*J. Mycopathol. Res.* **41**(2) : 171-175 (2003)


# Fungal spoilage of banana in eastern sub Himalayan region

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Random survey on spoilage of banana in Assam at different localities was made. It has been found that *Aspergillus terreus, Botryodiploidia theobromae, Fusarium oxysporum, Fusarium moniliforme, Penicilium italicum, Rhizopus stolonifer, Sclerotinia sclerotiorum* and *Trichothecium roseum* occurred on banana var. "Jahaji" with 100 percent frequency at all the places while on var. "Chenichampa", only six species, *viz., A. terreus, B. theobromae, F. oxysproum, P. italicum, R. stolonifer* and *T. roseum* occurred. Among all these species *B. theobromae* was identified as the major fungal pathogen causing post-harvest spoilage of banana. Factors influencing fungal spoilage and its chemical control are also discussed.

**Key words :** *Musa paradisiaca,* post-harvest spoilage, chemical control

## INTRODUCTION

Banana (*Musa paradisiaca*) is one of the major fruits horticulturally important in eastern Sub Himalayan region particularly in Assam. In Assam it occupies an area of 29.5 thousand hectare with an annual production of 376.1 thousand tons. Post-harvest diseases of banana play important role during storage and transit causing severe loss in production. Literature reveals that more than 20 species of fungi are responsible for post harvest spoilage of banana. Although, Assam, in the Eastern Sub-Himalayan region is a major banana producing belt, the post harvest losses have not yet been investigated in detail. Therefore surveys have been taken up with aspects like fungi associated with post-harvest decay, factors influencing fungal spoilage and its chemical control.

## MATERIALS AND METHODS

Fruit market of 12 major towns were visited for survey. Three representative sample shops were taken for a particular place. Estimation of spoilage was done at the same time of all places. Percentage spoilage was calculated from total number of fruits surveyed.

Symptoms of each post-harvest fungal disease were critically observed and recorded from naturally infected fruits.

Isolation was done under aseptic condition from pieces of the rotten materials including the tissues adjacent to the rottened area which were surface sterilised by dipping them in 0.1% $HgCl_2$ solution for 1-2 minutes and with three washings in sterilized distilled water. These pieces were then gently placed on PDA plates, incubated at 27±1°C for growth, and then transferred into PDA slants.

Various morphological characters (vegetative and reproductive structures) were examined under microscope by preparing histopathological slides (spores and mycelium of fungi were mounted in lactophenol and stained with cotton blue). Thus identification of the fungal species was done on the basis of microscopic observations and descriptions given by various authors. Fruits were inoculated artificially with the isolated fungi and symptoms were observed.

Occurrence of each organism causing rots over 12 different localities was calculated by the method described by Adisa (1985).

An experiment was conducted to observe the effect of seven different level of temp. *viz.,* 10, 15, 20, 25,

30, 35 and 40°C on the growth of fungi isolated from rottened fruits.

Experiments were carried out to determine the effect of RH on development of post-harvest fungal rot. Percentage rot was calculated by the method described by Srivastava and Tandon (1968).

Mature green fruits and fullripe fruits of banana with bruises, cracks and other mechanical injures were collected from market separately. All the injured and uninjured fruits were inoculated with 7 days old culture of respective fungal pathogen. Observations were taken after 7 days of inoculation at 27±1°C and percentage rot was calculated (Srivastava and Tandon, 1968).

This was studied taking mature green half ripe, full ripe fruits of banana. Fruits of these three stages of maturity were individually inoculated (Adisa, 1983) and percentage rot was claculated (Srivastava and Tandon, 1968) after 7 days of incubation.

For *in-vivo* studies, healthy ripe fruits were taken for two different treatments—pre inoculation and post inoculation. Fungicides and chemicals found to be highly effective *in-vitro* were taken in the experiment.

In pre-inoculation studies the fruits were inoculated with respective fungal suspension and dipped in fungicidal solutions or suspension for 2 minutes and kept in moist glass chamber. Suitable controls with dip in sterilized distilled water were maintained. The fruits were stored at 27±1°C. The severity of rot was recorded after 10 days of incubation by method described by Khanna and Chandra (1976) using a scale of 0-4 where : O = No progress of rot, 1 = Rots in 1-25% fruits, 2 = Rots in 26-50% fruits, 3 = Rots in 51-76% fruits and 4 = Rots in 76-100% fruits.

## RESULTS

The extent of spoilage of banana has been shown in Table 1. The results indicated that spoilage of banana var. Jahaji was not much higher than var. Chenichampa which was 19.60 and 18.07 per cent respectively.

**Table 1 :** Percentage spoilage of banana fruits in different places

| Places | Var Jahaji | Var. Chenichampa | Mean |
|---|---|---|---|
| Tinsukia | 21.3 (26.77) | 19.8 (25.89) | 20.82 (26.23) |
| Dibrugarh | 20.5 (26.91) | 17.9 (25.02) | 19.69 (25.90) |
| Sibsagar | 20.2 (26.70) | 18.5 (25.47) | 19.35 (26.08) |
| Jorhat | 18.9 (25.78) | 18.4 (25.39) | 18.8 (25.57) |
| Guwahati | 20.7 (27.05) | 17.8 (24.94) | 19.08 (26.00) |
| Goalpara | 18.1 (25.27) | 17.6 (24.79) | 18.00 (24.98) |
| Dhubri | 19.6 (26.27) | 18.3 (25.19) | 18.8 (25.68) |
| Mongaldai | 18.7 (25.61) | 17.7 (24.87) | 18.13 (25.24) |
| Jezpur | 19.8 (26.41) | 18.5 (25.47) | 18.9 (25.94) |
| North Lkhimpur | 20.3 (26.77) | 18.7 (25.61) | 19.53 (26.19) |
| Diphu | 16.8 (24.19) | 15.4 (24.64) | 16.32 (24.41) |
| Silchar | 20.4 (26.20) | 18.17 (25.21) | 18.88(25.71) |

Figures in parcuthesis are angular transformations

| C.D. | 5 Per cent | 1 Per cent |
|---|---|---|
| Places | 0.85 | 1.12 |
| Varieties | 0.35 | 0.46 |
| Places X Varieties | 1.19 | 1.59 |

**Table 2 :** Percentage occurrence of fungal species isolated from rottened fruits of banana

| Fungal species | Jahaji | | Chenichampa | |
|---|---|---|---|---|
| | Average occurrence | Frequency of occurrence | Average occurrence | Frequency of occurrence |
| *Aspergillus terreus* | 8.9 | 100 | 18.90 | 100 |
| *Botryodiploidia theobromae* | 17.6 | 100 | 20.71 | 100 |
| *Colletotrichum musae* | 11.2 | 100 | — | — |
| *Fusarium moniliforme* | 10.6 | 100 | — | — |
| *Fusarium oxysporum* | 9.2 | 100 | 18.27 | 100 |
| *Penicillium citrinum* | 9.5 | 100 | 14.46 | 100 |
| *Rhizopus stolonifer* | 10.0 | 100 | 15.85 | 100 |
| *Sclerotinia sclerotiorum* | 10.3 | 100 | — | — |
| *Trichothecium roseum* | 12.1 | 100 | 12.32 | 100 |

The rottened fruits of banana on repeated isolations yielded a few fungal organisms which were later identified on the basis of morphological characters. Nine species were recorded from two varieties of banana with 100 per cent frequency in all places and these were from var. Jahaji–*Aspergillus terreus, Botryodiploidia theobromae, Fusarium oxysporum, Fusarium moniliforme. Penicillium italicum, Rhizopus stolonifer, Sclerotinia sclerotiorum* and *Trichothecium roseum ;* from var. Chenichampa — *terreus, B. theobromae, F. oxysporum, F. moniliforme, P. italicum, R. stolonifer, S. sclerotiorum* and *T. roseum* with 100 per cent frequency (Table 2). Among all these species *Botryodiploidia theobromae* was identified as the major fungal pathogen causing post harvest spoilage of banana (Table 3). All these banana isolates of fungi grew best within the range of 25°-30°C. In

case of RH the results of experiments indicated that all banana isolates of fungi causing fruit rot could initiate infection at the lowest level of relative humidity (40%). Percentage rot found to be increased with increase in RH. Data have been presented in the Table 4.

Results of relative efficacy of fungicides in the control of post harvest decay *in-vivo* have been presented in Table 5. Benomyl (100 ppm) as post in-

**Table 3 :** Temperature (°C) in relation to development of various fungal rots in banana

| Fungal pathogen | Percentage rot after 7 days of incubation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10° | | 20° | | 30° | | 40° | | 50° | | 60° | |
| | Jahaji | Cheni champa | Jahaji | Cheni champa | Jahaji | Cheni champa | Jahaji | Cheni champa | Jahaji | Cheni champa | Jahaji | Cheni champa |
| *Botryodipodia* | 0 | 0 | 3.5 | 3.1 | 20.2 | 17.4 | 53.8 | 50.3 | 51.6 | 49.6 | 23.2 | 21.4 |
| *Fusarium oxysporum* | 0 | 0 | 2.6 | 2.3 | 20.9 | 18.4 | 58.6 | 55.3 | 51.2 | 49.3 | 18.4 | 16.2 |
| *Fusarium moniliforme* | 0 | - | 2.9 | - | 21.7 | - | 56.5 | - | 49.3 | - | 17.8 | - |
| *Penicillium citrinum* | 1.8 | 1.2 | 2.5 | 2.4 | 9.3 | 7.2 | 16.7 | 14.2 | 18.6 | 16.5 | 7.5 | 6.3 |
| *Colletorichum musae* | 0 | - | 3.2 | - | 19.6 | - | 69.2 | - | 52.5 | - | 18.6 | - |
| *Rhizopus stolonifer* | 0 | 0 | 3.7 | 3.1 | 22.4 | 20.4 | 68.5 | 65.1 | 50.9 | 47.6 | 21.6 | 19.5 |
| *Sclerotinia sclerotiorum* | 0 | - | 3.2 | - | 24.2 | - | 65.9 | - | 48.6 | - | 19.5 | - |
| *Trichothecium roseum* | 0 | 0 | 2.8 | 2.7 | 23.4 | 21.5 | 57.8 | 55.3 | 50.1 | 48.2 | 20.3 | 18.2 |
| *Asperillus terreus* | 1.5 | 1.2 | 2.1 | 1.9 | 8.6 | 7.4 | 15.6 | 12.3 | 17.8 | 15.4 | 6.2 | 8.2 |
| *Means* | 0.33 | 0.40 | 2.94 | 2.58 | 18.92 | 15.71 | 51.40 | 42.08 | 43.40 | 37.76 | 17.01 | 14.96 |

**Table 4 :** Effect or relative humidity on development of fungal rots in banana

| Fungal pathogen | Percentage rot after 7 days of incubation | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10° | | 20° | | 30° | | 40° | | 50° | | 60° | | 100° | |
| | Jahaji | Cheni champa | Jahaji | Cheni champa | Jahaji | Cheni champa | Jahaji | Cheni champa | Jahaji | Cheni champa | Jahaji | Cheni champa | Jahaji | Chen champa |
| *Botryodipodia* | 9.1 | 0 | 18.6 | 17.3 | 28.4 | 26.3 | 40.5 | 38.2 | 47.6 | 44.2 | 50.6 | 47.6 | 54.2 | 52.9 |
| *Fusarium oxysporum* | 7.6 | 6.9 | 17.1 | 16.0 | 30.1 | 28.0 | 43.0 | 13.6 | 50.9 | 47.2 | 53.9 | 50.5 | 56.6 | 55.2 |
| *Fusarium moniliforme* | 7.8 | - | 17.2 | - | 30.9 | - | 43.1 | - | 40.3 | - | 54.7 | - | 57.3 | - |
| **Penicillium citrinum* | 4.6 | 3.9 | 6.2 | 5.2 | 8.2 | 7.1 | 13.6 | 38.2 | 15.6 | 14.2 | 18.2 | 19.2 | 18.3 | 21.2 |
| *Colletorichum musae* | 8.0 | - | 20.3 | - | 26.3 | - | 42.3 | - | 49.6 | - | 53.2 | - | 59.2 | - |
| *Rhizopus stolonifer* | 8.2 | 7.0 | 20.6 | 18.6 | 25.9 | 23.6 | 39.1 | 37.2 | 45.6 | 43.6 | 48.6 | 46.3 | 55.5 | 53.2 |
| *Sclerotinia sclerotiorum* | 5.9 | - | 19.6 | - | 35.5 | - | 40.3 | - | 51.5 | - | 57.8 | - | 60.3 | - |
| *Trichothecium roseum* | 5.1 | 0 | 16.3 | 15.1 | 29.3 | 26.3 | 36.2 | 33.2 | 45.3 | 44.6 | 51.3 | 49.1 | 54.2 | 52.1 |
| **Asperillus terreus* | 5.6 | 4.2 | 6.3 | 5.3 | 9.2 | 7.3 | 12.6 | 10.5 | 16.2 | 14.2 | 19.3 | 17.3 | 19.5 | 20.6 |
| *Means* | 6.87 | 3.66 | 16.91 | 12.91 | 24.86 | 19.76 | 34.52 | 28.48 | 41.4 | 34.68 | 4.28 | 38.33 | 48.34 | 42.53 |

*In terms of crown rot

**Table 5 :** Relative efficacy of fungicides and chemicals in the control of post-harvest decay in banana *in-vivo*

| Treatments (dose in ppm) | Fungal pathogens | Category of rotting (0-4 scale) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AT | | BT | | CM | | FO | | FM | | PC | | RS | | SS | | TR | |
| | | J | C | J | C | J | C | J | C | J | C | J | C | J | C | J | C | J | C |
| Untreated (Control) | 4 | 4 | 4 | 4 | 4 | - | 4 | 4 | 4 | - | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | |
| Benomyl 100 | Pre | 1 | 0 | 0 | 0 | 0 | - | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 0 | - | 0 | 0 |
| | Post | 0 | 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 | 0 | 0 | 0 | 0 | - | 0 | 0 |
| Bavistin 100 | Pre | 1 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | 0 | 4 | 1 | 0 | - | 0 | 0 |
| | Post | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | 0 | 4 | 0 | 0 | - | 0 | 0 |
| Captan 2000 | Pre | 2 | 3 | 2 | 2 | 2 | - | 2 | 2 | 2 | - | 2 | 3 | 2 | 1 | 2 | - | 2 | 3 |
| | Post | 1 | 1 | 1 | 1 | 1 | - | 1 | 1 | 1 | - | 1 | 1 | 0 | 0 | 1 | - | 1 | 1 |
| Dithane M-45 1000 | Pre | 3 | 4 | 3 | 3 | 3 | - | 3 | 3 | 3 | - | 3 | 4 | 3 | 2 | 3 | - | 3 | 3 |
| | Post | 3 | 1 | 3 | 3 | 3 | - | 2 | 2 | 2 | - | 2 | 1 | 2 | 1 | 2 | - | 2 | 2 |
| Mycostatin 500 | Pre | 4 | 4 | 4 | 4 | 4 | - | 4 | 4 | 4 | - | 4 | 4 | 4 | 4 | 4 | - | 4 | 4 |
| | Post | 2 | 2 | 2 | 2 | 2 | - | 2 | 2 | 2 | - | 2 | 2 | 2 | 2 | 2 | - | 2 | 2 |
| Fytolan 1000 | Pre | 3 | 3 | 3 | 3 | 3 | - | 3 | 3 | 3 | - | 3 | 3 | 3 | 3 | 3 | - | 3 | 3 |
| | Post | 1 | 1 | 1 | 1 | 1 | - | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 | - | 1 | 1 |

J = Jahaji C = Chenichanpa

oculation dips could completely control all the fungal decays in banana var. Jahaji. Pre-inoculation dips in benomyl saved more than 75 per cent of jahaji fruits from infection by species. of *Aspergillus, Penicillium, Fusarium* and *Rhizopus.* Captan at 2000 ppm as post inoculation dips gave complete control of *Rhizopus* rot. Bavistin (100 ppm) could completely control all fungal decays except *Rhizopus* rot in chenichampa, as both pre and post inoculation dips.

## DISCUSSION

Post harvest spoilage of this fruit had been reported from time to time from different regions, which was primarily due to infection caused by fungal organisms (Dastur, 1916 ; Dhingra *et al.,* 1970 ; Srivastava and Tandon, 1971 ; Tandon and Misra, 1969 ; Griffe and Burden, 1976 ; Abdel-Satter *et al.,* 1977 ; Wallbridge, 1981).

Morphologically fungal species isolated from rottened fruits of banana were found to be identical to those described earlier by various authors (Subramanium 1971 ; Booth, 1971 ; Srivastava and Tandon, 1971). Thus based on morphological characters nine fungal species were recorded and these are mentioned above. Present observation of symptoms of different types of spoilage of banana had been found to be similar to those described earlier by different workers.

Temperature and relative humidity were found to have significant impact on development of fungal rots in banana. Present investigation reveals that all the fungal rots could develop within a temperature range of 15-35$^0$C with an optimum range of 25-30$^0$C. These observations of effective range of temperature for development of post harvest fungal rots of banana could be supported by the findings of other authors. In case of *Fusarium* rot of banana also Khanna and Chandra (1975) observed that a wide range of temperature was favourable for rotting though the occurrence was maximum at 25-30$^0$C. Fungal rots in both the varieties of banana were found to develop at the lowest level of RH (40%) which increase progressively reaching the maximum at 100 per cent RH. Fungi causing crown rots in var. Chenichampa initiated infection at RH of 50 per cent and above. However Badger (1965) reported that conidia of *Colletorichum musae* could survive humidity fluctuations between 32 and 83 per cent. *Botryodiploida theobromae* continued to grow and sporulate at 98-100 per cent RH.

Plants wounded before inoculation become more susceptible to pathogens since injury provides avenues of entry for such pathogens. Several workers have pointed out the role of wounds for post harvest fungal rots of banana (Pathak, 1980 ; Srivastava and Tandon, 1971, Knight *et al.,* 1977). Present investigation also indicated that injury facilitated easy entry of fungal pathogens leading to strong colonisation and ultimate rottening of banana fruits.

The significance of fruit maturity on post harvest spoilage had been investigated earlier (Edney, 1983). In our investigation also it was observed that the full ripe fruits were more severely infected than the half-ripe fruits. In case of chemical control our investigations reveal that Benomy1, Bavistin and Captan at 100. 100 and 2000 ppm respectively were found to be highly toxic to all the fungi. Benomyl 100 ppm could completely control all the fungal decays with no progress of rot (except *Rhizopus* rot of banana) and this was supported hy Khanna and Chandra (1976). They also found Benomyl 100 ppm to be effective against *Fusarium* rot of banana when used as pre and post inoculation dips.

## ACKNOWLEDGEMENT

Authors are thankful to Director, RRL. Jorhat for providing facilities to carry out our investigations.

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*(Accepted for publication July 25 2003)*