POSTHARVEST LOSSES OF BRINJAL AND THE CAUSES OF PATHOLOGICAL DISEASES

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1. INTRODUTION

1.1. Potential Postharvest losses

Chilling injury will occur in aubergine during prolonged storage at temperatures below 100C, rapid quality loss will occur shown by shriveling, skin and tissue discolouration and increased susceptibility to decay organisms.
Damage caused by overfilling or held crates or cartons, dropping or puncturing by stems will cause mechanical damage leading to rapid decay and microbial infection (medlicott, 2002).

1.2. Postharvest losses due to diseases

The information on the Postharvest losses of aubergine and the causes off these losses are meager. They also stated that Fruit rot and wilt are the most serious diseases of aubergine in the tropics and among the most common Postharves diseases of the aubergine are fruit rots and anthracnose (salunke et al., 1984).

Chilling injury and diseases also however, cause serious losses of aubergine in the tropical countries; Anthracnose is a serious disease in aubergine and may be caused by any of several species of Colletotrichum (salunke et al., 1984)

The objectives of this part of the research work are: carrying out a market survey in order to find out the Postharvest losses caused by Postharvest diseases and by Postharvest handling practices, studying the common Postharvest fungal diseases in this study area, and identifying the respective causal organisms of those diseases.

2. MATERIALS AND METHODS

2.1.1. Loss assessment

By conducting a market survey in peradeniya and kandy central markets, an assessment of Postharvest losses due to mechanical, physiological and pathological factors was carried out.

5 kg of auberine samples (variety with purple and white striped skin – 09674, plant Genetic Resources center, 1999) were collected at every weekly visit, between the periods of june 1998 to may 1999 in order to carry out the survey on Postharvest loss

of aubergine. The diseased samples were separately placed in polythene bags and brought to the Department laboratory for examinations the damages were identified losses caused by physiological, pathological and mechanical factors were assessed and recorded at every sample collection.

2.2.1.1. Questionnaire

Thirty copies of Questionnaire (appendix) were prepared and Distributed among 30 wholesalers and retailers in kandy and preradeniya central markets to collect the information on Postharvest aspects of aubergine. The questionnaires contained 15 questions, based on aubergine harvesting, transportation, marketing, storage practice and market losses of aubergine. It was worded in such away that an ordinary person to read and understand.

The Questionnaires were distributed among:

1. Ten people who transport fruits and vegetables to kandy market from more than 50km away from the study area.
2. Ten wholesalers of vegetables.
3. Ten retailers of vegetables.

The Questionnaires were collected one week later and the transporters, wholesalers and retailers were interviewed. The information furnished by Questionnaire on transportation, wholesale and retailed were pooled. Average losses that take place at each stage were determined.

2.2.2. Isolation of fungi from postharvest diseases of aubergine.

The specimens of common postharvest fungal diseases, such as anthracnose, Fusarium rot and phomphsis rot were obtained from the kandy and peradeniya markets and the visible symptoms were recorded. Based on the visible symptoms the diseased specimens were grouped and the symptoms were recoded. Three specimens of the five segments (3/4 cm^2) from each specimen were used for the isolation of the causal organism/s.

The segments of the diseased peel (1mm in thickness) were surface sterilized by immersing in 0.1% sodium hypochlorite (NaOCl) fro three minutes. The excess liquid Was removed from the tissue by placing them on a sterilized filter paper. Five segments of tissues were transferred under sterile condition onto Cook's no. 2 ($1/4^{th}$ strength) agar medium medium (appendix). Five replicate plates were prepared and incubated at room temperature (27±2^{0}c) for 4-5 days and examined.

The fungi isolated were further sub-cultured on the same medium in order to obtain pure cultures of the causal organisms. The fungi in these pure cultures were identified using their cultural and morphological features.

2.2. Pathogen city of causal organisms isolated from diseased aubergine.

Three fungi were isolated from the diseased aubergens; Colletotrichum capsici, fusarium solani and phomophsis vexans.

Suspensions of conidia of each fungus were prepared as follows and used as the inoculum with conidia obtained from previously sub –cultured plates. Five –day old cultures of each fungus were flooded with sterile distilled water and mycelia were scraped using sterile spatula. After shaking to release conidia, the suspension was filtered through glass wool and the filtrate was centrifuged at 3000rpm for 5 minuets. The supernatant was discarded and fresh sterile distilled water was added. And after shaking the suspension, it was centrifuged again. This was repeated three times. The number of conidia in the final suspension was adjusted to 5 x 10^0 conidia/ml.

Six sets of fresh healthy (with purple and white striped skin) each set containing 3 replicate fruits were wiped with a piece of colon in 70% of alcohol (ethanol) and allowed to dry. Each set was inoculated with a conidial suspension of each fungus separately by placing 20ul drops of conidial suspension. Tow sets of fruits were inoculated with c.capsici one of which was wounded with a sterile needle (2mm long) prior to inoculation and the other set was inoculated without wounding. Likewise another tow sets were inoculated with F.solani with and without wounds and remaining tow sets of fruits were inoculated with P.vexans .five inoculation along the long axis were made in each fruit. All inoculated fruits were inoculated in a humid chamber and observations were made for ted days at tow day intervals. The area of the lesions were measured and were recorded. This experiment was repeated three times.

In oder to re-isolate the fungal pathogen the segments of the disease peel (1mm in thickness) obtained from the above artificially inoculated fruits and were surface sterilized and the causal agents were re-isolated as described in 2.2.2 onto cook's No.2 agar medium. Five replicate plates were prepared and incubated at room temperature (27±2^0) for 4-5 days and the fungal culturas were compared with those isolated in 2.2.2.

Among the diseases collected, anthracnose and the Fusarium rot were selected for further studies, since these tow were found as the most common fungal diseases in aubergine in this study.

2.4 GERMINATION OF CONIDIA OF C.CAPSICI AND SOLANI

Conidial suspensions of both C.capsici and solani were prepared separately as described in 2.2.3 and the concentration of the conidia was adjusted to 5 X 10^{5}conidia/ml.

Drops (20ul) of conidia were placed on clean slides (two drops per slide). Fourteen slides were prepared for each fungus. The slides were prepared for each fungus. The slides were stacked in slide sacks and incubated in moist chambers. Tow slides from each fungus were removed at 2,4,6,7,10,16 and 24 hours intervals. A drop of lacto phenol was added to each spore drop to stop further germination and cover slip was placed.

At least 100 randomly selected conidia were counted from each drop under the high power of the light microscope for germination and appressoria formation. Percentage germination and appressoria formation were determined for each fungus at each incubation comparison period.

2.5. Statistical analysis

The data were statistically analyzed by using the general linear models procedure of SAS 6.12 the significant parameters were subjected to dungan Multiple Range Test (DMRT) for treatment comparison.

3. RESULTS

3.1. Loss assessment

The percentage of postharvest losses of every 5Kg of aubergine smaple that were caused by pathological, and mechanical factors is given in Fig 2.1

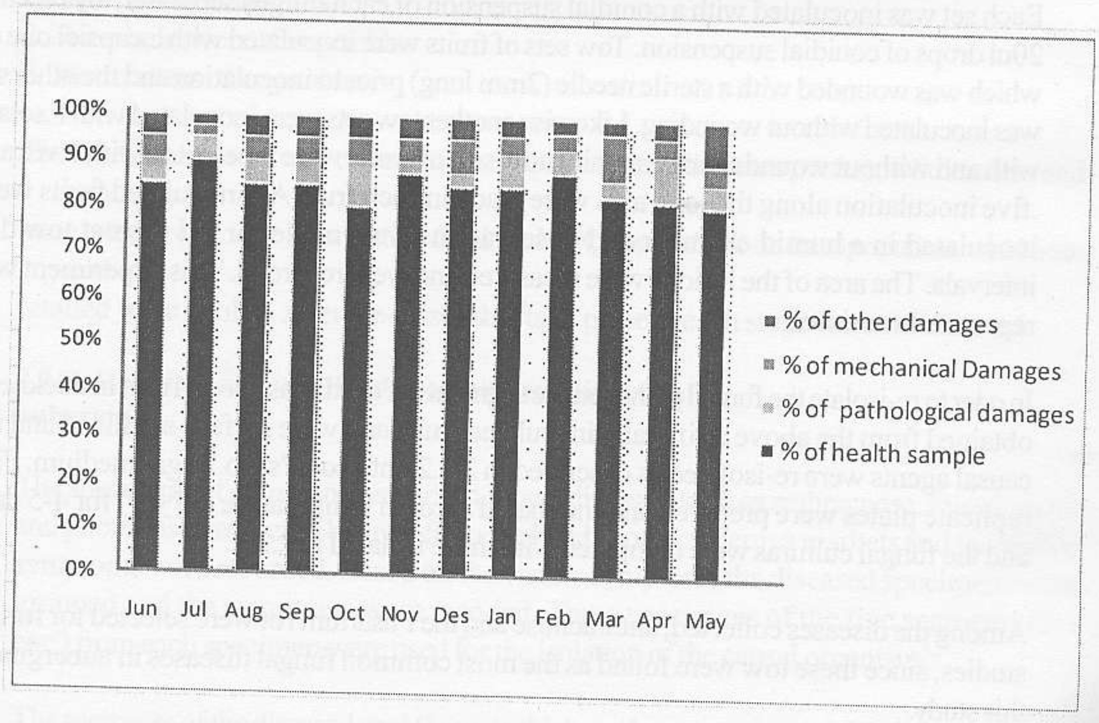


Fig 2.1 percentage (%) of postharvest losses of aubergine during the survey period – June 98 to May, 99.

As the figure shows, the average loss of harvested aubergine was observed as 18.67% (±0.697) during the survey. This total loss was mainly caused by pathological diseases, mechanical factors that occur during the postharvest handling practices and the other factors such as insect is given in table.

Table 2.2 percentage (%) of postharvest losses of aubergine Caused by different factors in the study area.

Cause of losses	% Mean loss
Pathological	7.49[a]
Mechanical	5.74[b]
others	5.44[b]

Means with the same letters are not significantly.

According to results, approximately 18.67% of fruit losses were observed during this period of survey as the postharvest losses. In fact, many factors contribute to these losses That includes pathological, mechanical and any others include insect attack etc. postharvest losses etc. However, the loss caused by pathological diseases was significantly higher ($p<0.05$) than the other factors (table 2.2). Even though mechanical factors do not cause a significant amount amount of loss, it is the second main factor for postharvest loss observed in this area.

Along with these postharvest diseases, several mechanical damages also were observed as one of the main causes of postharvest losses of auberegene in the study area. These mechanical damages contribute nearly 6% of loss among the 19% of total postharvest loss. Other than these factors, insect attack and postharvest disorders also were observed in harvested aubergine.

1.1.1. QUESTIONNAIRE

Harvesting

Aubergine pods are harvested mainly by hand. The selection of be harvested is generally based on size and colour made by just eye estimation. But in most cases, the immature pods are harvested, as the customers prefer it. Pod wastage due to mechanical damage during harvest was not recorded.

Peckaging and transportation

The primary mean of transport of Aubergine to the markets is by lorries, along with other vegetables. Pods are usually loosely packed in ventilated bags and transported. But not much care is taken in packing, loading and unloading.

Marketing and storage

Vegetable stalls in kandy and peradeniya market are usually furnished with Aubergine together with the other vegetables. These fruits are either kept in bags in wholesale places or arranged on floor. It is more often noticeable that the fruits with minor injuries and with insect attacks are also marketed together with the healthy ones. On the basis of the information collected from the questionnaire, only the fruits that are with severe injuries and diseases were discarded. These severe diseases will occur especially during the rainy season. Vegetable sellers always try to purchase more from the farmers and try to sell them quickly, in order to avoid fruit losses.

No proper storage methods are employed in any of the vegetable stalls examined. Vegetables are just spread on the floor during the night times and again collected into bags the next day. The sellers try to sell all pods they bought from the farmers within a period of 2-3 days.

Fruit losses

Mechanical and physiological damages are less at each stage of the fruit production chain, when compared to the pathological damages. However, the sellers try to sell the vegetables with such damages, along with the undamaged ones, on they sell them at low prices.

Fruit losses due to pathological factors

The result showed that, many species of fungi and bacteria generally cause pathological damages. Insects also make severe loss in aubergine by producing holes through the skin and bore the fruit inside where the larval stages are lodged inside. However, such exposed sites of the skin may also facilitate the entry of pathogen, and thereby lead to the other pathogenic diseases. During the survey, Anthracnose, *fusarium* rot and *phomophsis* blight were identified as very common postharvest fungal diseases in this study area (fig 2.2.1 -2.2.3). All these postharvest diseases are more prevalent during the rainy season compared to season. Especially, anthracnose disease was found as a major postharvest disease of aubergine during this period since it contributes 7.49% among the 19% of (approximately) total loss saused by pathological factors (Table 2..

Table 2.3 postharvest disease of aubergine in the study area

postharvest disease	Mean occurrence
Anthracnose	7.49^{A}
Fusarium rot	6.02^{B}
Phomophsis rot	5.44^{B}

Means with the same letters are not significantly different.

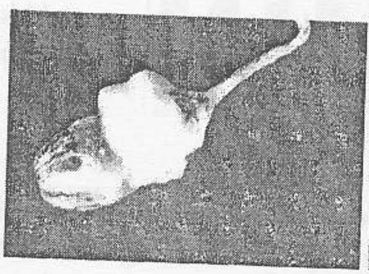


Fig. 1 *Fusarium* rot

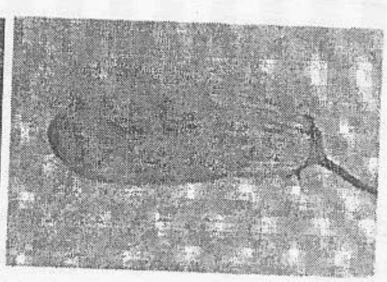


Fig. 2 Anthracnose

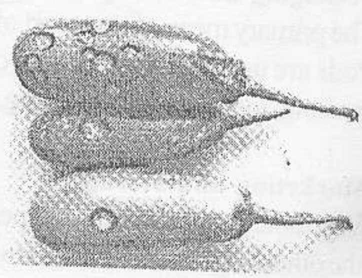


Fig. 3 *Phomophsis* rot

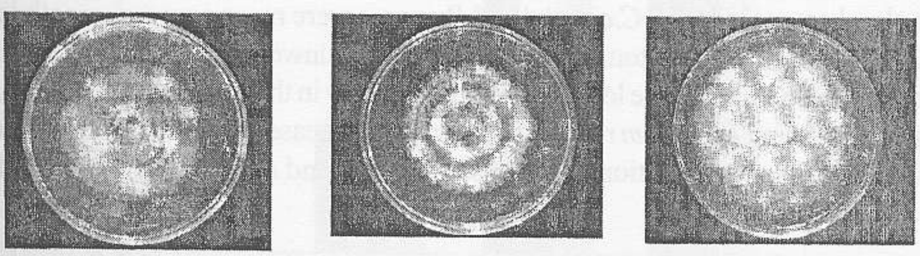
Fig. 2. Most common postharvest fungal diseases of aubergine found in the study area.

Lsolation of fungi from postharvest diseases of aubergine

The fungal pathogens isolated from the diseases collected from study area, are give in table 2.4.
Table 2.4. the causal organisms of aubergine diseases, isolated from the study area.

diseases	**Pathogen**
Anthracnose	*Colletorichum capsici*
Phomophsis rot	*Phomphsis vexans*
Fusarium rot	*Fusarium solani*

During the isolation, *Colletorichum capsici* (Fig. 2.3.1) showed repid growth and sporulation in cook's-2 (1/4th strength) medium whereas that of *Phomphsis vexans* (Fig. 2.3.2) and *Fusarium solani* (Fig. 2.3.3) was observed in potato dextrose Agar. The pure cultures of these fungi were maintained for maintained for experiments.



Colletorichum capsici *Phomphsis vexans* *Fusarium solani*

Fig. 2.3. Fungal pathogens isolated from The diseases collected in the study area.

3.3 Pathogenicity of causal organisms isolated from diseased aubergine

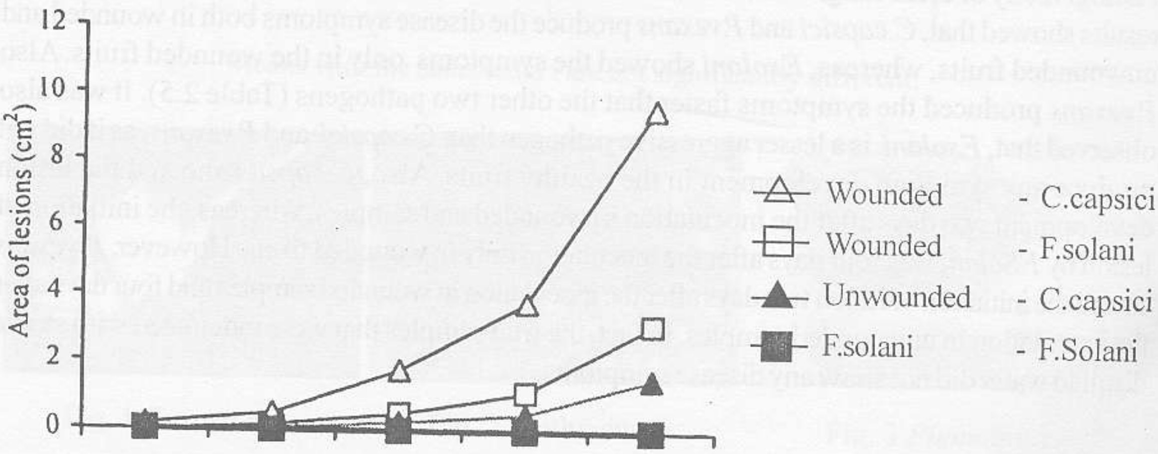
Pathogenicity of these fungi was studied in wounded as well as in healthy fruits separately. The results showed that, *C.capsici* and *P.vexans* produce the disease symptoms both in wounded and unwounded fruits, whereas, *F,solani* showed the symptoms only in the wounded fruits. Also *P.vexans* produced the symptoms faster that the other two pathogens (Table 2.5). It was also observed that, *F.solani* is a lesser aggressive pathogen than *C.capsici* and *P.vexans,* as it did not produce any symptom development in the healthy fruits. Also, *C.capsici* showed the lesion development two days after the inoculation in wounded and samples, whereas, the initiation of lesion by *F.Solani* was four days after the inoculation only in wounded fruits. However, *P. vexans* shwed the initiation of lesion two days after the inoculation in wounded samples and four days after the inoculation in unwounded samples. In fact, the fruit samples that were inoculated with sterile distilled water did not show any disease symptoms.

Time Days)	Pathogen	Treated	
		Wounded	Unwounded
2	*C.capsici*	v	x
	F. solani	x	x
	P. vexans	v	x
4	*C.capsici*	v	x
	F. solani	v	x
	P. vexans	v	x
6	*C.capsici*	v	x
	F. solani	v	x
	P. vexans	v	x

X - No symptoms v - Presence of symptom

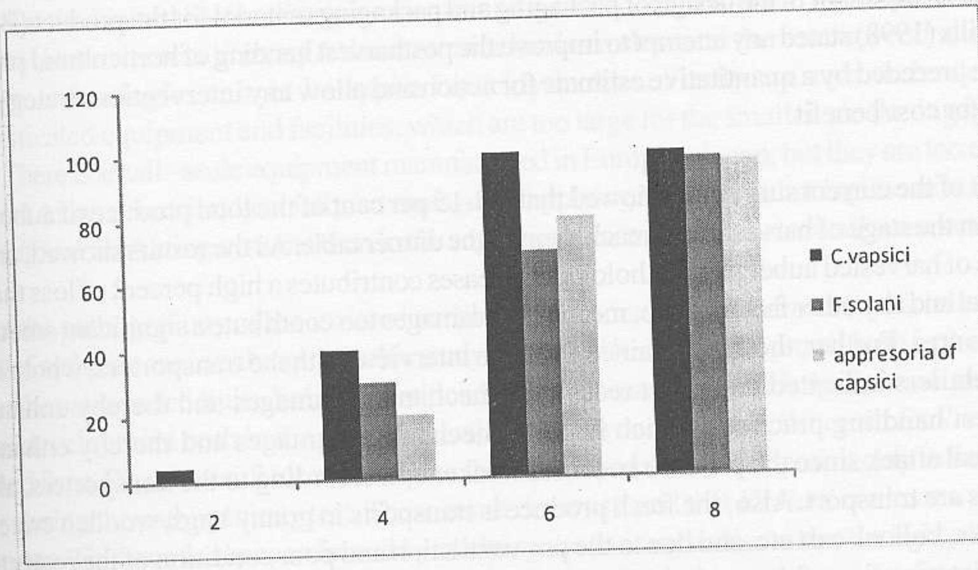
These results clearly revealed that, *C.capsici* and *P.vexans* were more aggressive pathogens in aubergine as they produced the symptoms in both wounded and unwounded fruits, whereas *F.solani* is a weak pathogen since it caused the lesion developmend only in the wounded fruits. Also, it was noted that, anthracnose and *Fusarium* rot are most common diseases and were found through out the period of survey. These observations, led to use *C.capsici* and *F. solani* were used for further studies.

Although, *C.capsici* and *F.solani* produce the lesions in wounded fruits, development of lesion was much faster by *C.capsici* than that of *F.solani* (Fig 2.4) and a sudden increase of lesion development was also observed eight days after the inoculation. similarty, the disease development in the other fruits too showed a sudden increase eight days after the inoculation. However, the lesion that the lesion developmend of fruits that were inoculated with *C.capsici* without any wounds was slower than the fruits that were inoculated with *F.solani* with wounds (Fig. 2.4) secondary infection by becteriya and fungi such as *Rhizophus, mucor* was observed 10days after the inoculation.



3.4. Germination of conidia of C.capsici and F.solani

The results of this experiment showed that the germination of conidia of *C.capsici* started after 2hours of incubation and reached 30% of germination at 4 hours. Among the Germinated conidia, 15% showed the appressoria as well (Fig. 2.4) However, after 8 hours of incubation, 95-100% of spores showed germination with the formation of appressoria. The germination of *F.solani* began after 2hours of incubation perion at which time 5% of spores showed germination and appressoria production was not observed. After 6 hours of incubation period they showed 95-100% of germination.



4. Discussion

Extending the posthervest life of horticultural produce requires knowledge of all the factors that can lead of quality or the generation of unsaleable material, as well as the use of this knowledge to develop affordable technologies that minimize the rate of deterioration. This field of scientific endavour in knows as "postharvest" (wills et al., 1998). The increased attention given to postharvest horticulture in recent year has come from the realization that faulty handing practices after harvesting can cause large losses to produce that require large imputes, materials and capital to grow. Informed opinion now suggests that increased emphasis should be placed on conservation after harvest, rather than endavouring to further boost crop production, as this would to offer a better return for available resources of labour, energy and capital.

On the other hand, horticultural crops not only provide human beings with nutritional and healthy foods, but also generate a considerable cash income for growers in many countries (Liu, 2001). However, horticultural crops typically have high a high moisture content, tender texture and high perishability. If not handled properly, a high-value nutrition product can deteriorate and rot in a matter of days or even hours. Therefore, a series of sophisticated technologies have developed and applied in posthrvest handling of horticultural crops in the last few decades. Unfortunately, many Asian countries have not been able to use this advanced equipment, owing to cost or adoptability problems. Postharvest losses, therefore, remain high. Ultimately, as Liu (2001) stated, a typical routs for a horticultural product to follow from harvest to srrival in the consumer's hands includes grading, packaging, transportation, wholesaling and rtailing. He further added that, in order to solve specific problems in specific areas effectively and economically, a comprehensive knowledge of the nature of postharvest losses, a grasp of various kinks of technologies and a tactical selection of strategies is necessary.

In fact, assessment of fruit susceptibility to mechanical damage is an important postharvest selection criterion because; it may provide information on the handling and the storage potential of the produce. It is important in the design of packaging and packaging material for the product (Burdon 1977). Wills (1998) stated any attempt to improve the postharvest handing of horticultural produce should be preceded by a quantitative estimate for action and allow any intervention strategy to be assessed for cost/benefit.

The result of the current survey too showed that, 13-15 per cent of the total produce of auberging is lost from the stage of harvesting to reach them to the dinner table. As the results showed, among these lose of harvested aubergine, pathological diseases contributes a high percent of loss that the mechanical and any other factors. Also, mechanical damages too contribute a significant amount of loss in this area. Further, the data obtained from the interview with the transporters, wholesalers and the retailers indicated the major reason for mechanical damages and thereby enhancing postharvest handling practices, which leads to mechanical damages and thereby enhancing pathological attack since the produce becomes weakened. According to the transporters, all the vegetables are transport. Also, the fresh produce is transports in gunny bags, wooden crates; in vans, trucks, bullock cart etc. and due to the por ventilation and poor condition of the roads there is a rapid deterioration of the produce. This attitude mainly causes mechanical damages, not only to the aubergine, but also to the other vegetables too. Kudagamage (2002), explains the methods of handling, packing and storage that are being adopted which have been developed over the years by producers, transport agents and dealers Using innovative abilities and skills using some cheep and commonly available materials.

Kudagamage(2002) Further indicated that, the mechanical damages are mainly caused by over – packing and under packing of vegetables, poor packaging and handling of packed fruits during loading and unloading and vibration (shaking) of vehicles specially on bad road, speed of transportation and type of suspension. Wills (1998) reported that, inappropriate packaging (eg. Overfilling, under-filling) might result in physical damage of produce due to bruising, or to abrasion as the commodity moves about during transport. Ideally, transport would take produce from the grower directly to the consumer, as in many developing countries losses directly attributed to transport conditions can be high . postharvest handling has a decisive effect on the extent of post-harvest looses, the final quality, and the market value of horticultural crops(Liu, 2001).

Herrgods (1998) stated that, postharvest handling is the final stage in the process of producing high quality fresh produce. Being able to maintain a level of freshness from the field to the dinner table presents many challenges. A grower, who can meet these challenges, will be able to expand his or her marketing opportunities and be better able to compete in the market place.

When considering the storage practices of aubergine, according to the result of the questionnaire, the whole sellers and the retail sellers do not adhere to any particular methods for the storage of aubergine, rather than keeping them on the floor during night time and arranging them all for sale on next day. Inadequate storage methods lead to damage of products and thus reduce the market value of too long and inappropriate storage conditions, storage for too long and inappropriate storage conditions for a particular commodity will also result in a poor quality product. According to the results of the survey carried out showed, the proper postharvest handling practices such as, transport, loading and unloading, storage etc. can minimize the postharvest losses in aubergine and thereby will increase the marketable quality and the shelf life of this produce.

Liu (2001) indicated that, although there are many Asian postharvest horticulturists who have been trained in the United States, Europe or japan and returned to theirned to therir home countries, technical improvement in many Asian countries has been slow and there are several reasons why western technologies cannot be applied quickly in Asia. Firstly, western technologies use sophisiticated equipment and facilities, which are too large for the small-scale faming systems in Asia. There is small –scale equipment manufactured in Europe or japan, but they are too expensive for most Asian countries. Secondly, advantages of applying Western technologies are less obvious in traditional marketing systems then in the supermarkets, wish dominate retail western countries.

When the pathogenicity of the isolated pathogens are concerned, *C.capsici,* which is the causal agent of antheacnose in aubergine in this study, produced lesion development both in the wounded and in the unwounded fruits during the artificial inoculation studies. Similarly, *P.vaxans* also showed lesion development both in the wounded and in the unwounded fruit. Whereas *F.solani* that was isolated from *Fusarium* soft rot of aubergine shwed the symptom development only in the wounded fruits during the pathogenicity test. These result demonstrated that *F.solani* is a lessesr aggressive pathogen. This was further confirmed by studying the fruiting bodise under the light microscope, where it has a black, long and hair like structur called 'setae' in between the conidiophores. *C.capsici* develops small, restricted infection points on the fruit skin. In the infection site especially in the center of the lesion, dark brown colour spore masses could be seen clearly due to the information of the fruiting bodise. Likewise, though several species of *fusarium* causes the soft rot in aubergine and in other fruits and vegetables, *F.salani* was isolated from aubergine soft rot in this study. Thus with the help of CMI description, all these species of pathogens were identified and their pathogencity also were confirmed since the strategies (Johnson and sangchote, 1993).

Among the postharvest diseases and the pathogens isolsted in this study, anthracnose is a most problematic disease and affects not only the aubergine but also a wide range of hosts. According to Baily *et al.,* (1992) species of *colletotrichum* are amongst the most successful plant pathogenic fungi, attacking an extremely wide range of plants, growing in both temperate are tropical environments. These pathogens cause damage to mast part of plants including roots, stems, leaves flowers, and fruits, but are even highly specific to individual tissues. Many are also specific to particular plant species or cultivars.

Therefore, further experiments were designed to study the above postharvest pathogens in detail and also to examine the relationship between the host and the pathogens, and thereby to workout on the eliciting an induced resistance response against the *C.capsici,* one of the major post harvest pathogen in aubergine, using a non-pathogen or a week pathogen.

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