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Deterioration in economical traits of sugarcane due to Pokkah boeng disease

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Abstract
During recent years Pokkah boeng is an emerging disease of sugarcane which has been recently found to cause losses in sugar and cane yield related traits. An experiment was conducted for three consecutive years from 2012-13 to 2014-15 at Sugarcane Research Institute, Shahjahanpur, UP. The results of three years mean data for twelve promising sugarcane varieties revealed that the reduction in yield and quality contributing parameters due to incidence of Pokkah boeng disease. The most important parameter which play a prime role in yield enhancement such as cane height and cane girth reduced due to this disease. Cane height decreased numerically ranging from 4.85 to 17.40% and cane girth reduced from 7.14 to 19.35%. Other yield related parameters i.e. number of green leaves, length of internodes and number of internodes also decreased ranging from 40 to 66%, 5.0 to 35.0% and 12.5 to 54.5%, respectively. Reduction in quality parameters were also observed in all promising sugarcane varieties. Pol percent in cane and sucrose percent in juice reduced from 3.65 to 10.48% and 0.60 to 5.80 %, respectively. Reduction in associated quality traits such as purity coefficient and extraction percent were also computed from 0.20 to 2.45% and 2.18 to 11.87%. Thus pokkah boeng is responsible for economic losses for Indian farmers as well as millers due to reductions in yields and quality of sugarcane.

Keywords: sugarcane, pokkah boeng, qualitative, quantitative, losses, parameters

Introduction
Sugarcane (*Saccharum* spp.) is one of the most important industrial crops of the tropical and subtropical areas of the world which also provides useful raw material to many industries. In India sugar industry had generated around 250 million tonnes white sugar, 52 million tonne jaggery and 12 million tonne molasses in 2012-2014 (ISMA 2015) [1]. Sugarcane is a perennial as well as a dependable and remunerative crop, therefore, it's considered as the backbone of Indian farming (Khan 1988; Srivastava *et al.* 1995) [2, 18]. Sugarcane is vegetatively propagated and this crop stands in the field for a year or more so it is easily affected by several pathogens viz; fungus, bacteria, virus and phytoplasma which are responsible for the decline in cane yield and sugar production (Matsuoka and Maccheroni 2015) [5].

In recent years Pokkah boeng disease (PBD) is a rising disease of sugarcane which has been recently found to cause major yield losses in most sugarcane producing regions, including South Africa, Malaysia, China, and India (Lin *et al.* 2014; McFarlane and Rutherford, 2005; Sidique and Nordahliawate 2007; Singh *et al.* 2006; Vishwakarma *et al.* 2013) [4, 6, 15, 16, 19]. This disease has major effect on sugar cane value in northern India and plays an important role on crop yield (Vishwakarma *et al.* 2013) [19]. Pokkah boeng is responsible for huge economic losses due to reductions in harvest yields and quality of sugarcane (Nelson *et al.* 1983; Sidique and Nordahliawate 2007; Singh *et al.* 2006; Leslie and Summerell 2006) [9, 15, 16, 3].

Pokkah boeng of sugarcane caused by *Fusarium moniliforme* was first described by Sheldon (Nirenberg and Donnell 1998) [10] and the perfect stage of pathogen is *Gibberella fujikuroi* described by Sawada in 1917. *Fusarium* is now confirmed by several workers as a causal agent of Pokkah boeng in Asia and established as pathogen of this disease (Mohammadi *et al.* 2012; Sidique and Nordahliawate 2007; Singh *et al.* 2006; Sidique *et al.* 2007; Viswanathan *et al.* 2012, 2014, 2017) [8, 15, 16, 15, 20, 22, 21]. Pokkah boeng disease has been reported in all the countries where the sugarcane crop is grown (Lin *et al.* 2014; McFarlane and Rutherford 2005; Sidique and Nordahliawate 2007; Singh *et al.* 2006; Viswanathan *et al.* 2017) [4, 6, 15, 16, 21]. During 2013–2014 its incidences were very high in UP, Uttrakhand, Bihar, Haryana, Punjab, Rajasthan, Maharashtra, Orissa, Gujarat, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh and Assam (Patil 1995) [12].

Materials and Methods

Quantitative analysis

The observations on yield contributing parameters were studied in pokkah boeng disease infected and healthy plants of twelve popular sugarcane varieties viz; CoS 8436, CoS 08272, CoS 03234, CoS 96275, CoS 97261, CoS 97264, CoS 98259, CoS 96268, CoSe 01434, CoSe 03251, Co 0238 and Co 0118 grown at the farm of Sugarcane Research Institute (UPCSR), Shahjahanpur to observe the quantitative losses in term of number of green leaves, cane height (cm), number of internodes, length of internodes (cm) and girth of internodes (cm) due to infection of Pokkah boeng disease and compared with them healthy ones of same variety. Data for morphological characters viz; number of green leaves, cane height in centimeter (cm), number of internodes, length of internodes in cm, girth of internodes (mid cane stalk) of both infected and healthy canes of each variety were recorded in three replications in the month of August.

Qualitative analysis

Twelve popular sugarcane varieties viz; CoS 8436, CoS 08272, CoS 03234, CoS 96275, CoS 97261, CoS 97264, CoS 98259, CoS 96268, CoSe 01434, CoSe 03251, Co 0238 and Co 0118 were taken for qualitative analysis to observe the losses in term of extraction percent, pol percent in cane, Sucrose percent in juice and purity percent due to infection of Pokkah boeng disease (PBD) and compared with them healthy ones of same variety. The cane samples were randomly collected in the month of January (crop age 11 months) and analyze them in terms of Pol percent in cane and sucrose percent, extraction percent and purity percent in three replicates. Sucrose percent in cane was calculated by Schmitz's table on the basis of Pol reading and Brix degree at constant temperature (20^{o} C). The average data of juice analysis with three replications were calculated for crop seasons 2012-13, 2013-14 and 2014-2015. All the above quality parameters were analyzed according to prescribed standard protocol by Meade & Chen 1977.

Results and Discussion

Quantitative losses

The results on yield parameters of six promising sugarcane varieties showed reduction in almost all yield contributing parameters due to Pokkah boeng disease. Number of green leaves decreased ranging from 40 to 66%, cane height decreased ranging from 4.85 to 17.40%. The number of internodes reduced ranging from 12.5 to 54.5%. The length of internodes reduced ranging from 5.0 to 35.0%. Girth of internodes decreased in a range from 7.14 to 19.35% (Table 1). Osman *et al.* (2014) [11] also observed a significant reduction in number of internodes/plant of almost all tested sugarcane varieties after infection with two highly pathogenic isolates of *Fusarium subglutinans*. The diameter of sugarcane stalk decreased markedly in plants infected with both isolates. These findings are in agreement with those obtained by Singh and Goswami (2002) [17] and Singh *et al.* (2006) [16], they also reported the reduction on quantitative traits viz; cane height, girth, number of green leave.

Table 1: Reduction percent in morphological alterations due the incidence of Pokkah boeng disease on sugarcane.

S.N.	Varieties	No. of green leaves	Cane height (cm)	No. of internodes	Length of internodes (cm)	Girth of internodes (cm)
		Reduction %	Reduction %	Reduction %	Reduction %	Reduction %
1	Co 0238	50.00	17.40	54.54	24.70	19.35
2	CoSe 03251	50.00	16.40	33.30	26.90	17.85
3	CoS 8436	40.00	9.09	40.00	35.00	18.75
4	CoSe01434	50.00	4.85	12.50	29.20	18.51
5	CoS 98259	66.00	11.71	25.00	17.40	14.28
6	CoS 97261	60.00	9.98	33.33	22.70	15.15
7	CoS 08272	42.80	13.86	20.00	17.47	13.33
8	CoS 03234	40.00	16.90	33.30	7.08	11.54
9	Co 0118	50.00	16.64	12.50	13.07	17.24
10	CoS 96275	66.70	6.54	14.28	5.00	8.00
11	CoS 08279	50.00	11.98	22.21	17.74	12.00
12	CoS 96268	66.00	13.14	25.00	8.03	7.14
	Range of reduction %	40-66	4.05-17.4	12.5-54.5	5.0-35.0	7.14-19.35

Qualitative losses

The results on quality parameters of twelve promising sugarcane varieties including early and mid late maturing were showed reduction in almost all quality contributing parameters due to infection of Pokkah boeng disease. Pol percent in cane decreased ranging from 3.65 to 10.48%. Sucrose percent decreased ranging from 0.60 to 5.80 % (Table 2). Purity coefficient percent decreased ranging from 0.20 to 2.45%. Extraction percent decreased ranging from 2.18 to 11.87% (Table 3). The average losses in cane yield and commercial cane sugar (CCS%) due to Pokkah boeng disease were found from 15 to 25% (25 t/ha) and 18-29% (3 to % t/ha) respectively by Patil *et al.* (2007) [13]. Pokkah Boeng is a re-emerging disease of sugarcane which has been found recently to cause major yield losses in most sugarcane producing regions, including South Africa, Malaysia, India, and China (Lin *et al.* 2014; McFarlane and Rutherford 2005; Sidique and Nordahliawate 2007; Singh *et al.* 2006; Vishwakarma *et al.* 2013) [4, 6, 15, 16, 19]. The disease is known to cause 10–38% yield losses in the susceptible sugarcane variety POJ 2878 (Ricaud *et al.* 2012) and 90% infection rate in susceptible varieties (Lin *et al.* 2014; Vishwakarma *et al.* 2013) [4, 19].

Table 2: Reduction percent in pol percent in cane and sucrose percent in juice on different varieties of sugarcane (January) due to pokkah boeng disease.

Sl. No.	Name of Varieties	Pol percent in cane (Reduction Percent)			Sucrose percent in juice (Reduction Percent)		
		2012-13	2013-14	2014-15	2012-13	2013-14	2014-15
1	CoS 08272	4.56	5.25	4.83	2.62	3.33	0.96
2	CoS 03234	4.76	5.11	5.14	2.66	2.97	1.38
3	Co 0238	4.85	5.60	4.76	2.67	3.82	1.80
4	Co 0118	5.38	6.88	6.77	3.99	5.80	5.50
5	CoS 96275	4.94	6.35	10.48	3.08	4.80	4.83
6	CoS 03251	5.04	6.52	8.78	3.04	4.22	4.24
7	CoS 97261	5.11	4.35	7.90	3.10	3.18	3.93
8	CoS 08279	5.05	5.64	6.16	2.93	4.25	3.94
9	CoS 8436	4.83	7.99	3.65	0.85	1.87	0.60
10	CoS 98259	4.46	5.73	5.75	1.04	1.59	2.06
11	CoSe 01434	4.33	5.83	8.97	1.22	0.98	1.28
12	CoS 96268	4.11	5.06	3.86	3.75	3.65	3.10
Range of reduction %		4.11-5.38	4.35-7.99	3.65-10.48	0.85-3.99	0.98-5.80	0.60-5.50
Overall reduction percent		3.65 to 10.48			0.60 to 5.80		

Table 3: Reduction percent in purity percent and extraction percent in cane on different varieties of sugarcane (January) due to pokkah boeng.

Sl. No.	Name of Varieties	Purity percent in cane (Reduction Percent)			Extraction percent in cane (Reduction Percent)		
		2012-13	2013-14	2014-15	2012-13	2013-14	2014-15
1	CoS 08272	0.76	0.70	0.20	6.83	9.58	6.89
2	CoS 03234	0.64	0.94	0.40	2.62	4.88	6.46
3	Co 0238	0.71	0.77	0.66	6.88	7.26	10.88
4	Co 0118	1.69	1.54	1.45	2.18	7.99	11.87
5	CoS 96275	1.08	0.98	1.03	6.95	7.42	6.23
6	CoS 03251	1.20	1.00	1.09	6.82	9.10	8.84
7	CoS 97261	1.24	1.01	1.16	5.44	3.78	7.61
8	CoS 08279	1.12	1.05	0.95	5.42	4.27	7.00
9	CoS 8436	0.34	0.54	0.30	3.86	2.90	5.41
10	CoS 98259	0.47	0.29	0.24	4.88	9.13	8.46
11	CoSe 01434	0.71	0.47	1.94	5.37	5.59	8.11
12	CoS 96268	2.45	2.28	2.15	5.25	5.11	6.86
Range of reduction %		0.34-2.45	0.29-2.28	0.20-2.15	2.18-6.95	2.90-9.58	5.41-11.87
Overall reduction percent		0.20 to 2.45			2.18 to 11.87		

Conclusion

Qualitative traits viz; number of green leaves, number of internodes, stalk girth found adversely affected due to the infection of Pokkah boeng disease. Hence these characters will adversely affect the cane yield. This disease also declines the juice quality of sugarcane in term of pol percent in cane, sucrose percent, extraction percent and purity. Pokkah boeng disease would play a major role in the economic losses to cane growers and sugar industry. Hence, the management of this disease should apply earlier to avoid cane yield and sugar losses.

Conflict of interest

The authors declare no conflict of interest.

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