CHAPTER III

ENVIRONMENTAL AND BIOLOGICAL FACTORS AFFECTING DISEASE DEVELOPMENT IN MELONS

3.1 INTRODUCTION

Effective assessment of disease development requires an understanding of the mode of infection of the pathogen together with the biology of the host and the influence of environmental factors. The pathogen requires certain conditions to establish the infection process and for further development of the disease (Barkai-Golan, 2001). Temperature and humidity are the two basic, and even limiting, factors for infection and disease development in storage of fresh produce. The incidence of decay and the quality in storage may also be affected by the physiology of the fresh produce such as harvest maturity (Evensen, 1983).

For survival and growth on host tissue, each pathogen has a particular range of temperature optima (Sommer, 1985; Dennis and Cohen, 1976). Although some pathogenic fungi are capable of germinating at low temperatures, growth may not continue at that temperature, limiting development of the disease (Barkai-Golan, 2001). Low temperature is an important method of controlling postharvest diseases because it slows down the rate of growth of pathogens and subsequent decay (Wadia *et al*., 1986). Despite this, some products cannot be stored at temperatures that would inhibit pathogen growth due to the physiological chilling injury. For example, to maintain quality, rockmelons should be stored between 2-5° C and honeydew melons at 8° C (Morris, 1992).

Exposure of harvested fruit to high humidity at ambient temperatures even for a short period of time helps to establish the infection by the pathogens (Bonnardeaux and Robinson, 1994). Melons need to be maintained in a cold saturated atmosphere to maintain good appearance and marketability and to keep weight loss below 1% (Lester and Burton, 1986). A weight loss of more than 5% results in shrunken fruit. However, a high relative humidity even in cold storage encourages the major postharvest diseases of melons (Wadia *et al*., 1986). Therefore, other postharvest factors such as surface disinfection (Halloran *et al*., 1999) and harvesting at a less mature stage must be considered to enhance storage time of melons (Evensen, 1983).

The attractive flavour and sweetness of rockmelons are developed in the last few days of maturation and so from a consumer point of view it is desirable to harvest melons when ripe (Morris, 1977). However, during senescence, when the melon fruit is approaching harvest maturity, changes occur in the tissue due to disintegration of antimicrobial compounds which can affect the susceptibility to storage pathogens (Eckert, 1975). With the ripening, the tissues soften causing the breakdown of physical defences, resulting in greater susceptibility to invasion of pathogens that cause storage rots (Paull *et al*., 1999; Eckert, 1978). Ripening also lessens the ability to produce antimicrobial compounds such as phytoalexins that reduce infection and disease development (Verhoeff and Liem, 1975).

Rockmelons are normally commercially harvested between an early stage of maturity known as “green half-slip” and the fully ripe stage known as “yellow full-slip” (Forbus *et al.,* 1991). Between these two maturity stages is “green full-slip” which is the recommended stage for melon harvest. At this stage of maturity the fruit is sweet enough for consumer acceptability and has a moderately good storage life of around 14 days

(Morris, 1977). At all stages of melon maturity, controlled atmosphere storage maintains excellent appearance for a few days after harvest, however, during longer storage the more mature melons decline in visual quality and incidence of decay (Evensen, 1983).

The growing conditions required for various postharvest pathogens are different. Similarly, host-pathogen interaction may vary for a pathogen even in the same crop grown under different environmental conditions (Barkai-Golan, 2001). An understanding of the biological and environmental factors in the development of storage rots of melons would assist in determining optimisation of postharvest techniques. Understanding the conditions affecting germination and growth of postharvest pathogens such as *Fusarium, Alternaria* or *Rhizopus* and the state of resistance of harvested melons is essential for the assessment of postharvest treatment methodologies. In the present research, storage procedures were tested in order to develop a research protocol for evaluating disease development in melons. Factors affecting disease development in storage such as humidity, temperature, packaging type, maturity of different melons were considered for assessment.

3.2 MATERIALS AND METHODS

A number of experiments were conducted on different types of freshly harvested melon fruit at green full-slip stage of maturity under different postharvest storage conditions to study rot development. Storage pathogen growth on rockmelon and honeydew was evaluated after inoculation at several levels of humidity at three temperatures commonly used in postharvest handling of melons. Both rockmelon and honeydew melons were tested for rot development by inoculating with the major pathogens at variable storage conditions. Also rockmelons were tested for the effect of harvest maturity on rot development by challenging fruit with three common pathogens *Fusarium, Alternaria* and *Rhizopus*.

3.2.1 *Source of fruit*

Unwashed and untreated fruit of the rockmelon variety "Hot Shot" and honeydew melon variety "Neon" were harvested from a commercial grower at Griffith, NSW, Australia and shipped within 24 hours of harvest to the laboratory. On arrival fruit were washed in 100 ppm of chlorine-water made from commercial sodium hypochlorite, rinsed with clean water and then air-dried before inoculation.

3.2.2 *Collection and preservation of pathogenic fungal strains*

The major pathogens of melon *Fusarium, Alternaria* and *Rhizopus* were isolated from diseased melons. The isolated fungi were tested for their pathogenicity by inoculating healthy melons and re-isolating the pathogen. The fungi were then identified as *Fusarium acuminatum, Alternaria alternata* and *Rhizopus* spp. by Nguyen Tran Ha a PhD student in the Plant Pathology Laboratory of the University of Sydney. The fungi were then cultured and re-cultured from a single spore in PDA media (3.9%) in agar slant slopes contained in sterile McCartney bottles and stored in a 0° C room for future use. The fungal strains were also freeze dried for long term storage.

3.2.3 *Culture and preparation of inoculum*

Fungal inoculum was prepared from spores. For sporulation a small plug of mycelium from the slant bottle was placed on PDA plates and incubated at 25° C, 7-8 days for *F. acuminatum* and *A. alternata* and 3-4 days for *Rhizopus* spp. for mycelial growth and spore formation. The fungal spores were harvested from PDA plates with sterile 0.1% peptone solution. Each inoculation suspension was adjusted to the following concentration of spores (Table 3.2.3.1):

Table 3.2.3.1 Concentration of the spores in 0.1% peptone solution at 700 nm in reference to air in a spectrophotometer (PERKIN ELMER LC – 55)

Pathogen	Optical Density	Haemocytometer count
Fusarium acuminatum	0.325	$1.6 \times 10^6 . ml^{-1}$
Alternaria alternata	0.450	$2.1 \times 10^6 . ml^{-1}$
Rhizopus sp	0.500	$1.8 \times 10^6 . ml^{-1}$

3.2.4 *Temperature and humidity effect on storage rots*

A humidity chamber was constructed to study the effect of humidity on storage pathogens at different temperatures. A glass fish tank was fitted with a small fan and an aluminium platform on which fruit were placed (Plate 3.2.4.1). A vertical sheet was placed on one edge of the bottom sheet to prevent fruit being exposed to direct air flow from the fan. To maintain a specific level of humidity a particular salt (Table 3.2.4.1) was placed at the bottom of each chamber underneath a platform. Water (0.5L) was added to the salt in the chamber to equilibrate the humidity level. Humidity levels in the chambers were obtained by using the following salts (Table 3.2.4.1) recommended by Greenspan (1977). A humidity probe was set to monitor the level of the humidity in the chamber every day.

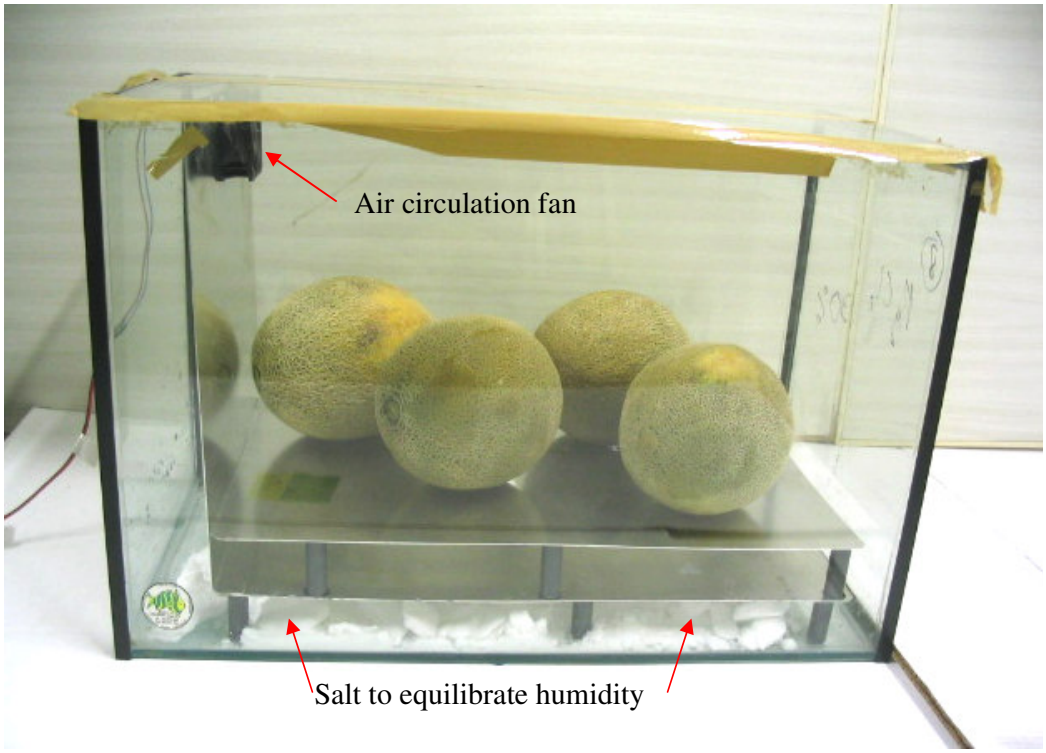

Plate 3.2.4.1 Humidity chamber for incubation of melons to observe rot development after inoculation with storage pathogens.

Table 3.2.4.1 Different salts (1000g) for the control of humidity levels inside the humidity chamber

% RH level	Salt used
100	Water
93	Sodium sulphate
88	Barium chloride
81	Ammonium sulphate
75	Sodium chloride
51	Calcium carbonate

3.2.5 *Inoculation and incubation*

For inoculation, freshly harvested rockmelons were washed by dipping in 100 ppm chlorine water for 1 min followed by a rinse with sterile water. After washing, melons were air dried for about 4 hours then given a scratch wound (3mm deep x 2 mm wide x 5 mm long) at 8 points of the fruit using a metal scraper. The fruit were inoculated through the scratch wounds with 50 µl of inoculum of the virulent strains of *F. acuminatum*, *A. alternata* or *Rhizopus* spp. at the concentration shown in Table 3.2.3.1. Pathogens were tested separately. Only one pathogen was inoculated onto the melons for each temperature level: 5° C, 20° or 30°. Depending on the incubation temperature and pathogen, fruit were incubated until a rot was visible at the inoculation site. Four inoculated rockmelons were placed in each humidity chamber.

3.2.6 *Rot assessment and weight loss*

The number of successful infected sites was recorded and expressed as % of total number of inoculation sites. Rot development was assessed by measuring the area (cm^2) of rotten surface at the inoculation site. Weight loss of melons was calculated as the percentage of weight loss at the end of the trial from the initial weight.

3.2.7 *Effect of fruit storage on rot development*

Rockmelon and honeydew fruit were evaluated for rot development caused by *F. acuminatum, A. alternata* and *Rhizopus* spp. at different storage conditions. Melons were obtained from Griffith and washed and air dried as described above in section 3.2.1. Fruit were inoculated through the scratch wounds with a spore solution diluted to the concentration shown in Table 3.2.3.1. There were eight scratch wounds on each melon. After inoculation fruit were air dried for 30 min and then placed inside industry standard

fibreboard cartons. There were nine fruit in each carton. The cartons were incubated at 15° C with or without a perforated plastic cover on them. A plastic cover was used to keep humidity at approximately 98% in and around the cartons. Without a plastic cover the humidity was about 75% around the cartons and about 85% at the centre of the carton stack (Plate 3.2.7.1 A and B). The level of humidity was measured daily using a humidity probe. Rot was assessed after 10 days of incubation by measuring the rot area as described in section 3.2.6.

Plate 3.2.7.1 Incubation conditions of inoculated melons for the development of storage rots. Cartons were incubated covered with perforated plastic (A) or without plastic (B).

3.2.8 *Effect of harvest maturity on storage rots*

Freshly harvested rockmelons of three maturity levels, green half-slip, green full-slip and yellow full-slip, were washed in 100 ppm chlorine, air dried and then inoculated with pathogens of *F. acuminatum, A. alternata* and *Rhizopus* spp. Inoculated fruit were incubated in fibreboard cartons covered with perforated plastic (Plate 3.2.7.1) at 15° C for 10 days. Rot development was assessed by measuring the rot size at the inoculation site.

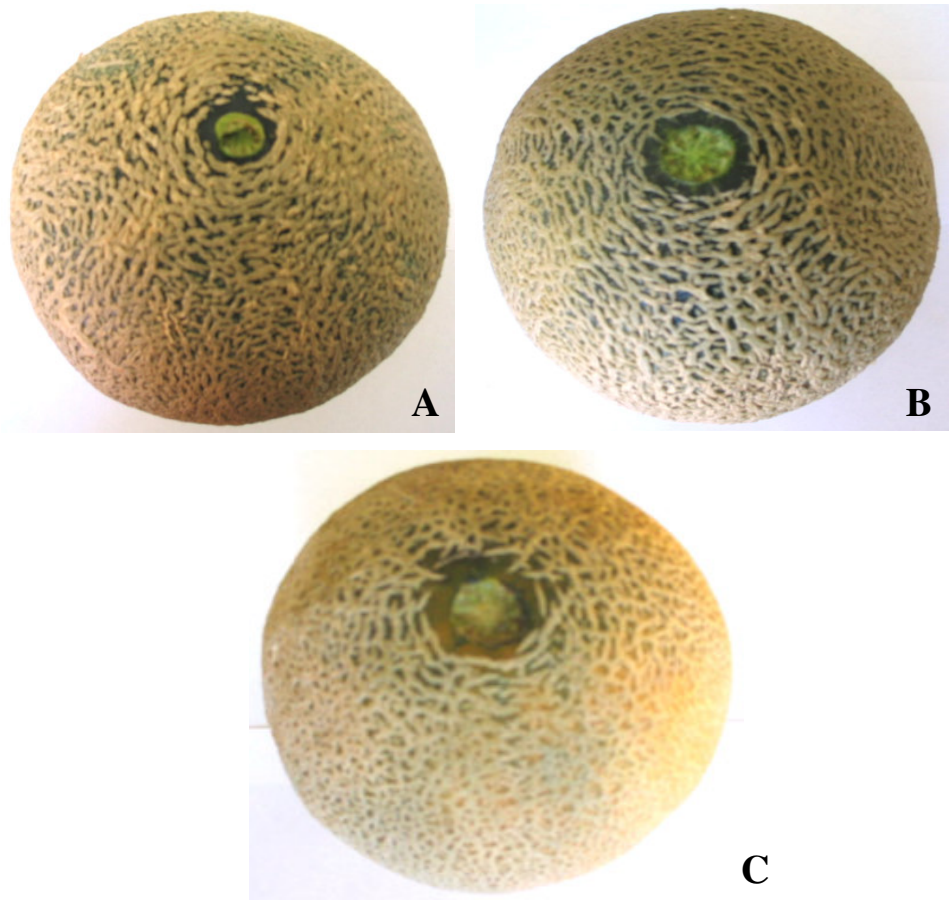

Plate 3.2.8.1 Harvest maturity stages of rockmelon: (A) green half-slip – early stage; (B) green full-slip – medium stage and (C) yellow full-slip – late stage.

3.2.9 *Statistical analyses*

Data were analysed with Simstat software, version 2.04 (Provalis Research, Montreal, Canada) for a generalised linear model (GLM) of analysis of variance using a factorial treatment design or a completely randomised design (CRD). The experiments testing humidity and temperature effects on disease development had four fruit per treatment each with eight inoculation sites for all three pathogens. There were four inoculated fruit in each humidity chamber to represent four replications. The protected least significant product at 5% ($P<0.05$) was used to test the differences between the treatment means.

3.3 RESULTS

3.3.1 *Temperature and humidity effect on storage rots*

Rot development of rockmelon fruit incubated in the humidity tank at 20° C after inoculation with *F. acuminatum, A. alternata* and *Rhizopus* spp. was affected by different levels of humidity (Figure 3.3.1.1). Those in the tank with a high level of humidity had a greater area of rot lesions compared to those incubated in low humidity conditions. When comparing the pathogen growth, at 20° C strains of *F. acuminatum* and *Rhizopus* spp. had three times the area of rot development compared with *A. alternata* when incubated at humidity levels of 100% and 93%. However, the trend of increasing area of rot development with increasing humidity was similar for all three pathogens. Among the pathogens *Rhizopus* spp. was very aggressive developing the same sized lesions in two days as *F. acuminatum* in eight days of incubation under similar conditions. Growth rate of *A. alternata* was the lowest of the three pathogens and *F. acuminatum* was intermediate.

Humidity levels at 20° C above 81% for *Rhizopus* spp. and above 88% for *F. acuminatum* and *A. alternata* were critical, showing a greater rate of growth in rot development above these humidity conditions. Similarly, a humidity level at or below 81% substantially reduced rot development in the tank.

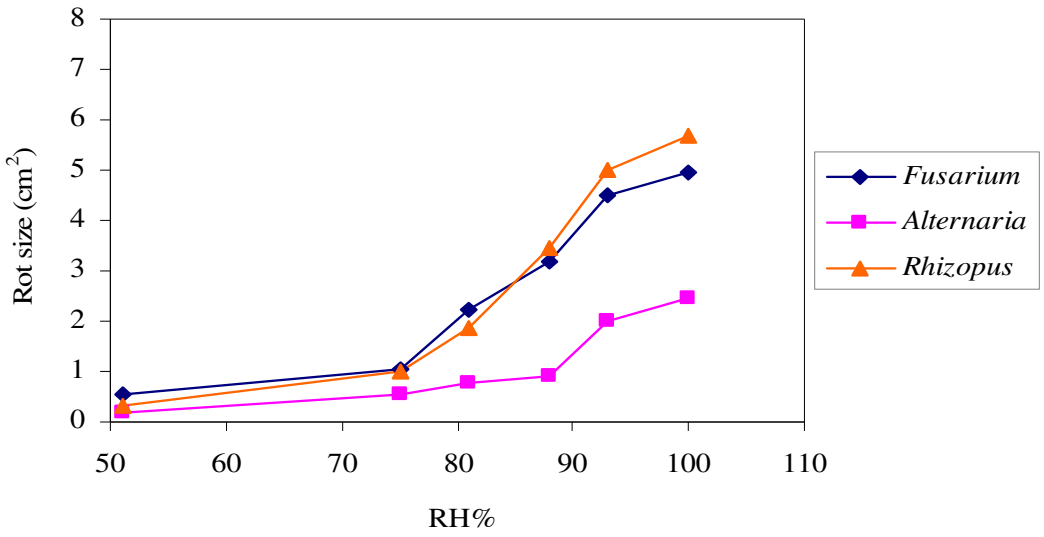

Figure 3.3.1.1 Effect of relative humidity (RH%) on the infection and development of rots caused by *F. acuminatum, A. alternata* and *Rhizopus* spp. on rockmelons. Fruit were inoculated and incubated at 20° C in the humidity chambers for eight days for *F. acuminatum* and *A. alternata*, and 2 days for *Rhizopus* spp. ($P<0.05$, n=4).

The number of wounds where infection was successful for *A. alternata* on rockmelons at 20° C followed a similar trend to that of *F. acuminatum*. Maximum percentage infection occurred at humidity levels of 100% and 93% and the lowest percentage infection occurred at 51% (Table 3.3.1.1). *Rhizopus* spp. had over 84% wound infection above humidity levels of 81% but had a similar percentage infection rate at humidity 88% and above as *F. acuminatum* and *A. alternata*. However, at a low level of humidity (51 and 75%) infection from *Rhizopus* spp. was reduced significantly and melons developed only a few lesions.

Table 3.3.1.1 Effect of humidity on the success of infection (%) at 20°C. Rockmelon were inoculated with the spores of *F. acuminatum, A. alternata* and *Rhizopus* spp. through scratch wounds. Inoculated fruits were immediately placed in the humidity chamber for the development of rots. Mean percent success in infection data are arc-sin transformed for the ANOVA test with back transformed means presented in parenthesis. Means followed by different letters in a column indicate significant difference ($P<0.05$, n=4)

RH level	% success infection		
	F. acuminatum	*A. alternata*	*Rhizopus* spp.
100	96.88 (5.26) c	93.75 (5.23) d	96.88 (5.26) c
93	93.75 (5.23) c	90.63 (5.20) d	93.75 (5.23) c
88	84.38 (5.12) bc	71.88 (4.96) c	90.62 (5.19) c
81	71.88 (4.96) b	65.63 (4.87) c	84.38 (5.12) bc
75	56.25 (4.69) a	46.88 (4.53) b	62.50 (4.82) b
51	46.88 (4.52) a	37.50 (4.29) a	25.00 (3.84) a

Lesion development in rockmelons stored in the incubation chamber at 5° C after inoculating with the pathogens of *F. acuminatum* and *A. alternata* was significantly affected by the levels of humidity (Figure 3.3.1.2). However, *Rhizopus* spp. did not survive or cause infection at this temperature even at a very high level of humidity. Inoculation with *F. acuminatum* developed similar levels of rot at 100% or 93% humidity at 5º C, but a reduced level of humidity at 75% caused reduction in the infection and lesion development. *A. alternata* was more sensitive to humidity at 5º C showing a more even reduction in growth with falling humidity.

The rate of infection on rockmelons at 5° C due to inoculation with various pathogens was affected by the levels of humidity in the incubation chambers (Table 3.3.1.2). A high level of humidity of 100% caused maximum infection from *F. acuminatum* and *A. alternata*. However, a reduced level of humidity caused reduction in the rate of infection by these pathogens.

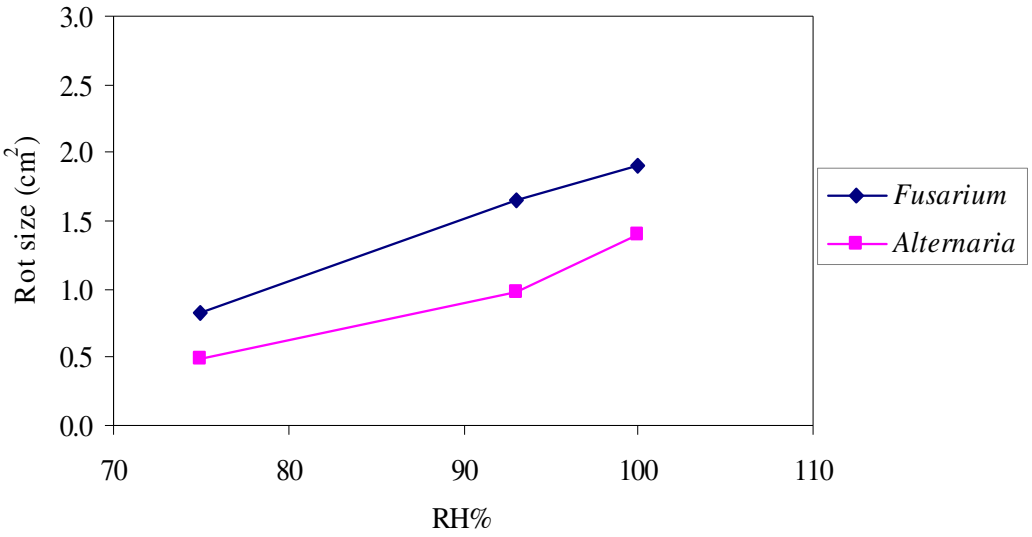

Figure 3.3.1.2 Effect of relative humidity (RH) on the infection and development of rots caused by *F. acuminatum* and *A. alternata* on rockmelons. Fruit were inoculated through scratch wounds and incubated at 5° C. Humidity chambers were incubated 21 days for both *F. acuminatum* and *A. alternata* ($P<0.05$, n=4).

Table 3.3.1.2 Effect of humidity levels on the rate of *F. acuminatum and A. alternata* infection (%) success at 5° C. Rockmelons were inoculated using spores of the fungi through scratch wounds and fruit were immediately placed in the humidity chamber for the development of rots. Mean percent of success of infection data were arc-sin transformed for the ANOVA test, with back transformed means presented in parenthesis. Means followed by different letters in a column indicate significant difference (P<0.05, n=4).

RH level	% success infection	
	F. acuminatum	*A. alternata*
100	71.88 (4.97) c	68.75 (4.92) c
93	46.88 (4.53) b	50.00 (4.60) b
75	31.25 (4.12) a	28.13 (4.01) a

At 30° C *Rhizopus* spp. growth was maximum at 100% and 93 % humidity (Figure 3.3.1.3). A low level of humidity of 75% caused substantial reduction of rot development. A small increase in rot development occurred from *F. acuminatum* higher levels of humidity. Humidity did not have any effect on growth of *A. alternata*.

The rate of success of infection from inoculation and incubation at 30° C was affected by the humidity levels in the incubation chambers (Table 3.3.1.3). Percent infection from *F. acuminatum* inoculation was similar at 100% and 93% levels of humidity. However, a reduced level of humidity (75%) caused significant reduction in rate of infection. A similar effect on infection rates occurred in inoculation with *A. alternata* and *Rhizopus* spp.

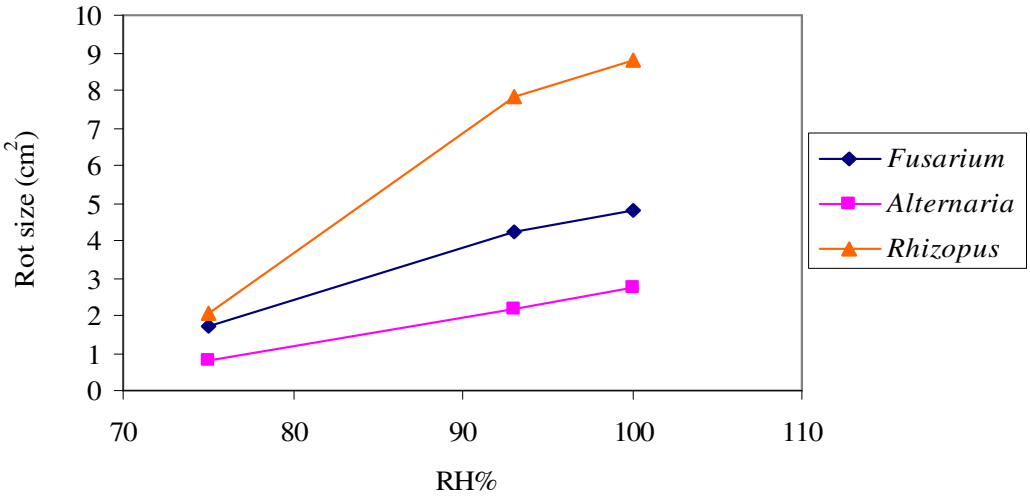

Figure 3.3.1.3 Effect of relative humidity (RH) on the infection and development of rots caused by *F. acuminatum, A. alternata* and *Rhizopus* spp. on rockmelons. Fruit were inoculated and incubated at 30° C. Humidity chambers were incubated 5 days for *F. acuminatum* and *A. alternata* and two days for *Rhizopus* spp. ($P<0.05$, n=4).

Table 3.3.1.3 Effect of humidity levels on the rate of *F. acuminatum, A. alternata* and *Rhizopus* spp. infection (%) success at 30° C on rockmelons. Rockmelons were inoculated using spores of the fungi through scratch wounds and fruit were immediately placed in the humidity chamber for the development of rots. Mean percent of success of infection data were arc-sin transformed for the ANOVA test, with back transformed means presented in parenthesis. Means followed by different letters in a column indicate significant difference ($P<0.05$, n=4).

RH level	% success infection		
	F. acuminatum	*A. alternata*	*Rhizopus* spp.
100	93.75 (5.23) b	87.50 (5.16) b	96.88 (5.26) b
93	90.63 (5.20) b	81.25 (5.09) b	93.75 (5.23) b
75	78.13 (5.05) a	68.75 (4.92) a	78.13 (5.05) a

Humidity levels and temperature of incubation affected the weight loss of fresh melons during storage in the humidity chambers (Table 3.3.1.4). Weight loss was minimal at 5° C at 100% or 93% of humidity. Incubation at the same temperature but with a low level of humidity of 75% significantly increased the percentage weight loss of fresh rockmelons. Higher incubation temperatures of 20° or 30° C caused rapid and greater loss in fresh weight of rockmelons in storage even at high levels of humidity (i.e. at 100 or 93%). At higher temperatures a decrease in the humidity results in further accelerated loss in fresh weight in storage.

Table 3.3.1.4 Percent loss in fresh weight of rockmelons during incubation at different RH percentage and at different temperature conditions. Weight loss of *F. acuminatum* and *A. alternata* inoculated fruit was examined but not of *Rhizopus* spp. At 20° C melons were incubated for 8 days, at 30° incubated for 5 days and at 5°C incubated for 21 days. At 20° C melons were incubated at all levels of humidity, at 30° and 5° C melons were incubated at 100%, 93% and 75% humidity. Means followed by different letters indicate significant difference at $P<0.05$ (n=4).

RH level	Weight loss (% fresh weight / day)		
	20° C	30° C	5° C
100	0.3222 b	0.4178 c	0.0929 a
93	0.4822 c	1.0588 f	0.1219 a
88	0.5930 d		
81	0.7688 e		
75	1.0473 f	2.2265 g	0.3289 b
51	1.2650 g		

The appearance of fruit after incubation at various levels of humidity and temperatures are shown in Plates 3.3.1.1 and 3.3.1.2. Quality of fruit stored at a lower temperature (5° C) with a high level of humidity (100%) was maintained and fruit were marketable. However, rockmelons stored at 20° C, with a low level of humidity (51%) reduced in quality from excessive loss of moisture that affected fresh weight as shown in Table 3.3.1.4.

Plate 3.3.1.1 Rockmelon fruit after 21 days of incubation in humidity chamber with 100% humidity at 5° C.

Plate 3.3.1.2 Rockmelon fruit after 10 days incubation in humidity chamber with 51% humidity at 20° C.

3.3.2 *Storage rots on melon cultivars at different conditions*

Storage rots caused by the pathogens of *Rhizopus* spp., *F. acuminatum* and *A. alternata* were affected by various conditions of storage in different cultivars of melons (Figure 3.3.2.1). Of the three pathogens examined *Rhizopus* spp. was found to be most aggressive in infecting and developing diseases on both honeydew and rockmelons in both open and plastic covered incubation conditions. *A. alternata* was least virulent while *F. acuminatum* was moderately aggressive for infection and disease development on both types of melons.

In open storage conditions smaller lesions developed on melons after inoculation with *Rhizopus* spp., *F. acuminatum* and *A. alternata* while the same pathogens developed significantly larger lesions when incubated covered with perforated plastic. For both covered and uncovered storage honeydew melon developed greater lesion size than rockmelon after inoculation with these pathogens. Comparison within melon type shows that covering with perforated plastic during incubation encourages rot development.

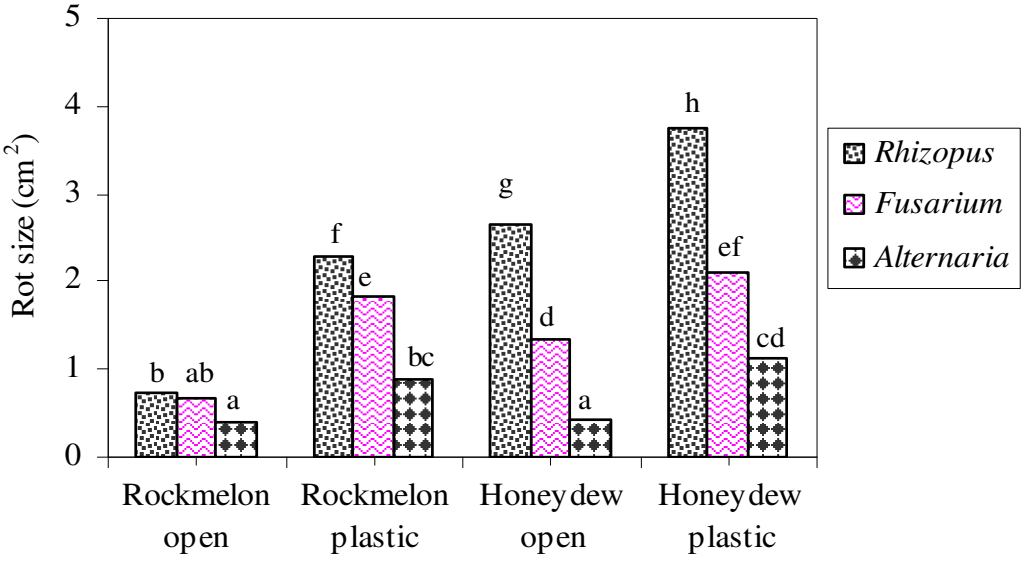

Figure 3.3.2 Storage rot size (cm^2) of *Rhizopus* spp., *F. acuminatum* and *A. alternata* on inoculated rockmelon and honeydew melons after fruit were placed in cartons for incubation with or without plastic (perforated) cover. Rot size was measured after 10 days of incubation at 15° C. Different letters indicate significant difference by LSD at $P<0.05$ (n=4).

3.3.3 *Effect of maturity of rockmelon on storage rots*

Rockmelon harvest maturity significantly affected rot development after inoculation with the pathogenic strains of *Rhizopus* spp., *F. acuminatum* and *A. alternata* (Figure 3.3.3). At green half-slip maturity the largest lesions were developed by *F. acuminatum* followed by *A. alternata* and *Rhizopus* spp. On green full-slip rockmelons *Fusarium* was most

aggressive while *A. alternata* was least aggressive but *Rhizopus* was moderately aggressive for the development of rots. However, yellow full slip rockmelons have shown different results from inoculation with the pathogens. *Rhizopus* spp. was most aggressive and developed much larger lesions than other pathogens; on the green half-slip or green full-slip or yellow full-slip rockmelons. *F. acuminatum* was found to be moderately aggressive and *A. alternata* was least aggressive for the development of rots on yellow full-slip rockmelons.

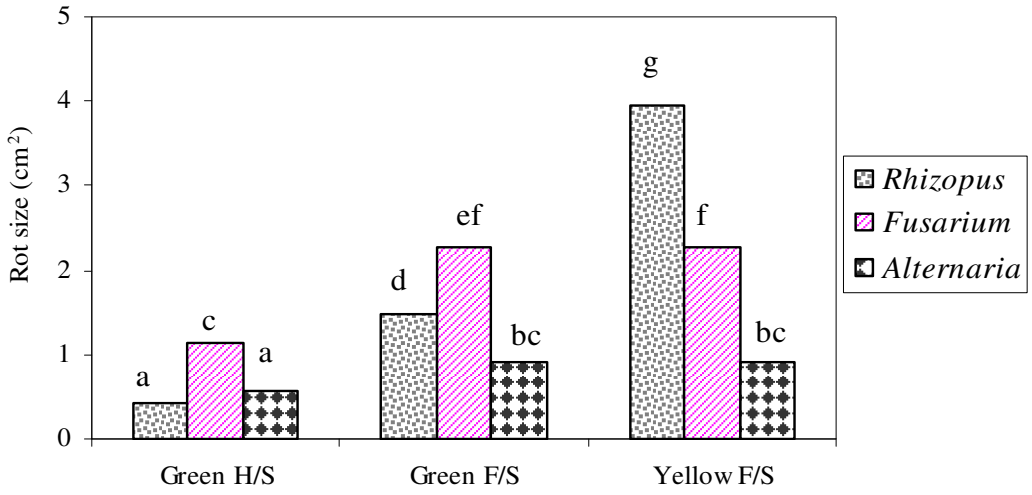

Figure 3.3.3 Storage rots developed on rockmelons harvested at different maturity stages and inoculated with different pathogens. The aggressive strains of *Rhizopus* spp., *F. acuminatum* and *A. alternata* were inoculated through scratch wounds. Inoculated fruits were incubated at 15°C for 10 days covered with perforated plastic. Different letters indicate significant difference by LSD at $P<0.05$ (n=4).

3.4 DISCUSSION

The results from studies on environmental factors suggest that temperature and humidity in storage have a significant influence on infection and lesion development of melons from different pathogens. A high level of humidity keeps wounds and the inoculated surface of the melon moist, encouraging infection by accelerating spore germination and invasion to host tissue (Wadia *et al*., 1986). Similar observations were made by Prasad and Bilgrami (1973), where they found more infection and disease in high humidity in storage and increase shelf life of melons (Rodov *et al*., 2003).

High water content in and around the host tissue has been considered to make them more prone to infection and promote larger lesions by the invading pathogens (Johnson, 1947). Presence of fungal spores on the postharvest product does not automatically ensure disease development. When coupled with a high level of humidity, even for a short period of time at ambient temperature, conditions are conducive for establishing infection by the pathogens (Bonnardeaux and Robinson, 1994). A higher level of humidity in storage has earlier been reported to encourage rot development in melons by the major postharvest strains of *Fusarium*, *Alternaria* and *Rhizopus* spp. (Morris, 1992).

This present study confirmed that high humidity conditions at ambient or at a moderately high temperature were most favourable for infection and disease development on melons in storage. Moreover, temperature was found to play a crucial role in infection and disease development in stored melons. In this study a higher temperature, even at lower levels of humidity, caused infection and disease development at a level that can occur in conditions of high humidity and low temperature. The low level of infection and disease development in low temperatures is believed to be because of low spore germination and slow growth of

the germ tube, which ultimately fails to initiate the infection process or causes slow growth of the lesion in the host tissue (Barkai-Golan, 2001; Dennis and Cohen, 1976).

All three pathogens studied for disease development in melons at controlled humidity conditions were most aggressive when incubated at 20° or 30° C. It is speculated that ambient or moderately high storage temperatures encourage infection of most of the pathogens in storage (Barkai-Golan, 2001). Similarly, Pardo *et al.* (2005) found maximum growth of postharvest rots of grapes occurred in the temperature range between 20° C and 30° C in the presence of high humidity. These same levels of temperature were found to enhance storage rots on most of the postharvest produce (Pardo *et al*., 2004). Even if a plant tissue is considered to be resistant, it has been reported that it may become susceptible and develop disease if exposed to a pathogen in favourable environmental conditions such as high temperature. Host tissues exposed to high temperature in storage rapidly lose cell membrane integrity and become prone to infection by the invading pathogens (Bonnardeaux and Robinson, 1994; Lester, 1988).

While pathogen infection is more likely to occur at high humidity, low humidity storage of melons results in dehydration of the fruit and poor marketability. Hence humidity levels during storage of melons can be a limiting factor for maintaining the quality and marketability of melons. At low humidity, the loss in fresh weight of melon occurred more rapidly than at high humidity storage, even at low temperature conditions. An increased loss in fresh weight causes a loss in cell integrity and rapid softening of the flesh (Ben-Yehoshua, 1985). An earlier report by Ryall *et al.* (1979) stated that a low level of humidity contributes to the relatively short storage life of netted melons due to high transpiration rate and fruit becoming soft and shriveled, even when stored under cool conditions.

Lester and Burton (1986) indicated that to maintain a good appearance of melons it was recommended to keep weight loss within 1% during 3-4 weeks of postharvest storage. However, they later reported that weight loss less than 5% does not significantly affect the marketability of melons. In this study, none of the storage conditions even at a low temperature and high humidity, was able to keep weight loss to 1% over a period of three weeks of storage. It was possible however, to keep weight loss less than 3% over a period of three weeks of storage by storing rockmelons at 5° C with more than 90% humidity. Furthermore, with moisture loss of less than 3% the rockmelons were still marketable after three weeks of storage.

Results of the experiments on incubation conditions with different cultivars of melons suggest a plastic covering, that generates high humidity in storage, encourages disease development by the pathogens. Storing melons with or without plastic covering mainly affected the levels of humidity around the fruit in the storage. The effects of humidity on the infection and development of storage rots has already been discussed above. However, irrespective of covering, variable amounts of rots developed on melons due to inoculation with various storage pathogens. This variation in rot development was due to differences in the nature of pathogen growth and environmental conditions required by different pathogens (Morris, 1977). The study also indicates a difference in rot development on different cultivars of melons after inoculation of pathogens. This variation in rot development may be because of differences in nutrients and structural variation in the host tissue of various cultivars of melons (Simandjuntak *et al*. 1996).

The stage of fruit maturity was a key factor in predicting the development of rots during storage. The least amount of infection and disease development was observed in green

half-slip melons and may be due to greater resistance to disease observed in younger fruit (Eckert, 1975; Paull *et al.*, 1999). As fruit maturity increased from green half slip to green full slip to yellow full slip, an increased trend of infection and disease development was observed. These results suggest that more mature fruit have the least ability to resist infection by storage rots (Evensen, 1983; Verhoeff and Liem, 1975). Rockmelon tissue in particular, with the advent of maturity, becomes softer than that of honeydew melons (Lester, 1988) making rockmelons more prone to storage diseases than honeydew melons.

The difference in rot development in rockmelons of various stages of maturity may also be due to variation in nutrient status of the host tissue, as well as the presence of antifungal metabolites for resistance (Barkai-Golan, 2001). For *A. alternata* infection lesion size only increased slightly as maturity of the melon increased, reflecting a less aggressive and slower growing pathogen, whereas *F. acuminatum* is a moderately aggressive fungus, and developed significantly larger lesions on fruit with advanced maturity. On early mature rockmelons, *Rhizopus* spp. did not grow well, which may be due to host resistance, as well as less availability of nutrients. However, *Rhizopus* spp. infection developed very rapidly on yellow full-slip melons after inoculation, because of relatively soft tissues and abundant nutrients in the host tissues (Eckert, 1978).

3.5 SUMMARY

The results of the study on storage environment for the postharvest diseases of melons demonstrated that a high level of more than 90% humidity, highly encouraged infection and disease development during storage. Similarly, temperatures between 20°-30ºC were shown to promote rapid infection and quick growth of lesions by the postharvest pathogens. However, a combination of both high humidity and ambient temperature is

required for maximum disease development from the inoculum (pathogens) especially in a situation of variable host resistance in particular experimental conditions. The time period required for disease development depends on the incubation temperature and also on the nature of the growth of the pathogens such as virulence of pathogenicity. Therefore, a low incubation temperature requires a longer incubation time, whereas higher temperatures promote rapid pathogen growth. Furthermore, covering the cartons during storage with plastic kept moisture levels high during incubation of the fruit.

All three pathogens tested were pathogenic to both types of melons; however, *F. acuminatum* was moderately aggressive as measured by the rate of lesion development. Moderate growth of *F. acuminatum* was also observed on melons of different maturity and with incubation at variable levels of humidity and temperature. Among the maturity levels of rockmelons, green full-slip fruit was more resistant to infection and rot development than either green half-slip or yellow full-slip. Green half-slip fruits exhibited resistance against the development of pathogens and rot development was limited to a smaller scale. By contrast, melons of yellow full-slip maturity exhibited very low levels of resistance and encouraged the pathogens to grow fast. Hence, for the examination of treatment effects on the expression of pathogenicity, green full-slip rockmelons would be ideal to use in the experiments.