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Research Article *Stress Management*

Current Status of Yellow Leaf Disease (YLD) of Sugarcane Caused by Sugarcane Yellow Leaf Virus (ScYLV) in the states of Andhra Pradesh and Telangana

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Abstract

Yellow Leaf Disease (YLD) of Sugarcane caused by Sugarcane Yellow Leaf Virus (ScYLV) is becoming a major threat to the sugarcane crop in the recent past. A survey was undertaken during 2012-13 to 2015-16 planting seasons in different sugarcane growing regions of Andhra Pradesh and Telangana states to assess the incidence levels and spread of Yellow Leaf Diseases (YLD) of sugarcane, a major threat to the crop in the recent past. A total of 521 fields covering 52 mandals in 8 districts of the states of Andhra Pradesh (2012-16) and Telangana (2013-14) were surveyed and kept under surveillance during different growth stages and the severity in both plant and ratoon fields was recorded. The mean YLD incidence ranged between 10 to 56.5%, with increased incidence being observed in ratoon fields (15-74.5%) compared to plant fields (5-38.5%). Further, Telangana region recorded higher incidence levels than Andhra Pradesh region. The study indicated that, replacement of varieties and planting material in sugar factory areas resulted in decreased incidence of YLD during 2014-15 and 2015-16 seasons with a mean incidence pegged at 26.3%. The YLD incidence and disease grades were mapped using GPS information of the surveyed areas in collaboration with CRIDA, Hyderabad. The GIS based mapping clearly showed the distribution and progress of the disease in different districts of AP and Telangana states over the study period.

Keywords: Sugarcane, YLD, survey, disease distribution, Andhra Pradesh and Telangana, GPS mapping

1. Introduction

Sugarcane is one of the important cash crops in India and plays pivotal role in both agricultural and industrial economy of our country. India ranks first in the world with an area of 4.73 million hectares having 2.46% share of total area with a production of 376.9 million tonnes (2017-18). Andhra Pradesh ranks seventh in sugar crop area of the country with a share of 4.83% (0.22 mha). The average production of Andhra Pradesh is 796.5 q ha^{-1} with around 92.4% area under irrigation. (Agricultural statistics at a glance, 2014 and Pocket Book of Agricultural Statistics, 2018). More than 100 diseases have been recorded in India caused by diverse group of pathogens such as fungi, bacteria, virus and phytoplasma (Rao et al., 2002; Rott et al., 2000; Shailbala and Amarenderkumar, 2016, Bharathi and Sudhakar, 2012; Rakeshkumar et al., 2015;). A conservative estimate

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of losses due to diseases in total sugarcane production ranges from 10-25% in terms of yield and juice quality. Maximum damage is caused by sett transmissible diseases. In addition to the major diseases *viz;* Red rot and smut, viral diseases like Yellow Leaf Disease (YLD) and Sugarcane Mosaic are emerging as major threat to sugarcane productivity in certain pockets of Andhra Pradesh in recent years. Yellow leaf disease (YLD) of sugarcane was first reported in Hamakua (Hawaii) on variety H65-0782 in 1989 as yellow leaf syndrome (Schenck, 1990 and Schenck et al., 1997) and subsequently from the United States mainland (Comstock *et al*. 1994) and many other sugarcane growing countries. YLD is reported worldwide in more than 30 countries (Lockhart and Cronje, 2000, Tran-Nguyen et al., 2000 and Schenck, 2001). In India, Viswanathan et al. (1999) reported the disease for the first time and the associated Sugarcane yellow leaf virus which assumed its severity on different sugarcane varieties. In India, the disease is prevalent in major sugarcane growing states like Andhra Pradesh, Karnataka, Tamilnadu and Madhya Pradesh (Viswanthan, 2002; Suresh et al., 2014; Viswanathan and Rao, 2011; Suresh et al., 2016). Continuous cultivation of a single variety and multiple ratooning are the major factors responsible for spread of systemic diseases like red rot, smut along with YLD and mosaic. Yellow Leaf Disease (YLD) posing serious problems during the recent past and severe losses reported in several sugarcane growing regions of both Andhra Pradesh and Teangana states (Rajakumar et al., 2012). Vega et al. (1997) first identified the causative virus as *Sugarcane Yellow Leaf Virus* (SCYLV). Viswanathan et al. (1999) reported the occurrence of disease and the associated *Sugarcane Yellow Leaf Virus*, a member of Luteoviridae, for the first time in the country. Rao et al. (2000, 2001) and Viswanathan (2002) reported further spread of YLD in sugarcane in different regions. SCYLV is a Polerovirus (Family Luteoviridae) evolved by recombination between the ancestors of Luteovirus, Polerovirus and Enamovirus (Moonan et al., 2000 and Smith et al., 2000). There is a strong evidence that Sugarcane yellow leaf phytoplasmas (SCYP) are also associated with leaf yellowing in some countries *viz;* South Africa, Mauritius and in Cuba. Several workers reported the association of phytoplasmas with YLD (Cronje et al. 1998, Cronje and Bailey, 1999, Marcone, 2002, Parmessur et al. 2002 and Arocha et al. 2005) from nine African countries. After detailed studies on the etiology of YLD in Mauritius, Aljanabe et al. (2001) concluded that either SCYLV or SCYP or their combination is associated with YLD symptoms. In view of the losses caused by this viral disease in both the states of AP and Telangana, present study was taken up to assess the status of YLD in Andhra Pradesh and Telangana states to assess the severity and distribution of the disease so as to develop integrated disease management strategies.

2. Materials and Methods

2.1. Survey

Survey was taken up for four planting seasons, annually during 2012-13 to 2015-16 to determine the occurrence, distribution and severity of Yellow Leaf Disease (YLD) in popular commercial varieties grown in different sugarcane growing areas of Andhra Pradesh and Telangana states. Survey was carried out in both traditional sugarcane growers for jaggery preparation as well as in different sugar factory operational areas for \these four planting seasons. Rowing and fixed plot survey was taken up to assess the disease incidence levels in both plant and ratoon crops respectively. YLD incidence was recorded in different varieties grown in each area and the growth stage of the crop was recorded at the time of observation. Fixed plot survey was taken up in ratoon fields following the general survey methods (Viswanathan, 2002; Suresh et al., 2016; Suresh et al., 2014; Suresh and Umadevi, 2017; Rajakumar et al., 2012).

2.2. Data recording

Disease incidence was assessed using the scale developed by SBI, Coimbatore and AICRP on sugarcane (AICRP Annual report 2014-15) as given in Table 1. The visual observation of the symptoms for assessing the disease spread both vertically and horizontally was assessed using the pictorial depiction of the disease grades as given in Figure 1 (AICRP Annual report

Table 1: Yellow Leaf Disease (YLD) severity grades (Source: AICRP on Sugarcane-Annual report 2014-15)

Disease grade	Description
0	No symptom of the disease
1	Mild yellowing of midrib in one or two leaves, no sign of typical bunching of leaves caused by YLD
2	Prominent yellowing of midrib on all the leaves in the crown. No bunching of leaves
3	Progress of midrib yellowing to laminar region in the whorl, yellowing on the upper leaf surface, and bunching of leaves
4	Drying of laminar region from leaf tip downwards along the midrib, typical bunching of leaves as a tuft
5	Stunted growth of the cane combined with drying of symptomatic leaves

Figure 1: Symptoms of YLD displaying different severity grades (Adopted from AICRP annual report 2014-15)

2014-15). The GPS coordinates of the recorded localities were taken up using a handheld GPS recorder and mapping was done using the model Trimble Geoxt 2008.

3. Results and Discussion

A total of 521 fields covering 52 mandals in 8 districts of the states of Andhra Pradesh (2012-16) and Telangana (2013-14) were surveyed. A total of 133 plant fields and 388 ratoon fields were monitored to assess the incidence levels of YLD (Table 2), indicating the status and trend of YLD incidence in plant and ratoon fields.

During 2012-13, out of 119 fields (32 plant crop fields and 88 ratoon fields) of Andhra Pradesh state, highest YLD incidence was observed in East Godavari (30.6%) followed by Chittor (30.0%), Vizianagaram (15.0%) and Visakhapatnam (10.0%) in plant crop. Ratoon fields of East Godavari also recorded highest YLD incidence of 51.0% with a mean incidence of 40.8% followed by Chittor (40.0% and 35.0%) and the least mean incidence was observed in Visakhapatnam district (17.0%) than in Vizianagaram (26.3%). During 2013-14, 183 fields covering 48 plant fields and 135 ratoon fields were surveyed, mean disease incidence ranged between 19.5 to 30.6% in the state of Andhra Pradesh while in Telangana state it ranged between 30.0 to 56.5% covering 3 districts each, with least disease incidence in Visakhapatnam (14.0%) followed by Vizianagaram district (24.8%) and East Godavari (28.0%) in plant crop. While in ratoon fields, the disease incidence was maximum in East Godavari (53%), followed by Vizianagaram (36.3%) and Visakhapatnam (25.0%). In the state of Telangana, the disease incidence ranged between 5-80%, with a mean incidence of 30.0% to 56.5%, with highest disease incidence levels of 38.5% in plant and 74.5% in ratoon fields of Medak district followed by Nizamabad (38.0% in plant and 74.0% in ratoon crop) and Karimnagar (25.0% in plant and 35.0% in ratoon) districts.

During 2014-15 season, the survey revealed a mean incidence

Table 2: Status of the YLD incidence in different sugarcane growing areas in the states of Andhra Pradesh and Telangana during 2012 to 2015

Sl. No.	Crop season	District	Number of fields surveyed			Disease severity (PDI %)			Mean YLD incidence a
						Mean incidence		Range	
			Plant	Ratoon	Total	Plant	Ratoon		
1.	2012-13	Visakhapatnam	12	36	48	10.0	24.0	15-25	17.0
2.		East Godavari	12	25	37	30.6	51.0	30-60	40.8
3.		Vizianagaram	5	17	21	15.0	37.5	10-40	26.3
4.		Chittor	3	10	13	30.0	40.0	20-50	35.0
		Total/Mean	32	88	119	21.4	38.1		29.8
5.	2013-14	Visakhapatnam	15	41	56	14.0	25.0	5-25	19.5
6.		East Godavari	12	16	28	28.0	53.0	30-60	40.5
7.		Vizianagaram	7	22	29	24.8	36.3	10-50	30.6
8.		Karimnagar	2	4	6	25.0	35.0	5-30	30.0
9.		Nizamabad	5	21	26	38.0	74.0	35-80	56.0
10.		Medak	7	31	38	38.5	74.5	40-80	56.5
		Total/ Mean	48	135	183	28.1	49.6		38.8
11.	2014-15								
		Visakhapatnam	16	56	72	28.0	35.6	10-50	24.3
12.		East Godavari	19	12	31	15.0	35.8	15-60	25.4
13.		West Godavari	5	0	5	5.0	15.0	5-10	10.0
		Total/ Mean	40	68	108	12.7	27.1		19.9
14.	2015-16	Visakhapatnam	6	72	78	25.0	42.6	10-70	32.4
15.		East Godavari	5	20	25	15.0	42.0	35-50	28.5
16.		West Godavari	2	5	7	10.0	20.0	10-15	15.0
		Total/ Mean	13	97	110	20.0	40.0		25.3

[a]Mean incidence levels were calculated by summarizing disease incidence levels of all the fields in each district

of 10%, 24.3% and 25.4% in West Godavari, Visakhapatnam and East Godavari districts of Andhra Pradesh state respectively which ranged between 5-60%. Ratoon fields showed higher incidences in all the surveyed areas ranging between 15% to 35.8%. During, 2015-16, a total of 110 fields comprising 13 plant and 97 ratoon fields were surveyed in the state of Andhra Pradesh. The YLD visual symptom ranged between 10-70%. Mean disease incidence was lowest in West Godavari (15%) followed by East Godavari (28.5%) and Visakhapatnam (32.4%) districts.

The results of the survey from 2012 to 2016 in both the states indicated that the incidence of YLD increased over the years in all sugarcane growing areas. The survey conducted during 2012-13 season indicated a lower incidence and there upon reached to maximum by 2013-14. Earlier studies indicated the incidence of YLD only in few isolated pockets of the sugarcane growing region of this zone till 2012 (Raja Kumar et al., 2012). The disease spread was rapid in the following years due to the usage of infected setts, as farmers are unaware of the diagnostic symptoms of the disease, and also due to multi ratooning of the infected fields. A similar trend was also observed in surveyed areas of Telangana region with a very high disease incidence during 2013-14 in both plant and ratoon crops. The incidence was much higher in ratoon crop compared to plant crop in Medak and Nizamabad districts. Thus it is inferred from these results that the disease incidence levels are higher in ratoon crop compared to plant crop in both Andhra Pradesh and Telangana states.

Overall a declining trend was observed in the disease especially in plant crop fields with a mean YLD incidence level pegged at 26.3% over these four years. In the sugarcane factory operational areas the disease spread was low and further showed a decreasing trend when compared non-factory areas/traditional jaggery areas. The decrease in the incidence levels during 2014-15 was mainly attributed to the continuous monitoring and replacement of planting material by the concerned factory authorities towards change of seed material, awareness among the farming community towards the disease also prompted them to go for healthy planting material which lead to the marked reduction in disease incidence in newly planted areas. While, the disease continued to increase in ratoon fields.

In ratoon fields, there was an increase in the severity levels compared to the plant crop (Figure 2). The ratoon crops in these three districts showed a marked increase in disease incidence over the years of study. For example, in Munagapaka area of Visakhapatnam district of Andhra Pradesh, a traditional sugarcane growing area, during 2012-13 season, maximum YLD grade observed was 2 with a mean incidence of 15%. These fields showed gradual increase in the incidence levels during 2013 and 2014 and reached a maximum of 70% incidence showing a grade of 5 in the 4th ratoon. Similar trend was observed in the ratoon crop areas in the three major districts of Andhra Pradesh (Figure 2). In

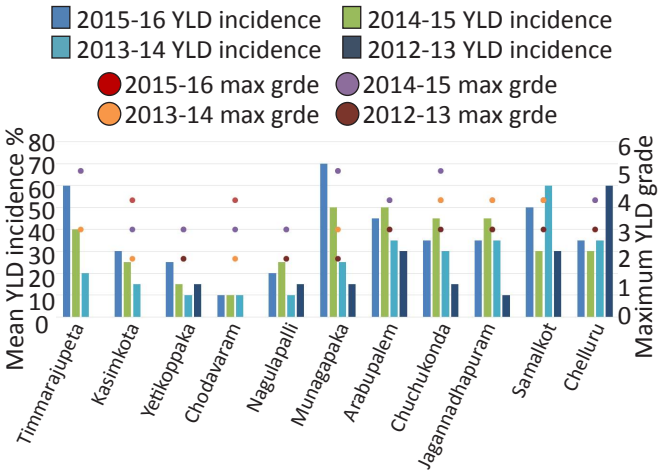


Figure 2: YLD incidence in ratoon fields during the study period (2014-15 & 1015-16)

the jaggery areas like Munagapaka, Timmarajupeta of Andhra Pradesh state, where multi ratooning is a common practice, the fourth ratoon crop showed 35 to 70% disease incidence levels grades of 4 and 5. Even the disease grade increased with increasing number of ratoons. Similar trend was reported by earlier workers (Suresh et al., 2014 and Rajakumar et al., 2012) in major sugarcane growing areas of north coastal zone of Andhra Pradesh. Thus, it is established that the disease incidence and spread increased with increased ratoons compared to plant crop.

Detailed survey conducted during the grand growth stage of the sugarcane crop in the different sugarcane growing areas in the states of Andhra Pradesh and Telangana states revealed that all the popular varieties were infected with YLD (Table 3). Disease incidence was recorded in many popular varieties viz; 2003V 46, 87A 298, Co 6907, 2001A 63, 93V 297, 81V 48, Co 86032 *etc* with different incidence levels. It was reported that in the state of Tamilnadu most of the varieties under cultivation in field such as Co 86010, Co 86032, Co 94003, CoV 92102, CoV 94101 *etc*. recorded varying intensities of the disease under field conditions (Viswanathan, 2012). Thus the present study confirmed that irrespective of the variety grown there was high incidence of YLD in the sugarcane growing areas of Andhra Pradesh and Telangana states. This was evident by the YLD incidence observed during 2012-13, in Therlam and Nemalam areas of Vizianagaram district of Andhra Pradesh, showing 35-40% disease incidence in first ratoon crop which increased to 45 and 50% in the 2nd ratoon crop (2013-14) in these two areas. The increased disease incidence was due to the poor management of the crop and complete rainfed conditions during the crop growth stage. Similarly increased disease incidence was also observed in Ranastahlam (35%) and Rajam (30%) mandals of Srikakulam district in 2013-14 compared to the ratoon crop in 2013-14 (35 and 30% respectively) which is mainly due to the ratooning of YLD infected plant crop. Earlier studies (Viswanathan 2004, 2012) revealed that poor management, poor or excess

Table 3: Location/Mandal wise YLD incidence levels in different sugarcane growing areas of Andhra Pradesh and Telangana states

Sl. No.	District	Locations/mandals	Varieties	Mean YLD incidence range (%)			
				2012-13	2013-14	2014-15	2015-16
Andhra Pradesh							
1.	Visakhapatnam	Tummapala, Tandava, Yetikoppaka and Chodavaram sugar facotories area. (Nagulapalli, Achutapuram Koduru, Munagapaka, payakaraopeta, Eikoppaka)	Co 6907 CoA 92081 (87A 298) 81V 48, CoA 6321 2001A 63	15-25	15-25	15-50	15-70
2.	East Godavari	Samalkot sugar factory area (Kilampudi, Karapa, Atreyapuram, Peddapuram, Samalkot,	93V 297, CoA 92081, 2003V 46, 83A 15	30-35	Up to 60	15-30	Upto 50
		Chellur sugar factory area (Muramalla, Dhulla, Chelluru, Yeleswaram)	93V 297, CoA 92081, 2003V 46, 83A 15	20-30	30-40	30-60	Upto 35
3.	West Godavari	Chagallu factory area (Chagallu)	2003V 46 2001A 63	-	-	Upto 10	Upto 15
Telangana State							
4.	Karimnagar	Kothapalle	93 V 297	-	Upto 30	-	-
5.	Nizamabad	Maagi sugar factory area (Birkur, Banswada, Pitlam, Bodhan)	CoA 92081 83R 23	-	35-80	-	-
6.	Medak	Trident sugar factory area (Sangareddy, Hathnoora, Andole, Pulkal)	Co 7805 85R 186 83A 30	-	40-75	-	-
7.	Rangareddy	Annasagar /Yalal	Co 86032, Co 95026	-	50-80	-	-

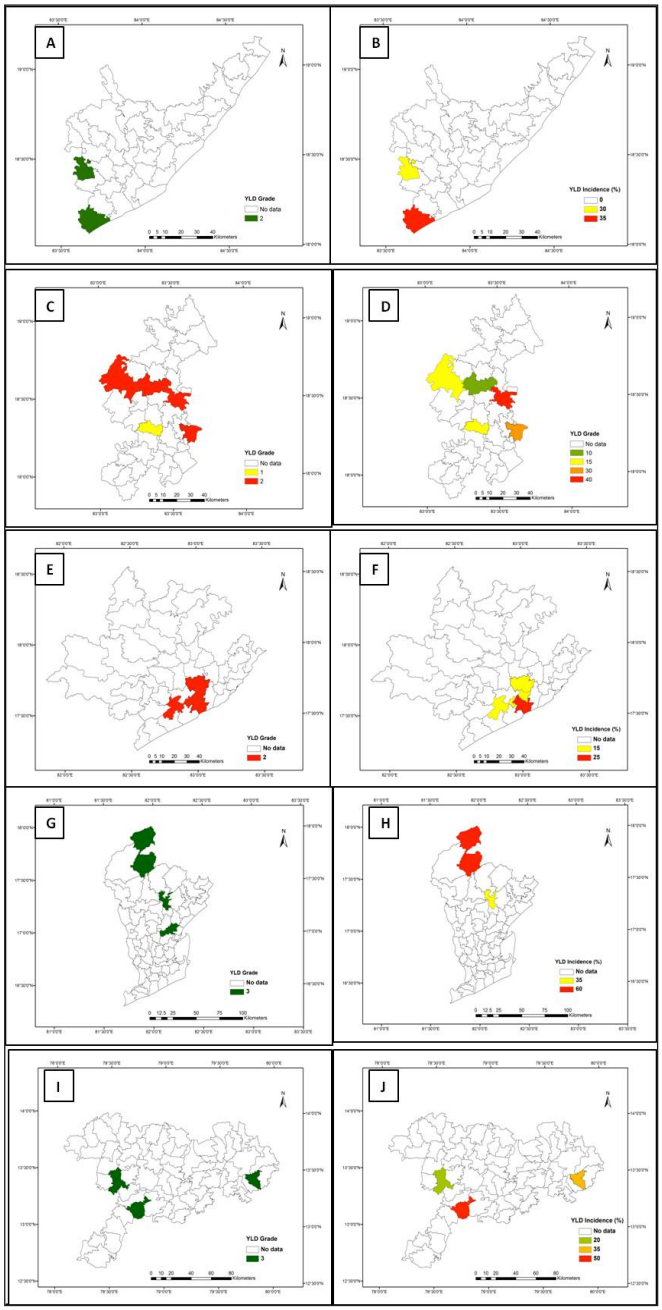
nutrition, drought, water logging and infection due to fungal and bacterial pathogens may aggravate the severity of the disease incidence.

Similar trend was recorded in all other areas during 2012 to 2015 (Table 3). Viswanathan (2012) observed that ratoon crops record more intense symptoms of the disease and suffer more due to disease. He reported that the disease incidence levels can reach as high as 100% in the field. Tis trend is more particular in traditional jiggery making areas *viz;* Munagapaka mandal of Andhra Pradesh, where the disease incidence reached to a maximum of 70% in the ratoon fields during 2015-16 compared to previous years (50% in 2014-15, 25% in 2013-14 and 15% in 2012-13). This is mainly due to their practice of continuing the ratoons for more than two seasons. In some fields the farmers have gone for more than 4 ratoon with the same infected material which resulted in more virus accumulation and degeneration of the variety and severe expression of the symptoms with highest grade. Viswanathan (2012) reported that varietal degeneration is commonly observed in the fields infected with YLD, especially in the fields with multiple ratoons.

Based on the incidence levels of YLD in different sugarcane growing areas of Andhra Pradesh and Telangana states, mapping was done using GPS information of the surveyed areas in collaboration with CRIDA, Hyderabad using the model Trimble Geoxt2008. The YLD incidence and disease grades were mapped and presented in Figures 3 to 6. These maps clearly revealed the distribution and progress of YLD in all the major sugarcane growing areas of both Andhra Pradesh and Telangana states over the study period *i.e.*2012-15. During 2012-13 planting season the disease observed only in few patches of the districts surveyed (Figure 3) with least disease grades of around 2. But the disease spread to newer areas during 2013-14 season in both Andhra Pradesh (Figure 4a) and Telangana states (Figure 4b) recording higher disease incidence and disease grades. During 2014-15, there was a slight increase in disease incidence though not much progress with respect of disease grades in the new areas like Chillangi, Peravaram, Muramalla and Dulla in East Godavari district (Figure 5) in plant fields. However, the increased disease levels were mainly due to the continuous ratoon crops in the major jaggery areas. During 2015-16, there was no marked increase in the disease incidence and disease grades (Figure 6). Further, the spread of the disease to newer areas was not observed during the period, mainly due to increased awareness among the farming community towards usage of healthy planting material and reduced ratooning in the sugar

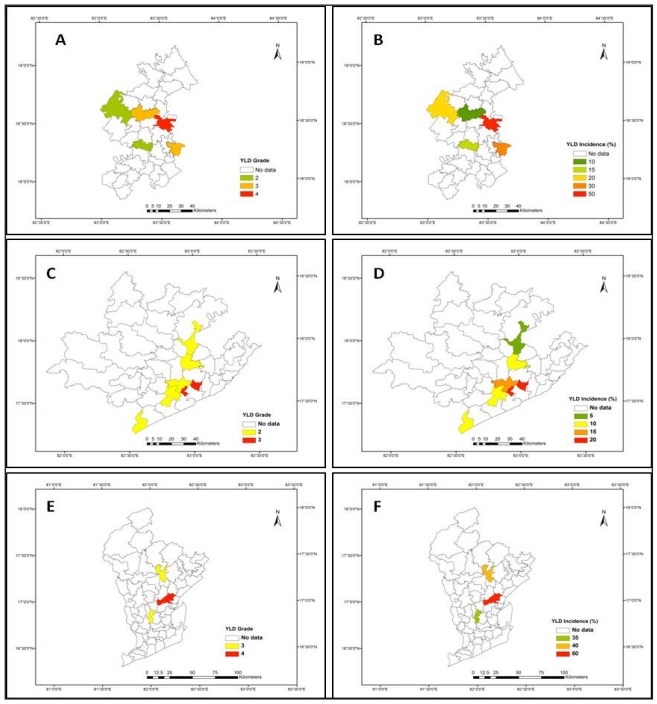
factory operational areas.

The mapping of the disease was done for the first time during the present study to ascertain the distribution and spread of the disease in different parts over the years especially in north coastal districts of Andhra Pradesh, where sugarcane is a major crop for both sugar and jaggery making. This mapping provides a comprehensive idea of the disease status in north



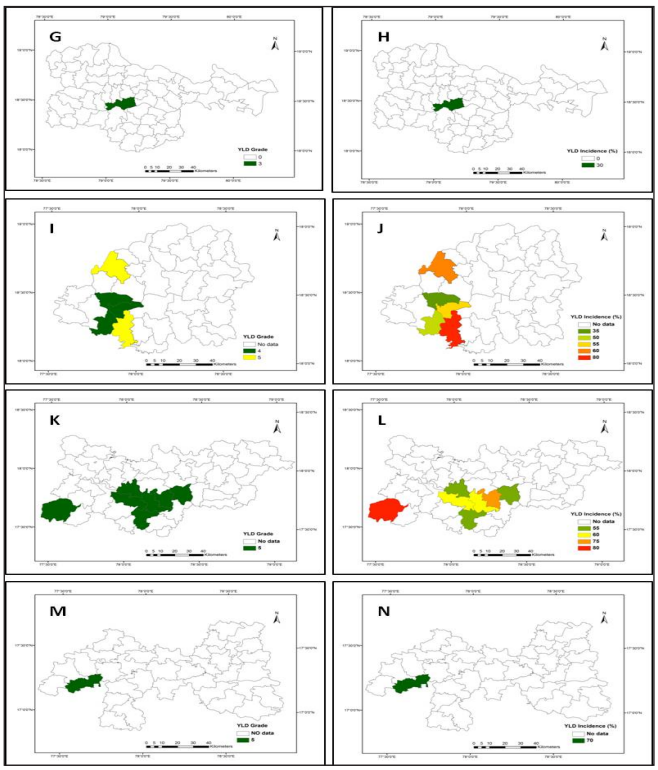
A&B: Srikakulam district; C&D: Vizianagaram district; E&F: Visakhapatnam district; G&H: East Godavari district; I&F: Chittore district

Figure 3: Mandal wise YLD distribution and severity during 2012-13 planting season in AP & Telangana states



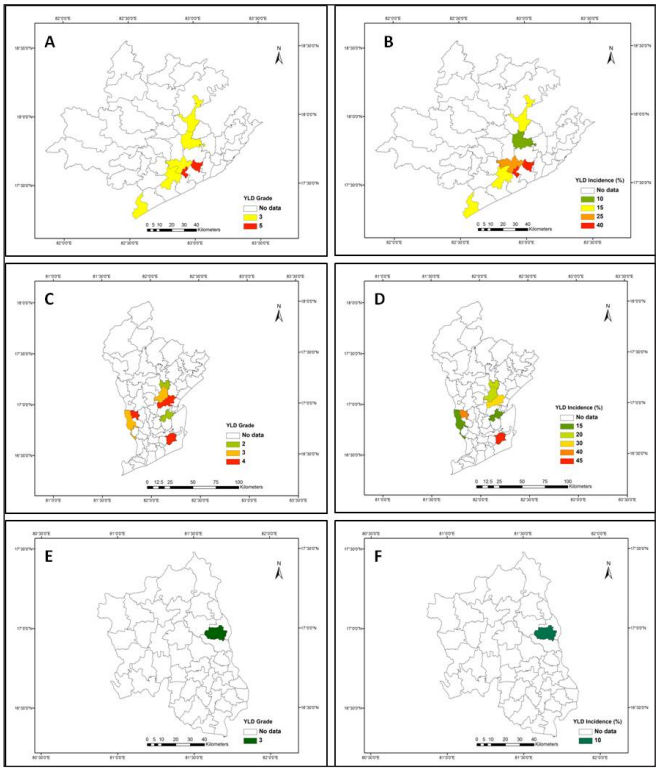
A&B: Srikakulam district; C&D: Visakhapatnam district; E&F: East Godavari district

Figure 4a: Mandal wise YLD distribution and severity during 2013-14 planting season in AP



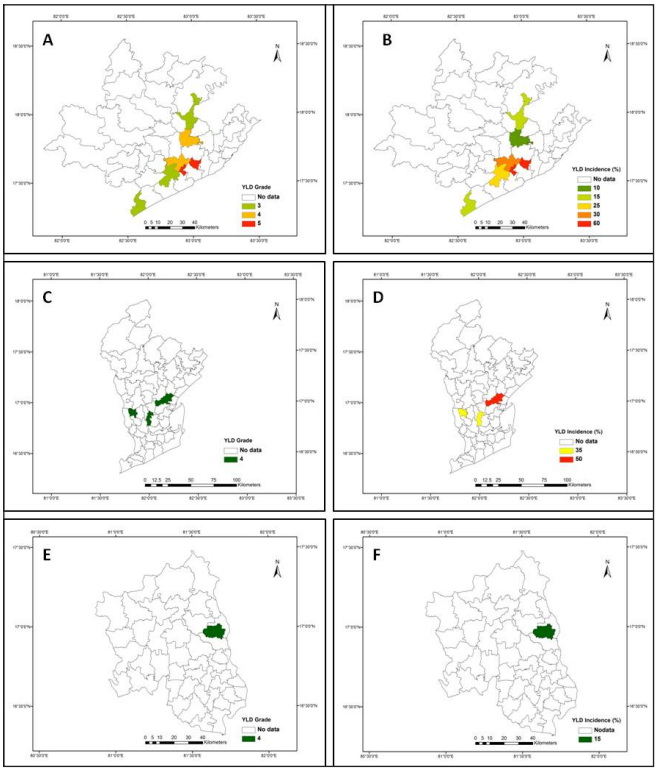
G&H: Kareemnagar district; I&J: Nizamabad district; K&L: Medak district; M&N: Rangareddy district

Figure 4b: Mandal wise YLD distribution and severity during 2013-14 planting season in Telangana state



A&B: Visakhapatnam district; C&D: East Godavari district; E&F: West Godavari district

Figure 5: Mandal wise YLD distribution and severity during 2014-15 planting season in AP



A&B: Visakhapatnam district; C&D: East Godavari district; E&F: West Godavari district

Figure 6: Mandal wise YLD distribution and severity during 2015-16 planting season in AP

coastal zone of the state and helpful in preparation of action plan for seed/planting material replacement in disease prone areas towards effective monitoring and management of the disease.

4. Conclusion

In Andhra Pradesh state, this study is first of its kind, establishing the occurrence of YLD in different parts of the major sugarcane growing areas of Andhra Pradesh and Telangana states with with higher level in areas with multi rationing. All the major sugarcane varieties had YLD infection in the range of 10-70% suggesting the lack of resistant source in the available germplasm. The GIS based mapping clearly showed the distribution and progress of the disease in these two states.

5. Further Research

As the disease is most prevalent in all the sugarcane growing areas, both for traditional jaggery and factory purpose, continuous monitoring of the disease is very essential. Being a viral disease transmitted by the aphid vectors, surveillance over the spread and distribution of the YLD will enable the researchers for formulation of effective integration of available management options. GIS based mapping has to be extended to all the cane growing areas for effective monitoring of the disease progress.

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