Influence of weather, vector and variety on incidence of Yellow Leaf Disease in Sugarcane

ABSTRACT

Yellow leaf disease of sugarcane (*Saccharum* spp.) caused by the Sugarcane yellow leaf virus (SCYLV), vectored by aphids has attained epidemic proportions causing severe yield losses, ranging from 20 to 40 % in susceptible varieties. Yellow leaf spread by aphids depends on cultivar susceptibility as well as weather parameters and thus the present studies were conceptualized. The observations on meteorological parameters were taken from the observatory at the station. The data on incidence of vector(aphids) and yellow leaf disease were recorded at weekly interval during the entire crop growth period on three sugarcane varieties viz., 2005 A 128, 2001 A 63 and 2003 V 46. The data on vector and disease incidence was correlated with weather parameters. The aphid incidence on 2005 A 128 initiated (4.6 per leaf) at 30 SMW and gradually increased to 19.1 per leaf at 40 SMW. In the variety 2001 A 63, the aphid incidence was first observed (2.2 per leaf) at 27 SMW and reached the peak population of 19.1 per leaf at 38 SMW. The aphid incidence on 2003 V 46 initiated (2.1 per leaf) at 29 SMW and gradually increased to 18.1 per leaf at 42 SMW. With regard to yellow leaf disease the incidence was first observed (1.0 per cent) at 26 SMW and reached the peak (28.7 per cent) at 37 SMW in the variety 2005 A 128. In the variety 2001 A 63, the incidence of yellow leaf disease was 1.8 per cent at 26 SMW which later on increased up to 29.4 per cent by 46 SMW. The incidence of yellow leaf disease was 3.5 per cent at 28 SMW which later on increased up to 27.6 per cent by 44 SMW in the variety 2003 V 46.The observations on incidence of aphids and YLD in susceptible varieties revealed that aphids contribute significantly to the initial spread of YLD, from initial incidence of aphids and YLD in 29-30 SW up to 42-44 SMW when the aphids reach peak incidence and YLD also leaps to above 25 per cent. The aphid population exhibited positive correlation with maximum temperature (r^2=0.62), minimum temperature (r^2=0.55) and relative humidity I (r^2=0.65), whereas, negative correlation with rainfall (r^2=-0.63). The yellow leaf disease exhibited positive correlation with minimum temperature (r^2=0.75) and relative humidity I (r^2=0.67), whereas, negative correlation with rainfall (r^2=-0.63). The leaf and aphid samples were collected at peak incidence of Yellow leaf disease and were tested and found positive for presence of virus using ELISA reader at 405 nm.

Comment [LEGA1]: Too long, shorten.

Keywords: Yellow leaf disease, Sugarcane, aphid, weather.

Comment [LEGA2]: Do not repeat words presents in the title

INTRODUCTION

Sugarcane (*Saccharum* spp.) is one of the most important commercial crops grown mainly for sugar in many countries and also for bio energy production from its by-products bagasse and molasses. Sugarcane is also one of the important cash crops in India and plays pivotal role in both agricultural and industrial economy. 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 (FAOSTAT, 2020). It is being affected by several biotic factors like fungi, bacteria, viruses and phytoplasma causing reduction in production and productivity according to its severity. Among the viral diseases affecting sugarcane, Yellow leaf disease of sugarcane (Saccharum spp.) is an important and widely spread disease has attained epidemic proportions causing severe yield losses, ranging from 20 to 40 % in susceptible varieties (Lehrer *et al.*, 2008; Rassaby*et al.*, 2004). Globally yellow leaf disease severity and its impact on sugarcane productivity were reported from almost all the sugarcane growing countries. The disease severely reduces cane growth in terms of number of canes per clump, cane weight, juice quality and sugar yield. This disease is caused by the Sugarcane yellow leaf virus (SCYLV), a polerovirus vectored in a persistent, circulative, non-propagative manner by different aphid species (Arocha*et al.*, 1999; Cronje *et al.*, 1998). In India, it was first reported during the year since then its occurrence and severity continued in all the varieties (Viswanathan *et al.*, 2006). Yellow leaf spread by aphids depends on cultivar susceptibility and local epidemiological conditions as well as climatic parameters (Daugrois*et al.*,2011) and aphid predator populations. Temperature, relative humidity, sunshine hours, and rainfall all play a crucial role in the initiation and progression of plant disease over time (Bana *et al.*,2020). In this backdrop, the influence of weather, vector and variety on incidence of Yellow Leaf Disease in Sugarcane was studied at Regional Agricultural Research Station, Anakapalle, Andhra Pradesh.

MATERIALS AND METHODS

The research work was carried out at the Regional Agricultural Research Station, Anakapalle, Visakhapatnam, Andhra Pradesh during 2019-20 and 2020-21to investigate the

influence of weather parameters, vector population and variety on occurrence of yellow leaf disease in sugarcane under field conditions.

Cultivation of Sugarcane

The sugarcane crop was raised in bulk plots of 0.2 ha adopting a spacing of 90 cm between 2 rows for three varieties *viz.*, 2005A128, 2001A63and 2003V46. All recommended agronomical practices were adopted. The seed rate of 35,000 three budded setts ha^{-1} was used and fertilizers applied were 112 kg N/ha in two equal split doses at 45 and 90 days after planting, 100 kg P_2O_5 and 120 kg K_2o/ ha at basal. At a week to 15-20 days interval during summer and at monthly intervals during maturity phase. Intercultivation and weedings were taken up as per need. No plant protection measures were taken up during the entire crop growth period during both the seasons.

Aphid population

Population data for aphids (both adults and nymphs) in the sugarcane was recorded per leaf from ten clumps selected randomly in the plot of 0.2 ha and mean population data on aphid was calculated. Aphid population was recorded standard week-wise from initial appearance till crop maturity.

Yellow leaf disease incidence

Characteristic Yellow leaf disease symptoms such as midrib yellowing, laminar discolouration, drying of discoloured laminar tissues, bunching of leaves in the crown, progressive decline in the health of the plants were recorded. Ten cane clumps were randomly chosen and the total number of canes exhibiting Yellow leaf disease symptoms had been counted out of total canes and the percentage of disease occurrence was determined (Yadav *et.al.*, 2012).

$$Diseaseincidence(\%) = \frac{Totalnumberofinfectedcanes}{Totalnumberofcanesexamined} X100$$

Weather parameters

Data on weather parameters pertaining to minimum and maximum temperature, minimum and maximum percent of relative humidity and rainfall were collected following meteorological standard weeks from the observatory located at Regional Agricultural Research Station, Anakapalle.

Statistical analysis:

Using Microsoft Excel software, data on aphid population, yellow leaf disease incidence and weather parameters were statistically analyzed for correlation following the standard weather week (SMW) as per Steel and Torry,1980.

$$r_{xy} = \frac{\sum XY - \sum X \sum Y}{\sqrt{\left[\sum X^2 - \frac{\sum X^2}{n}\right] - \left[\sum Y^2 - \frac{\sum Y^2}{n}\right]}}$$

Where

$r_{xy} = Simplecorelationcoefficient$

X, Y = Variables (weather parameter/ aphid population/ yellow leaf disease)

n = Number of observations

The correlation coef icient (r)values were subjected to the test of signi icance using t − test

$$t = \frac{r}{\sqrt{1 - r^2}} X \sqrt{n - 2} \sim t_{n-2} d.f$$

The calculated t-value obtained was compared with tabulated t-value at 5% level of significance

Serological studies - DAS-ELISA

DAS-ELISA was carried out using the kit obtained from M/s. ACDiagnostics, USA (Code-V093-K1) following the standard protocol land observations were taken visually and the colour change wasobserved photo metrically at 405 nm using thermo fischer scientific Multi scan- X, ELISA reader and the readings were documented. DAS-ELISA test results were treated as positive if the absorbance value (OD 405) is more than 0.626 i.e., more than twotimes the OD 405 value of negative control (OD405 = 0.313), whereas, as negative if absorbance value is less than that value.

RESULTS

Sugarcane crop was raised in bulk plots of 0.2 ha adopting a spacing of 90 cm between 2 rows for three varieties *viz.*, 2005A128, 2001A63and 2003V46. The sugarcane crop growth period started from 24 SMW and lasted till 2 SMW of the consecutive year during both the years under study. Data on incidence of yellow leaf disease, aphid population and weather parameters were recorded for two consecutive years 2019-20 and 2020-21. Correlation studies were made between weather parameters, aphid population and yellow leaf disease incidence. The results obtained are presented.(Table 1 and 2 & graphs 1,2 and 3).

The aphid incidence on 2005 A 128 initiated (4.6 per leaf) at 30 SMW and gradually increased to 19.1 per leaf at 40 SMW and later gradually decreased to 0.2 per leaf in 2 SMW. In the variety 2001 A 63, the aphid incidence was first observed (2.2 per leaf) at 27 SMW and reached the peak population of 19.1 per leaf at 38 SMW and later declined to 0.0 per leaf in 2 SMW. The aphid incidence on 2003 V 46 initiated (2.1 per leaf) at 29 SMW and gradually increased to 18.1 per leaf at 42 SMW, which reduced to nil incidence by 1 SMW.

With regard to yellow leaf disease the incidence was first observed (1.0 per cent) at 26 SMW and reached the ~~peak(~~peak (28.7 per cent) at 37 SMW in the variety 2005 A 128. In the variety 2001 A 63, the incidence of yellow leaf disease was 1.8 per cent at 26 SMW which later on increased up to 29.4 per cent by 46 SMW. The incidence of yellow leaf disease was 3.5 per cent at 28 SMW which later on increased up to 27.6 per cent by 44 SMW in the variety 2003 V 46.The observations on incidence of aphids and YLD in susceptible varieties revealed that aphids contribute significantly to the initial spread of YLD (Graphs 1, 2 and 3), from initial incidence of aphids and YLD in 29-30 SW up to 42-44 SMW when the aphids reach peak incidence and YLD also leaps to above 25 per cent.

The peak incidence of aphids in all the varieties was noticed at the mean maximum temperature of 32.0-34.0 ^{O}C, mean minimum temperature of 24.0-26.0 ^{O}C, RH I of 85.0-90.0 per cent, RH II of 65.0-70.0 per cent and Rainfall of 5.0-10.0 mm. The aphid population exhibited positive correlation with maximum temperature (r^2=0.62), minimum temperature (r^2=0.55) and relative humidity(r^2=0.65), ~~whereas, negative~~whereas, negative correlation with rainfall(r^2=0.66).

The peak incidence of YLD in all the varieties was noticed at the mean maximum temperature of 30.0-35.0 ^{O}C, mean minimum temperature of 21.0-24.0 ^{O}C, RH I of 89.0-92.0 per cent, RH II of 65.0-70.0 per cent and Rainfall of 5.0-10.0 mm.The yellow leaf disease exhibited positive correlation with minimum temperature (r^2=0.75) and relative humidity I (r^2=0.67), whereas, negative correlation with rainfall (r^2=-0.63).

The samples of leaf tissue and aphids were collected at peak incidence of yellow leaf disease in the field from three varieties *viz.*, 2005A128, 2001A63and 2003V46. Visual observations on micro titre plate as well as ELISA readergave clear indication of the presence of the SCYLV inthe varieties as well as in the aphids with respectto colour change. All the six samples of three leaf samples and three aphid population samples from plants with typical YLD symptoms under field conditions were tested positive in DAS-ELISA, with OD 405 values(nm) ranging between 1.097 to 3.299.(Table 3 and Photograph 1).

DISCUSSION

The aphid incidence on 2005 A 128 initiated (4.6 per leaf) at 30 SMW and gradually increased to 19.1 per leaf at 40 SMW. In the variety 2001 A 63, the aphid incidence was first observed (2.2 per leaf) at 27 SMW and reached the peak population of 19.1 per leaf at 38 SMW. The aphid incidence on 2003 V 46 initiated (2.1 per leaf) at 29 SMW and gradually increased to 18.1 per leaf at 42 SMW. The incidence of aphids on sugarcane initiated in late June and July as per the findings of Akbar *et.al.*,2011 and McAl-lister *et.al.*,2008.

With regard to yellow leaf disease the incidence was first observed (1.0 per cent) at 26 SMW and reached the peak (28.7 per cent) at 37 SMW in the variety 2005 A 128. In the variety 2001 A 63, the incidence of yellow leaf disease was 1.8 per cent at 26 SMW which later on increased up to 29.4 per cent by 36 SMW. The incidence of yellow leaf disease was 3.5 per cent at 28 SMW which later on increased up to 27.6 per cent by 34 SMW in the variety 2003 V 46.~~However~~However, the peak yellow leaf disease incidence (29-32 per cent) was observed during 49 SMW and 2 SMW which is in consensus with the findings of Jeena*et.al.*,2022 and Mubeen *et.al.*,2020, who found that high incidence of yellow leaf disease was observed in December and January. The observations on incidence of aphids and YLD in susceptible varieties revealed that aphids contribute significantly to the initial spread of YLD, from initial

incidence of aphids and YLD in 29-30 SW up to 42-44 SMW when the aphids reach peak incidence and YLD also leaps to above 25 per cent.

The aphid population exhibited positive correlation with maximum temperature (r^2=0.62), minimum temperature (r^2=0.55) and relative humidity I (r^2=0.65), whereas, negative correlation with rainfall (r^2=-0.63). As per Lee *et.al*.,(., (2023) and Dampc*et.al.*,2021, temperature has a positive effect on aphid development. Relative humidity had positive effect on aphid population development as per the findings of Narjary*et.al.*,2013 and Kulat*et.al.*, (1997).

The yellow leaf disease exhibited positive correlation with minimum temperature (r^2=0.75) and relative humidity I (r^2=0.67), whereas, negative correlation with rainfall (r^2=-0.63). According to Jeena*et.al.*,2022 and Mandal *et.al.*, 2017 yellow leaf disease of sugarcane expressed significantly positive correlation with minimum temperature and relative humidity. Hence, it can be interpreted that warm and humid weather encourages the initiation of yellow leaf disease of sugarcane in the field and the disease reaches its peak during cool and fairly humid conditions.

The leaf and aphid samples were collected at peak incidence of Yellow leaf disease and were tested and found positive for presence of virus using ELISA reader at 405 nm. DAS-ELISA proved to be effective in detecting the SCYLV presence in leaf tissue and aphids as per the studies conducted by Viswanathan and Balamuralikrishnan(2004) and also Suresh and Umadevi(2018).

CONCLUSION

It is concluded from two years pooled data that, the aphid population exhibited positive correlation with maximum temperature (r^2=0.62), minimum temperature (r^2=0.55) and relative humidity I (r^2=0.65), whereas, negative correlation with rainfall (r^2=-0.66). The yellow leaf disease exhibited positive correlation with minimum temperature (r^2=0.75) and relative humidity I (r^2=0.67), whereas, negative correlation with rainfall (r^2=-0.63). It can also be deduced that aphids contribute significantly to the initial spread of YLD, from initial incidence of aphids and YLD in 29-30 SW up to 42-44 SMW when the aphids reach peak incidence and YLD also leaps to above 25 per cent.

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Table1: Incidence of aphids and yellow leaf disease in Sugarcane varieties

Std. week	2005A128		2001A63		2003V46	
	Aphids /leaf	YLD ~~Incidence(~~Incidence (%)	Aphids /leaf	YLD ~~Incidence(~~Incidence (%)	Aphids /leaf	YLD ~~Incidence(~~Incidence (%)
24	0.0	0.0	0.0	0.0	0.0	0.0

25	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	2.0	0.0	2.0	0.0	0.0
29	0.0	5.0	4.2	3.5	2.1	4.0
30	5.0	6.0	4.5	6.4	6.2	9.9
31	9.0	8.0	4.2	8.5	8.2	13.0
32	10.0	14.0	7.9	12.6	12.0	10.0
33	12.0	13.0	10.1	14.3	13.5	12.1
34	14.0	16.4	13.1	15.3	17.6	16.5
35	18.0	26.5	17.6	15.8	14.7	18.5
36	18.6	25.1	17.9	18.4	19.4	19.8
37	16.3	26.7	18.7	20.7	14.6	20.1
38	14.9	27.5	15.5	21.4	17.4	21.4
39	13.0	27.0	10.6	23.7	6.3	21.0
40	13.8	28.4	7.9	27.0	4.6	24.3
41	13.0	26.7	8.6	27.0	3.8	28.0
42	8.0	27.0	9.4	28.4	2.1	29.7
43	6.0	28.9	5.4	28.7	2	31.3
44	5.3	28.4	3.4	28.7	2.1	32.1
45	3.3	29	3.7	29.0	1.8	31.4
46	4.9	29.5	3.0	29.0	2.2	32.4
47	0.6	30.3	1.7	30.0	1.5	34.6
48	0.9	30.4	0.6	30.0	1.8	36.8
49	0.5	30.5	0.5	29.8	0.3	34.4
50	0.4	30.2	0.4	29	0.1	28.7
51	0.4	31.0	0.3	29.4	0.1	32.8
52	0.3	30.5	0.4	30.4	0.0	31.7
1	0.2	29.6	0.1	30.5	0.0	32.4
2	0.2	30.0	0.0	30.5	0.0	35.5

Table2: Correlation between aphids, yellow leaf disease and weather parameters in Sugarcane

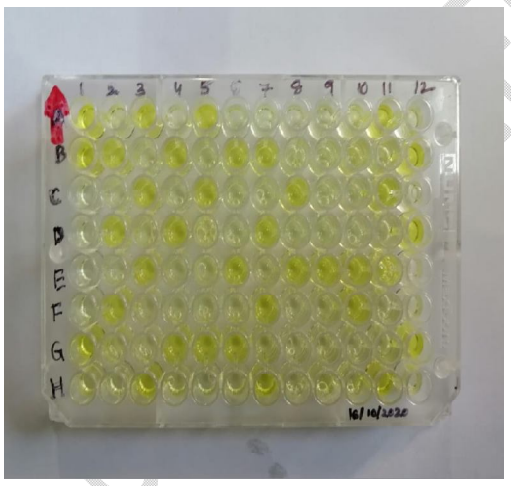
Particulars	T_{max}	T_{min}	RH I	RH II	Rainfall
Aphids	0.62	0.55	0.65	0.32	-0.66

Yellow leaf disease	0.48	0.75	0.67	0.46	-0.63

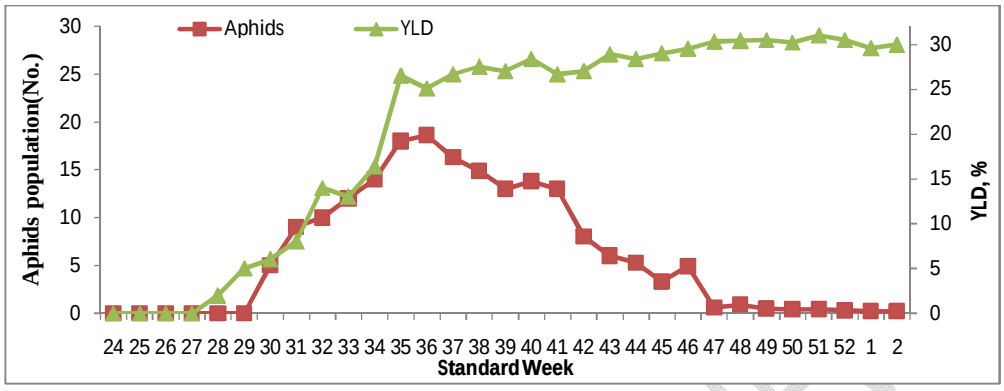
Table3: DAS-ELISA readings of yellow leaf disease infected sugarcane leaves and aphids

Variety	Values		Leaf sample	Aphid sample
2003 V 46	+ ve	3.725	1.756	2.507
	- ve	0.735		
2001 A 63	+ ve	3.693	2.005	2.167
	- ve	0.895		
2005 A 128	+ ve	3.957	2.123	2.344
	- ve	0.957		

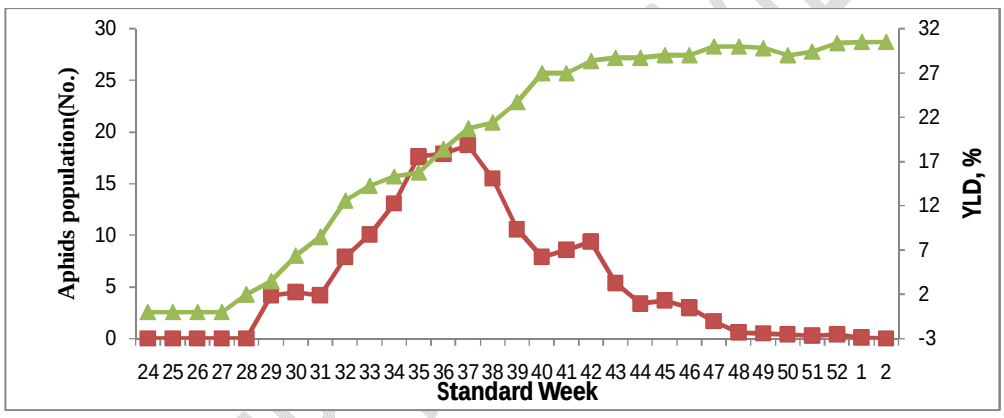
Photograph 1: DAS-ELISA readings of yellow leaf disease infected sugarcane leaves and aphids



Graph 1: Influence of weather on incidence of aphids, yellow leaf disease in variety 2005A128



Graph 2: Influence of weather on incidence of aphids, yellow leaf disease in variety 2001A63



Graph3: Influence of weather on incidence of aphids, yellow leaf disease in variety 2003V46