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Original Research Article

Epidemiological Relations to *Phytophthora* Spp. Causing Citrus Root Rot in Nagpur Mandarin

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Keywords

Nagpur mandarin, root rot, intensity, incidence

A B S T R A C T

Epidemics caused by *Phytophthora* spp. were monitored in four commercial citrus orchards to plot correlation between environmental and soil factors with root rot disease caused by *Phytophthora* spp. in citrus. Agro-meteorological data was recorded by using wireless sensors (for air temperature 107 Temperature probe, for relative humidity HC2S3 with 30 minutes time interval for both the sensors and for rainfall measurement Texas Electronic rain gauge) in selected plots. The soil moisture, soil pH and soil EC was recorded at fortnightly interval. The observations recorded in order to characterise the progression of the symptoms expression over the time and to provide evidence for the possible correlation of inoculum dynamics with root rot and environmental factors. The relationship of rainfall, temperature, relative humidity, soil moisture, soil pH and soil EC on disease development was investigated. Sensor based data was recorded for rainfall, temperature, relative humidity and converted to forth nightly interval. The disease progress and inoculum potential recorded at forth nightly interval from June 2016 to May 2017. There was significant progression in the disease development with the increase in the rainfall and soil moisture. There was significant increase in the disease at second fort night of August (38.53%) and progression continued up to October (87.58%). Progress in disease was attributed to increase in soil moisture, relative humidity and decrease in the air temperature. A tendency of spreading the disease at adjoining trees was observed. Drainage of water, possibly containing propagules of the pathogen may have been responsible for disease progression. The disease initially low but gradually increases with time. There was positive correlation between rainfalls, soil moisture, relative humidity, soil EC with disease progression and inverse correlation with air temperature.

Introduction

Citrus decline has been a wide spread problem in central India and Phytophthora disease has been identified as the major cause of decline. *Phytophthora* spp. *i.e. Phytophthora nicotianae, Phytophthora palmivora* and *Phytophthora citrophthora* causing severe losses to citrus plants from nursery level to various stages of plant growth in the form of root rot, collar rot, crown rot, gummosis and brown rot in orchards, damping off and root rot in seed beds and nurseries appear to be the major cause of citrus decline. The survey of citrus nursery in central India revealed 24% mortality of nursery plants due to root rot and collar rot diseases in virgin areas.

Diseases cause tremendous losses in Citrus nurseries and orchards. Foot rot, root rot, Collar rot, crown rot, gummosis caused by *Phytophthora* spp. (Naqvi, 1999; Gade and Armarkar, 2011).

Phytophthora root rot is one of the most important soil borne diseases of Nagpur mandarin causing mortality, slow decline and yield loss of mature trees. All citrus orchards in central India and other citrus cultivation belts of India are infected by Phytophthora diseases. More than 20 per cent seedling mortality has been reported in central India due to *Phytophthora* spp. in Madhya Pradesh adjoining to Vidarbha region of Maharashtra, 20-50% Nagpur mandarin plants were found to be affected resulting in severe decline due to *P. parasitica*, *P. citrophthora* along with *P. palmivora*. In Andhra Pradesh also, 20-100% acid lime plantation was severely affected with *P. parasitica* along with *P. citropthora* and *P. palmivora*. In kinnow growing areas of Punjab state,10-80% plants of *C. sinensis* and 10-100% plants of kinnow mandarin (12-25 years old) showed symptoms of diseases caused by *P. parasitica*, *P. citrophthora* and *P. palmivora* due to excessive flood irrigation (Savita *et al.*, 2012).

Correlation of environmental factor *viz*., relative humidity, temperature and rainfall with Phytophthora root rot epidemic in citrus has the potential to provide important information for management of the disease. Since high soil moisture is correlated with increase in incidence and severity of root rot caused by *Phytophthora* spp. in many crops. Thus, correlation of environmental factors with the disease will be valuable tool for epidemiological studies of this pathogen and may be important for the development of suitable management strategies (Benson *et al.*, 2006).

The amount of rainfall and frequency of irrigation can have large effect on the rate of development of phytophthora, amount of pathogen spread. The dispersal of inoculums down row in surface rain of irrigation leads the rate of disease development (Shew, 1987).

Phytophthora nicotianae was present consistently while incidence of *Phytophthora citrophthora* was greatest in the soil during low temperature and then decreased with increased temperature. This behaviour confirmed hypothesis that *P. citrophthora* could attack citrus root during cool period (Goldschmidt and Golomb, 1982). Studies showed that peak period of disease expression was November-January after high rainfall in August because many studies have demonstrated importance of water in the development and spread of disease (Cafe-Filho *et al.*, 1995) The peak period of disease expression was August-September which was concomitant with heavy rainfall, high humidity percentage and optimum temperature range 18–35^{o}C (Singh, 2002).

In relation of H- ion concentration it was found in avocado that there was no significant difference in the disease progression in range of 3.5 and 8.0 (Bingham and Zentmyer, 1958). However salinity in soil favours in increasing the population of *Phytophthora parasitica* in citrus. When rootstocks are exposed to high levels of salinity (EC = 22 dS/m) before inoculation, those of in sweet orange cultivar pineapple were predisposed to severe root rot, whereas, Troyer citrange was unaffected. However, Troyer seedlings grown for 9 week in soil salinized to an EC of 3-4 dS/m and infested with *P. parasitica* had 30% of their total root length decayed by Phytophthora, whereas plants in infested non-saline soil had only 10% decay. Similar results were obtained with pineapple, sweet orange seedlings at even lower levels of soil salinity (Blanker and Donald, 1986).

The purpose of disease study was to describe epidemiology of Phytophthora root rot in citrus field in relationship to dispersal of *Phytophthora* spp. from disease foci and importance of inoculum sources. We correlated field parameters such as rainfall, temperature, relative humidity, soil moisture, soil p^H and soil EC with Phytophthora root rot. Result analysis may provide insight into management consideration for growers.

Epidemiological study of the pathogen will be helpful to estimate Phytophthora severity and also it is useful for getting advanced information that how many sprays are needed during a growing season as a function of the weather and to prevent occurrence of Phytophthora diseases.

Materials and Methods

Experimental plots

The experiment was conducted at six fixed locations (villages) *viz.* plot A and plot –B (Nagziri), plot C (Goregaon), plot D (Bargaon) and plot E and F (Benoda) in Warud tahsil of Amravati district.

Collection of weather and soil factors data

The data on relative humidity and temperature was recorded with 30 minutes interval and received rainfall measured without any interval by the wireless sensors installed in each location (selected experimental plots) with the collaboration of IIT, Bombay and IIT, Hyderabad. The sensors *viz*. Model 107 Temperature probe based on Thermistor principle; HC2S3 used to measure relative humidity on principle of ratio of actual vapour pressure to saturation vapour pressure and Texas Electronic rain gauge 0.01 inch (0.254 mm) were used. The HC2S3 sensors used for measuring relative humidity in the range of 0 to 100% RH, Temperature probe used for measuring air temperature in the range of -40°C to 60^{o}C, and Texas Electronic rain gauge used for measurement of rainfall. Air temperature, relative humidity and rainfall probes typically consist of three separate sensors packaged in the same farm tower in all selected plots.

The soil moisture measured within 24 hours of soil sample collection by using electronic soil moisture meter at department of Horticulture, Dr. P.D.K.V., Akola, while soil p^H meter and soil EC meter were used for measurement of soil pH and EC at Department of Soil science and Agricultural Chemistry, Dr. P.D.K.V., Akola. Soil factors (soil moisture, pH and EC) were analysed at 15 days regular interval from collected soil samples.

Development of disease rating scale for disease intensity

The intensity of root rot of citrus was recorded on the basis of levels of visible symptoms that showed dulling, yellowing, browning of leaves with some eventually dropping off and drying of branches.

The modified disease rating scale (Gade and Koche, 2012) was adopted for recording the data of disease intensity.

Environmental parameters *viz*., relative humidity, temperature and rainfall were correlated with population of Phytophthora and intensity of root rot of citrus. Statistical analysis was performed by using analysis of variance. Means were tested by significance and critical differences were used for comparison (Gomez and Gomez, 1984).

Disease intensity and incidence of root rot in Nagpur mandarin

Data on root rot incidence and intensity in Nagpur mandarin orchards at 15 days regular interval was carried out in Warud tahsil of Amravati district during the period of June 2016 to May 2017. Six different experimental fields Viz. Plot A, B, C, D, E and F were selected for forth nightly observations on incidence and intensity of root rot and soil samples were collected from these Nagpur mandarin orchards.

Results and Discussion

Six different plots were selected to study the correlation of environmental and soil factors with root rot intensity and incidence of Nagpur mandarin in selected plots. The correlations were worked out at fifteen days intervals in selected plots. Three species of Phytophthora *i.e. Phytophthora palmivora*, *P. nicotianae*, and *P. citrophthora* were associated with root rot in selected plots.

Present results of relative humidity, soil moisture, soil pH, soil EC, rainfall and temperature were correlated with disease intensity and incidence in Nagpur mandarin. The results presented in Table 1 shows that highest disease intensity was observed in plot B (38.53%) in first forth night of August with high relative humidity (83.80%), rainfall (181.50 mm), temperature (21.54ºC), soil moisture (29.33%), pH (7.60) and EC (0.32 dS/m), followed by 38.31% and 37.48% in plot C and F, respectively during the same period. The lowest disease intensity was found in plot D in first forth night of June (12.03%). Similarly the data presented in Table 2 evident that, highest disease incidence (87.58%) was recorded in plot C in second forth night of October with relative humidity (78.94%), rainfall (1.23 mm), temperature (30.84ºC), soil moisture (25.03%), p^H (7.30) and EC (0.32 dS/m), followed (87.50%) root rot incidence in first forth night of November in both B and F plots. The lowest disease incidence was recorded in second forth night of May in plot D (29.00%). The intensity and incidence of Nagpur mandarin root rot was related with environmental and soil factors for knowing which factors are responsible for increasing disease severity.

These findings are in agreements with (Benson, 1984 and Duniway, 1975) who reported that development of Phytophthora root rot in landscape and nursery crop is favoured by soil moisture near saturation in the root zone which is critical in sporangium production, zoospore release and subsequent infection of host root tips. The present results confirm the findings of Tsao (1959) observed that low p^H contain reduced the incidence of root rot caused *Phytophthora nicotiana* in citrus. The work carried out by Workneh *et al.*, (1993) who established negative correlation between electrical conductivity and the presence of *P. parasitica* or the incidence of the disease in tomato plant but the present finding are in contrast with this result may be due the variation in soil conditions of different continents. Since the H-ion concentration was increased from pH 6.0 to 3.5 the disease decreased markedly (Bingham and Zentmyer, 1958). Wagh (2016) conducted fixed plot survey for root rot incidence and intensity during the period June 2015- May 2016 and recorded incidence of root rot in the range of 29.17 to 83.33% while intensity in the range of 12.96 to 39.64%.

Environmental and soil parameters *viz.*, mean relative humidity, rainfall, temperature, soil moisture, soil pH and soil

EC were correlated with root rot intensity of Nagpur mandarin in Nagpur mandarin orchards. It is seen from results presented in Table 3 (Figure A and B) that positively significant correlations existed between mean relative humidity, soil moisture, p^H, EC and rainfall (plot A). The correlation between rainfall, temperature (except plot A and B) and root rot of Nagpur mandarin were negatively non-significant in all plots.

Similarly environmental and soil parameters were correlated with root rot incidence in selected orchards. It is seen from results presented in Table 3 (Figure C and D) that positively significant correlations existed between mean relative humidity, soil moisture, p^H, EC and rainfall (plot A). The correlation between temperature (except plot A and B) and root rot of Nagpur mandarin were negatively non-significant in all plots. The negatively significant correlations of Nagpur mandarin root rot and mean temperature were existed in plot A and B. These finding are in support of (Benson *et al.*, 1986), who conducted studies on temporal and spatial analysis of Phytophthora root rot epidemics in Fraser fir. High soil moisture is an important factor for disease development in Nagpur mandarin. High soil moisture is also correlated with increased in incidence and severity of root rot caused by *P. cinnamomi* in many crops such as avocado (*Persea Americana*) (Zentmyer and Richards, 1952). The present findings are also in supported of Benson *et al.*, (2006). The excessive soil moisture favours the sporulation and infection by the existing inoculums of the pathogen. There is a possibility that the dispersal of *Phytophthora* spp. through either root to root contact or movement of inoculum from infected trees through irrigation water. The progression of symptoms expression supported that the infection most often began in the roots and increase with time during favourable environmental factors *viz.* Rainfall, soil moisture, relative humidity and temperature in the range of 20^oC to 25^oC. The outbreaks of the disease are usually associated with several consecutive rains even and occur mostly during August to October months.

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Development of disease rating scale for disease intensity

Scale	Remark
0	No yellowing
1	Yellowing of leaves and leaf fall (1-10%)
3	Yellowing of leaves and leaf fall (11-25%)
5	Yellowing of leaves and leaf fall (26-50%)
7	Above 50% Yellowing of leaves and leaf fall
9	Drying of branches

Table.1 Effect of environmental and soil factors on intensity of root rot in Nagpur mandarin

Tr. No.	Month	Rainfall (mm)	Humidity (%)	Temp. (°C)	Soil moisture (%)	p^H	EC (dS/m)	Intensity of root rot (%)						Mean
								Plot A (Nagziri)	Plot B (Nagziri)	Plot C (Goregaon)	Plot D (Bargaon)	Plot E (Benoda)	Plot F (Benoda)	
T_1	June-1	109.50	65.32	23.22	22.44	7.30	0.25	17.59* (24.80)**	12.49 (20.70)	14.35 (22.26)	12.03 (20.29)	18.05 (25.14)	13.42 (21.49)	14.66
T_2	June-2	108.70	65.71	23.87	24.51	7.34	0.26	20.69 (27.06)	19.69 (26.34)	21.62 (27.71)	17.51 (24.74)	19.79 (26.41)	17.51 (24.74)	19.47
T_3	July-1	108.50	65.80	24.56	25.14	7.41	0.28	24.04 (29.36)	22.22 (28.12)	23.61 (29.07)	20.69 (27.06)	19.69 (26.36)	17.51 (24.74)	21.29
T_4	July-2	90.70	72.45	22.51	27.38	7.44	0.31	25.59 (30.39)	25.00 (30.00)	26.37 (30.90)	22.68 (28.44)	25.00 (30.00)	22.25 (28.14)	24.48
T_5	August-1	186.00	80.51	20.56	29.41	7.51	0.33	34.92 (36.22)	35.77 (36.73)	37.44 (37.73)	30.53 (33.54)	31.73 (34.28)	34.98 (36.26)	34.23
T_6	August-2	181.50	83.80	21.54	29.33	7.60	0.32	36.48 (37.16)	38.53 (38.37)	38.31 (38.24)	35.40 (36.51)	35.09 (36.33)	37.48 (37.75)	36.88
T_7	September-1	123.00	82.65	22.64	30.27	7.74	0.34	33.71 (35.49)	34.79 (36.14)	36.18 (36.98)	34.57 (36.01)	33.11 (35.13)	35.18 (36.38)	34.59
T_8	September-2	111.80	81.03	28.49	24.27	7.76	0.35	30.09 (33.27)	32.65 (34.85)	35.81 (36.76)	31.35 (34.05)	30.81 (33.72)	32.81 (34.95)	32.25
T_9	October-1	4.87	76.50	29.84	26.51	7.40	0.34	29.61 (32.97)	35.18 (36.38)	34.08 (35.72)	33.13 (35.14)	30.35 (33.43)	29.81 (33.09)	32.03
T_{10}	October-2	1.23	78.94	30.84	25.03	7.30	0.32	27.59 (31.69)	33.33 (35.26)	34.51 (35.98)	34.42 (35.92)	28.53 (32.29)	28.37 (32.18)	31.13
T_{11}	November-1	0.60	65.12	32.85	24.54	7.34	0.33	28.32 (32.15)	30.63 (33.60)	33.49 (35.26)	34.39 (35.90)	26.76 (31.15)	27.74 (31.78)	30.22
T_{12}	November-2	0.20	66.84	31.54	23.8	7.28	0.31	23.05 (28.69)	29.08 (32.63)	30.68 (33.63)	31.26 (33.99)	27.92 (31.10)	26.91 (31.25)	28.15
T_{13}	December-1	00.00	68.81	33.61	22.71	7.36	0.30	22.31 (28.19)	24.29 (29.53)	26.20 (30.79)	25.78 (30.51)	27.61 (31.70)	27.98 (31.94)	25.70
T_{14}	December-2	00.00	69.51	34.65	21.11	7.30	0.29	25.00 (30.00)	26.37 (30.90)	30.53 (33.54)	30.53 (33.54)	31.35 (31.90)	30.53 (31.25)	29.05
T_{15}	January-1	00.00	55.31	34.70	21.05	7.29	0.29	25.00 (30.00)	25.00 (30.00)	29.81 (33.09)	28.81 (32.46)	30.53 (33.54)	29.81 (33.09)	28.16
T_{16}	January-2	00.00	53.10	34.10	20.80	7.30	0.28	24.48 (29.65)	24.48 (29.65)	28.81 (32.46)	27.74 (31.78)	28.81 (32.46)	28.37 (32.18)	27.12
T_{17}	February-1	00.00	48.60	35.80	20.45	7.28	0.30	25.00 (30.00)	23.61 (29.07)	27.74 (31.78)	26.37 (30.90)	29.81 (33.09)	27.74 (31.78)	26.71
T_{18}	February-2	00.00	42.75	35.40	20.10	7.26	0.29	24.48 (29.65)	22.68 (28.44)	26.37 (30.90)	25.00 (30.00)	27.74 (31.78)	26.91 (31.25)	25.53
T_{19}	March-1	00.00	35.23	35.38	19.86	7.25	0.27	23.61 (29.07)	20.69 (27.06)	25.00 (30.00)	24.48 (29.65)	26.37 (30.90)	25.00 (30.00)	24.19
T_{20}	March-2	00.00	29.66	35.50	19.77	7.25	0.28	22.68 (28.44)	19.69(26.34)	24.48 (29.65)	23.61 (29.07)	25.00 (30.00)	24.48 (29.65)	23.32
T_{21}	April-1	00.00	25.30	36.20	19.65	7.24	0.27	21.41 (27.56)	18.05 (25.14)	23.61 (29.07)	22.68 (28.44)	24.48 (29.65)	23.61 (29.07)	22.31
T_{22}	April-2	00.00	23.11	38.65	18.62	7.25	0.26	20.69 (27.06)	17.51 (24.74)	22.68 (28.44)	20.69 (27.06)	23.61 (29.07)	22.68 (28.44)	21.31
T_{23}	May-1	00.00	20.71	42.12	18.50	7.22	0.25	19.69 (26.36)	15.55 (23.22)	20.69 (27.06)	18.05 (25.14)	22.68 (28.44)	20.69 (27.06)	19.56
T_{24}	May -2	00.00	19.30	43.22	18.21	7.21	0.26	18.05 (25.14)	14.32 (22.24)	19.69 (26.34)	17.09 (24.42)	20.69 (27.06)	19.69 (26.34)	18.26
	F Test							Sig	Sig	Sig	Sig	Sig	Sig	
	GM							25.17	25.07	28.00	26.20	26.90	26.31	
	SE(m)±							0.54	0.50	0.54	0.48	0.53	0.47	
	CD@5 %							1.55	1.42	1.54	1.37	1.52	1.35	

*Average of three replications

** Values in parenthesis are arc sine transformed.

Table.2 Effect of environmental and soil factors on incidence of root rot in Nagpur mandarin

Tr. No.	Month	Rainfall (mm)	Humidity (%)	Temp. (^oC)	Soil moisture (%)	p^H	EC (dS/m)	Incidence of root rot (%)						Mean
								Plot A (Nagziri)	Plot B (Nagziri)	Plot C (Goregaon)	Plot D (Bargaon)	Plot E (Benoda)	Plot F (Benoda)	
T_1	June-1	109.50	65.32	23.22	22.44	7.30	0.25	33.33* (35.26)**	29.17 (32.69)	29.17 (32.69)	29.17 (32.69)	33.33 (35.26)	37.50 (37.76)	31.95
T_2	June-2	108.70	65.71	23.87	24.51	7.34	0.26	45.83 (42.61)	31.94 (34.41)	41.67 (40.20)	33.33 (35.26)	45.83 (42.61)	37.50 (37.76)	39.35
T_3	July-1	108.50	65.80	24.56	25.14	7.41	0.28	54.17 (47.59)	50.00 (45.00)	54.18 (47.40)	41.67 (40.20)	45.83 (42.61)	45.83 (42.61)	48.61
T_4	July-2	90.70	72.45	22.51	27.38	7.44	0.31	54.17 (47.39)	50.00 (45.00)	45.83 (42.61)	58.33 (49.80)	41.67 (40.20)	58.99 (50.18)	51.50
T_5	August-1	186.00	80.51	20.56	29.41	7.51	0.33	58.33 (49.80)	54.17 (47.39)	58.33 (49.80)	62.50 (52.24)	54.17 (47.39)	62.50 (52.24)	58.33
T_6	August-2	181.50	83.80	21.54	29.33	7.60	0.32	66.67 (54.74)	62.50 (52.24)	62.50 (52.24)	66.67 (54.74)	62.50 (52.24)	66.67 (54.74)	64.59
T_7	September-1	123.00	82.65	22.64	30.27	7.74	0.34	75.00 (60.00)	66.67 (54.74)	70.83 (57.31)	75.00 (60.00)	70.83 (57.31)	70.50 (57.10)	71.47
T_8	September-2	111.80	81.03	28.49	24.27	7.76	0.35	70.83 (57.31)	75.00 (60.00)	75.00 (60.00)	70.83 (57.31)	75.00 (60.00)	75.00 (60.00)	73.61
T_9	October-1	4.87	76.50	29.84	26.51	7.40	0.34	75.00 (60.00)	79.17 (62.85)	80.19 (63.57)	75.00 (60.00)	80.55 (63.83)	80.94 (64.11)	78.48
T_{10}	October-2	1.23	78.94	30.84	25.03	7.30	0.32	80.55 (63.83)	80.19 (63.57)	87.58 (69.50)	83.33 (65.90)	85.50 (67.62)	83.33 (65.90)	83.40
T_{11}	November-1	0.60	65.12	32.85	24.54	7.34	0.33	79.17 (62.85)	87.50 (69.30)	75.00 (60.00)	81.94 (64.85)	83.33 (65.90)	87.50 (69.30)	82.41
T_{12}	November-2	0.20	66.84	31.54	23.8	7.28	0.31	72.75 (58.53)	83.33 (65.90)	83.33 (65.90)	77.78 (61.81)	81.94 (64.85)	81.94 (64.85)	80.18
T_{13}	December-1	00.00	68.81	33.61	22.71	7.36	0.30	66.67 (54.74)	77.78 (61.88)	77.78 (61.88)	70.83 (57.31)	80.55 (63.83)	80.55 (63.83)	75.69
T_{14}	December-2	00.00	69.51	34.65	21.11	7.30	0.29	70.83 (57.31)	80.18 (63.56)	81.94 (64.85)	75.00 (60.00)	81.94 (64.85)	82.41 (65.20)	78.72
T_{15}	January-1	00.00	55.31	34.70	21.05	7.29	0.29	60.67 (51.16)	77.18 (61.40)	79.17 (62.85)	72.75 (58.53)	79.17 (62.85)	80.55 (63.83)	74.92
T_{16}	January-2	00.00	53.10	34.10	20.80	7.30	0.28	64.59 (53.48)	75.00 (60.00)	78.48 (62.36)	66.67 (54.74)	78.48 (62.36)	77.18 (61.45)	73.40
T_{17}	February-1	00.00	48.60	35.80	20.45	7.28	0.30	62.50 (52.24)	71.47 (57.71)	75.00 (60.00)	62.50 (52.24)	75.00 (60.00)	71.47 (57.71)	69.66
T_{18}	February-2	00.00	42.75	35.40	20.10	7.26	0.29	58.33 (49.80)	66.67 (54.74)	66.67 (54.74)	58.33 (49.80)	66.67 (54.74)	62.50 (52.24)	63.20
T_{19}	March-1	00.00	35.23	35.38	19.86	7.25	0.27	51.50 (45.860	58.33 (49.80)	54.17 (47.49)	51.50 (45.86)	54.17 (47.39)	58.33 (49.80)	54.67
T_{20}	March-2	00.00	29.66	35.50	19.77	7.25	0.28	50.00 (45.00)	51.50 (45.86)	50.00 (45.00)	45.83 (42.61)	50.00 (45.00)	54.17 (47.39)	50.25
T_{21}	April-1	00.00	25.30	36.20	19.65	7.24	0.27	45.83 (42.61)	50.00 (45.00)	45.83 (42.61)	41.67 (40.20)	45.83 (42.61)	50.00 (45.00)	46.53
T_{22}	April-2	00.00	23.11	38.65	18.62	7.25	0.26	41.67 (40.20)	45.83 (42.61)	41.67 (40.20)	37.27 (37.63)	41.67 (40.20)	45.83 (42.61)	42.32
T_{23}	May-1	00.00	20.71	42.12	18.50	7.22	0.25	37.27 (37.63)	41.67 (40.200	37.27 (37.63)	33.33 (35.26)	37.27 (37.63)	41.67 (40.20)	38.08
T_{24}	May -2	00.00	19.30	43.22	18.21	7.21	0.26	34.09 (35.720	37.27 (37.63)	33.33 (35.26)	29.00 (32.49)	34.03 (35.69)	34.03 (35.69)	33.65
	F Test							Sig	Sig	Sig	Sig	Sig	Sig	
	GM							58.74	61.77	61.87	58.35	61.89	63.62	
	SE(m)±							1.18	1.15	1.14	1.13	1.10	1.22	
	CD@5 %							3.36	3.26	3.26	3.22	3.12	3.49	

*Average of three replications

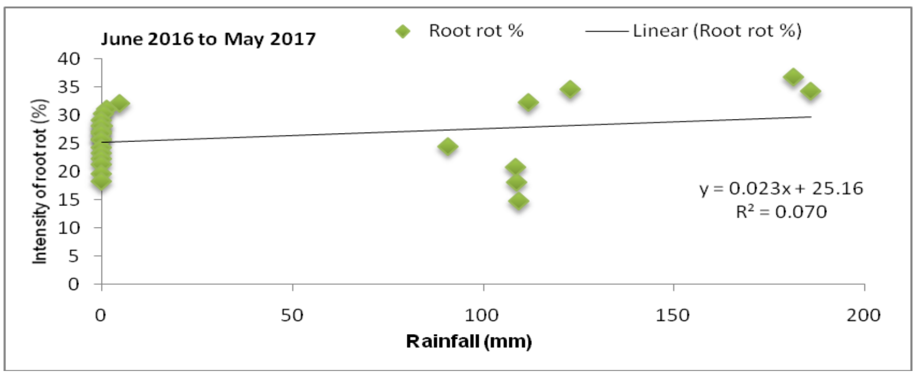
** Values in parenthesis are arc sine transformed.

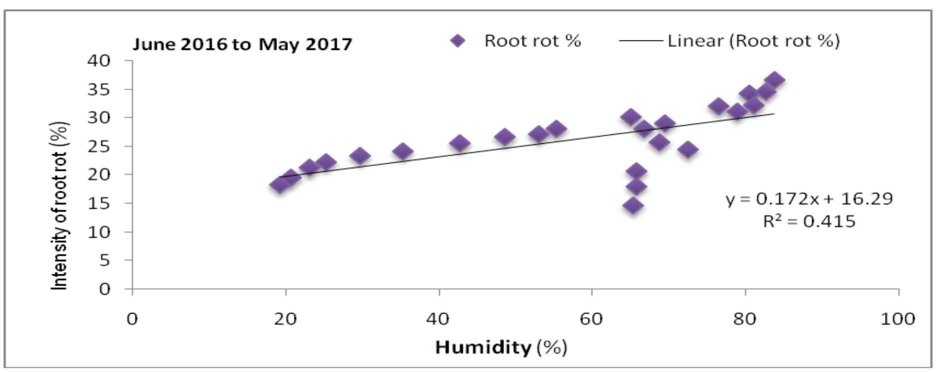
Table.3 Correlation coefficients between environmental factors and incidence and intensity of root rot in Nagpur mandarin

Sr. No.	Meteorological parameter and soil factors	Experimental fields											
		A	B	C	D	E	F	A	B	C	D	E	F
		Incidence (%)						Intensity (%)					
1	Humidity	0.687*	0.448*	0.585*	0.648*	0.570*	0.605*	0.698*	0.787*	0.673*	0.600*	0.502*	0.498*
2	Rainfall	-0.024	-0.313	-0.191	-0.071	-0.216	-0.171	0.554*	0.394	0.295	0.075	0.136	0.202
3	Temperature	-0.251	-0.055	-0.097	-0.196	-0.074	-0.136	-0.577*	-0.523*	-0.379	-0.232	-0.188	-0.205
4	Soil moisture	0.515*	0.208	0.289	0.466*	0.304	0.350	0.799*	0.790*	0.670*	0.548*	0.448*	0.487*
5	p^H	0.439*	0.199	0.244	0.386	0.251	0.274	0.770*	0.694*	0.651*	0.503*	0.522*	0.582*
6	EC	0.840*	0.693*	0.670*	0.825*	0.711*	0.730*	0.854*	0.927*	0.908*	0.866*	0.756*	0.784*

R value 0.404* Significant at 5% level.

Fig. A Correlation between environmental factors and root rot intensity (%)





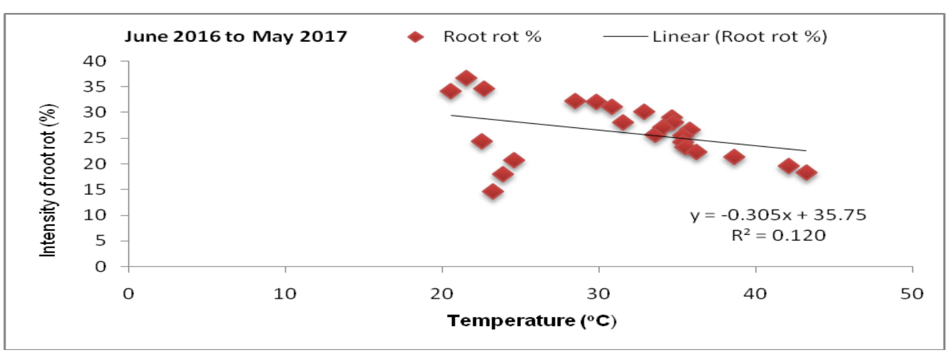
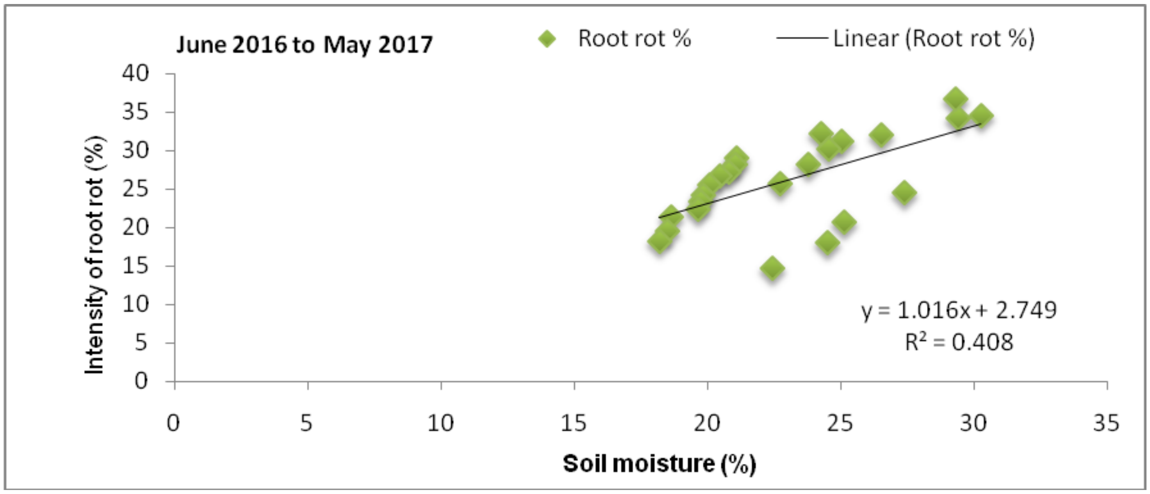
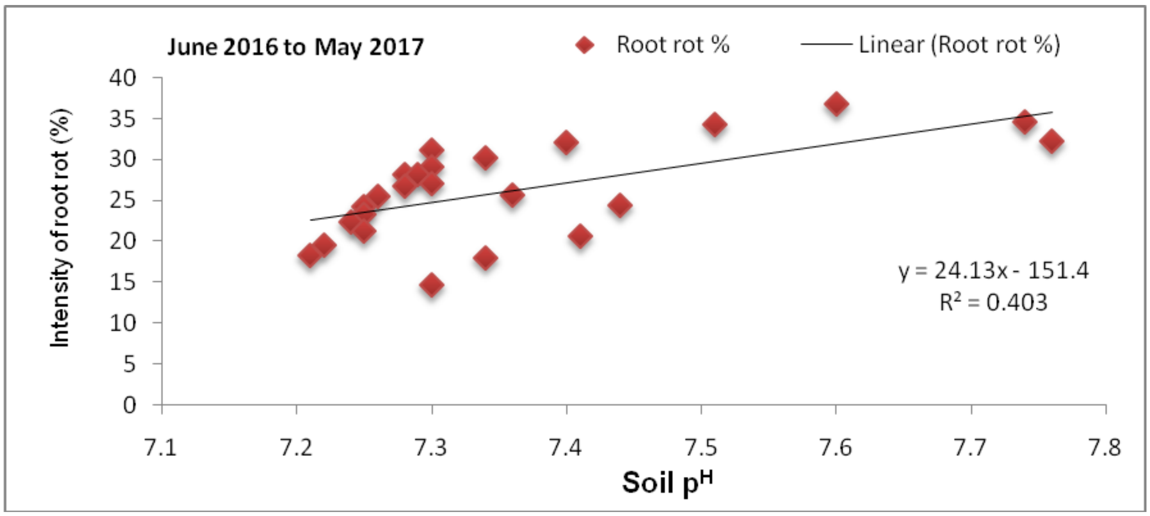


Fig. B Correlation between soil factors and root rot intensity (%)





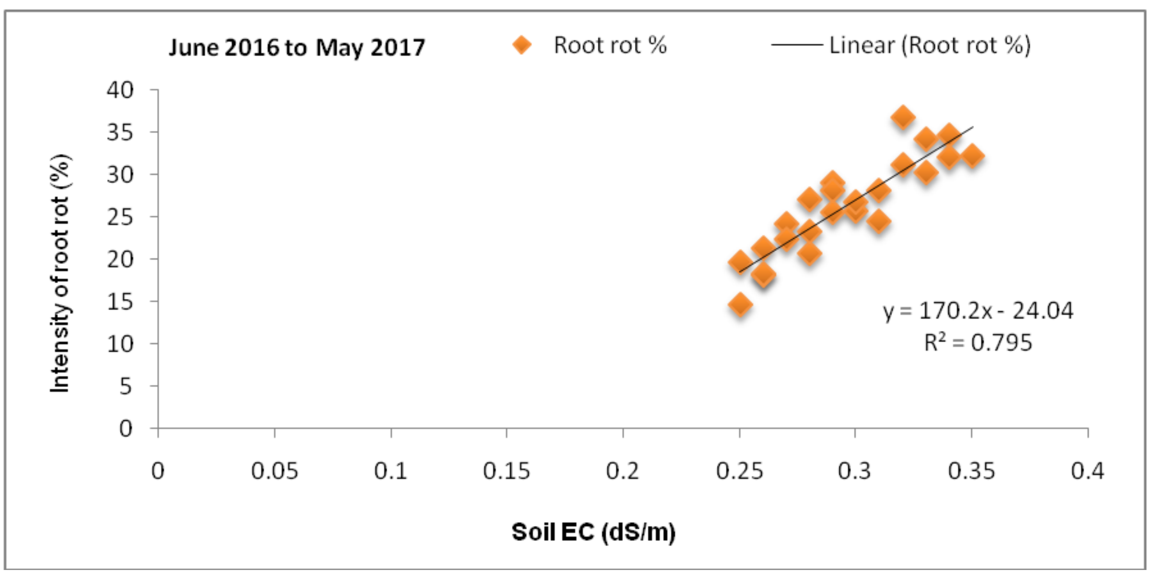
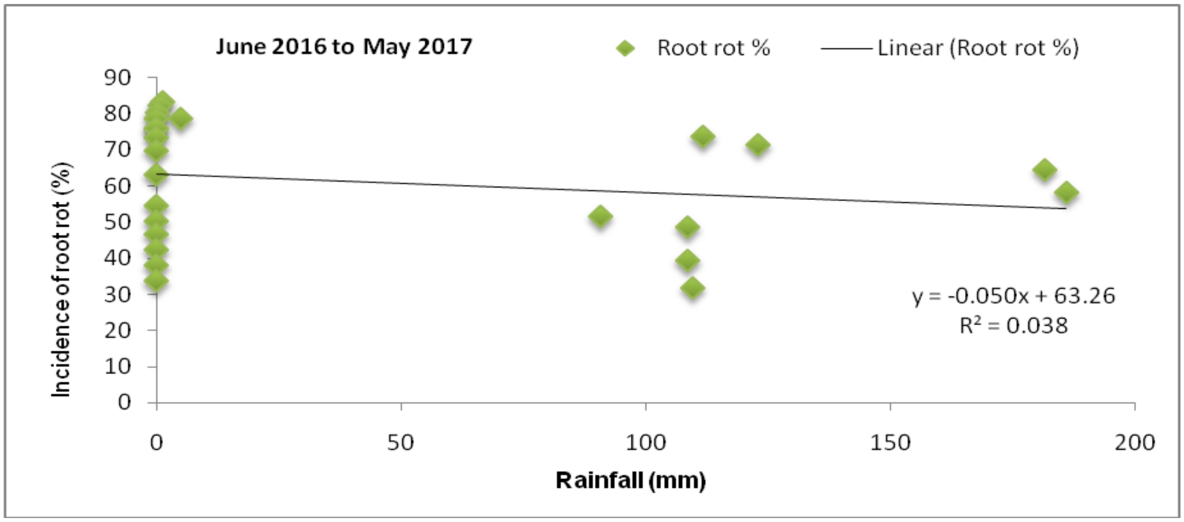
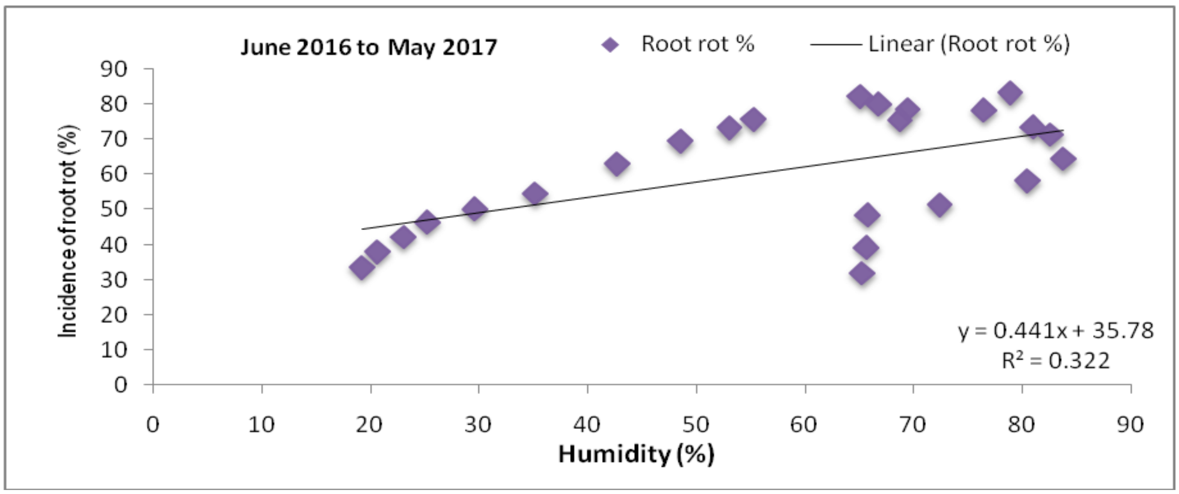


Fig. C Correlation between environmental factors and root rot incidence (%)





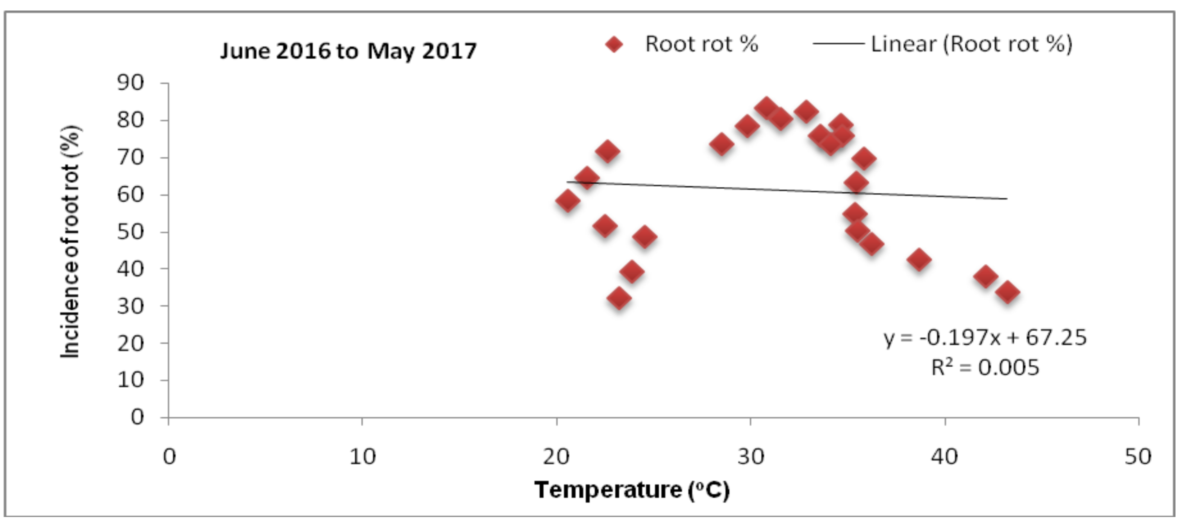
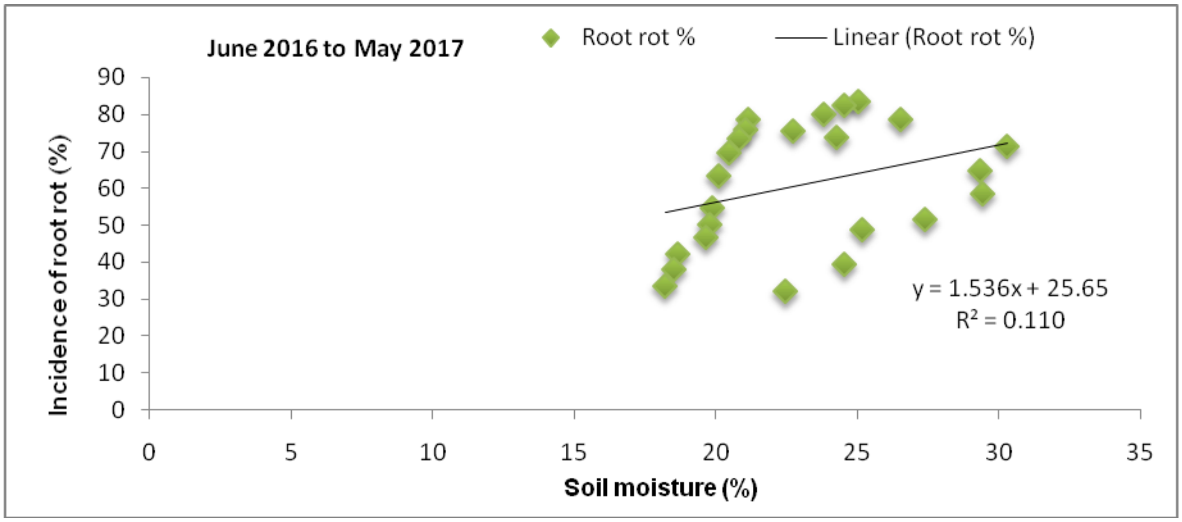
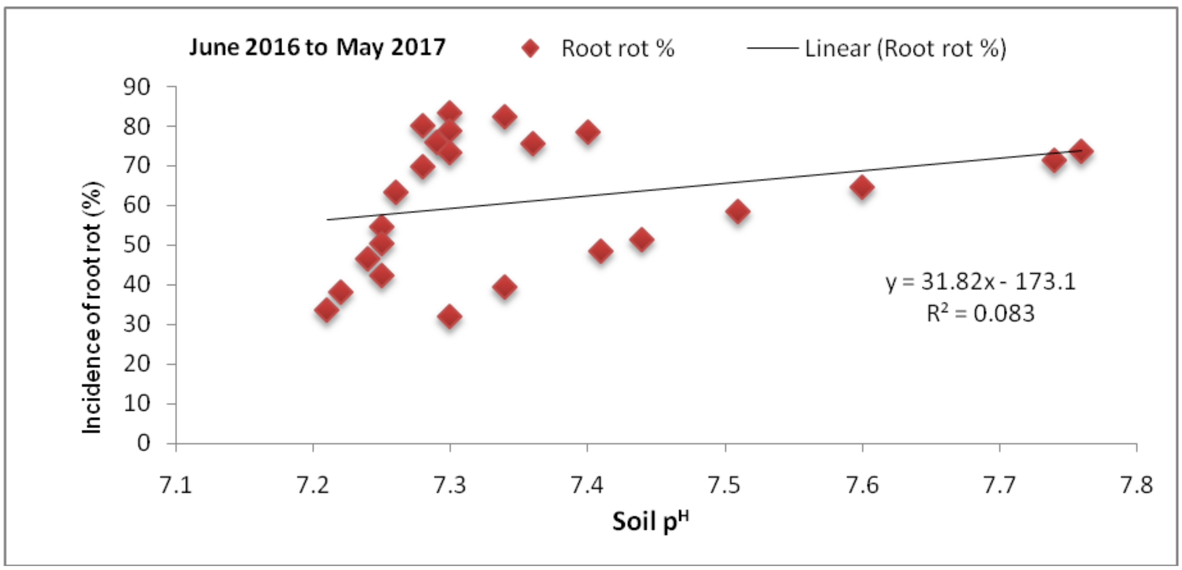
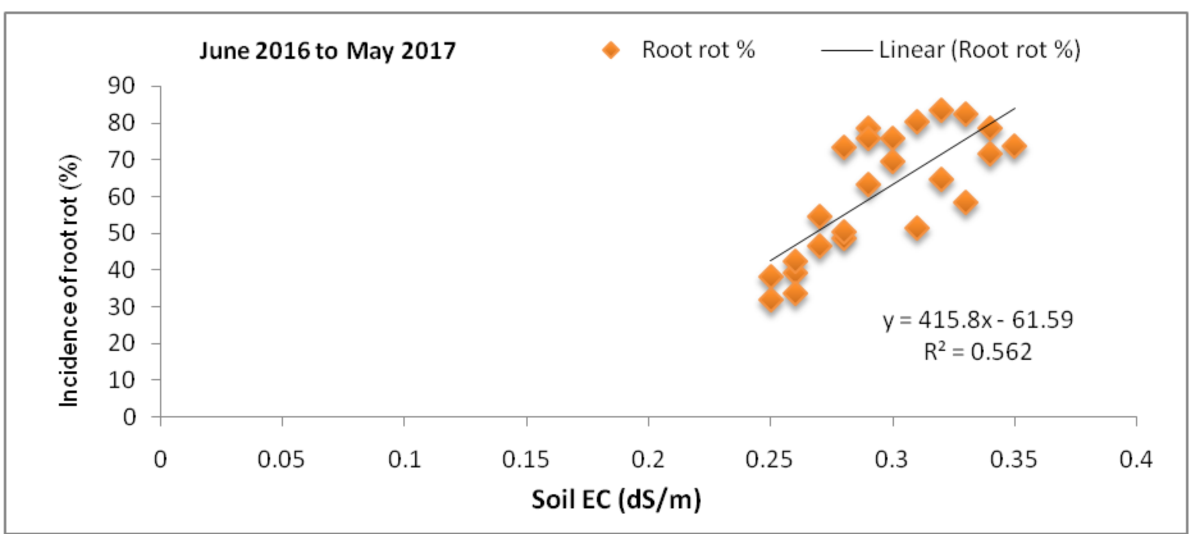


Fig. D Correlation between soil factors and root rot incidence (%)







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