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# Post-Harvest Treatment of Inorganic Salts Reduces the Disease Severity of Banana Anthracnose

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**A B S T R A C T**

The present investigations intended to revise the effect of inorganic salts as post-harvest treatment aiming at reduction severity of banana anthracnose, a predominant postharvest disease of banana caused by *Colletotrichum musae*. Experiments were carried out during 2016 in department of plant pathology, UAS, Dharwad. Four inorganic salts were tested for their efficacy at three concentrations (1, 5 and 10 % w/v) *in vitro* against *Colletotrichum musae* and also evaluated post-harvest fruit treatment *in vivo* viz; Boric acid ($HBO_3$), Sodium bicarbonate ($NaHCO_3$), Sodium hypochlorite (NaClO), Mono potassium phosphate ($K_2HPO_4$) with surfactant. Findings of present study shown that postharvest treatment of banana with Boric acid at 5.0 and 10.0 per cent concentration and Sodium bicarbonate at 10.0 per cent concentration showed maximum disease severity reduction (91.18 %) which was significantly superior to all other salts evaluated *in vivo* at different tested concentrations.

## Introduction

Inorganic salts have anti-fungal properties that make them desirable for inclusion in disease management programmes of field diseases of many crops as well as post-harvest diseases of perishables like fruits and vegetables (Deliopoulus *et al.*, 2010). Banana is very important tropical fruit suffers post-harvest losses due to fruit rots mainly by anthracnose caused by *Colletotrichum musae* is most prevelent postharvest disease, it has been a major constraint in the marketing of fruit intended for local as well as distant markets (Ghazanfar *et al.*, 2007). Control of postharvest diseases has been traditionally achieved by pre and postharvest applications of fungicides. However, low availability of effective and approved fungicides for post-harvest treatment, resistance development in pathogens and environmental concerns as well as the low level of acceptance of plant derived products by market place, indicate the necessity of intensifying research towards novel and sustainable disease management approaches. Inorganic salts can be alternative to chemical fungicides as studied by many researchers for their antifungal efficiency to control postharvest diseases of fruits and vegetables by various workers (Olivier *et al.*, 1998; Palmer *et al.*, 1997). The effect of inorganic salts with or without surfactant on the reduction of the colony growth of postharvest pathogens associated with banana crown rot (*Lasiodiplodia theobromae*, *Colletotrichum musae*, *Thielaviopsis paradoxa* and *Fusarium verticillioides*) was tested *in vitro* by Alvinda and Natsuaki (2007). Jawandha *et al.,* (2012) recommended the treatment of freshly harvested fruits of kinnow with 3.0 per cent boric acid followed by storage in LDPE bags for effective management of fruit decay caused by storage fungi.

Moreover, Inorganic salts such as sodium carbonate ($Na_2CO_3$), sodium bicarbonate ($NaHCO_3$), calcium chloride ($CaCl_2$), sodium chloride (NaCl) and sodium hypochlorite (NaClO) are common food additives for leavening, pH control, taste, texture modification, disinfectant and spoilage control (Biggs, 1999; Alvindia *et al.,* 2004). These salts are classified as ‘Generally recognized as safe’ (GRAS) substances and are exempt from residue tolerances on all agricultural commodities. According to the EPA, the use of $KHCO_3$ and $NaHCO_3$ as fungicides was not expected to be harmful for humans and the environment and could therefore offer as a safe alternative to toxic conventional fungicides (Deliopoulos *et al.,* 2010).

## Materials and Methods

### *In vitro* evaluation of inorganic salts

Four inorganic salts were tested for their efficacy at three concentrations (1, 5 and 10 % w/v)against *C. musae* viz., Boric acid ($HBO_3$), Sodium bicarbonate ($NaHCO_3$), Sodium hypochlorite (NaClO), Mono potassium phosphate ($K_2HPO_4$)

Poisoned food technique was used in the *in vitro* study. Inorganic salts of required quantity were taken with the help of analytical balance and added to molten PDA flasks to achieve final concentrations of 1, 5 and 10 %(w/v) and stirred well before pouring into 90 mm Petri dishes, PDA without salts served as a control. Dishes were seeded in the centre with a five mm mycelial disc taken from the edge of actively growing colony of the *C. musae* with the help of sterile cork borer and incubated at 25 ± 2°C. For each concentration of treatments, three replications were maintained. Colony diameter was measured in all the petridishes when the fungus occupied the entire dish in control and per cent inhibition of mycelial growth was calculated by using the following formula (Vincent, 1947).

### *In vivo* evaluation of inorganic salts

The same treatments were tested for their efficacy in reducing the disease severity of anthracnose on banana fruits at three concentrations (1.0, 5.0 and 10.0 %). Fruits selected for *in vivo* studies were at mature green stage, free from blemishes and injuries. Banana fingers with intact crown portion were sterilized in 1.0 per cent sodium hypochlorite and rinsed with sterilized distilled water. These fingers were dipped in postharvest treatment solutions of required concentration which were for ten min and allowed to dry in aseptic chamber. These fruits were dipped in spore suspension of *C. musae* ($1x10^5$) for one min and allowed to dry aseptically. The fingers dipped in sterilized water for ten min followed by spore suspension of *C. musae* ($1x10^5$) served as untreated control. Cotton swabs dipped in sterile water were placed in moist chamber to maintain sufficient humidity during incubation. Observations were recorded on per cent area infected on fruit in 0-5 scale after eight days of inoculation. Per cent disease index was computed by using the formula given by Wheeler (1969) and analysed statistically. Per cent disease reduction in different treatments over control was derived by using the formula suggested by Vincent (1947).Per cent disease index and per cent disease reduction were calculated in different treatments.

### Statistical analysis

The experiment was laid out in a completely randomized design (CRD) with a factorial combination of treatments in different concentrations in three replications. The experiment was conducted at room temperature in the laboratory. Statistical analysis was done as per the procedures given by Gomez and Gomez (1984).

## Results and Discussion

### *In vitro* evaluation of inorganic salts

Present experiment carried out to determine the efficacy of four salts *viz.*, boric acid, sodium bicarbonate, monopotassium phosphate and sodium hypochlorite at three concentrations against *C. musae*. Results (Fig. 1) indicated that, complete inhibition of mycelial growth was recorded with boric acid and sodium bicarbonate at both 5.0 and 10.0 per cent concentration which were on par to each other and superior to the rest of treatments. Second best treatment was monopotassium phosphate at 10.0 per cent (88.55 %) followed by boric acid at 1.0 per cent (74.00 %). Antifungal efficacy of these salts may be attributed to the changes in pH of the growth media to the level of discouraging fungal growth. Several reports discussed on these aspects; according to Fallik *et al.*, (1997), in addition to the ability to elevate the pH of its exogenous environment, $NaHCO_3$ can impose a number of inhibitory actions against fungi, sodium bicarbonate can inactivate extracellular enzymes of fungi and may directly interact with cell membranes and disrupt the cellular physiology.

These findings are in accordance with De Costa and Gunawardhana (2012) who reported efficacy of $NaHCO_3$ against *C. musae*. Similarly Alvinda and Natsuaki (2007) reported the antifungal activity of $NaHCO_3$ against postharvest pathogens associated with crown rot of banana (Table 1 and 2).

**Table.1** *In vitro* evaluation of inorganic salts on mycelial growth of *Colletotrichum musae*

| Inorganic salts | Per cent inhibition of mycelial growth | | | Mean |
|---|---|---|---|---|
| | At concentrations (%) | | | |
| | 1.0 | 5.0 | 10.0 | |
| Boric acid | 74.00 (59.34) * | 100.00 (90.00) | 100.00 (90.00) | 91.33 (72.88) |
| Sodium bicarbonate | 60.60 (51.12) | 100.00 (90.00) | 100.00 (90.00) | 86.87 (68.75) |
| Sodium hypochlorite | 32.53 (34.77) | 35.76 (36.73) | 54.41 (47.53) | 40.90 (39.76) |
| Monopotassium phosphate | 33.77 (35.53) | 62.29 (52.11) | 88.55 (70.23) | 61.54 (51.67) |
| Mean | 50.22 (45.13) | 74.51 (59.68) | 85.74 (67.81) | |
| Source | S.E m ± | | CD at 1% | |
| Treatment (T) | 0.19 | | 0.75 | |
| Concentration (C) | 0.16 | | 0.65 | |
| T×C | 0.33 | | 1.30 | |

*Arcsine transformed values

**Table.2** Bioefficacy of inorganic salts for the management of banana anthracnose

| Inorganic salts | Per cent disease index | | | | Per cent disease reduction over control | | | |
|---|---|---|---|---|---|---|---|---|
| | At concentrations (%) | | | | At concentrations (%) | | | |
| | **1.0** | **5.0** | **10.0** | **Mean** | **1.0** | **5.0** | **10.0** | **Mean** |
| Boric acid | 13.33 (21.42)* | 6.67 (14.96) | 6.67 (14.96) | 8.89 (17.35) | 82.35 (65.16) | 91.18 (72.72) | 91.18 (72.72) | 82.35 (65.16) |
| Sodium bicarbonate | 31.11 (33.90) | 13.33 (21.41) | 6.67 (14.96) | 17.04 (24.38) | 58.83 (50.10) | 82.35 (65.16) | 91.18 (72.72) | 58.83 (50.10) |
| Sodium hypochlorite | 35.56 (36.61) | 28.89 (32.51) | 20.00 (26.57) | 28.15 (32.04) | 52.94 (46.69) | 61.77 (51.83) | 73.53 (59.04) | 52.94 (46.69) |
| Monopotassium phosphate | 28.89 (32.51) | 22.22 (28.12) | 13.33 (21.41) | 21.48 (27.61) | 61.77 (51.83) | 70.59 (57.21) | 82.35 (65.16) | 61.77 (51.83) |
| Untreated control | | | | 75.56 (60.37) | | | | |
| **Source** | **S.E m ±** | | **CD at 5%** | | **S.E m ±** | | **CD at 5%** | |
| **Treatment (T)** | 0.45 | | 1.32 | | 0.65 | | 1.89 | |
| **Concentration (C)** | 0.52 | | 1.52 | | 0.56 | | 1.64 | |
| **T×C** | 0.91 | | 2.64 | | 1.22 | | 3.28 | |

*Arcsine transformed values

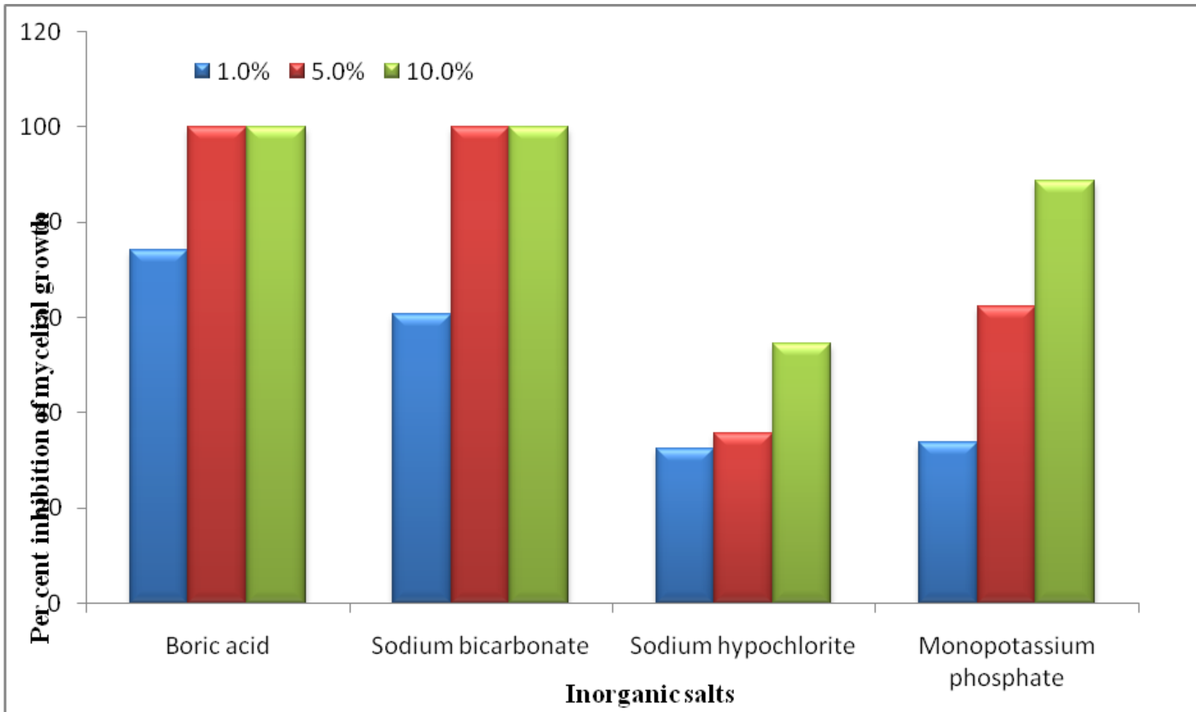


**Fig. 1: *In vitro* evaluation of inorganic salts against *Colletotrichum musae***

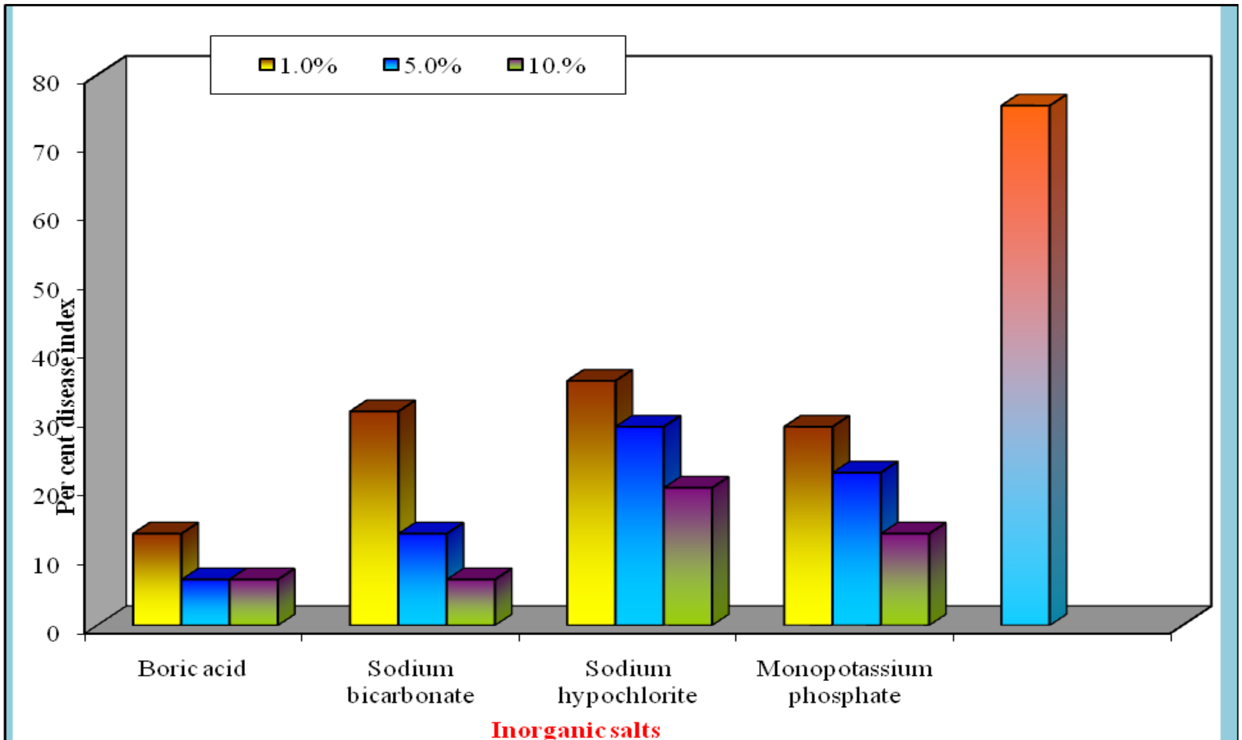


**Fig2 : Bioefficacy of inorganic salts for the management of banana anthracnose**

## *In vivo* evaluation of inorganic salts

The ability of these inorganic and organic salts in controlling postharvest decay of bell pepper (Fallik *et al.*, 1997), citrus (Smilanick *et al.*, 1999), melon (Aharoni *et al.*, 1997) and anthracnose of papaya (Sivakumar *et al.*, 2002) has been documented. The first application of inorganic salts to tropical fruit was tested by Alvinda *et al.*, (2004) against crown rot disease in bananas.

Findings of present investigations shown that, out of four salts tested for the management of anthracnose in banana (Fig. 2), boric acid at 5.0 and 10.0 per cent and sodium bicarbonate at 10 per cent concentration resulted in maximum disease reduction (91.18 %) which was significantly superior to all other treatments at different concentrations tested. Next to these were boric acid at 1.0 per cent, sodium bicarbonate at 5.0 per cent and monopotassium phosphate at 10.0 per cent concentration which showed 82.35 percent reduction in disease. Antifungal efficacy of these salts may be attributed to the changes in pH of the growth media to the level of discouraging fungal growth. Indeed, specific experiments conducted by Youssef *et al.*, (2010) pointed out an indirect action of some salts mediated by tissue-induced resistance; Further trials have shown also an increase in the phytoalexins scoparone, scopoletin and umbelliferone in $Na_2CO_3$ and $NaHCO_3$ treated orange tissues (Youssef *et al.*, 2011). Supporting the present findings, pre and postharvest treatment of fruits with $K_2CO_3$ and $Na_2CO_3$ (1.0 %) against grey mould and sour rot of table grapes was demonstrated by Nigro *et al.*, (2006). In similar study, Alvinda and Natsuaki (2007) proposed postharvest treatment of banana fruits with $Na_2CO_3$, NaClO and $NaHCO_3$ for effective control of crown rot disease of bananas.

Post-harvest treatment of banana with Boric acid at 5.0 and 10.0 per cent concentration and Sodium bicarbonate at 10.0 per cent concentration resulted maximum disease reduction (91.18 %) which was significantly superior to all other salts evaluated *in vivo* at different tested concentrations. The potential of inclusion of inorganic salts in post-harvest disease management merits further investigations and greater regulatory innovations near future.

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