Original Research Article

Antibacterial Activity of Antagonists, Botanical and Chemical against *Pantoea stewartii* sub sp. *Indolegenes* Causing Bacterial Leaf Blight of Rice

J. Vinodhini* and R. Kannan

Department of Plant Pathology, Agriculture College and Research Institute, Killikulam, Tamil Nadu Agricultural University, Tamil Nadu, India

*Corresponding author

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

Rice is one of the important cereal crop and known to be affected by many diseases. Bacterial leaf blight of rice is a destructive disease of rice, known to be caused by *Xanthomonas oryzae* pv. *oryzae* and it also be reported to cause by species of *Pantoea*. BLB diseased samples were collected from southern districts of Tamil Nadu and upon isolation, the pathogen was thought to be *Xanthomonas oryzae* pv. *oryzae*. But, the results of biochemical and molecular characterization revealed that the causal agent was not *Xanthomonas*, but a new species of bacterium *Pantoea stewartii* subsp. *Indolegenes* (Accession No. SUB2733370: MF163273; MF163274; MF16327). The present study was conducted to investigate the antibacterial activity of different botanicals, antagonists, chemicals and antibiotics on the growth of *Pantoea*. *In vitro* studies revealed, the extract of *Prosopis* (10.33mm) was proved to having anti-bacterial activity at 10 per cent and *Bacillus subtilis* (8.66mm) was the potent antagonist. The evaluation of different fungicides and antibiotics revealed that copper oxy chloride (5.56mm)and streptomycin (7.13mm) having maximum inhibitory effect on *Pantoea*.

**Keywords**

Bacterial leaf blight, *Xanthomonas oryzae* pv. *oryzae*, *Pantoea stewartii* subsp. *Indolegenes*, Biochemical and molecular characterization

**Article Info**

Accepted: 15 July 2019
Available Online: 10 August 2019

**Introduction**

Rice is one of the major cereal crops in India and also primary staple food for huge population in Asia, Africa and Latin America. Global rice utilization is projected over around 501.2 million tonnes (milled basis) in 2016-17. In India, rice is being grown in 44.10 Mha area with production of 106.5 million tonnes and productivity of 3.52 MT/ha respectively (USDA, 2016). In Tamil Nadu, rice is grown in an area of 20.16 lakh hectares with the production of 62.53 lakh million tonnes with the average productivity of 3,102 kg/ha (INDIADSTAT, 2015). Around 40% of world’s rice crop lost annually due to various biotic stresses like pathogens, insects and weeds (Hossain, 1996). The damage results of rice diseases are enough to feed 60 million peoples in the world (Asghar *et al.*, 2007). The highly valuable crop is affected by diverse fungal and bacterial attacks (Khan, 2009). Bacterial leaf blight of rice caused by *Xanthomonas oryzae* pv. *oryzae* is the most important and oldest known bacterial disease of rice in Asia. It considered as a serious bacterial diseases in many of the rice growing regions of the world (Xu *et al.*, 2010). The disease known to be
caused by *Xanthomonas oryzae* pv. *oryzae* and also reported to be caused by *Pantoea* (Lee et al., 2010; Mondal et al., 2011). *Pantoea* spp are opportunistic pathogens documented to cause different diseases in economically important crop plants including grain discoloration in China (Yan et al., 2010) and leaf blight of rice reported in Korea (Lee et al., 2010), India (Mondal et al., 2011), Venezuela (Gonzalez et al., 2015), Benin and Togo (Kini et al., 2017). *Pantoea ananatis* is the causal agent of the newly emerged rice leaf blight disease reported in northern India (Mondal et al., 2011). The screening of phyto extracts, bio control agents, fungicides and antibiotics under *in vitro* provides preliminary information in short time about their efficacy against the pathogens. It is economical and time saving in planning of control measures for plant diseases in the field condition.

**Materials and Methods**

**Isolation of pathogen**

The diseased leaves of rice showing typical bacterial blight (BLB) symptoms were collected in brown paper bags from Tirunelveli, Tuticorin, Madurai, Virudhunagar and Kanyakumari districts of Tamil Nadu, India. Small portion of BLB infected leaf bits sterilized with 1 per cent sodium hypochlorite solution, placed on petridish containing nutrient agar medium and incubated at 27 ± 2°C for 48 hours. The bacterial colonies were transferred to the nutrient agar slant and pathogenicity test has been performed subsequently.

**Characterization of pathogen**

To identify the bacterium isolated from blighted rice leaves, different biochemical test and molecular analysis have been performed. The standard bacteriological and biochemical methods were employed *viz.*, Gram staining (Jonit et al., 2016), KOH test (Jonit et al., 2016), Catalase test (Jonit et al., 2016), Citrate utilization test, Production of yellow pigment on YDC medium (HaliaturRahma et al., 2014), Anaerobic growth test (Jonit et al., 2016), Starch hydrolysis test and tween 80 hydrolysis test (Lelliot and Stead, 1987). In molecular characterization, the isolates which showed higher level of virulence have been selected for characterization based on the earlier symptom expression and percent leaf area blighted.

The genomic DNA has been extracted from the isolated bacterial culture and used for PCR analysis. The purified PCR products of approximately 1,400 bp were sequenced by using the primers (785F 5’ GGA TTA GAT ACC CTG GTA 3’ and 907R 5’ CCG TCA ATT CCT TTR AGT TT3’). Sequencing was performed by using Big Dye terminator cycle sequencing kit (Applied BioSystems, USA). Sequencing products were resolved on an Applied Biosystems model 3730XL automated DNA sequencing system (Applied BioSystems, USA).

**Inhibitory effect of botanicals against Pantoea**

The phyto extracts of commonly available plant species like Pungam (*Pongamia pinnata*), Onion (*Allium cepa*), Garlic(*Allium sativum*), Neem (*Azadirachta indica*), Mehandi (*Lawsonia inermis*), Adathoda (*Adathodav asica*), Tulsi (*Ocimum sanctum*), Chilli (*Capsicum annum*), Prosopis (*Prosopis juliflora*), Calatrophis (*Calatrophis gigantea*), Nochi (*Vitex negundo*), Nithyakalyani (*Vincarosea*), Lantana (*Lantana camera*) and Ginger (*Zingiber officinale*) were screened *in vitro*.

Ten per cent of aqueous extract prepared (1:1) and the medium was added with 0.1ml of bacterial suspension (10^9 cell/ml). The
sterilized 5 mm diameter filter paper discs were dipped in phyto extract and placed on petridish which is analysed by measuring the zone of inhibition radius after 48 hrs of incubation to know their anti-bacterial effect on the growth of the Pantoea.

Antagonistic effect of different microorganisms to Pantoea

Antagonistic effect of Trichoderma viride, Penicillium digitatum, Aspergillus niger, Trichoderma harzianum, Bacillus amyloliqufaciens, Pseudomonas fluorescens and Bacillus subtilis have been tested against Pantoea under paper disc method.

The medium was added with 0.1ml of bacterial suspension (10^9 cell/ml) and filter paper discs were dipped in previously prepared suspension (10^8 cells or spore/ml) of different microorganisms then placed on petridish. The zone of inhibition radius was measured after 48 hrs of incubation.

Inhibitory effect of fungicides and antibiotics against Pantoea

Six fungicides belonging to different chemical groups like, Mancozeb, Copper oxy chloride, Carbendazim, Hexaconozole, Propiconozole and copper hydroxide have been tested at three different concentrations (0.1%, 0.2% & 0.3%) to know their inhibitory effect against Pantoea under paper disc method by measuring the zone of inhibition radius after 48 hrs of incubation.

Antibacterial activity of five antibiotics viz., Streptomycin sulphate, Rifamycin, Kanamycin, Ampicillin and Chloromphenical at 250 ppm, 500 ppm and 750 ppm were tested by dipping the paper disc in different antibiotics at three concentrations and inhibition radius measured after 48 hrs of incubation to assess the antibacterial activity of antibiotics on the growth of the Pantoea.

Results and Discussion

Isolation and characterization of pathogen

The diseased leaves of rice showing typical bacterial blight (BB) symptoms were visually observed, collected and the disease symptom was characterized by yellowing and orange to brown stripes on the leaf blade. The symptoms enlarged to the entire leaf and showed brown stripes below the leaf tip used for isolation of pathogen. Upon plating on nutrient agar medium, yellow pigmented straw to yellow colored, raised and translucent with smooth margin colonies were obtained after incubation at 28°C for 2 days. The bacteria are gram-negative, facultative anaerobes with small rods either arranged singly or in chains. The isolated bacteria proved to be pathogenic to rice beyond doubt satisfying Koch’s postulate.

All the isolates showed positive results in gram staining, KOH test, Catalase test, Citrate utilization test, Production of yellow pigment on YDC medium, Anaerobic growth test, Starch hydrolysis test, Tween 80 hydrolysis medium except some isolates. Some of the biochemical tests gave overlapping results regarding the identification of the causal organism of bacterial blight.

Based on 16S rRNA sequence analysis the causal agent was identified as Pantoea stewartii sub sp. indolegenes.

The sequencing data obtained has been deposited in NCBI gene bank with accession no. SUB2733370: MF163273 (ASD 16), MF163274 (TN 1), MF163275 (CO 43). The alignment showed maximum (99%) homology with the related sequence in the data bank. The biochemical and molecular analysis revealed that the causal agent was not Xanthomonas oryzae pv oryzae, but it was Pantoea stewartii sub sp. indolegenes.
In vitro evaluation of inhibitory effect of botanicals and antagonistic effect of microorganisms against Pantoea

The results revealed that among fourteen phyto extracts, the extract of Prosopis (10.33mm) followed by Chilli (10.00mm) and Nochi (9.33mm) recorded maximum inhibition radius, significantly better in checking the growth of Pantoea under paper disc method. The phyto extract of Adathoda (0.00), Onion (0.00) and Pongam (0.00) failed to inhibit the growth of Pantoea as the inhibition radius of these treatments were all most zero, same as control. The observations of inhibition radius were recorded in mm, which is statistically analysed and presented in Table 1.

The inhibition radius was recorded significantly more in case of Bacillus subtilis (8.66mm) followed by Bacillus amyloliquefaciens (7.64mm) than the rest of antagonists and control treatment, during all the three period of observation. The antagonist Trichoderma failed to inhibit the growth of Pantoeaas in case of control. The inhibitory effect of Bacillus subtilis was reduced significantly from first observation to second observation and second observation to third observation i.e. 96 hours.

The observations of inhibition radius were recorded in mm, which is statistically analysed and presented in Table 2.

In vitro screening of antibacterial properties of fungicides and antibiotics against Pantoea

It is evident from the result, Copper oxychloride (5.56mm) followed by Copper hydroxide (4.87mm) and Mancozeb (3.64mm) recorded the highest inhibition radius significantly at all the three concentrations under paper disc method.

Table 1 Inhibition radius exhibited by botanicals against Pantoea

| Trt. No | Botanicals     | Mean of inhibition radius in mm |
|---------|---------------|---------------------------------|
| 1       | Prosopis      | 3.29ᵃ⁺ (10.33)**                |
| 2       | Chilli        | 3.24ᵃ (10.00)                   |
| 3       | Nochi         | 3.13ᵃᵇ (9.33)                  |
| 4       | Tulsi         | 3.08ᵃᵇᶜ (9.00)                 |
| 5       | Ginger        | 2.91ᵇᶜᵈ (8.00)                 |
| 6       | Garlic        | 2.85ᵇᶜᵈ (7.67)                 |
| 7       | Neem          | 2.82ᵇᶜᵈ (7.50)                 |
| 8       | Mehandi       | 2.79ᵇᶜᵈ (7.33)                 |
| 9       | Lantana       | 2.76ᵇᶜᵈ (7.17)                 |
| 10      | Vinca         | 2.75ᵇᵈ (7.10)                  |
| 11      | Calatrophis   | 2.73ᵇᵈ (7.00)                  |
| 12      | Aadathoda     | 0.71ᵉ (0.00)                    |
| 13      | Onion         | 0.71ᵉ (0.00)                    |
| 14      | Pongum        | 0.71ᵉ (0.00)                    |
| 15      | Control       | 0.71ᵉ (0.00)                    |

The treatment means are compared using Duncan Multiple Range Test (DMRT). In a column, means followed by a common letter (s) are not significantly different (P = 0.05).
* Indicate square root +0.5 transformed values
**Figures in the parenthesis are original values.
Table.2 Inhibition radius due to various microorganisms

| T. No | Antagonists                  | Inhibition radius in mm |
|-------|------------------------------|-------------------------|
|       |                              | 24 hrs | 48 hrs | 96 hrs | Mean  |
| 1     | Bacillus subtilis            | 3.16(9.50) | 2.99 (8.46) | 2.92(8.03) | 3.02** (8.66) |
| 2     | Bacillus amyloliquefaciens   | 2.99 (8.43) | 2.82 (7.47) | 2.74 (7.02) | 2.80b (7.64) |
| 3     | Pseudomonas fluourescens     | 2.41 (5.32) | 2.20 (4.33) | 2.09 (3.87) | 2.23c (4.50) |
| 4     | Trichoderma viridae          | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71d (0.00) |
| 5     | Trichoderma harzianum,       | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71d (0.00) |
| 6     | Control                      | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71d (0.00) |

The treatment means are compared using Duncan Multiple Range Test (DMRT). In a column, means followed by a common letter (s) are not significantly different (P = 0.05). * Indicate square root transformed values. Figures in the parenthesis are original values.

Table.3 Inhibition radius due to various fungicides at different concentrations

| Trt. No | Name of chemicals   | Inhibition radius at 0.1% (mm) | Inhibition radius at 0.2% (mm) | Inhibition radius at 0.3% (mm) | Mean of inhibition radius (mm) |
|---------|---------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| 1       | Copper oxy chloride | 2.21(4.39)                     | 2.38 (5.18)                     | 2.76 (7.12)                    | 2.45** (5.56)                  |
| 2       | Copper hydroxide   | 1.96 (3.36)                     | 2.27 (4.68)                     | 2.65 (6.57)                    | 2.20b (4.87)                   |
| 3       | Mancozeb           | 1.71 (2.45)                     | 1.88 (3.04)                     | 2.43 (5.42)                    | 2.01c (3.64)                   |
| 4       | Propiconazole      | 1.39 (1.45)                     | 1.73 (2.50)                     | 2.28 (4.70)                    | 1.80d (2.82)                   |
| 5       | Hexaconazole       | 1.01 (0.53)                     | 1.46 (1.91)                     | 1.84 (2.91)                    | 1.44e (1.78)                   |
| 6       | Carbendazim        | 0.71 (0.00)                     | 0.71 (0.00)                     | 0.71 (0.00)                    | 0.71f (0.00)                   |
| 7       | Control            | 0.71 (0.00)                     | 0.71 (0.00)                     | 0.71 (0.00)                    | 0.71f (0.00)                   |

The treatment means are compared using Duncan Multiple Range Test (DMRT). * Indicate square root transformed values. ** Figures in the parenthesis are original values.

Table.4 Inhibition radius due to various antibiotics at different concentrations

| Trt. No | Name of antibiotics | Inhibition radius at 250 ppm (mm) | Inhibition radius at 500ppm (mm) | Inhibition radius at 750 ppm (mm) | Mean of inhibition radius in mm |
|---------|---------------------|----------------------------------|----------------------------------|----------------------------------|--------------------------------|
| 1       | Streptomycin sulphate | 2.39 (5.22)                     | 2.66 (6.61)                     | 3.17 (9.56)                    | 2.74** (7.13)                  |
| 2       | Rifamycin           | 2.26 (4.64)                     | 2.50 (5.77)                     | 2.81 (7.45)                    | 2.52b (5.95)                   |
| 3       | Kanamycin           | 0.97 (0.45)                     | 1.43 (1.55)                     | 1.70 (2.39)                    | 1.37c (1.46)                   |
| 4       | Carbenicillin       | 0.71 (0.00)                     | 0.71 (0.00)                     | 0.71 (0.00)                    | 0.71d (0.00)                   |
| 5       | Ampicillin          | 0.71 (0.00)                     | 0.71(0.00)                      | 0.71(0.00)                     | 0.71d (0.00)                   |
| 6       | Control             | 0.71 (0.00)                     | 0.71 (0.00)                     | 0.71 (0.00)                    | 0.71d (0.00)                   |

The treatment means are compared using Duncan Multiple Range Test (DMRT). * Indicate square root transformed values. ** Figures in the parenthesis are original values.
It is clearly evident, in case of most effective and better treatments, higher concentration is positively correlated with maximum inhibition radius. But, Carbendazim (0.00) does not show any effect on the control of Pantoea. The observations of inhibition radius were recorded in mm, which is statistically analysed and presented in Table 3.

In accordance with the results of antibacterial effect of antibiotics, the maximum inhibition radius were recorded in Streptomycin sulphate (7.13mm) followed by Rifamycin (5.95mm) under paper disc method. Carbencillin (0.00) and Ampicillin (0.00) does not show any effect on the control of Pantoea. The observations of inhibition radius were recorded in mm, which is statistically analysed and presented in Table 4.

The BLB symptom was observed as yellowing of leaves and orange to brown stripes on the leaf blade. Later, symptom enlarged to the entire leaf showed brown to orange water soaked lesions at margin and below the leaf tip. Similarly, Mondal et al., (2011) revealed that the symptom exhibited as water soaked lesions at the tip of rice leaves and turned light brown, exhibiting a blighted appearance. Morphological and biochemical characterization revealed the pathogen is gram-negative, facultative anaerobes with small rods either arranged singly or in chains and yellow pigmented. The results were in accordance with Mondal et al., (2011) and Gonzalez et al., (2015). Anaerobic growth test is a key test for the identification of the bacterial genera Erwinia and Pantoea. Most of the isolates exhibit positive result on anaerobic growth test indicated clearly that the organism belongs to Enterobacteraeae (i.e. facultative anaerobes) not belong to Xanthomonadaceae family (i.e. True aerobes). The production of yellow pigmentation on YDC medium indicates the isolate belongs to Pantoea species. Similar results were observed by Pérez-y-Terrón et al., (2009) and Haliatur Rahma et al., (2014).

Our finding of new bacterial leaf blight of rice caused by Pantoea stewartii sub sp. Indolegenes coincidental with Mondal et al., (2011) who gave a first report on ‘New leaf blight of rice caused by Pantoea ananatis’ in India.

The hazardous effect of chemicals used in plant disease management has been diverted plant pathologists to find out the alternative method with little or no adverse effect on environment. From our experiment, it is clear that leaf extract of Prosopis (Prosopis juliflora L.), Chilli (Capsicum annum L.) and Nochi (Vitex negundo) may have antibacterial activity, which directly affects the growth of Pantoea causing BLB of rice. They may kill or inhibit the Pantoea bacteria presentin radius of poison zone near the paper disc.

Rajeswari (1991) reported that the antibacterial activity of Prosopis against bacterial pathogen might be explained to have high level of glycoprotein and tannin. Therefore, in our experiment the extract of Prosopis was found most effective in inhibiting the growth of Pantoea. In this study, significantly more inhibition radius was recorded in case of Bacillus subtilis as compared with other treatments.

Our findings were in agreement with Ahmed and Thind (1992) and Manmeet and Thind (2002) who reported the effectiveness of Bacillus subtilis and P. fluorescens against BLB causing bacteria in vitro. Velusamy et al., (2006) who reported that P. fluorescens strain produced the antimicrobial antibiotic namely 2, 4-diacetylphloroglucinol (24-DAPG) which plays major role in mechanism of bio control. They also reported that the
compound inhibited the growth of the devastating rice BLB pathogen.

The results indicated that copper oxychloride and copper hydroxide at three different concentrations was found to having the inhibitory effect to Pantoea. But, carbendazim (0.00) does not show any effect on the control of Pantoea. Chauhan and Vaishnav (1980), Horti (1973) and Tagami and Mizukami (1962) reported the spraying of copper oxy chloride completely inhibits the growth of bacterium. Antibacterial activity exhibited by streptomycin sulphate (34.82%), rifamycin (28.28%) and kanamycin (21.27%) even at higher concentration and those were found highly effective in checking the growth of Pantoea. Carbenicillin and ampicillin does not show any effect on the control of Pantoea. Rahul singh et al., (2015) reported that streptomycin and streptomycin + copper oxychloride reduced the bacterial disease intensity. Erasmus et al., (2014) reported that streptomycin was found effective in inhibiting the growth of pathogen at higher concentrations significantly. Pereyra et al., (2009), Nayak et al., (2008) and Nithya et al., (2007) also proved that higher concentrations of the antibiotics responded significantly for the control of BLB of rice.

**References**

Ahmed, M. and B.S. Thind. (1992). Biological control of BB of rice. *Indian Journal of Mycology and Plant Pathology*, 22 (1): 81.

Asghar, A., Rashid, H., Ashraf, M., Khan, M.H., Chaudhary, Z., (2007). Improvement of Basmati Rice against fungal infection through gene transfer technology. *Pakistan Journal of Botany*, 39(4): 1277-1287.

Chauhan, H.L. and Vaishnav, M.U., (1980). Control of bacterial blight of rice caused by *Xanthomonas oryzae*. *Indian Journal of Mycology and Plant Pathology*, 10 (1): 77-79.

Erasmus, P., Cook, A., and Coyne, V.E., (2014). The role of bacteria in the digestion of seaweed by the abalone *H. midae*. *Aquaculture*, 155:377-386.

Gonzalez, A.D., Franco, M.A., Galindo-Castro, I. and Graterol, E., (2015). First report on *Pantoea agglomerans* causing Rice leaf blight in Venezuela. *Plant Disease*, 99 (4): 552.

HaliaturRahma, MeitySinaga, S., MemenSurahman and Fiyanto. (2014). First report of Stewart’s wilt of maize by *Pantoea stewartii* sub sp. *Stewartii* in Bogor district, Indonesia. J. ISSAAS., 20(2): 131-141.

Hori, M., (1973). Nippon Shin – noyaku Mongatri. *Japan plant protection Association*, Tokyo, Japan. Pp-622.

Hossain, M., (1996). Recent developments in the Asian rice economy: challenge for the rice research. In Rice research in Asia: progress and priorities. *CAB International.*, Wellington, UK. pp. 17.

INDIASTAT. (2015). Online databases. In: http://www.indiastat.com.

Jonit et al., (2016). *Xanthomonas oryzae* pv. *oryzae*, Biochemical tests, Rice (*Oryza sativa*), Bacterial leaf blight (BLB) disease, sekinchan. *Journal of applied & Environmental Microbiology*, 4(3): 63-69.

Khan, A.S., Imran and Ashfaq, M., (2009). Estimation of genetic variability and correlation for grain yield components in rice (*Oryza sativa* L.). *Journal of Agriculture and Environmental Sciences*, pp: 6585 – 590.

Kini, R., Agnimonhan, O., Afolabi, B., Milan, B., Soglonou, V., Gbogbo, R. Koebnik and Silue, D., (2017). First report of a new bacterial leaf blight of Rice caused by *Pantoea ananatis* and *Pantoea stewartii* in Benin. *Plant Disease*. 101: 242.

Lee, H.B., Hong, J.P., and Kim, S.B., (2010). First report on leaf blight caused by *Pantoeaagglomerans* on Rice in Korea. *Plant Disease*. 94: 1372.

Lelliot, R.A., and Stead, D.E., (1987). Diagnostic procedures for bacterial plant
diseases. Methods for the diagnosis of bacterial diseases of plants. Pp: 37-131.

Manmeet, M., and Thind, B.S., (2002). Management of bacterial blight of rice with bioagents Plant Disease. 17(1): 21-28.

Mondal, K.K., Mani, C., and Singh, J., (2011). A New leaf blight of Rice caused by Pantoea ananatis in India. Plant Disease. 95:1582.

Nayak, D., Shanti, M.L., Bose, L.K., Singh, U.D., and Nayak, P., (2008). Pathogenicity association in X. o. pvoryzae, the causal organism of rice bacterial blight disease. ARPN Journal of Agricultural and Biological Science. 3 (1): 12-27.

Nithiya, S., Meenakshi, P.R., Manian, J.R., 2007. Degradation of the fungicide, azoxystrobin and difenconazole in soil and their influence on soil microbial activity. Pest Technology.1:133-138.

Pereyra, M.A., Ballesteros, F.M., Creus, C.M., Sueldo, R.J., Barassi, C.A., (2009). Ecology and application of Azospirillum and other plant growth promoting bacteria (PGPB). European Journal of Biology. 45: 20-27.

Pérez-y-Terrón, R., Villegas, M.C., Cuellar, A., Munoz-Rojas, J., Castañeda-Lucio, M., Hernández-Lucas, I., Bustillos-Cristales, R., Bautista-Sosa, L., Munive, J.A., Caicedo-Rivas, R., and Fuentes-Ramírez, L.E., (2009). Detection of Pantoea ananatis causal agent of leaf spot disease of maize, in Mexico. Australasian Plant Disease Notes, 4(1): 96-99.

Rahul Singh., Ramesh Singh, Yadav and ShairyJaveria. (2015). Management of bacterial leaf blight of Basmati rice caused by Xanthomonas oryzae pv. oryzae with some available antibiotics and plant products. International Journal of Innovative and Applied Research, 13(11): 1-6.

Rajeswari, E., (1991). Effect of plant derivatives on rice blast pathogen (Pyricularia oryzae). M.Sc. (Agri.) Thesis, TNAU, Coimbatore, India. Pp. 129.

Tagami, Y., and Mizukami, T., (1962). Historical review of the researches on bacterial leaf blight of rice caused by Xanthomonas oryzae (Uyeda and Ishiyama) Dowson. Special report of the plant diseases and insect pests forecasting service No. 10: 112.

USDA. 2016. Rice Outlook, Economic Research Service /RCS-16J/October 14, 2016. Pp.1-25. http://www.ers.usda.gov/media/2150132/rice-outlook-october-2016.pdf.

Velusamy, P., Immanuel, J.E., Gnanamanickam, S.S., and Thomashow, L., (2006). Biological control of rice bacterial blight by plant associated bacteria producing 2,4-diacetylphlorogluclinol. Canadian Journal of Microbiology, 52 (1): 56-65.

Xu, Y., Zhu, X.F., Zhou, M.G., Kuang, J., Zhang, Y., Shang, Y., and Wang, J.X., (2010). J. Phytopathol., 158: 601-608.

Yan, H., Yu, S.H., Xie, G.L., Fang, W., Su, T., and Li, B., (2010). Grain discoloration of rice caused by Pantoea ananatis (synonym Erwinia uredovora) in China. Plant Disease, 94(4): 482-482.