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QUALITY AND SHELF-LIFE OF MANGO (*Mangifera indica* L.) cv. ALPHONSO AS INFLUENCED BY MULCHING AND PRE-HARVEST SPRAY OF CHEMICALS AND BIO-INOCULANT (*Pseudomonas fluorescens*)

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ABSTRACT

Investigations were undertaken to assess the effects of mulching, bio-inoculants and inorganic chemicals on shelf-life of mango cv. Alphonso. Pre-harvest sprays with bio-inoculant (*Pseudomonas fluorescens* FP7 along with chitin) were sprayed six times at 15 days interval starting from 15 days before expected flowering time of mango trees. Calcium chloride (2, 4 and 6%), calcium nitrate (4%), potassium sulphate (1%) and borax (1%) were sprayed 30 days prior to harvest. Highest tree height, tree girth and tree spread were observed when mulching with mango dried leaves was done along with spraying of *Pseudomonas fluorescens* FP7 (0.2%) with chitin (0.5%) and 1% $CaCl_2$. At post-harvest stage the same treatment exhibited delayed ripening, lowest physiological loss in weight, reduced anthracnose infection, increased duration for degreening and resulted in extended shelf- life. It also registered the highest TSS, reducing sugars, non-reducing and total sugars, lowest titrable acidity, ascorbic acid content at the end of storage period of 15.20 days.

Key words: Anthracnose, bio-inoculants, chemicals, quality, PLW and shelf-life

INTRODUCTION

Fruits are considered as protective as they play a significant role in human diet through supply of required vitamins and minerals. Among the fruits, mango (*Mangifera indica* L.) is one of the best fruit in world market due to its excellent flavour, attractive fragrance, beautiful colour, delicious taste and health giving properties. It is popularly called the 'King of fruits'. One medium sized mango of 200 g provides more than daily requirement of vitamin A and three fourth requirement of vitamin C to an adult (Veeraragavathatham *et al.,* 1996). Post-harvest loss starts from pre-harvesting stage followed by harvesting, handling, cleaning, transportation, storage, packing, processing and marketing. The rapid changes that occur after harvest soften the fruit which gives a way for easy entry of pathogen causing diseases, especially anthracnose resulting in heavy post harvest loss. Harvest fresh mangoes are vulnerable to attack by microorganism because of their

moisture content, vital heat produced due to accelerated rate of respiration, high temperatures in transport containers and in storage. Substantial losses due to post harvest diseases during storage and marketing of this commodity is the rule rather than exceptions (Sharma and Alam, 1998). The most common and wide spread storage diseases of mango are anthracnose, stem end rot and black rot (Srivastava, 1968). Diseases often are the most important constraint to the production of tropical fruit. They indirectly reduce yields by debilitating the plant and directly reduce the yield or quality of fruit before it could be recognized and managed. These diseases successfully can result in the catastrophic losses (Ploetz, 2003). Calcium ions are important intercellular messengers in plants and that calcium is intimately involved in many vital physiological processes involving cell walls, cell membranes, chromosomes and enzyme activation (Sharples and Johnson, 1977). Calcium compounds extend the shelf life of several fruits by maintaining firmness, minimizing the rate of respiration, protein breakdown and disease incidence (Gupta *et al.*, 1980). Dry spells during flowering and early fruit development stages, adversely affects the fruit quality. Therefore, application of mulches on soil surface may be a viable option for maintaining in soil health (Singh *et al.*, 2008). Hence, pre-harvest treatments using chemicals in combination with mulching were applied to study their effect on the quality and post harvest loss in mango.

MATERIALS AND METHODS

The present experiment was carried out at the Department of Fruit Crops, Horticultural College and Research Institute, Periyakulam, Tamil Nadu (India). The material used in present study comprised of mulch, bio-inoculant and chemicals as pre-harvest field sprays on mango cv. Alphonso. The treatments included mulching alone with dry leaves or mulching + $CaCl_2$ spray @ 2, 4 or 6% (30 days prior to harvest), mulching + 4% $Ca(NO_3)_2$ spray, mulching + 1% K_2SO_4 spray, mulching + 1% borax spray, mulching + *Pseudomonas fluorescens* FP7 (@ 0.2 %) + chitin (0.5%) applied 6 times at 15 days interval starting from 15 days before expected flowering time + 1% calcium chloride spray and untreated control (without spray and mulching). Mulching was done in March and mango leaves are used as a mulching material it applied as till to the edges of canopy. The chemical spray was done 30 days prior to harvest. The experiment was conducted in a randomized block design and each treatment replicated 4 times. The 9 year old mango trees, spaced at 7 m x 7 m, were selected. The fully matured treated and untreated fruits of Alphonso collected from these trees were used as sample for post-harvest studies. The observations on morphological characters *viz.*, tree height, girth and spread and physical characters of fruits such as shelf-life was assessed on basis of fruit firmness, colour and extend of shrinkage, physiological loss in weight (PLW) at 5 days interval from harvest.

$$PLW = \frac{\text{initial weight – weight after storage}}{\text{Initial weight}} \times 100$$

The anthracnose disease incidence was recorded at regular interval of 5 days after harvest using the disease score chart of Rose (1974) wherein 0 = no infection; 1 = <25% fruit surface infected; 2 = 26-50% fruit surface infected; 3 = 51-75% fruit surface infected; and >75% fruit surface infected. Disease infection was calculated by individual fruit rating.

$$PDI = \frac{\text{Sum of all individual ratings}}{\text{Total number of fruits graded} \times \text{maximum disease grade}} \times 100$$

Total soluble solids in juice was measured by using a hand refractrometer (ERMA make). Total sugars, reducing and non-reducing sugars, titrable acidity and ascorbic acid content were estimated at end of storage period by AOAC method (1986). The data were statistically analyzed as per the method suggested by Panse and Sukhatme (1978). The critical differences were worked out for 5% probability level.

RESULTS AND DISCUSSION

A fruit can have a long storage life only if the metabolic rate is low, consequent of minimal loss of nutrients (Burton, 1982). Extension of shelf-life is possible by checking the degradative metabolism, fungal and microbial infections**.** Calcium compounds have been reported to extend storage life and quality of mango fruits by minimizing the rate of respiration, transpiration and disease incidence and also by retarding senescence. Mulching with dried leaves along with foliar spray of potassium sulphate 1% recorded the highest tree height of 3.87 m, 4.05 m and 4.11 m at vegetative, flowering and harvesting stages, respectively. This was at par with treatment of mulching + *Pseudomonas fluorescens* FP7 along with chitin and calcium chloride 1% with values of 3.67, 3.92 and 4.00 m at vegetative, flowering and harvesting stages, respectively (Table 1). Similarly tree girth recorded significant changes due to mulching and pre-harvest treatments at vegetative, flowering and harvesting stages. The highest tree girth of 56.78, 56.84 and 56.92 cm was recorded at vegetative, flowering and harvesting stages, respectively, by mulching with dried leaves along with spraying of 1% potassium sulphate (Table 1). Tree spread in the (east-west directions) was significantly influenced by mulching and pre-harvest treatments during all stages of growth. The tree spread in the east-west direction was highest i.e. 4.63, 4.70 and 4.78 m at vegetative, flowering and harvesting stages, respectively, in mulching with dried leaves along with spray of 1% potassium sulphate (Table 2.) Mulching with dried leaves along with pre-harvest spray of 1% potassium sulphate recorded highest tree spread (north–south directions) i.e. 4.74, 4.80 and 4.86 m at vegetative, flowering and harvesting stages, respectively (Table 2) The positive response of mulching treatments on growth characteristics might be attributed to congenial environment in root zone due to lower weed population, optimum soil moisture level, increased availability of nutrients, favourable soil temperature and increased beneficial microbial population. These results are in conformity with Borthakur and Bhattacharya (1992) in Guava. The increase in growth of plant was possible due to increased availability of soil moisture and nutrients and reduced evaporation from soil surface. This is in accordance with the findings of Shirgure *et al.* (2003) in mango. The plant growth promoting rhizobacteria has often been found associated with increased rate of plant growth (Kloepper *et al.,* 1980). This might be due to synthesis of phytohormones like gibberellins, cytokinins and indole acetic acid due to application of plant growth promoting rhizobacteria (Ramamoorthy and Samiyappan, 2001).

The shelf-life of mango fruit differed significantly among the various treatments (Table 3). The high shelf-life of fruits was observed in mulching + *Pseudomonas fluorescens* FP7 application

Table 1: Effect of mulching, bio-inoculants and pre-harvest chemical treatments on tree height and girth of mango cv. Alphonso

Treatments	Tree height (m)			Tree girth (cm)		
	Vegetative	Flowering	Harvesting	Vegetative	Flowering	Harvesting
Mulching (dried leaves) (DLM)	3.31	3.46	3.55	56.10	56.16	56.20
DLM + 2% $CaCl_2$ spray	3.63	3.79	3.86	56.43	56.47	56.52
DLM + 4% $CaCl_2$ spray	3.56	3.71	3.77	56.51	56.56	56.65
DLM + 6% $CaCl_2$ spray	3.48	3.66	3.74	56.35	56.40	56.47
DLM + 4% $Ca(NO_3)_2$ spray	3.42	3.60	3.66	56.26	56.31	56.40
DLM + 1% K_2SO_4 spray	3.87	4.05	4.11	56.78	56.84	56.92
DLM + 1% borax spray	3.36	3.53	3.60	56.17	56.20	56.28
DLM + [*Pseudomonas fluorescens* FP7 (0.2%) + chitin (0.5 %)]** + 2% $CaCl_2$ spray	3.76	3.92	4.00	56.62	56.68	56.75
Control (no spray and mulching)	3.19	3.34	3.39	56.02	56.10	56.15
$CD_{0.05}$	0.2242	0.2361	0.2417	0.0607	0.0409	0.0205

*spray done 30 days prior to harvest; **6 times at 15 days interval starting from 15 days before expected flowering

Table 2: Effect of mulching, bio-inoculants and pre-harvest chemical treatments on canopy spread of mango cv. Alphonso

Treatments	East-West directions (m)			North-South directions (m)		
	Vegetative	Flowering	Harvesting	Vegetative	Flowering	Harvesting
Mulching (dried leaves) (DLM)	4.06	4.13	4.20	4.21	4.28	4.35
DLM + 2% $CaCl_2$ spray	4.40	4.49	4.54	4.46	4.54	4.61
DLM + 4% $CaCl_2$ spray	4.46	4.55	4.62	4.54	4.60	4.67
DLM + 6% $CaCl_2$ spray	4.31	4.38	4.44	4.39	4.46	4.52
DLM + 4% $Ca(NO_3)_2$ spray	4.22	4.29	4.35	4.33	4.40	4.47
DLM + 1% K_2SO_4 spray	4.63	4.70	4.78	4.74	4.80	4.86
DLM + 1% borax spray	4.15	4.21	4.27	4.27	4.34	4.40
DLM + [*Pseudomonas fluorescens* FP7 (0.2%) + chitin (0.5 %)]** + 1% $CaCl_2$ spray	4.54	4.63	4.71	4.63	4.69	4.77
Control (no spray and mulching)	3.97	4.05	4.12	4.10	4.16	4.22
$CD_{0.05}$	0.0091	0.0119	0.0048	0.0171	0.0430	0.0276

*spray done 30 days prior to harvest; **6 times at 15 days interval starting from 15 days before expected flowering

along with chitin and 1% $CaCl_2$ spray (15.2 days) treatment, followed by 4% $CaCl_2$ spray (14.6 days). The anthracnose infection which differed significantly among the treatments was studied every 5 days from 10, 15 and 20th day of storage of mango fruits. The infection was least in *P. fluorescens* FP7 application along with chitin and 1% $CaCl_2$ spray with 0.70, 1.23 and 1.74%, respectively (Table 3). The least incidence of anthracnose might be due to the systemic resistance exerted by *P. fluoroscens* (Ippolilo and Nilgro, 2000). Further, the production of defense mediating lytic enzymes *viz.* chitinase (PR-3) and p-1,3 glucanase (PR-2) which hydrolase the chitin and p-1,3 glucan, respectively, were known to suppress the pathogen (Viswanathan and Samiyappan, 2001). Physiological loss in weight (PLW) indicates the initiation of reduction in fruit shelf-life. Higher the PLW greater is the rate of basic metabolism and shorter is shelf-life. PLW was lowest at 5, 10, 15 and 20 days after harvest [3.98, 10.02, 19.79 and 36.39%, respectively] (Table 4). This might be attributed to the calcium which on deposition in cell wall as calcium pectate makes the cell wall thick. It further reduced the respiration rate and delayed ripening which, in turn, delayed latent infection; thereby minimized water loss resulting in reduced PLW. The least PLW might be also due to the beneficial effect of *P. fluorescens* and chitin giving protection against disease incidence (Saha and Verma, 1999).

In present study, mulching + spray of *P. fluorescens* FP7 along with chitin + $CaCl_2$ registered highest TSS in mango (Table 5). The enhanced TSS even at 20 days of shelf-life might be due to

Table 3: Effect of mulching, bio-inoculants and pre-harvest chemical treatments on shelf life and anthracnose incidence in mango cv. Alphonso fruits

Treatments	Shelf life of fruits (days)	Anthracnose incidence (%)		
		10 days after storage	15 days after storage	20 days after storage
Mulching (dried leaves) (DLM)	12.5	1.06 (5.71)	1.57 (7.27)	2.70 (9.46)
DLM + 2% $CaCl_2$ spray	13.4	0.80 (5.26)	1.36 (6.80)	2.53 (9.10)
DLM + 4% $CaCl_2$ spray	14.6	0.77 (4.91)	1.32 (6.55)	2.51 (9.10)
DLM + 6% $CaCl_2$ spray	13.1	0.95 (3.95)	1.39 (6.80)	2.60 (9.28)
DLM + 4% $Ca(NO_3)_2$ spray	12.9	0.97 (5.59)	1.47 (7.04)	2.61 (9.28)
DLM + 1% K_2SO_4 spray	14.3	0.71 (4.46)	1.30 (6.55)	2.45 (9.10)
DLM + 1% borax spray	13.6	1.00 (5.55)	1.51 (7.04)	2.67 (9.46)
DLM + [*Pseudomonas fluorescens* FP7 (0.2%) + chitin (0.5 %)]** + 2% $CaCl_2$ spray	15.2	0.70 (4.69)	1.23 (6.29)	1.74 (7.49)
Control (no spray and mulching)	11.3	1.12 (5.99)	1.74 (7.49)	2.87 (9.81)
$CD_{0.05}$	0.028	0.0054	0.0053	0.0052

*spray done 30 days prior to harvest; **6 times at 15 days interval starting from 15 days before expected flowering

Table 4: Effect of mulching, bio-inoculants and pre-harvest chemical treatments on physiological loss in weight (PLW %) in mango cv. Alphonso fruits on various storage days

Treatments	5 days	10 days	15 days	20 days
Mulching (dried leaves) (DLM)	4.92	13.40	25.00	46.10
DLM + 2% $CaCl_2$ spray	4.66	12.79	24.73	45.01
DLM + 4% $CaCl_2$ spray	4.42	11.61	24.16	42.95
DLM + 6% $CaCl_2$ spray	4.77	12.86	24.89	45.22
DLM + 4% $Ca(NO_3)_2$ spray	4.79	12.91	24.98	45.87
DLM + 1% K_2SO_4 spray	4.50	12.58	24.44	43.64
DLM + 1% borax spray	4.61	12.63	24.62	44.60
DLM + [*Pseudomonas fluorescens* FP7 (0.2%) + chitin (0.5 %)]** + 2% $CaCl_2$ spray	3.98	10.02	19.79	36.39
Control (no spray and mulching)	5.07	13.81	25.12	46.75
$CD_{0.05}$	0.8100	1.3458	1.9176	2.7106

*spray done 30 days prior to harvest; **6 times at 15 days interval starting from 15 days before expected flowering

the induced synergistic action of *Pseudomonas* in arresting the physiological loss of weight and fungal infection which ultimately saved the inherent stored carbohydrate level reflecting on higher TSS level. In addition, hydrolysis of starch in presence of α- and β-amylase and starch phosphorylase resulting in increase in TSS with regard to reducing, non-reducing and total sugar contents of fruits. The treatment *P. fluorescens* along with chitin and 1% calcium chloride with mulching) proved superior over other treatments exhibiting the values of 6.30, 12.43 and 18.73%, respectively, and also due to the role of *P. fluoroscens* along with chitin in suppressing the incidence of fungal infection, thus preventing the expression of sugar substrate by fungus (Vivekananthan *et al.*, 2004) in mango. Similar trend was observed in titrable acidity of fruits. Treatment *P. fluorescens* along with chitin and 1% $CaCl_2$ with mulching recorded least titrable acidity of 0.18%. This may be attributed to the conversion of acids into salts and sugars by enzymes, particularly invertase that leads to a significant decrease in acidity content during storage in mango (Joshi and Roy, 1985). Ascorbic acid content was more in fruits of *P. fluorescens* FP7 application along with chitin and 1% $CaCl_2$ (39.65 mg /100 g). Relative increase in ascorbic acid content especially with bio-inoculant along with chitin with $CaCl_2$ may be ascribed to the synergistic effect of *P. fluoroscens* and calcium in suppressing the entry of fungal pathogens in fruits during biosynthesis of glucose, which is considered to be the precursor of vitamin C.

Table 5: Effect of mulching, bio-inoculants and pre-harvest chemical treatments on quality characters at the end of storage period in mango cv. Alphonso fruits

Treatments	TSS (°Brix)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Titrable acidity (%)	Ascorbic acid (mg 100 g^{-1})
Mulching (dried leaves) (DLM)	19.10	5.10	11.21	16.30	0.72	36.75
DLM + 2% $CaCl_2$ spray	19.82	5.56	11.58	17.14	0.55	37.63
DLM + 4% $CaCl_2$ spray	20.42	6.21	11.84	18.05	0.29	39.30
DLM + 6% $CaCl_2$ spray	19.65	5.35	11.51	16.86	0.62	37.44
DLM + 4% $Ca(NO_3)_2$ spray	18.76	5.15	11.42	16.57	0.65	37.16
DLM + 1% K_2SO_4 spray	20.14	6.13	11.72	17.85	0.37	38.18
DLM + 1% borax spray	19.71	5.63	11.65	17.28	0.45	37.72
DLM + [*Pseudomonas fluorescens* FP7 (0.2%) + chitin (0.5 %)]** + 2% $CaCl_2$ spray	21.02	6.30	12.43	18.73	0.18	39.65
Control (no spray and mulching)	19.04	5.03	11.13	16.15	0.78	34.67
$CD_{0.05}$	0.017	0.005	0.005	0.006	0.005	0.035

*spray done 30 days prior to harvest; **6 times at 15 days interval starting from 15 days before expected flowering

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