrobin (7 ml/10 l) or tebucanozole (3.5 ml/10 l) reduced purple blotch of red onion. Wickramaarachchi *et al.* (2004) also reported that complete control of disease even with fungicides is difficult to achieve in Aralaganwila area (DL $_{2b}$) during the wet season. Studies conducted by Priyantha *et* *al.* (2010) on the efficacy of foliar fungicides reported that trifloxystrobin + tebuconazole 75 wg, pyraclostrobin + metiram 60 wg and fluzinam 500 g/l sc were effective in controlling purple blotch in onion.

Spraying of sulphur develops a thin sulphur coat on the leaf surface, which could act as a protective barrier against pathogen infection (Edirimanna and Rajapaksha, 2003). They suggested further that significantly higher seed yields could be obtained with this treatment although sulphur was not a recommended fungicide for purple blotch disease. Covering of onion seed crop with white polythene at night and during rainy periods can be used as a cultural practice to minimize crop damage due to rain and dew formation and to obtain higher seed yield. Spraying water on onion leaves in the morning to wash-off the dew drops from the plants is practiced by many farmers. On the contrary, Edidimanna and Rajapaksha (2003) reported that removal of dew drops by spraying water early in the morning did not reduce the severity of purple blotch disease.

Based on the research, IDM package has been suggested for the management of purple blotch disease in onion in Sri Lanka. Since the fungus cannot survive if buried deep in the soil, deep ploughing the debris can be used as one of the sanitary precautions. The field should be well drained to prevent further spread of the disease. The most important precaution is the use of disease free seeds and bulbs. Seed and bulb treatment with fungicides like thiram, captan, thiophanate methyl + thiram are also recommended to reduce seed borne inoculums. Covering of the seed crop with white polythene at night during rainy periods is recommended as a cultural practice to minimize crop damage. Spraying of fungicides like chlorothalonil, tebuconazole, mancozeb, fluzinam and pyraclostrobin + metiram are recommended to spray as soon as first lesion is noticed or before the seed stalk is attacked.

Bulb Rot

Bulb rot in onion was first reported in 1986 and causal organism was identified as *Sclerotium* spp. and *Fusarium* spp. (Soyza *et al.*, 1986). Fungal bulb rot caused by *Fusarium* spp., *Sclerotium* spp., *Pythium* spp. and bacterial bulb rot caused by *Ralstonis* spp., *Erwinia* spp. are ranked first among the diseases of economic importance (Priyantha, 2014). Both pathogen groups are widely distributed in the soil of major onion growing areas. Although there are no published data on the actual yield loss of onion due to bulb rot, heavy losses up to 10-75% have been experienced by farmers. In severe cases, entire crop may be lost.

Fungal bulb rot (Sclerotium spp.)

Leaves of plants infected with fungal bulb rot show yellowing, leaf dieback, and wilting. Leaf decay begins at the base with older leaves collapsing first (Plate 4, left). A semi-watery decay of the bulb scales results. Roots also rot and the plant can be easily pulled from the ground. Fluffy white growth is associated with, the fungal mycelium, which develops around the base of the bulb. If damage is caused by *Sclerotium* spp. as the disease progresses, the mycelium becomes more compacted, less conspicuous, with numerous small spherical black bodies (sclerotia - resting bodies of the pathogen) forming a mycelia mat. Plants can become infected at any stage of growth (Plate 4, right).

Bacterial bulb rot (Erwinia spp.)

Soft rot starts in the field when the crop is maturing (Plate 5). When infected bulbs are pressed, bacterial exudates ooze out. The slimy decay is accompanied by a foul sulphurous smell (Priyantha, 2014). The bacterial bulb rot can be caused by *Erwinia* spp. and *Pseudomonas* spp. The primary inoculum of these bacteria comes from soil. Presently there are no commercially acceptable onion varieties with known resistance to bulb rot. Crop rotation offers some promise for soil borne disease management. However, onion production is location specific and very intensive. Diverting a land, which is being used for onion production for any length of period, is practically impossible and justifiable. Thus, crop rotation is not an acceptable management alternative for onion disease management.

Plate 4. Fungal bulb rot symptoms (left) and numerous sclerotia on infected bulb (right).

Plate 5: Symptoms of bacterial bulb rot caused by *Erwinia* spp. and *Pseudomonas* spp.

Amending soil with organic matter increases natural suppressiveness against soil borne pathogens. Soil amendments of ipil-ipil and gliricidia reduced the sclerotia formation while soy straw enhanced the sclerotia formation (De Soyza *et al.*, 1988). Cow dung application (15-20 t/ha) was effective for the fungal bulb rot management of cluster onion in DL_{2b} agro ecological region (Fernando *et al.*, 2013). Priyantha *et al.* (2013) reported that effective control of bulb rot in big onion can be achieved using the following combined approaches of pathogen exclusion and removal:

1. Use of disease free planting materials for cultivation as they are the initial source of disease infestation.
2. Dipping of bulbs / seedlings before planting in an aqueous solution of thiram + thiophanate methyl (20 g / 10 l water).
3. The bulb rot causing pathogens may survive in the soil for extended periods of time often coming from debris from past infected plants or spores living in soil. These pathogens therefore,can easily spread with the movement of disease plants, soil or surface water. In onion growing areas water is pumped to flood irrigate the plots. Water is delivered from plot to plot once the initial plot is filled with water. Pathogens move easily with water. If pathogen contaminated irrigation water is used to irrgate fields, contamination in adjoining fileds may take place. Controlling water logging and limiting surface water movement from plot to plot by deepening the furrows between beds and using drainage channels have been recommended (Figure 1).
4. Field population of resting spores can be reduced by collection and removal of infected bulbs. Farmers are advised to remove infected plants with soil at 10 days interval.
5. Drenching infected plants and adjoining plants during the growing season with an aqueous solution of thiram + thiophanate methyl (5 g/ 5 l water / m^2). Thiophanate methyl + thiram foliar application has been proved ineffective in reducing severity of bulb rot while drenching and spot application result in more effective control.

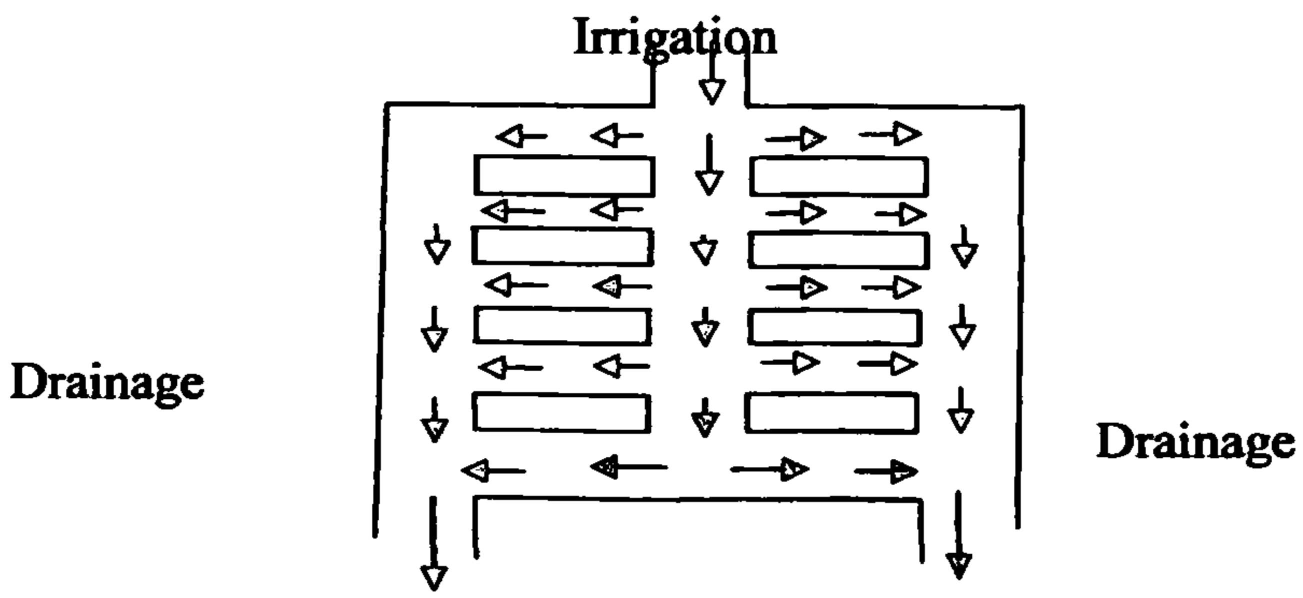

Figure 1: Field layout of irrigation in onion.

Storage Losses

Bulb rot caused by fungi is one of the major causes for storage losses and contributes to about 10-20% of the total storage losses. Mettananda and Edirimanna (1998;1999) reported low rotting losses in Rahangala, Bandarawela and Seethaeliya areas in the up country wet zone where the minimum environmental temperature ranged between 15-20 °C. The activity of one of the major storage fungi *Aspergillus niger* was lower when the storage temperature was below 17 °C. Storage losses due to rotting could be reduced by selecting low temperature (< 15 °C) locations for big onion storage.

Small bulbs had lower rotting loss when compared to large bulbs during the storage. On average, there was about 8% less rotting loss in small bulbs compared to the large bulbs (Mettananda, 2011). Bulb rotting is caused by a number of micro organisms. Among them fungi are the major causal organisms responsible for storage losses. The field survey revealed that five fungal genera are associated with rotting of big onion bulbs (Rajapaksha and Edirimanne, 2002). Among them, major causal agents are *Fusarium* spp., *C. gloeosporioides* and *Sclerotium* spp. *Alternaria* spp. and *Aspergillus* spp. grew on surface of onion bulbs but those pathogens were not responsible for rotting. Application of carbendazim 50% wp, two weeks before harvesting reduced the storage losses of big onion up to 40% due to fungal pathogens (Rajapaksha and Edirimanne, 2002).

Seed Associated Diseases

Micro flora associated with onion seed was studied by Rajapaksha (1998) in locally produced onion seed lots collected from different location in Sri Lanka. Among them *C. gloeosporioides*, *Alternaria porri*, *Aspergillus* spp. and *Penecillium* spp. were identified as most commonly associated fungal pathogens with onion seeds. Onion seeds are imported to Sri Lanka by the private sector and cultivated by many farmers. These varieties are marketed in the country without screening for their susceptibility to local diseases. Thus, the possibility for a disease outbreak cannot be excluded. Exotic big onion variety Nashik Red seeds and local variety

Rampur has been tested for major diseases and agar plate test revealed the presence of *Aspergillus flavus*, *Aspergillus niger* and *Rhizopus* spp. (Priyantha *et al*., 2010; 2011). The exotic onion variety Nashik Red seeds sample was free from seed borne pathogens. Many seed associated fungi are reported to live on the surface of the seeds as contaminant micro-organisms. The fungi *C. gloeosporioides* and *Alternaria porri* can attack any aerial parts of the onion plant, including seeds, suggested their seed borne nature and systemic transmission from seeds to seedlings (Weeraratna, 1996; 1997; Priyantha, 2014).

Future Strategies

Future strategies for the management of onion diseases should be an integrated effort of the plant breeders, plant pathologists and agronomists. Breeding for disease resistance has to be considered a priority. Effective integrated disease management practices should be developed for all diseases and it is an urgent need to minimize the use of fungicides.

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