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Management of post-harvest diseases and fruit fly of mango using hot water treatment

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Abstract
The present investigation was undertaken to study the management of post-harvest diseases and fruit fly of mango using hot water treatment. For this purpose, the mango cultivars Alphanso, Totapuri, Kesar, Sonpari and Langra fruits were harvested at proper stage of maturity and given hot water treatment. The mango fruits were then packed in corrugated fibre board box and then stored in room temperature. It was observed that among various treatments, hot water dip at 50 °C for 20 min, hot water dip at 48 °C for 60 min and hot water dip at 52 °C for 10 min found effective for management of post harvest diseases and fruit fly in mango. The untreated (control) fruits were found to have infected with stem end rot, anthracnose and fruit fly.

Keywords: Mango, hot water treatment, stem end rot, anthracnose, fruit fly, TSS

Introduction
India is second largest producer of fruits in the world and also largest producer of mango with production share of 45.1 per cent, respectively. Despite such huge production, the post-harvest losses are reported in the range of 25-40% for mango. Mango being a highly perishable fruit suffers from huge postharvest losses to the extent of about 30-40 per cent (Waskar and Gaikwad, 2005) [5]. These post-harvest losses are mainly due to microbial infection, insect infestation, physiological changes as well as physical damage. Among various spoilage causing factors insect infestations as well as microbial infection play an important role in augment of post-harvest losses. Among several post-harvest diseases, stem end rot and anthracnose are usually considered to be the most severe post-harvest disease of mango worldwide (Ko *et al*., 2009: Malik *et al.* 2010) [2-3]. These fruit infestation/infection hinder the export potential of these fruits, thus causes heavy monitory losses. These losses can be minimized by application of irradiation, vapor heat treatment, waxing and hot water treatment. Among different post-harvest treatments, irradiation is banned in Japan; however, vapor heat treatment is costly treatment while hot water treatment is easy and simplest for its application. This technology involves dipping of commodities in mild hot water (50-55 °C) for certain time to control fungal pathogen and insect in the harvested produce. Hot water treatment also helps to reduce the respiration rate, ethylene bio-synthesis and improve the post-harvest quality of fruits. Dose of hot water treatment vary according to commodity and purpose of application to enhance the storability of fresh produce. Fungal spores and latent infections are either on the surface or in the first few cell layers under the peel of the fruit or vegetable. Most important feature of this technology is that the pathogenic microbes are killed by thermal processing treatment and produce may be popularised as chemical free. Thus hot water treatment is being easily applied as quarantine treatment before export. Hot water dips are effective for fungal pathogen control because fungal spores and latent infections are either on the surface in the first few cell layers under the peel of the fruit. Many fruits tolerate exposure to water temperatures of 50-60 °C for upto 10 minutes, but shorter exposure at these temperatures can control many postharvest plant pathogens (Barkai-Golan and Phillips, 1991) [1].

Materials and Methods
The experiment was conducted at Department of Post-Harvest Technology, ASPEE College of Horticulture and Forestry, NAU, Navsari during the year 2018-19, 2019-20, 2020-21.The experiment was laid out on a completely randomized design (CRD) including 5 treatments *viz.*, T1: Hot Water Dip at 50 °C for 20 Min, T2: Hot Water Dip at 48 °C for 60 Min., T3: Hot

Water Dip at 52 °C for 10 Min., T4: Hot Water Dip at 58 °C for 05 Min. and T5: Control (Without Dip) with 8 repetitions and each treatment contain 5kg fruits of Alphanso, Totapuri, Kesar, Sonpari and Langra mango varieties. Fruits were exposed to fruit fly, anthracnose and stem end rot as per standard methodology. After exposure of 24 hours collected fruits were treated with hot water dip treatment in batch type hot water treatment unit. In this system, baskets of fruits were loaded into a platform, which was then lowered into the hot water immersion tank, where the fruits were held at prescribed temperature for a certain period of time, then were taken out, usually by means of an overhead hoist. The fruits were cut with the help of sharp knife and visually observed the larvae of the fruit fly at the end of storage. The number of damaged fruits attacked by fruit fly were counted and expressed as percentage. The fruits were examined visually for the infection of post-harvest diseases *viz;* anthracnose and stem end rot. The number of infected fruits were counted and expressed as percentage. The TSS (total soluble solid content) of the mango pulp for each treatment was measured using digital pocket refractometer of 0-85ºBrix range and expressed as percent TSS of the fruit. For measuring the TSS (ºBrix), fruit juice samples each of 0.3ml were placed into the well of refractometer and the data were recorded. (Mon *et. al.* 2017) [4].

Results and Discussion

Year 2018-19

Results revealed that no incidence of fruit fly (Table1), anthracnose (Table 2) and stem end rot (Table 3) were observed in hot water dip at 50 °C for 20 min (T1), hot water dip at 48 °C for 60 min (T2) and hot water dip at 52 °C for 10 min (T3) but, fruit fly, anthracnose and stem end rot were observed in the hot water dip treatment at 58 °C for 5 min (T4). In treatment T4 and T5, maximum incidence of fruit fly (30.02% & 42.57%) and stem end rot (45.09% & 28.43%) were recorded in Sonpari. However, the variety Langra showed no incidence of fruit fly, anthracnose and stem end rot in the treatment T4. Maximum incidence of anthracnose was observed in Alphanso (36.60%) in treatment T4. The highest TSS was recorded in the control (T5) as compared to treated fruits in different hot water dip (Table 4).

Year 2019-20

During the second year of experiment results revealed that among all the five treatments, hot water dip at 50 °C for 20 min (T1), hot water dip at 48 °C for 60 min (T2) and hot water dip at 52 °C for 10 min (T3) recorded none of the incidence of fruit fly, anthracnose and stem end rot as compared to control. (Table 1-3). Whereas, fruit fly, anthracnose and stem end rot were observed in the hot water dip treatment at 58 °C for 5 min (T4). In treatment T4 and T5, maximum incidence of fruit fly (27.41%% & 38.51%) and stem end rot (48.94% & 32.54%) were recorded in Sonpari. However, the variety Langra showed no incidence of fruit fly, anthracnose and stem end rot in the treatment T4 while maximum incidence of anthracnose was observed in Sonpari (45.47%) in treatment T4. The highest TSS (Table 4) was recorded in the control (T5) as compared to treated fruits in different hot water dip.

Year 2020-21

During the third year of experiment results also revealed the same trend. Hot water dip at 50 °C for 20 min (T1), hot water dip at 48 °C for 60 min (T2) and hot water dip at 52 °C for 10 min (T3) recorded none of the incidence of fruit fly, anthracnose and stem end rot as compared to control.

Whereas, fruit fly, anthracnose and stem end rot (Table 1-3) were observed in the hot water dip treatment at 58 °C for 5 min (T4). In treatment T4 and T5, maximum incidence of fruit fly (28.40%% & 46.30%) and stem end rot (48.20% & 27.83%) were recorded in Sonpari. However, the variety Langra showed no incidence of fruit fly, anthracnose and stem end rot in the treatment T4. Maximum incidence of anthracnose was observed in Sonpari (38.40%) in treatment T4. The highest TSS (Table 4) was recorded in the control (T5) as compared to treated fruits in different hot water dip.

Pooled year

The three year pooled data presented in table 1 to 4 revealed that among all the five treatments, hot water dip at 50 °C for 20 min (T1), hot water dip at 48 °C for 60 min (T2) and hot water dip at 52 °C for 10 min (T3) recorded none of the incidence of fruit fly, anthracnose and stem end rot as compared to control. The incidence of fruit fly, anthracnose and stem end rot was observed in the hot water dip treatment at 58 °C for 5 min (T4) in all the varieties except Langra. Maximum incidence of fruit fly (28.61%), anthracnose (40.10%) and stem end rot (47.41%) was found in Sonpari in treatment T4. The highest TSS was recorded in the control (T5) as compared to treated fruits in different hot water dip. The increase and decrease in TSS was recorded irrespective to different treatments due to varietal characters.

Table 1: Effect of hot water treatment on fruit fly in mango

Treatment	Variety	Fruit fly incidence (%)			
		2018-19	2019-20	2020-21	Pooled
T_1	Alphanso	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Totapuri	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Kesar	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Sonapari	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_2	Alphanso	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Totapuri	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Kesar	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Sonapari	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_3	Alphanso	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Totapuri	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Kesar	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)

	Sonapari	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_4	Alphanso	9.14 (18.49)	7.52 (16.89)	8.93 (18.27)	8.53 (17.89)
	Totapuri	12.15 (21.2)	8.49 (17.88)	15.43(23.86)	12.02(20.98)
	Kesar	5.95 (15.21)	6.2 (15.47)	3.84 (12.68)	5.33 (14.45)
	Sonapari	30.02 (33.81)	27.41 (32.18)	28.4 (32.72)	28.61 (32.9)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_5	Alphanso	9.94 (19.16)	10.74 (19.82)	9.55 (18.92)	10.08 (19.3)
	Totapuri	22.49 (28.35)	18.33 (25.59)	22.85(29.16)	21.22 (27.7)
	Kesar	21.27 (27.95)	22.43 (28.66)	18.39(25.97)	20.7 (27.53)
	Sonapari	42.57 (41.28)	38.51 (38.92)	46.3 (43.32)	42.46(41.17)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
CD 5%	Factor A (Hot water treatment)	0.99	0.89	0.87	0.52
	Factor B (Variety)	0.99	0.89	0.87	0.52
	Treatments (Ax B)	2.21	2.00	1.94	1.17
CV%		18.38	18.38	16.17	17.28

Note: Figures inside the parentheses are arcsin values (n + 1) and those outside are original values

Table 2: Effect of hot water treatment on anthracnose in mango

Treatment	**Variety**	**Anthracnose incidence (%)**			
		2018-19	**2019-20**	**2020-21**	**Pooled**
T_1	Alphanso	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Totapuri	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Kesar	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Sonapari	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_2	Alphanso	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Totapuri	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Kesar	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Sonapari	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_3	Alphanso	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Totapuri	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Kesar	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Sonapari	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_4	Alphanso	36.6 (37.81)	42.28 (41.13)	35.4 (37.04)	38.09(38.66)
	Totapuri	12.15 (21.24)	17.38 (25.36)	11.81 20.92)	13.78(22.51)
	Kesar	11.89 (20.91)	14.21 (22.84)	11.51(20.63)	12.54(21.46)
	Sonapari	36.44 (37.61)	45.47 (42.97)	38.4 (38.79)	40.1 (39.79)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_5	Alphanso	24.87 (30.19)	28.92 (32.78)	26.53(31.52)	26.77 (31.5)
	Totapuri	11.91 (20.94)	15.9 (24.13)	10.86(20.02)	12.89 (21.7)
	Kesar	14.24 (22.97)	19.2 (26.66)	15.41 (23.8)	16.28(24.48)
	Sonapari	42.65 (41.34)	49.62 (45.36)	43.58(41.86)	45.28(42.85)
	Langra	45.09 (42.75)	52.02 (46.73)	48.91(44.95)	48.67(44.81)
CD 5%	Factor A (Hot water treatment)	0.97	1.16	0.91	0.58
	Factor B (Variety)	0.97	1.16	0.91	0.58
	Treatments (Ax B)	2.18	2.59	2.04	1.31
CV%		14.95	16.35	13.84	15.16

Note: Figures inside the parentheses are arcsin values (n + 1) and those outsides are original values

Table 3: Effect of hot water treatment on stem end rot in mango

Treatment	Variety	Stem end rot incidence (%)			
		2018-19	2019-20	2020-21	Pooled
T_1	Alphanso	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Totapuri	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Kesar	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Sonapari	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_2	Alphanso	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Totapuri	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Kesar	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Sonapari	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_3	Alphanso	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Totapuri	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Kesar	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Sonapari	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_4	Alphanso	36.6 (37.69)	38.26 (38.7)	34.61(36.57)	36.49(37.65)
	Totapuri	36.44 (37.57)	31.78 (34.82)	32.86(35.47)	33.69(35.95)
	Kesar	41.63 (40.76)	44.54 (42.44)	39.85(39.54)	42.01(40.91)
	Sonapari	45.09 (42.74)	48.94 (44.96)	48.2 (44.54)	47.41(44.08)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
T_5	Alphanso	9.95 (19.19)	7.14 (16.56)	10.55(19.82)	9.21 (18.52)
	Totapuri	23.81 (29.74)	26.87 (31.81)	24.61 (30.3)	25.1 (30.62)
	Kesar	21.36 (28.03)	20.51 (27.49)	19.54(26.81)	20.47(27.44)
	Sonapari	28.43 (32.85)	32.54 (35.39)	27.83(32.38)	29.6 (33.54)
	Langra	0 (5.74)	0 (5.74)	0 (5.74)	0 (5.74)
CD 5%	Factor A (Hot water treatment)	1.13	0.87	1.14	0.60
	Factor B (Variety)	1.13	0.87	1.14	0.60
	Treatments (Ax B)	2.52	1.94	2.56	1.35
CV%		17.35	13.25	17.78	16.23

Note: Figures inside the parentheses are arcsin values (n + 1) and those outside are original values

Table 4: Effect of hot water treatment on TSS in mango

Treatment	Variety	TSS			
		2018-19	2019-20	2020-21	Pooled
T_1	Alphanso	13.800	20.020	20.45	18.09
	Totapuri	15.470	11.820	12.81	13.37
	Kesar	25.590	14.520	14.85	18.32
	Sonapari	17.690	20.820	21.40	19.97
	Langra	21.230	21.220	20.63	21.02
T_2	Alphanso	12.250	18.920	18.99	16.72
	Totapuri	16.310	12.320	13.04	13.89
	Kesar	18.560	20.220	19.60	19.46
	Sonapari	20.510	17.820	17.76	18.70
	Langra	22.430	24.020	24.13	23.52
T_3	Alphanso	13.420	20.920	21.61	18.65
	Totapuri	11.900	12.120	12.18	12.06
	Kesar	21.710	17.120	16.44	18.42
	Sonapari	16.800	19.120	18.73	18.21
	Langra	23.520	24.690	24.16	24.12
T_4	Alphanso	12.840	19.840	20.09	17.59
	Totapuri	15.700	13.020	12.71	13.81
	Kesar	20.690	18.120	17.23	18.68
	Sonapari	15.690	22.320	23.18	20.39
	Langra	20.510	22.820	22.31	21.88
T_5	Alphanso	18.270	20.120	19.71	19.37
	Totapuri	15.600	13.520	13.54	14.22
	Kesar	19.840	19.220	19.59	19.55
	Sonapari	19.420	19.520	19.48	19.47
	Langra	22.640	24.670	25.35	24.22
CD 5%	Factor A (Hot water treatment)	0.14	0.13	0.28	0.11
	Factor B (Variety)	0.14	0.13	0.28	0.11
	Treatment/ (A x B)	0.32	0.30	0.62	0.25
CV%		1.79	1.60	3.31	2.37

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