International Journal of Plant & Soil Science

20(6): 1-8, 2017; Article no.IJPSS.37614
ISSN: 2320-7035

Effects of Soil Edaphic Components on Incidence of Tomato Collar Rot Disease Caused by *Sclerotium rolfsii* (Sacc.)

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Authors' contributions

This work was carried out in collaboration between all authors. Author AM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MKB managed the analyses of the study. Authors AM and SP managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2017/37614
Editor(s):
(1) Abigail Ogbonna, Department of Plant Science and Technology, Faculty of Natural Sciences, University of Jos, Nigeria.
Reviewers:
(1) Ismet Yildirim, Duzce University, Turkey.
(2) Mokhtar Mohamed Abdel-kader, Egypt.
(3) Tariq Mukhtar, Pir Mehr Ali Shah Arid Agriculture University, Pakistan.
(4) Edgar Martinez Granja, Colombia.
Complete Peer review History: http://www.sciencedomain.org/review-history/22488

Original Research Article

Received 22nd October 2017
Accepted 18th December 2017
Published 28th December 2017

ABSTRACT

The collar rot caused by *Sclerotium rolfsii* is most destructive soil borne disease of tomato. The soil edaphic components *i.e.,* available soil Nitrogen (N), Phosphorous (P), Potassium (K), soil organic carbon, soil pH, soil moisture, soil texture and resting structures of plant pathogens etc. were reported to influence the disease incidence. Hence to know the relation between these components to disease development, experiments were carried out at Department of Plant Protection, Palli-Siksha Bhavana, Visva-Bharati during 2014-15. Soil samples were collected from tomato growing areas of red and lateritic zone of West Bengal and thereafter different soil edaphic components *viz.* available soil Nitrogen, Phosphorus, Potassium, organic carbon, soil pH, number of sclerotia of *S. rolfsii* was determined following the standard techniques. The disease incidence was also recorded during soil sample collection. Appropriate statistical tool was employed for correlation and

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regression analysis. Also to know the effect of soil texture, soil pH and soil moisture on the development of disease pot experiments were conducted during 2014-15. The soil analysis revealed that the available quantity of different soil edaphic components *i.e.,* Nitrogen (N), Phosphorous (P), Potassium (K), Organic carbon (OC), soil pH and No. of Sclerotia / gm of soil were ranged from 185.0 -488.0 kg/ha, 17.0-63 kg/ ha,122.0-446.0 kg/ ha, 0.33-0.98%, 5.1-6.6 and 0.2-1.2 respectively and disease incidence was ranged from 7.36% to 21.06% in red and lateritic zone of West Bengal. Disease incidence showed significantly positive correlation with available soil Nitrogen, Organic carbon, Soil pH and Sclerotia population of soil but negatively correlated with available soil Potassium (K) and Phosphorous (P). Sandy clay loam soil, 6.5-7.0 pH level, and 15% moisture level of soil found highly favorable for collar rot disease.

Keywords: Tomato; disease; collar rot; Sclerotium rolfsii; soil edaphic components.

1. INTRODUCTION

The tomato (*Solanum lycopersicon* L.) is one of the most important commercial vegetable crops throughout the world. It is rich in lycopene which is an active antioxidant present in vegetarian diet. India is the second largest producer of tomato. Area under tomato in India is about 8.82 lakh hectares and it is about 9.4% of the total cropped land under vegetables [1]. Annual production of tomato in India is about 18.73 million tonnes which is 11.5% of the total vegetable production [2]. The major tomato producing states are Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh and West Bengal. West Bengal has about 56.50 thousand hectares area under tomato cultivation with production base at 11.41 lakh tonnes and it contribute about 6.09% share of total production in India [2]. The collar rot disease caused by *Sclerotium rolfsii* (Sacc.) is one of theme which not only decreases the production but also deteriorate the quality of the produce. The pathogen is polyphagous, ubiquitous, omnipathogenic, facultative saprotroph and most destructive soil inhabitant, sclerotia forming fungus which causes wilting, blight, basal stem rot and fruit rot in tomato [3], [4] and [5]. As soil borne disease incidence is strongly influenced by soil edaphic components *i.e.,* available soil Nitrogen (N), Phosphorous (P), Potassium (K), soil organic carbon, Soil pH, Soil moisture, soil texture, population of resting structure and the biological activity of suppressive microorganisms. Organic matter is known to affect soil structure, aeration, drainage, moisture holding capacity, nutrient availability, and microbial ecology [6]. Hence, the present study was conducted to find out the role of soil edaphic components on collar rot incidence in tomato.

2. MATERIALS AND METHODS

2.1 Relationship between Collar Rot Incidence with Different Soil Edaphic Factors

To study the relationship between collar rot disease incidence with different soil edaphic factors composite soil samples from 0-15 cm depth were collected at the time of disease incidence survey at different locations of red and lateritic zone of West Bengal during 2014-15. In each place, field of more or less uniform size was selected at random and observation on the incidence of the diseases was recorded. The collected soil samples were analysed for various physico-chemical characters in laboratory i.e. available nitrogen (N), phosphorous (P), potassium (K), organic carbon, soil pH, pathogen population, soil texture and soil moisture. To estimate the available nitrogen (N) in collected soil sample, the 'alkaline permanganate method' [7] was used. Available phosphorus content of soil samples was estimated by Bray's No. 1 method [8] using spectrophotometer at 660 λnm. Available potassium of soil samples was determined in 1:5 ratio of soil: neutral normal ammonium acetate extract of the soil using flame photometer [9]. Organic carbon was determined by wet digestion method of Walkey and Black [10] as described by Jackson [9]. The soil pH was measured through 1:2.5 ratio of soil : water by pH meter [11]. The population density of *S. rolfsii* was determined by direct counting of viable sclerotia in soil [12]. Soil samples of 30 g air-dried, sieved soil were placed in 135 mm diameter dishes and watered to saturation. The dishes were sealed in plastic bags and incubated at 30 0C for 48 h. The bags were opened and the germinating sclerotia were counted.

2.2 Effect of Soil Texture, Soil pH and Soil Moisture on Disease Incidence

Pot experiments were conducted to know the effect of soil texture, soil pH and soil moisture on the development of disease, using one month old tomato seedlings (cv. Punjab Chuhara). The soil which used for experiments was sterilized by formaldehyde. Each plastic pot was filled with 2.5 kg sterilized soil. The pot soils were inoculated with 7 days old inoculums of *S. rolfsii* (@ 12.5 g kg^{-1} soil grown on wheat grains. Six pots were kept for each treatment as one replication and four replications were maintained. The pots were irrigated and covered with polythene sheet to allow inoculums establishment. Single seedlings per pot and twenty four pots per treatment were maintained. One seedling of tomato was sown in each pot and data on seedling death were recorded weekly after sowing, up to four weeks.

2.2.1 Effect of soil texture

In order to determine the efficacy of inoculums in different texture soil (*viz.,* silty loam, silty clay loam, sandy clay loam, clay loam and sandy) soil sample of different texture were collected from different places of red and lateritic zone of West Bengal and determined by the international pipette method [13].

2.2.2 Effect of soil moisture

Moisture levels *viz.,* 15, 20, 25, 30 and 35 per cent on weight basis, within the water holding capacity of soil were maintained throughout the study by adding required amount of water after every 24 hour by taking weight of each pot to assess the water loss [14].

2.2.3 Effect of soil pH

Sandy clay loam soil was used in this experiment. Six soil pH levels *viz.,* 5.5, 6.0, 6.5, 7.0, 7.5 and 8.0 tested in this study were maintained by adding sodium hydroxide solution for obtaining soil pH above 5.5 and 1N, 2N Sulphuric acid (H_2S0_4) for getting soil pH below 5.5 [15].

3. RESULTS AND DISCUSSION

3.1 Relationships between Collar Rot Incidence and Edaphic Components of Soil

The relationships between collar rot incidence and soil edaphic factors have been presented in Tables 1, 2 and Figs. 1, 2. The disease incidence was ranged from 7.36% to 21.06% in different locations of red and lateritic zone of West Bengal during 2014-15. The available quantity of different soil edaphic components *i.e.* Nitrogen (N), Phosphorous (P), Potassium (K), Organic carbon (OC), soil pH and Number of Sclerotia - gm^{-1} of soil were ranged from 185.0-488.0 kg-ha^{-1}, 17.0-63 kg- ha^{-1}, 122.0-446.0 kg- ha^{-1}, 0.33-0.98%, 5.1-6.6 and 0.2-1.2 nos respectively. In correlation coefficient study, the disease incidence showed significant positive correlation with available soil Nitrogen, Organic Carbon, Soil pH and Pathogen population where as negative correlation was recorded between Phosphate and Potassium. This finding also corroborated with the reports of Banyal et al. [16] where they noticed similar relationship between collar rot disease incidence and soil edaphic factors of different soils collected from of different locations of Himachal Pradesh.

3.2 Relationship between Soil Texture, Soil pH and Soil Moisture and the Incidence of Collar Rot

The relationships of different types of soil texture, soil pH and soil moisture on the incidence of collar rot disease have been presented in Table 3 (Figs. 3, 4 and 5). The incidence of collar rot varied with different soil textures. Maximum incidence (100%) was observed in sandy clay loam followed by sandy clay (88.33%), silt clay loam (56.67%), Clay loam (43.33%) and minimum disease incidence recorded in silt loam (36.67%) soils. Significant differences in disease incidence were noticed among different soil textures except in silt clay loam and clay loam soils. Wokocha [17] while studying the effect of soil type on damping of tomato seedling caused by *Sclerotium rolfsii* reported similar results. In agreement to above finding Hussain et al. [18] found that in clayey soil, seedling death was 94% whereas in clay loam, sandy loamy and sandy soils, it was 82, 78 and 60%, respectively. Seedling death in sandy soil was significantly less than that noted in all other types of soil. Banyal et al. [16] also reported that lighter soils were more favourable to the collar rot disease of tomato caused by *Sclerotium rolfsii* than the heavy textured soils.

It was indicated from Table 3 (Fig. 4) that highest incidence (100%) was recorded at 6.5 and 7.0 pH level and lowest incidence (51.67%) was recorded at 8.0 pH level. The pathogen prefers near acidic to alkaline soils for its growth and

proliferation as indicated from higher incidence at pH 5.5 to 7.5, though it grows on a wide pH range of 5.5 to 9.0. Prasad et al. [19] have found *in vitro* the pH range of 5.0 to 7.0 as best for sclerotial formation at different temperatures. Wide range of pH with optimum near 6.0 for the growth of various isolates of *Sclerotium rolfsii* have been reported by Aycock [3], Narasimhan [20] and Sharma and Kaushal [21]. Banyal et al. [16] reported that maximum death of tomato caused by *Sclerotium rolfsii* at 6.5-7.5 pH level in green house experiments.

Table 1. Incidence of collar rot of tomato, pathogen density and nutrient status of soils collected from different locations of red lateritic zone of West Bengal

Location	Disease incidence (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	OC (%)	Soil pH	Pathogen population (Sclerotia /g soil)
Hura (Daldali)	13.64	225	44.0	135.0	0.33	5.7	0.5
Raghunathpur-1 (Nanduara)	21.06	488	17.0	285.0	0.98	6.6	1.2
Chatna (Chatna)	15.36	390	50.0	229.0	0.75	5.4	0.6
Borjora (Borjora)	11.75	258	55.0	303.0	0.46	5.6	0.5
Bolpur Sriniketan (Benuria)	17.34	220	32.0	122.0	0.38	5.8	1
Ilambazar (Khayerbani)	9.65	225	35.0	357.0	0.54	5.3	0.3
Pandebeswar (Gobindapur)	7.36	285	58.0	446.0	0.4	5.1	0.2
Raniganj (Belebathan)	14.04	338	34.0	245.0	0.66	6.2	0.8
Gorbetha (Garberia)	9.48	185	42.0	367.0	0.44	5.2	0.2
Binpur (Binpur)	8.10	190	63.0	386.0	0.38	6.1	0.3

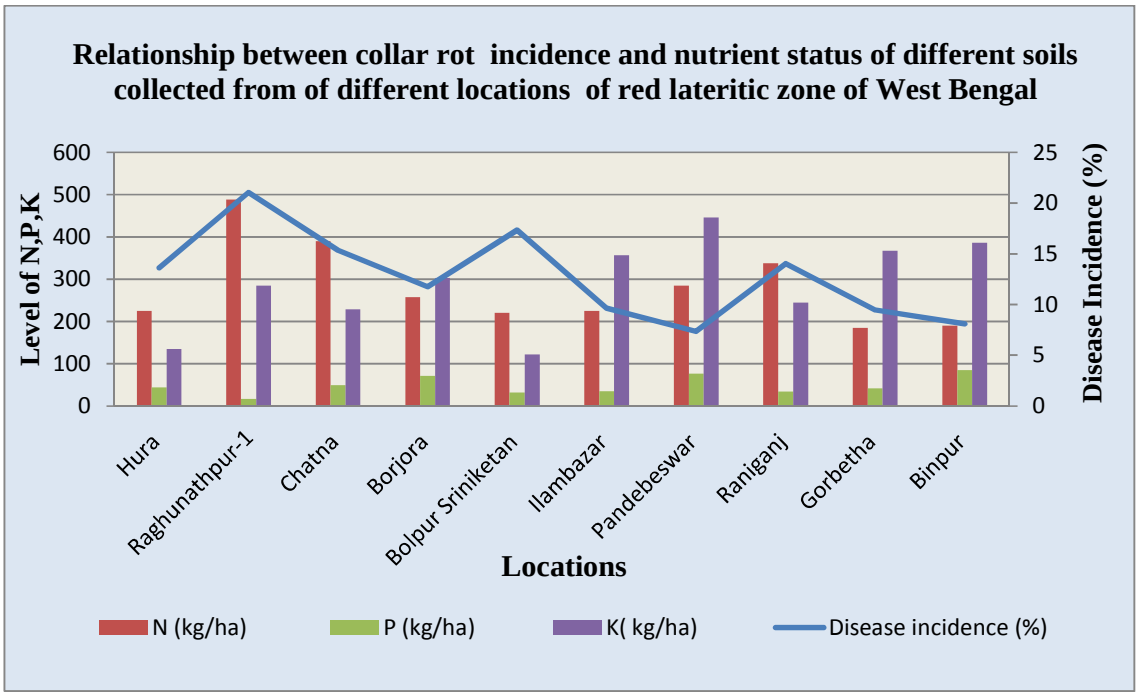

Fig. 1. Relationship between collar rot incidence and nutrient status of different soils collected from of different locations of red lateritic zone of West Bengal

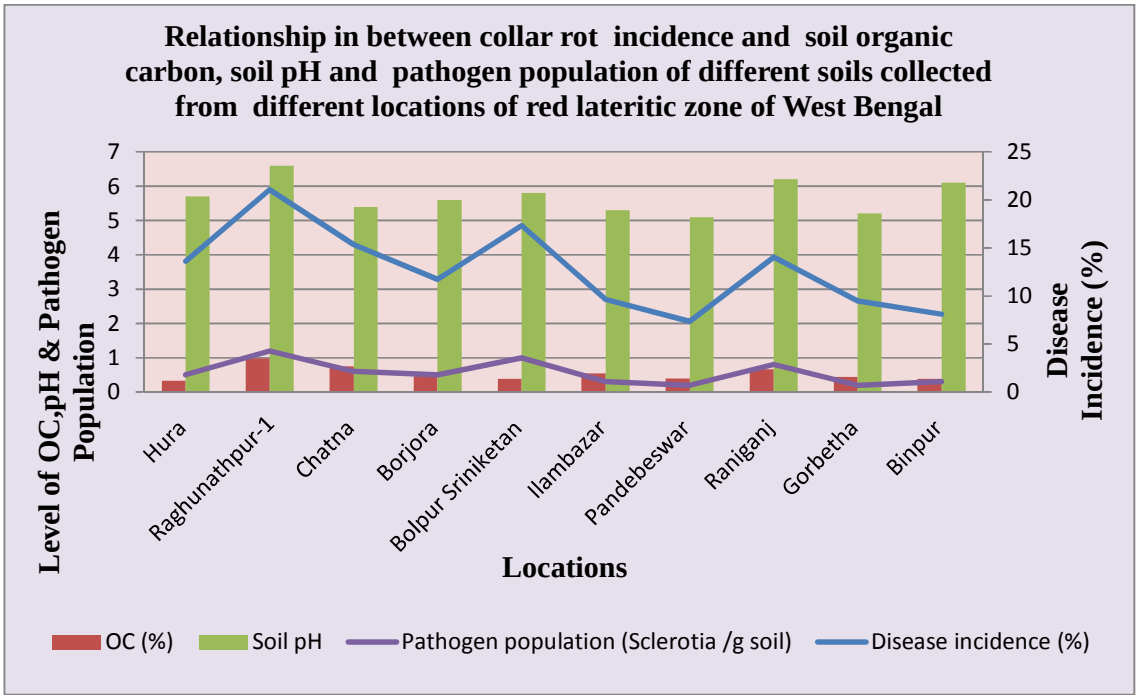

Fig. 2. Relationship between collar rot incidence and Soil organic carbon, Soil pH and pathogen population of different soils collected from different locations of red lateritic zone of West Bengal

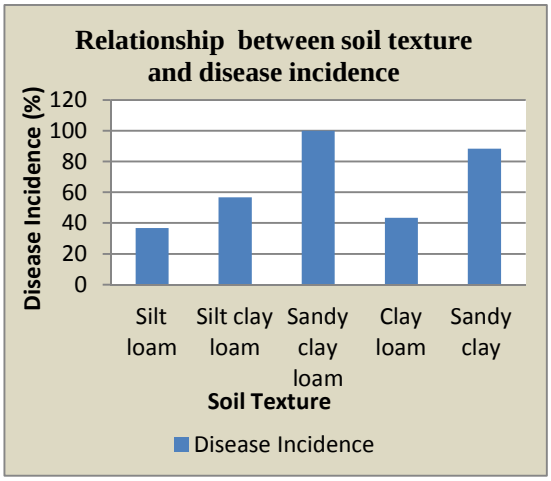

Fig. 3. Relationship between soil texture and disease incidence

It revealed from Table 3 (Fig. 5) that the collar rot disease incidence was decreases with the increases of moisture level. The maximum disease incidence (93.33%) was recorded at 15 % level of soil moisture where as lowest disease incidence (26.67%) at 35% level of soil moisture. Similar result was also reported by Tu et al. [22] and Banyal et al. [16] who have reported maximum disease incidence at 15 percent soil moisture level. Palakshappa et al. [23] and Devi et al. [24] reported better survival of S. *roltsii* at low soil moisture levels as compared to high moisture though the optimum level for the development of disease varied to some extent.

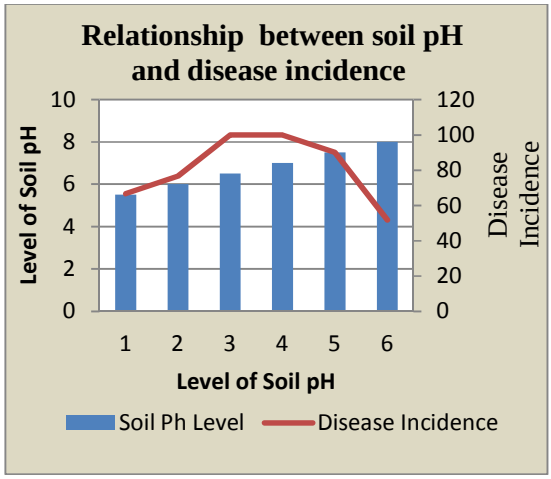

Fig. 4. Relationship between soil pH and disease incidence

Table 2. Simple correlation coefficient and linear regression analysis of collar rot incidence with pathogen population and soil factors

Factors	Simple correlation	Coefficient of multiple determination (R^2)	Equation
N (X_1)	0.693*	0.48	$Y=4.104 +0.031X_1$
P (X_2)	-0.758	0.58	$Y= 22.949-0.237X_2$
K (X_3)	-0.700	0.49	$Y=21.020-0.029X_3$
OC (%) (X_4)	0.620*	0.44	$Y=5.348+13.967X_4$
Soil pH (X_5)	0.640*	0.41	$Y=-5.785+ 20.19\ 8X_5$
Pathogen population (X_6)	0.955**	0.91	$Y=5.993+12.116X_6$

**Significant at 5% and ** significant at 1% level of significance*

Table 3. Effect of soil texture, soil pH and soil moisture on the incidence of collar rot disease

Soil texture		Soil pH		Soil moisture	
Texture	**Disease incidence (%)**	**pH**	**Disease incidence (%)**	**Moisture (%)**	**Disease incidence (%)**
Silt loam	36.67 (37.17)	5.5	66.67 (54.79)	15	93.33 (79.62)
Silt clay loam	56.67 (48.88)	6.0	76.67 (61.42)	20	83.33 (66.49)
Sandy clay loam	100.00 (90.00)	6.5	100.00 (90.00)	25	43.33 (41.12)
Clay loam	43.33 (41.12)	7.0	100.00 (90.00)	30	35.00 (36.04)
Sandy clay	88.33 (73.13)	7.5	90.00 (74.26)	35	26.67 (30.62)
-	-	8.0	51.67 (45.99)	-	-
Sem ∓	3.52		3.05		4.21
CD (p=0.05)	10.60		9.05		12.70
CV	12.11		8.78		16.60

Note: Figures in parenthesis are angular transformed values

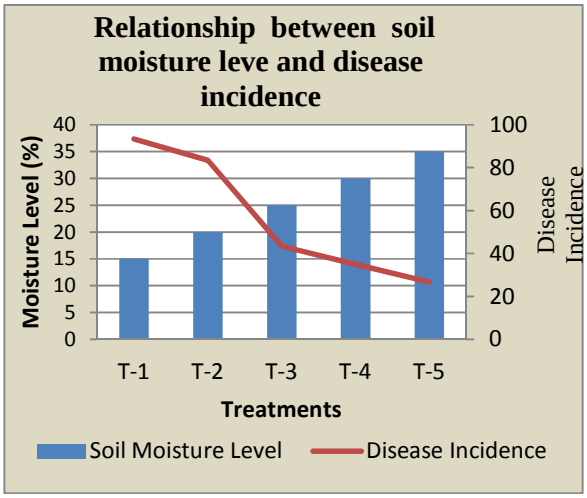

Fig. 5. Relationship between soil moisture level and disease incidence

4. CONCLUSION

Tomato collar rot caused by *Sclerotium rolfsii* was prevalent in all the districts of undulating red and lateritic agro-climatic zone of West Bengal (India) and the disease incidence showed significantly positive correlation with the available soil Nitrogen (N), Organic carbon (OC), Soil pH and Sclerotia population of soil but negatively correlated with the available soil Potassium (K) and Phosphorous (P). Sandy clay loam soil, 6.5-7.0 pH level and 15% moisture level of soil showed highly favourable conditions for collar rot disease incidence.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/22488