

## Pokkah Boeng: An Emerging Disease of Sugarcane

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### Abstract

Sugarcane is one of the most important crops for the sugar production in India and Uttar Pradesh (UP) is the top on sugarcane while second in sugar production. Many biotic and abiotic stresses affected the sugarcane production among the reported diseases of sugarcane; Pokkah boeng is now playing a very important role due to its economic threats in UP. Recent survey during 2007-13 showed increasing trend of disease incidence and most of the commercial cultivars affected by the disease ranged from 1%-90%. Although Pokkah boeng comes under minor concern but these days it is going to be major on basis of their rapid epidemiology during last few years. Nowadays, the incidence and severity of Pokkah boeng disease has been reported from major sugarcane growing states like Uttar Pradesh, Maharashtra, Punjab, Haryana, Assam, Tamil Nadu and Bihar in India and other sugarcane growing countries. Keeping in view the seriousness of the problem, the present review summarise the distribution, establish a suitable genetic base and disease management practices through various approaches.

**Keywords:** *Fusarium moniliforme*; Malformed; Epidemiology; Symptomology; Management

### Introduction

Sugarcane is a cash crop and cultivated in most of the states of India with total area coverage 4.2 M ha [1]. India is the largest consumer of sugar in the world with annual consumption of about 19 million MT (Metric Tons) and the second largest producer of sugar next to Brazil, with production in the sugar year 2009-10 crossing 28 million Mt in India. Uttar Pradesh occupies as premier position of sugarcane cultivation accounting for 42.2 million hectare and 30% of the area and production respectively. Average cane yield of UP (58.2 MT/ha) is very lower than the national average (66.9 MT/ha). Similar to yield, sugar recovery in UP is also lower (9.51%) than national average (10.27%), respectively due to the several diseases.

Pokkah boeng of sugarcane caused by *Fusarium moniliformae* and the pathogen was first described by Sheldon [2] and the perfect stage of pathogen is *Gibberella fujikuroi* (Sawada). *Fusarium* is now confirmed by several workers as a causal agent of Pokkah Boeng in sugarcane in Asia as well established pathogen by many workers [3-5]. Pokkah Boeng is the most serious and devastating disease not only in central Uttar Pradesh but also in the whole of the Southern and Northern sugarcane growing zone of India. Pokkah Boeng is a Javanese term denoting a malformation or distorted top was originally in Jalva but in that time no causal agent was established and its incidence was recorded by Padwick [6]. Pokkah Boeng disease recorded in all over the countries where sugarcane grown and pathogen spreads in wind-blown rain, infected cane cuttings, pupae and adults of sugarcane stem borers [7-9]. This disease was well-known in sugarcane for long time but severity of disease reported in two commercial varieties Co7219 and Co C671 in Maharashtra 1983-1984 [10]. *Fusarium moniliforme* var. *subglutinans* reduce the quality of the harvested crop mainly among varieties with high sugar yields the sugar production depending upon the variety up to 40.8-64.5% [11].

### Symptomology

The characteristics symptoms of Pokkah Boeng disease are the appearance of chlorotic patches towards the base of the young leaves, in acute cases disease shows distortion of stalk with external and

internal cut like lesions and rotting of apical part of stalk. Under field conditions, the disease may develop many variations from the general symptoms, but the final result is usually a malformed or damaged top and stalk. The base of affected leaves is often narrower as compared to normal leaves. Knife cut symptoms of the disease were reported in varieties CoS767, CoC671, CoC8014, Co1158, CoS8315 and CoS 8436 [12]. Development of disease symptom in four phases was observed namely chlorotic phases I and II, top rot and knife cut phase (Figure 1). The apical leaves may also show pronounced wrinkling and twisting depending upon the susceptibility of varieties and existing climatic conditions also malformed or damaged top and stalk due to this disease [13]. The symptoms of Pokkah boeng disease were mainly two types i.e., chlorotic phase and acute phase of top rot [10] and knife cut (fourth phase) of this disease in Maharashtra [12]. Similar findings of about the disease symptom were also reported by workers [14-16].

### Epidemiology

#### Status of Pokkah Boeng disease

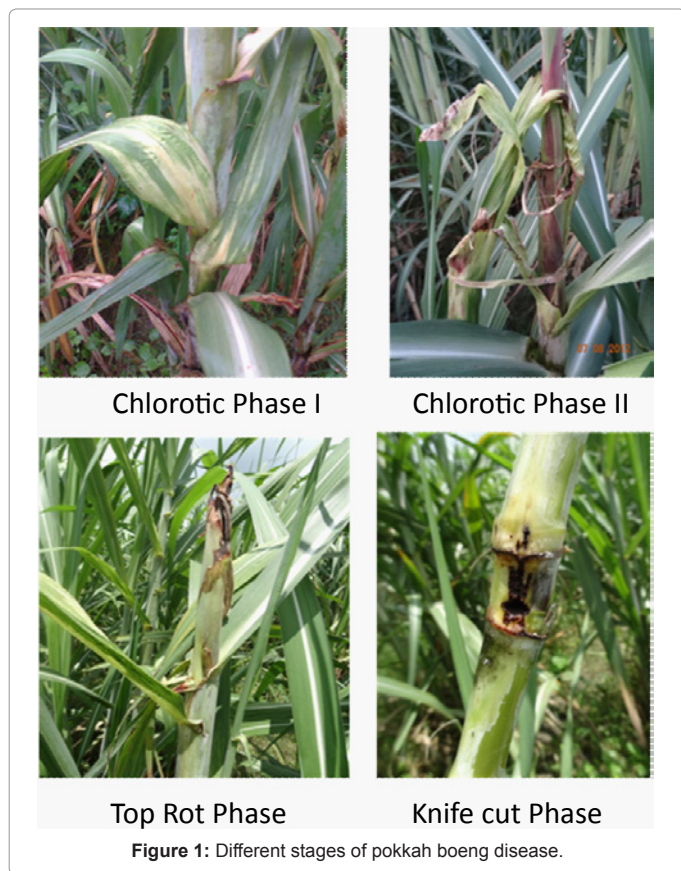
During the survey of different sugarcane areas of last few years (2007-13), it has been observed that the incidence severity of Pokkah Boeng disease increases and affects almost all the sugarcane cultivars which is recommended for general cultivation for different agro climatic regions. During this year (2012-13), 90% and 5%-30% infection was observed in genotype S. 224/10 and promising variety CoSe 01434 at Sugarcane Research Institute, Shahjahanpur. However, 15% infection was noticed in variety CoS 07240 at Sugarcane Research Station, Gola

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(Lakhimpur Kheri). Beside this, it has also been reported from other districts like Bareilly (Baheri), Sitapur and Pilibhit in many sugarcane cultivars viz: CoS 8436, Co 0238, CoS 97264, CoS 8432, CoS 91269, CoS 84212, CoSe 92423, CoS 98259, CoS 07250 and CoS 07240 in stray

to moderate level. Knife-cut stage of Pokkah Boeng was also observed in CoS 07240, Colk 9709, CoS 09231, S. 4386/07 and S.3438 from Gola, Baheri and Shahjahanpur respectively. In Western Uttar Pradesh (Saharanpur, Muzzafarnagar, Bijour, Khatauli, Mawana, Shimbhawali, Titawi, Seohara districts), the disease were observed in varieties CoS 8436, CoS88230, CoS94257, CoS767, CoS94270, CoSe95422, CoSe98231 and CoJ64 with stray to moderate level and in Eastern Uttar Pradesh (Gonda, Baharaich and Kushinagar districts), the disease were noticed in varieties CoS91269, Co0238 and CoSe01434 in trace to moderate level. Knife-cut stage was observed in varieties CoS91269 from Maizapur sugar factory zone of Bahraich district in traces (Table 1).

According to the disease scenario of different states of India viz. Assam, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Bihar, Haryana, Maharashtra, it was observed that the incidence of Pokkah Boeng disease were found in trace to moderate level on most of commercial varieties but the incidence severity is high in Uttar Pradesh and Maharashtra rather than other states and these two are major sugarcane growing states of India. Symptoms of the diseases have been observed in many varieties of Andhra Pradesh (Co7805, CoA 99082, CoV94102, 98V95 & 2000V59) and Haryana (CoH151, CoJ85 & CoS8436). Top rot symptom of the disease was noticed in Haryana (CoS8436, CoH152, CoH133, Co89003 and CoH136) and Punjab (CoJ 854). In Maharashtra, amongst the foliar diseases, Pokkah Boeng disease is becoming a major threat to sugarcane and incidence were observed in many varieties (CoV19805, Co 05002, CoM 08090, Co 8014, Co 94012, VS 1434, CoC 671, Co 7527, Co 86032). In Bihar, trace to moderate levels of Pokkah Boeng disease was observed in many varieties.

Disease were reported from different other country after the first report of disease from java in 1896 by walker and went and studied by several workers [13]. From Malaysia, the disease was recorded in 1973 and it concluded that the disease incidence occur when crops are grown in a climate where hot and dry season persists followed by a wet season that was helpful for the spread of Pokkah Boeng [17]. Disease started when plants aged 3-7 months older, then plant growing very rapidly than the older crop [18]. Giatgong [19] from Thailand reported *F. moniliforme* Sheldon and *G. fujikuroi* (Saw) Wr. were the causal agents of Pokkah Boeng. Several *Fusarium* species were isolated from the Pokkah Boeng affected tissue of sugarcane in Indonesia i.e., *F. anguoides* Sherb. *F. bulbigenum* Cke. and Mass. var. *tracheiphilum* (E. Sm.) Wr., *F. moniliforme* Sheld., *F. moniliforme* Sheld. var. *subglutinans* Wr. and Rkg. [*Gibberella fujikuroi* (Saw.) Ito ap. Ito and Kamura], *F. moniliforme* Sheld. var. *anthophilum* (A. Br.) Wr., *F. neoceras* Wr. and Rkg., *F. orthoceras* App. and Wr. var. *longius* Wr. and *F. semitectum* B. and Rav [20]. *Fusarium andiyazi* and *F. Sacchari* play important role in the development of pookah boeng disease and prove the association of *F. andiyazi* with sugarcane pokkah boeng *in vitro* from South Africa [4]. Pokkah Boeng of sugarcane also reported from Iran by *F. verticillioides*. Morphological characteristics, pathogenicity test on healthy sugarcane and VCG's for correctly identification of *Fusarium* species causing Pokkah Boeng; and also reported the genetic diversity among the *F. verticillioides* in sugarcane fields using the vegetative compatibility group technique [5,21].

### Characteristics of pathogen

*Fusarium moniliforme* showed different colour for its mycelium pale white, pink and purple mycelium and for pigmentation of metabolites also during the growth on artificial medium and its conidial growth is affected by glucose concentration (Figure 2) [22,23]. Morphological study of *Fusarium* spp. by earlier worker on Potato Dextrose Agar

Year	Area surveyed	Varieties affected	No. of affected varieties/genotypes	Incidence % range
2012-13	Shahjahanpur, Baheri, Gola, Ajbapur, Seorahi, Gonda, Baharaich, Kushinagar, Pilibhit	CoS07250, Co0238, CoS 97261, CoS98231, CoS8436, CoS97264, CoS88230, CoS98259, CoS05125, CoS 91269, Co0238, CoS 01434, Co0239	13	1-15
		CoSe01434 (SRI, Shahjahanpur Farm)	01	25
		S. 224 (SRI, Shahjahanpur)	01	90
2011-12	Shahjahanpur, Balrampur, Ghazipur, Gola, Sultanpur	CoSe01224, CoS05452, CoS06455, CoS06456, CoS05434, CoSe92423, CoSe01235, CoSe96436, CoS8436, CoS07250, CoS96275, CoS8432, CoS99259,	13	Stray
2010-11	Seohara, Neoli, Tilhar, Gola, Baheri, Hargaon, Pallia, Rudrabilaspur	CoS8436, CoS767, CoS8432, CoS88230, CoS97261, CoS98259, CoSe95422, CoSe01424, CoSe92423	09	Stray to 5%
2009-10	Shahjahanpur, Bareilly, Hardoi, Sitapur, Lakhimpur.	CoJ84, CoS8436, CoS88230, CoSe98231.	04	Traces
2008-09	Shahjahanpur, Hardoi, Muzzafarnagar.	CoS8436, CoS88230, CoS8432	03	5-25
2007-08	Sharanpur, Bijnour, Sitapur, Sultanpur, Lakhimpur.	CoS8436, CoS88230, CoS8432, CoS97261, CoSe95422, CoSe98231.	06	Traces
2006-07	Neoli, Semikhera Gola	CoS8436, CoS8432, CoS88230, CoS97261	04	1.0-3.0
2005-06	Roza, Rupapur, Pallia, Seohara	CoJ64, CoS8436, CoS8432, CoS88230, CoSe95422	05	1.0-8.0
2004-05	Neoli, Tilhar, Biswan	CoS8432, CoS94257, CoS94270, CoSe92423, CoLk8102	09	0.5-3.0
2003-04	Khatauli, Mawana, Shahjahanpur, Shimbhawli, Titawi, Gola	CoS88230, CoS8432 CoJ64, CoS767	04	2-10

Table 1: Incidence status of Pokkah Boeng disease during last ten years in Uttar Pradesh (Source: Annual reports of UPCS, Shahjahanpur).

Meteorological observations during the year 2012							
Months	Rainfall (mm)	Relative humidity (%)			Temperature (°C)		
		8.30 A.M.	5.30 P.M.	Ave.	Max.	Min.	Ave.
January	36.8	87.0	64.0	76	17.5	6.2	11.8
February	Nil	80.0	45.0	63	23.1	9.4	16.2
March	Nil	70.0	35.0	52	30.4	13.7	22.0
April	6.2	58.2	29.2	43.7	36.6	19.9	28.2
May	Nil	41.0	23.0	32.0	40.0	24.4	32.2
June	3.4	47.0	31.0	55.0	41.1	28.1	34.6
July	332.3	83.0	75.0	79.0	33.7	26.5	30.1
August	479.0	89.0	82.0	85.5	32.4	26.0	29.2
September	249.6	89.0	71.0	80.0	33.4	25.2	29.3
October	Nil	82.0	50.0	66.0	32.0	17.6	24.8
November	Nil	82.0	62.0	72.0	27.5	11.9	19.7
December	2.6	89.0	67.0	78.0	23.1	8.9	16.0

Source : Division of Plant Physiology, Sugarcane Research Institute, Shahjahanpur, U.P.

Table 2: Metrological observations during the year 2012.

medium (PDA) and the growth of conidia range from 9.3-29.7  $\mu\text{m}$  in length and 2.7-6.0  $\mu\text{m}$  in width; mycelium width of ranged in between 1.75-7.00  $\mu\text{m}$  [24]. Mycelium of *F. moniliforme* was generally dense in delicately floccose to felted with powdery appearance due to formation of macro conidia (Figure 3). Many workers reported that *F. sacchari* as causal agent for Pokkah Boeng in sorghum and also cause the same in sugarcane belongs to the Section Liseola [8,25,26]. In India, *F. sacchari* from sugarcane was first described as *Cephalosporium sacchari* by Butler and Khan [27]. Later *F. moniliforme* and *C. sacchari* are separate as distinct organism based on their enzymes and pathogenicity characteristics [12,28]. Different media had profound influence on the cultural growth characters while the modified Czapeks dox agar was selective medium for *F. moniliforme* and malt extract medium is suitable for the growth [29-31]. On PDA, virulent strains *F. moniliforme* grew faster than the non-virulent strains and growth is influenced by the nitrogen sources magnesium nitrite followed by sodium nitrate, iron also enhanced the growth and sporulation [32-34]. However Patil and Hapase [10] reported that starch, xylose, fructose, sucrose, glucose and maltose as good carbon source and urea for nitrogen.

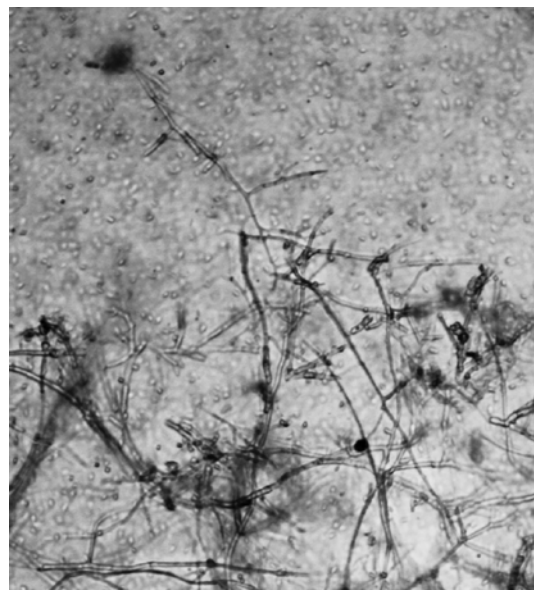


Figure 3: Mycelium and spores of *Fusarium moniliforme* isolated from pokkah boeng.

Major and minor (N, P, K, S, Zn, Fe, Cu and Mg) study of the sugarcane plant affected by the Pokkah Boeng showed the decreasing pattern in stalks and leaves of diseased plant as compared to healthy ones and its incidence have been noticed on broad leaves varieties of sugarcane during monsoon. This may lead to the reduction in weight of cane, length of internodes, juice percent, girth, pol percent and total sugars in juice in infected canes of varieties CoS 8436 and CoS 88230 [3].

### Pathogenesis

The pathogen enters into the host tissues through any injury by insects/borers or natural growth cracks, etc. After the entry of pathogen, the infection thread develops normal hypha which grows within the

host tissues for some time and then emerges out through the cells to the outer surface and develops acervuli. Rains and heavy dews usually wash the acervuli developed on nodes and internodes and the spores get lodged around the nodes behind the leaf sheath. The spores germinate and the mycelium gets established in bud scales, root primordial or leaf scars and later within the plant tissues. Electron microscopic of infected leaves revealed that after lodging of conidia and incubation of minimum one month at the time of germination, the thin walled bulliform cells of the epidermis are attacked and soon collapse then the older cells of the epidermis are attacked [12]. From the epidermal cells, the hyphae enter the underlying tissues. Changes in the structure of stomata were also observed in the infected leaves but there was no evidence found for the entry of pathogen through stomata.

### Host range

*Fusarium moniliforme* associated with a wide range of hosts such as banana [35], corn [12], cotton [31], mango [36], sugarcane and other important crops [37]. The *F. moniliforme* causes the disease in maize, sorghum, rice and sugarcane, and produce different mycotoxins (fumonisins, moniliformin and beauvericin). It was reported from *Gramineae* family along with 31 other families of plants [38]. The Pokkah Boeng pathogen also attacks sorghum and had been reported that the disease was caused by *F. moniliforme* (*Gibberella fujikuroi*) [5]. Fungus infects a wide range of species including monocotyledons and dicotyledons causing various diseases such as seedling blight, scorch, stalk and root rot, abnormal stunting or hypertrophy. Pokkah Boeng disease of sugarcane has associated with several diseases of sugarcane such as sett rot, root rot [39], wilt [40,41] and knife cut [42,43].

### Transmission and viability of pathogen

Basically it is an air-borne disease and primarily transmitted through the air-circulation and secondary infection takes place through the infected setts, irrigation water, splashed rains and soil. The pathogen (*F. Moniliforme*) can survive for 12 months in the plant debris under natural conditions and can remain viable for more than 10 months under laboratory conditions ([http://www.vsisugar.com/india/agriculture\\_divisions/plantpathology/pokkaboengdisease-sugarcane.htm](http://www.vsisugar.com/india/agriculture_divisions/plantpathology/pokkaboengdisease-sugarcane.htm)). Fungus could not grow at 50°C but it remained viable for at least six months. It is also reported that the survival of a *F. moniliforme* can observed for 12 months, although incidence is noticed low after nine months. Under natural conditions, maximum survival occurred more than 11 months at 30 cm in soil. Cool and dry conditions favoured the survival of a fungus in plant debris [43]. Disease may also spread from seeds contaminated with the fungus [11]. Pokkah Boeng pathogen is transmitted by spore movement from one locality to another by air currents and will colonised on leaves, flowers and stems of the plants [44]. Dispersal of spores depends on the environmental condition (windy day, rainy day or dry day) that require different strategies to disperse. Two mechanisms describe by Deacon [45] for the dispersal of the fungal spores: i) Fungus that disperse by rainsplace are based on the “puff” and “tap” mechanism that will cause the dry spore become airborne and usually the spores are curved like *Fusarium* species. ii) Fungi that grow on leaf surfaces and produces chains of spore can be removed by wind, by mist-laden air or by hygroscopic (drying) movements that cause spore to buckle. Hot and dry weather will lead to the opening of leaves between partially unfolded leaves that provide an opportunity for airborne conidia to settle on the leaves [45]. When the rains start, the conidia are washed down to the susceptible parts of the spindles along the margin of a partially unfolded leaves where they germinate. The conidia germinate and the mycelium can pass through the soft cuticle of young leaves to the inner tissues because the epidermis

tissues are still fragile and not protected by the plant system [46]. The mycelium spreads to vascular bundles of the immature stem and blocks the vessels that eventually leads to growth distortions and rupture and the development shows the ladder-like lesions [47]. Bourne [48] reported that the pupae and adults of sugarcane stem borers also can spread the fungus. The top borer known as *Chilo* spp. often results in a distortion and shortening of the leaves which is similar to that caused by Pokkah Boeng disease [46].

### Effect of environmental factors

Temperature is an important natural factor governing the distribution of a pathogen and it grows and sporulates luxuriantly in a temperature range of 20-30°C in both *in-vitro* and *in-vivo* condition. Minimum, optimum and maximum temperature for growth of pathogen are 10-15°C, 30°C and 35-40°C, respectively. The severe incidence of the disease occurred in the range of temperature between 20°C-32°C with high humidity up to 70-80% and cloudy weather in rainy season from July to September. We also found the incidence of the disease in month of July to September when humidity range from 79.0-85.5, temperature ranging 29.0-30°C and rain fall is high (Table 2). Temperature ranging from 20-30°C and humidity ranging from 75-85% is the best suitable for the growth of *Fusarium* pathogen [36].

### Control management

Spraying of different fungicides like Bavistin (1 gm/lit. of water) or Blitox (0.2%) or Copper oxychloride or 0.3% Dithane M-45 (3 gm/L of water) are the effective for reducing the Pokkah Boeng disease [43]. Two to three sprayings with an interval of 15 days interval reduces the multiplication of a pathogen and losses in yield and quality of cane and therefore, paired row or wider spacing planting of sugarcane is necessary to facilitate the plant protection operations. Canes showing ‘top rot’ or ‘knife cut’ should be rouged out from the fields as they are shown. Planting of healthy seed material/use of resistant varieties and follow of Integrated Disease Management practices are the best way to prevent disease incidence [49]. *F. moniliforme* can be disseminated horizontally by airborne spores or crop debris and vertically through the seed pieces. So it is important to uses of resistant varieties and fungicide applications. Both the processes for controlling, is limited and there is increasing need for novel and environmentally sound strategies to control this and other diseases of sugarcane. *Burkholderia* isolates from sugarcane plants is a crucial step toward further development of these isolates for biological control of Pokkah Boeng and other sugarcane diseases. The endophytic bacteria community associated with sugarcane harbours multiple genera with potential for plant growth promotion and disease control [50].

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