ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 9, Issue 3, pp: (48-55), Month: July - September 2021, Available at: www.researchpublish.com

The Study of Wound Response on a Lesion of Tomato Fruits during Storage and Shelf Life – Impact of Postharvest Treatments

Nasiru Yahaya Ahmed[1] and Haruna Ibrahim[2]

[1]Department of Agricultural and Bio Environmental Engineering, School of Engineering Technology. Federal Polytechnic Bali, Taraba State.

[2]Department of Science Laboratory Technology, School of Science and Technology. Federal Polytechnic Bali, Taraba State.

Corresponding author: nasiryahyaahmed@yahoo.com, +2347035055015

Abstract: **This research work aimed at the investigating wound response on a lesion of tomato fruits during storage and shelf life. The research determine the most effective post-harvest treatment on tomato fruits subjected to wounding and infected with Grey Mould (Botrytis cinerea). The trial was conducted in series of four experiments, a single low and high concentrations, interaction of 30 mM Ca with low and high concentrations. Tomatoes treated with 10% ethanol solutions were included as controls in each experiment. The fruits were inoculated with Botrytis cinerea spores 10 minutes after the treatments and incubated at 10℃ ±1℃ and 85-90% RH for 14days in every successions. The result revealed that among the single treatments 30 mM SA and 30 mM Ca had the greater inhibition effect of Botrytis cinerea on the tomato fruits considering their mean lesion diameter at (d_{14}). However, the combination of 30 mM SA and 30 mM Ca resulted to a significant treatment that inhibit the effect of the fungus. Hence this research suggests a combination of 30 mM SA with 30 mM Ca in suppressing the spread of Botrytis cinerea in tomato fruits. From the high concentration treatment the result show that the levels of different treatment are associated with the lesion size of the disease spread, because the P-value (0.0357) is ≤ the significant level of (0.05), hence the different treatments are statistically significant. The incubation days is also associated with the lesion size diameter at P-value (0.0411). Equally there is significant difference statistically at different measurement days of incubation in respect to lesion size diameter.**

Keywords: **Tomato Fruit, Botrytis Cineria, Calcium Chloride, Salicylic Acid.**

I. INTRODUCTION

Tomatoes are highly perishable commodity with short shelf-life and vulnerable to fungal infection attributes to their low pH, high moisture content and nutrient composition, thus, affecting its quality and nutritional value hence make the fruit unfit for consumption [17]. The world post-harvest losses of the fresh fruits were estimated between 30 – 40% by [1] and 25 – 40% by [17]. Pre-harvest and post-harvest disease, improper post-harvest handling and other conditions are some of the factors that highly affect the wholesomeness of the fresh tomato fruits, as well as storage and shipping conditions [12], other principal causes of post-harvest losses and poor quality include bruising, over-ripening at harvest, water losses, chilling injury, compositional changes, and decay [5]. Bacteria and fungi are the main classes of plant pathogens that cause decay and responsible for the progressive deterioration of tomato, but fungi are more responsible than bacteria [4]. Grey Mould caused by *Botrytis cinerea* is a common and often serious fungal post-harvest disease of tomato plant, the pathogen has a wide host range and can be spread by wind, its survive on plant debris and soil, it usually requires a wound or dead tissue to begin its infection [6] [13]. The fungal agent affects stems, leaves, flowers and fruits of the plant either by direct penetration or through wounding caused by cultivation practices [5]. Cold and high humid conditions favour the

development of grey mould [6] [12], others are low calcium or poor-limed soil, chilling and physical injuries, and storage temperature. It mostly appears as fuzzy, grey-brown mould and occurrence of 'ghost spots' on the fruits [13]. Salicylic acid (SA) is a plant hormone that acts in regulating the stress response, disease resistance and plant developmental process, SA induced plant defence against biotic and abiotic stress [2], Calcium (Ca) improved stress tolerance, maintain fruit firmness and delay decay in fresh fruits like tomatoes. Ca is effective in sensing and identifying a variety of biotic and abiotic signals such as wounding and pathogen attack also facilitate plant response to these stress signals [17]. The aim of this study is to determine the most effective post-harvest treatment on tomato fruits subjected to wounding and infected with *Botrytis cinerea* using different concentrations of Salicylic acid (SA) and Calcium chloride (Ca).

II. LITERATURE REVIEW

Tomato crop is one of the most commercially viable of all agricultural commodities due to its general popularity and health benefits [17]. Tomatoes have significant nutritional value and are an important source of vitamin A, B and C, potassium, iron and calcium. Tomato is also a source of essential nutrient which have a positive impact on human health such as lycopene, β – carotene and vitamin C [3], it is also source of minerals, essential amino acids, sugar and dietary fibres, and plays a vital role in a well-balanced diet of human consumption [10]. The fresh tomatoes are not only traded in the market, but also used in the processing industries in soups, as a paste, ketchup's, juices and concentrates [3] [18]. Tomatoes are eaten in different forms fresh in salad or processed into soups and other products, some other processed product like canned and dried tomato have much economic value when used to prepare different dishes [10]. Tomato production and amount consumed mostly increase with the increase in the population growth.

Post-harvest losses in tomato

Post-harvest losses in tomato are mainly caused by mechanical, physical and chilling injuries, and decay due to fungal and bacterial attack during handling, storage and transportation [17]. The losses is also influenced by some factors such as; lack of appropriate production techniques in the farming system (selection of variety with short shelf life, poor control measure for insect pest and disease infestation, and abiotic stresses); poor or non-application of the recommended treatments; inadequate maturity, sub-optimal harvesting; bulk packaging, without cleaning, sorting and grading; poor storage facilities and method; bad transportation system; distance of the distribution point and time taken to reach the final consumers [11]. Post-harvest deterioration rate increases with the effect of exposure to high temperature, which is one of the significant environmental factors [16]. Besides, tomato growers, processors and dealers encountered great losses due to the aforesaid factors which lead to lower income returns, likewise the producing countries experience earning setback in terms of foreign exchange [11]. Because of the drastic losses it is necessary to adopt proper pre-harvest and post-harvest handling procedures during tomato cultivation for optimum product quality and profitable marketing [12]. Similarly control of storage environment is one of the important factor to reduce post-harvest losses in tomatoes [16].

Common post-harvest disease of tomato

Bacteria and fungi are the two major classes of microorganism that causes tomato rot. However, some certain species of plant pathogen like virus and nematode may be responsible for post-harvest disease and losses, but do not cause progressive deterioration of tomatoes [1] [4]. Bacteria are single celled microbes, they reproduce asexually by fission, which rapidly multiply and spread, especially with a supportive medium like water. A thin layer of water can sustain the brisk movement and growth of the organism on wet or moist materials such as tomato fruits, leaves or packing house machineries [4]. Fungi are either single celled or very complex multicellular organisms known as yeast or moulds, characterised with thread like, cottony or as yeast-like scum in nature. Tomato decay can occur as a result of numerous fungal species infections and they are essentially difficult to eradicate compared to bacterial infection, because fungi produce spores that are relatively resistant to drying and other environmental stress [1] [4]. Fungi are the most significant prevalence pathogens that infect a wide range of host plant, it's caused a lot of destruction and economic losses in tomato either in the field, storage or during transportation, previous research indicates that the extent of post-harvest damage as a result of spoilage fungi also depend on tomato cultivars [4] [5].

Grey Mould

This is caused by ***Botrytis cinerea,*** occurs predominantly on greenhouse tomatoes, especially if they are film-wrapped, the affected tissue is normally firm, dry and brown to black in colour [12]. The examples of the infection point (figure 1a – d) include pruning wounds on stems and fallen flower petals on leaves [6] [7]. The pathogen is an excellent saprophyte

ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 9, Issue 3, pp: (48-55), Month: July - September 2021, Available at: www.researchpublish.com

which grows on an extensive host range with a typical diagnostic fuzzy grey coloured mould on the lesion surface. The lesion may occur anywhere on the fruits, including the stem-end and the blossom-end. The most characteristic symptoms of grey mould include grey-brown fuzzy mould, ghost spots on the fruit which appeared as a pale halo or ring, rapid expansion of the infected area covering the stems, leaves, or fruits, production of halo or ghost rings on the fruit [6] [13], also manifestation of dead brown patches on the leaves, stems and buds, white or pale brown spots on the petals and fruit, and rotting on an unplanted bulbs (Ingram and Meister 2006). Infection occurs at an optimum temperature between 18° and 24°C, with high relative humidity for the production of prolific spore's, while temperature above 28°C suppress the growth and spore production [4] [17]. Control measure includes the avoidance of chilling and physical injuries, the use of appropriate pre-harvest fungicides and the use of adequate storage temperature [12]; others controls are removal of the plant debris on which the fungus could proliferate as part of good hygiene practice, constructing a greenhouse from special ultra-violate-absorbing film to inhibit spore production, use of fumigants and post-harvest treatment [13].

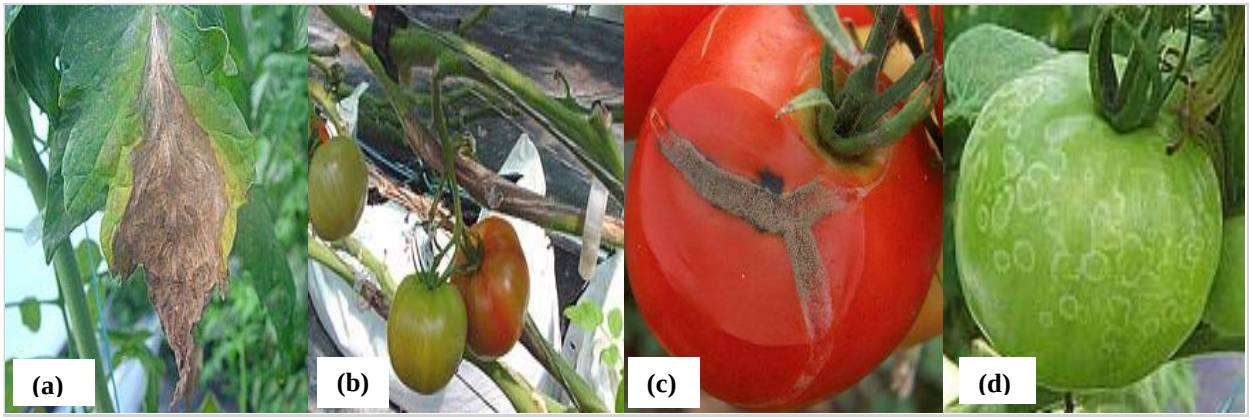

Figure 1: Shows the various effect of *Botrytis cinerea* on tomato plants. Source: [7]

Manifesting on (a) The leaves, (b) the stem, (c) the fruit and (d) the ghost spots

Various control measures of tomato disease

The tomato producers suffered a substantial economic loss due to post-harvest decay caused by pathogenic organisms. Pre-harvest practices have been reported to provide effective control methods to reduce post-harvest disease and losses of the tomato fruit [19]. The common method of controlling post-harvest disease have been reported to be the used of synthetic fungicide treatment [20]. However, there are accumulative harmful effects from over use of the synthetic fungicide on human health due to pesticide residues in food and effects on non-target organisms in environment, as well as the occurrence of pathogen resistance to fungicide, and there is an increasing concern internationally over this practice and need for new and safer alternatives for controlling post-harvest disease with low residues and little or no toxicity to non-targeted organism [19] [20]. A considerable alternative method have been employed in controlling post-harvest disease of tomato fruit among which includes; heat treatment, bioactive compound, biological control [14], chitin and its derivative Chitosan [19], water treatment and yeast antagonists [20], such as *Rhodosporidium paludigenum* [15], hygiene [4], other hormones like salicylic acid and methyl jasmonate [18], and calcium chloride [8] [15].

III. MATERIALS AND METHODS

The matured tomatoes were obtained from a six growers at Bali local Government Area of Taraba state. The town lies between latitude 7°46' and 7°54' of the equator and longitude 10°30' E and 11°00' E of the prime meridian. Bali is the largest Local Government in Taraba State with an estimated land area of 11.540 km^2 and a population density of about 211.024 (NPC 2006). The town is found in dry guinea savannah, with a tropical climate marked by two seasons; dry and rainy seasons. The major occupation of the inhabitants are farming, fishing and nomadism. The samples were collected by observing a supplier quality assurance that certifies highest product safety and quality for example free from defect, contamination, decay symptoms or any other disorders on the fruit.

ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 9, Issue 3, pp: (48-55), Month: July - September 2021, Available at: www.researchpublish.com

Wounding and treatments

The fruit epidermis was mechanically cut-off on each equator of the tomato with sterilize 6mm diameter Cork borer and disposable sterile scalpel. The prepared treatment solution was dispense on the wounded tomato samples using a 200µL pipette and a disposable 200µL pipette tip. Each experiment consists 3 replicates of 20 fruits per replicates. Experiment-1 consists of treatment with (0.2, 0.5, 1.0) mM SA and a sterilized sample with 10% ethanol solution as control (untreated sample). Experiment-2 consists of treatment with (10, 30) mM SA, 30 mM Ca and control. Experiment-3 consists of treatment with (0.2, 0.5, 1.0) mM SA + 30 mM Ca and control. Experiment-4 consists of treatment with (10, 30) mM SA + 30 mM Ca, 30 mM SA and control (Yang *et al.* 2012 and Loon *et al.* 2006).

Fungal pathogen and incubation

The fungal pathogen *Botrytis cinerea* was inoculated onto freshly treated wounds 10 minutes after applying the treatment using a disposable inoculation loop. The inoculated fruits were arrange in a plastic punnet with a wet paper towel underneath and wrapped in a cling film to support the rise of humidity at approximately 95 – 100%. Then, the samples were incubated at 10°C for the period of the experiment [8]. The disease spread was measured three days after inoculation after which the symptoms of the infection start to manifest on the lesion of the fruits. The disease spread was measured for the period of 2 weeks to determine the affected area (lesion size) on the tomato fruits as describe by [9].

Statistical Analysis

The data generated from laboratory were analysed by comparing the treatments analytically using descriptive statistics and analysis of variance to determine the significant differences in the fruit attributes between the treatments. A two-way ANOVA was used to determine whether each main effect and the interaction effect is statistically significant by comparing the p-value for each term to the significance level. Statistical package for social sciences (SPSS) was used to analyse all the data collected in the experiment.

IV. RESULTS AND DISCUSSION

Treatment with different concentration of SA and 30 mM Ca

Tomatoes were treated with different concentrations (0.2, 0.5, 1.0, 10 and 30 mM) of SA to enhanced resistance to *Botrytis cinerea* and inoculation with *B. cinerea* spores. The spread of lesion diameter of treated fruits were most obvious at the 14 days (d_{14}) of incubation. Treatment with 0.5 mM display the highest rate of the disease spread throughout the measurement days even above the control. However, by day 7 and thereafter infection rates between the remaining treatments were comparable (figure 2).

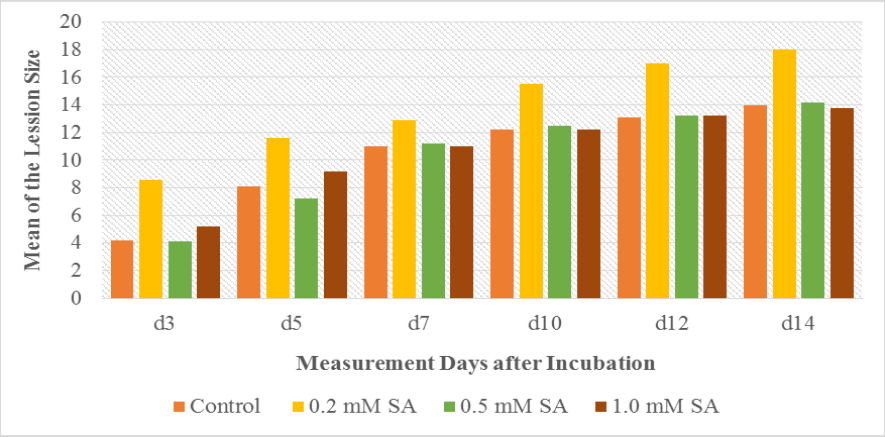

Figure 2: Effect of treatment with low concentrations of SA on the lesion size of tomato

Base on the P-value (0.0318) and the significant level of (0.05) obtained from the Anova table, the result from table 1 show that the levels of different treatment as the main effect are associated with the lesion size of the disease spread. Similarly the different treatments are statistically significant because p-value is ≤ significant level. The incubation days is also associated with the lesion size diameter at P-value (0.0421). Likewise there is significant difference statistically at

ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 9, Issue 3, pp: (48-55), Month: July - September 2021, Available at: www.researchpublish.com

different measurement days of incubation in respect to lesion size diameter considering the p-value and the significant level.

Table 1: Mean of the lesion size for treatment with low concentrations of SA

Measurement Days after Incubation	d_3	d_5	d_7	d_{10}	d_{12}	d_{14}
Control	4.2	8.1	11.0	12.2	13.1	14.0
0.2 mM SA	8.6	11.6	12.9	15.5	17.0	18.0
0.5 mM SA	4.1	7.2	11.2	12.5	13.2	14.2
1.0 mM SA	5.2	9.2	11.0	12.2	13.2	13.8

The mean lesion diameters of treatment with a high concentration (10 and 30 mM) of SA at d_{14} are 15.8 and 13.1mm respectively as shown in Table (2). The prevalence of *Botrytis cinerea* is much less with 30 mM SA compared to 10 mM SA, also less compare to control which has 14.0mm lesion diameter. Meanwhile, 30 mM Ca treatment resulted in 12mm lesion diameter at same d_{14} and it revealed to be an effective resistance to *Botrytis cinerea* compare with 30 mM SA on the same series of experiment (figure 3).

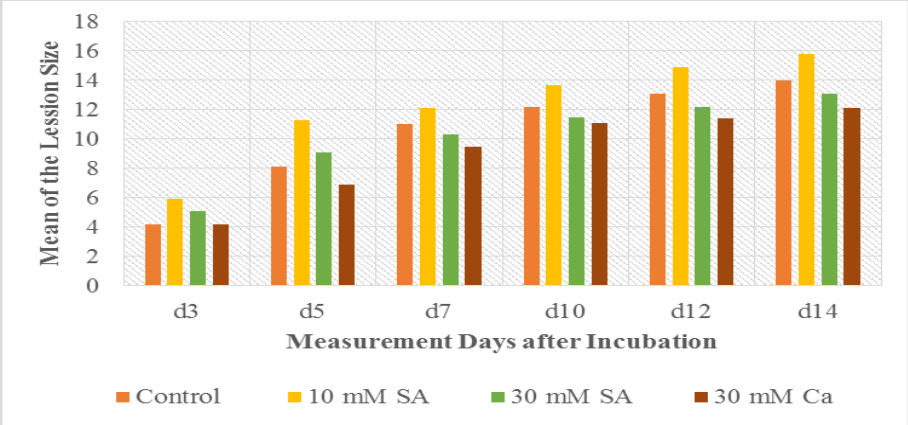

Figure 3: Effect of treatment with high concentrations of SA and Ca on the lesion size of tomato

The table 2 below show that the levels of different treatment are associated with the lesion size of the disease spread, because the P-value (0.0401) is ≤ the significant level of (0.05). Also the different treatments are statistically significant. The incubation days is also associated with the lesion size diameter at P-value (0.0388). Equally there is significant difference statistically at different measurement days of incubation in respect to lesion size diameter.

Table 2: Mean of the lesion size for treatment with high concentrations of SA and Ca on the lesion size of tomato

Measurement Days after Incubation	d_3	d_5	d_7	d_{10}	d_{12}	d_{14}
Control	4.2	8.1	11.0	12.2	13.1	14.0
10 mM SA	5.9	11.3	12.1	13.7	14.9	15.8
30 mM SA	5.1	9.1	10.3	11.5	12.2	13.1
30 mM Ca	4.2	6.9	9.5	11.1	11.4	12.1

The mean lesion sizes of the treated fruits with low concentrations (0.2, 0.5 and 1.0 mM) of SA + 30 mM Ca to each were 12.2, 11.8 and 12.0mm respectively Table (3). From d_3 to d_7, there are geometric increase in pathogen spread. Control display high spread of the pathogen with a mean lesion sizes of 14.0 at d_{14}. However, from d_7 to d_{14}, (0.2, 0.5 and 1.0 mM SA) + 30 mM Ca rate of disease spread were almost similar (figure 4).

ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 9, Issue 3, pp: (48-55), Month: July - September 2021, Available at: www.researchpublish.com

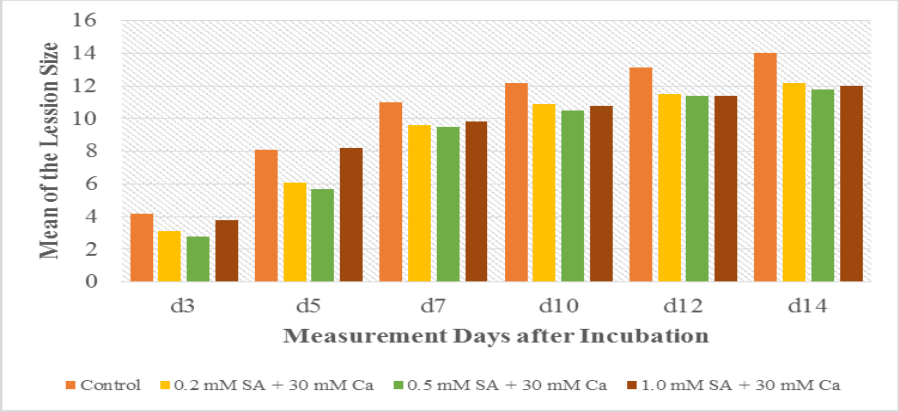

Figure 4: Effect of treatment with low concentrations of SA+30mMCa on the lesion size of tomato

Considering the P-value (0.0399) and the significant level of (0.05) obtained, the result from table 3 show that the levels of different treatment are associated with the lesion size of the disease spread. Hence there is significant difference statistically at different treatments and lesion size diameter. The incubation days is also associated with the lesion size diameter at P-value (0.0375). Likewise there is significant difference statistically at different measurement days of incubation in respect to lesion size diameter because p-value is ≤ significant level.

Table 3: Mean of the lesion size for treatment with low concentrations of SA+30mMCa on the lesion size of tomato

Measurement Days after Incubation	d_3	d_5	d_7	d_{10}	d_{12}	d_{14}
Control	4.2	8.1	11.0	12.2	13.1	14.0
0.2 mM SA + 30 mM Ca	3.1	6.1	9.6	10.9	11.5	12.2
0.5 mM SA + 30 mM Ca	2.8	5.7	9.5	10.5	11.4	11.8
1.0 mM SA + 30 mM Ca	3.8	8.2	9.8	10.8	11.4	12.0

Comparing the rate of spread of *Botrytis cinerea* for control with high concentrations treatment (10 and 30 mM SA) + 30 mM Ca as well as 30 mM Ca on same experimental series resulted in 11.7, 11.2 and 12.4mm mean lesion diameter at d_{14} respectively Table (4). These high concentration treatments significantly inhibited the incidence of the disease compared to control with 14mm mean lesion diameter. Equally, 30 mM SA + 30 mM Ca indicates an effective inhibition over a treatment with 10 mM SA + 30 mM Ca and 30 mM Ca. This, gives confidence in using a combination of high concentrations of SA and Ca on induced disease resistance to *Botrytis cinerea* in tomato fruits (figure 5).

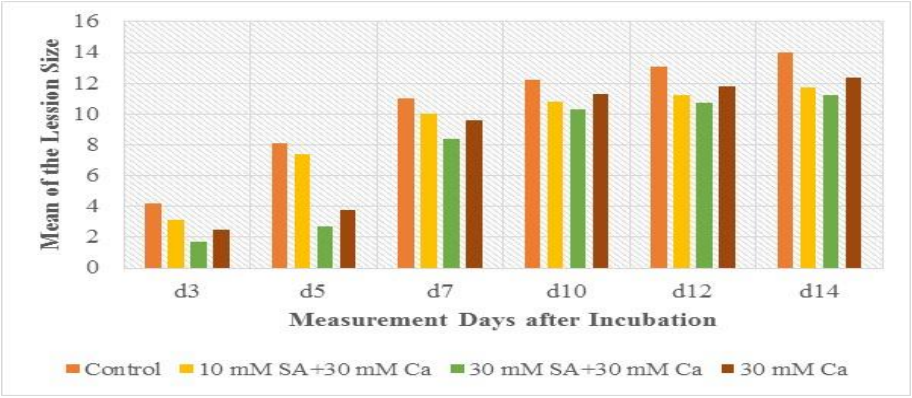

Figure 5: Effect of treatment with high concentrations of SA+30mMCa on the lesion size of tomato

From table 4 below show that the levels of different treatment are associated with the lesion size of the disease spread, because the P-value (0.0357) is ≤ the significant level of (0.05). Also the different treatments are statistically significant. The incubation days is also associated with the lesion size diameter at P-value (0.0411). Equally there is significant difference statistically at different measurement days of incubation in respect to lesion size diameter.

ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 9, Issue 3, pp: (48-55), Month: July - September 2021, Available at: www.researchpublish.com

Table 4: Mean of the lesion size for treatment with high concentrations of SA+30mMCa on the lesion size of tomato

Measurement Days after Incubation	d_3	d_5	d_7	d_{10}	d_{12}	d_{14}
Control	4.2	8.1	11.0	12.2	13.1	14.0
10 mM SA+30 mM Ca	3.1	7.4	10.0	10.8	11.2	11.7
30 mM SA+30 mM Ca	1.7	2.7	8.4	10.3	10.7	11.2
30 mM Ca	2.5	3.8	9.6	11.3	11.8	12.4

Discussion

The effect of fungal pathogen on fruits like tomato generally starts as a result of wound infection or latent infection generated during cultivation practices [15]. The results from this experiment indicated that an integrated method combining different concentrations of SA and Ca prove to be the successful strategy to inhibit post-harvest decay on cherry tomatoes under post-harvest storage conditions. These experiments used wounded and inoculated tomatoes; the effect on less susceptible fruit may be greater than what we have observed under these artificial conditions favourable for infection spread. The inoculated tomatoes were treated with different single low and high concentration of SA, as well as the combined with 30 mM Ca. The result revealed that the combined treatments are more effective than the single treatments. However, the combination of 30 mM SA + 30 mM Ca considered to be the most effective treatment compared with neither the 30mMSA nor 30 mM Ca as a single treatment. The efficiency of 30 mM SA + 30 mM Ca treatment significantly inhibited the effect of *Botrytis cinerea* on lesion size of cherry tomato fruits. These results are in line with [8] who reported that Ca had the ability to enhance SA accumulation, and pathogen resistance with high concentration of Ca treatment, also Ca had a positive effect on SA-dependent signalling pathogen in tomato seedlings against *Botrytis cinerea*. In controlling post-harvest losses of horticultural crops like tomato, SA has been recognised as a natural and safe phenolic compound that exhibited a high potential in reducing disease spread [2]. In addition, SA treatment of the harvested tomato fruit trigger the host-plant defence genes which contributes in reducing decay incidence and lessen chilling injury [2] [9] [18]. Moreover, post-harvest application of Ca has a significant effect on enhancing the shelf life of tomato fruits and other horticultural crops like pears, apple and peaches by maintaining their firmness, preventing background colour loss and quality during storage and marketing. Also Ca application increases the Ca contents of the fruits which help in delaying the fruit ripening, controls the development of many physiological disorders and reduce the post-harvest decay, consequently, improved the fruits nutritional value [12]. During the experiment, it is also observed that the inoculated tomatoes that were treated with single and combine high concentrations of SA and Ca maintain their colours and remain firm even at d_{14} of incubation and measurement of the lesion size, this is due to Ca efficacy and its synergistic interaction with SA, which enhanced the immune response and maintained the firmness of the fruits. In the same way, [18] reported that Ca has been shown to enhance stress tolerance, maintain firmness and reduce decay in tomato fruit. Similarly, [8] also reported that SA is an important hormone that plays a major role in plant defence responses.

V. CONCLUSIONS

Experimental determination of effect of *Botrytis cinerea* on wounded tomato fruits was carried out using SA and Ca with 60 samples per four series of experiment. The result of the study indicates that the combined high concentration treatment with 30mMSA + 30mMCa proved the most effective treatment inhibiting the prevalence of *Botrytis cinerea* development on wounded tomato fruits. The treatment significantly enhanced pathogen resistance in the inoculated fruits. The treatments with 30mMCa, 30mMSA and 10mMSA + 30mMCa reduced decay incidence on the inoculated fruits. The fruits remain firm retaining background colour 14 days after inoculation (d_{14}.). During this study it was not possible to determine whether the combination of SA and Ca was able to induced plant defence against biotic stress or whether the treatments directly affected the growth of the Botrytis fungi. Individually both treatments have the potential to reduce the rate of infection and when combined together there are additive benefits in terms of reducing lesion spread. These treatments if apply pre-harvest have the potentials to control decaying incidence, extends shelf-life and without excessive deterioration during packing, storage and transportation. Moreover, reducing post-harvest disease will increase retention of the nutritional quality of the fruit. The effectiveness of treatments is often dose related and studies tested whether reducing the amount of SA used could improve the control of disease spread. The combination of low concentrations of SA with 30 mM Ca treatment express less impact in inhibiting the effect of *Botrytis cinerea*. The research suggest the use of high doses 10-30mM SA as the most effective treatment under the laboratory conditions. From the high concentration

treatment the result show that the levels of different treatment are associated with the lesion size of the disease spread, because the P-value (0.0357) is ≤ the significant level of (0.05), hence the different treatments are statistically significant. The incubation days is also associated with the lesion size diameter at P-value (0.0411). Equally there is significant difference statistically at different measurement days of incubation in respect to lesion size diameter. As shown in Table 5 and 6, the disease index increased gradually throughout the entire period in all treatment groups.

REFERENCES

[1] Agrios, G.N. (2005). Plant pathology, Elsevier Academic press, 5th Edition pp8-54 New York, USA.

[2] Ashghari M., Aghdam MS., (2010). Impact of Salicylic Acid on Postharvest Physiology of Hoticultural crops. Trent Food Science Technology, 21: 502 – 509.

[3] Bergougnoux, V. (2014). The history of tomato: from domestication to biopharming, *Biotechnology advances*, **32(1)**, 170-189.

[4] Bartz, J., Mahovic, M. and Sargent, S. A. (2004) Guide to identifying and controlling postharvest tomato diseases in Florida, *Universidad de Florida* IFAS Bulletin HS866

[5] Etebu, E., Nwauzoma, A. and Bawo, D. (2013) Postharvest Spoilage of Tomato and Control Strategies in Nigeria, *Journal of Biology, Agriculture and Healthcare*, **3(10)**, 51-61.

[6] Harrison G. (September**,** 2010) Grey mould (Botrytis) in greenhouse tomato crops. Reviewed in Chemical Standards and Neville Fernando, Farm Services Victoria.

[7] Ingram, D. M. and Meister, C. W. (18 July 2006). Managing *Botrytis*, Gray Mould in Greenhouse Tomatoes Using Traditional and Bio-Fungicides, *PHP*.

[8] Li, L., Li, T., Xu, T., Qi, M., Yu, Z. and Zhang, K. (2012) Role of calcium in tomato resistance to *Botrytis cinerea*, *African Journal of Biotechnology*, *Pretoria*, **11(37)**, 9013-9022

[9] Loon, L. C., Geraats, B. P. and Linthorst, H. J. (2006) Ethylene as a modulator of disease resistance in plants, *Trends in plant science*, **11(4)**, 184-191.

[10] Naika S. Jeude, J.L. de Goffau, M. Hilmi, M. and van Dam, B. (2005) Cultivation of tomato: Production, Processing and Marketing. 4th ed. de Netherland: Agromisa Foundation, Wageningen. pp. 6-8, p60-86.

[11] Rehman, M., Naushad, K. and Inayatullah, J. (2007). Post-Harvest losses in tomato crop (A case study of Peshawar Valley). *Sarhad Journal of Agric.***23(4)**, 1271-1284

[12] Rees, D. (2012) Crop Post-Harvest: Science and Technology, Perishables. G. Farrell and J. Orchard. pp. 5-17. John Wiley and Sons

[13] Snowdown, A. L. (1991). A colour atlas of post-harvest diseases and disorders: Vegetable Vol 2, pp. 25-78. Manson Publishing Ltd

[14] Sharma, R., Singh, D. and Singh, R. (2009) Biological control of postharvest diseases of fruits and vegetables by microbial antagonists: A review, *Biological control*, **50(3)**, 205-221.

[15] Wang, Y., Ren, X., Song, X., Yu, T., Lu, H., Wang, P., Wang, J. and Zheng, X. (2010) Control of postharvest decay on cherry tomatoes by marine yeast *Rhodosporidium paludigenum* and calcium chloride, *Journal of applied microbiology*, **109(2)**, 651-656.

[16] Wills, R.B.H., (2007) An introduction to the physiology and handling of fruit, vegetable and ornamentals, McGlasson, W.B., Graham, D. and Joyce D.C. 5th ed. Australia: University of New South Wales. pp 1-5.

[17] Yang T., Peng H., Bruce D., and Jurick M., (2013). Differential expression of calcium/calmodulin regulated *SISRs* in response to abiotic and biotic stress in tomato fruit. *An international Journal for Plant Biology*, 148: 445 – 455.

[18] Yang T.B., Peng H., Whitaker BD. and Conway WS. (2012). Characterization of a Calcium/Calmodulin regulated SR/CAMTA gene family during tomato fruit development. BMC Plant Biology 12: 19.

[19] Zhang, H., Li, R. and Liu, W. (2011) Effects of chitin and its derivative chitosan on postharvest decay of fruits: a review, *International journal of molecular sciences*, **12(2)**, 917-934.

[20] Zong, Y., Liu, J., Li, B., Qin, G. and Tian, S. (2010) Effects of yeast antagonists in combination with hot water treatment on postharvest diseases of tomato fruit, *Biological Control*, **54(3)**, 316-321.