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Analysis of Physicochemical Properties, Available Nutrients of Soil and their Correlation with Incidence of Telya Disease of Pomegranate at Northern Nasik, Maharashtra

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ABSTRACT

Maharashtra government reported 10,000 crore production loss of Pomegranate every year, due to the incidence of Telya disease. The present study was aimed to analyse the physical, chemical properties, and available micro-macronutrients in the soil of pomegranate orchards infected with Telya disease. Estimation of incidence and severity of disease was done on fifty selected orchards from different villages that were MangiTungi, Daswel, Dasane, Mulher, and Sompur. Results revealed that minimum incidence (58.66%) and severity (59.89%) were recorded in Sompur village whereas maximum incidence (74.40%) and severity (68.70%) were recorded in Daswel and MangiTungi village respectively. The pH (7.5-7.9) and free lime concentration 7.4-9.4%) were exceptionally very high for all test and control samples. Deficiency of essential macronutrients N (<150-250 Kg/ha) and K (<125-200 Kg/ha) was recorded in all test samples along with additional deficiency of Zn micronutrient (<1.0-2.0 ppm). In the case of mock orchards, all the parameters were in accordance with reference values.Statistical analysis of data declared that there was a significant difference among parameters of tested groups (P>0.05) while for control fields there were no significant differences (P<0.05). Further, a positive correlation between macro-micronutrients (Na, Ca, N, P, K, Mn) and incidence of disease was recorded which concludes that an imbalance in nutrients promotes growth of pathogens and increases susceptibility of plants to pathogenic attack. Further, balancing nutrients through fertilisers or foliar spray could be an effective strategy for an integrated pest management system.

Keywords: Integrated pest management; Pomegranate; Soil nutrients; Telya

1. INTRODUCTION

Pomegranate is one of the most preferred table fruit crops and has a place with the family Lythraceae.[17] Each part of plant viz; fruit, roots, stems, rind (skin of fruit), flowers and flower buds are known to possess pharmaceutical and therapeutic properties. Arils, the edible part of the fruits contains acids, sugars, vitamins, polysaccharides, polyphenols, steroids, tannins, flavonoids and minerals. These compounds are responsible for many biological and pharmacological applications such as antimicrobial, anti-inflammatory, anti-diabetic, anti-cancer, and antioxidant activities.[3] It is economically developed in tropical and sub-tropical locales of the world. Due to its winter hardy, drought-tolerant and long duration of storage properties India has become one of the largest producers and exporter of pomegranate in the world. In India, this economically and nutritionally important plant is mainly concentrated in Maharashtra followed by Karnataka, Gujarat, Andhra Pradesh, Madhya Pradesh, Tamil Nadu, and Rajasthan.[37] At present various bacterial diseases and fungal diseases viz.; Alternaria fruit spot (*A. alternate*), Heart rot (*Aspergillus niger*), Grey mould rot (*Botrytis cinerea*), Wilt (*Ceratocystis fimbriata, Fusarium oxysporum, Rhizoctonia*), Anthracnose (*Colletotrichum gloeosporioides*), Blue mould fruit rot (*Penicillium implicatum*), Shoot blight (*Neofusicoccum parvum*), Leaf spot or blight (*Xanthomonas axanopodis*pv*punicae*)[37] affect pomegranate production among which epidemic proportion of Telya (caused by *Colletotrichum* sp.; unpublished data) disease leads to 60-80 per cent crop loss. Due to this disease, every year around 10,000 crore production loss and around 2000 crore export opportunity loss is faced by Maharashtra state only (Anonymous, 2014).

The plant is also susceptible to various abiotic stresses viz.; environmental conditions, the nutritional quality of soil, ripening, storage, and post-harvest treatments.[19] Among all soil acts as a medium for plant growth and regulates the supply of nutrients, water, gases and heat to the crop. Moreover, the timing of seeding, crop rotation,

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mulching, tillage, seedbed preparation, irrigation, and application of mineral nutrients, liming and organic amendments are major factors of occurrence and extremity of plant diseases.[9] Among all nutrient deficiencies and toxicities contribute more in disease severity. There are 18 nutrient elements; grouped as primary macronutrients (N, P, K), secondary macronutrients (Ca, S, Mg) and micronutrients (B, Cl, Mn, Fe, Zn, Cu, Mo)[9] can affect the development of a disease by acting on host or pathogens, or both of them.[31,23] These supplements can change the physiology, biochemistry and growth rate of the host by changing the integrity of the cell walls, membrane leakage, chemical composition and empowering seedling to avoid infection respectively.[16] In addition, nutrients present in the soil naturally and incorporated in the soil artificially as fertilisers both have impact on soil climate which eventually influences the pathogenicity of the microbe.[31]

The effect of nutrients on growth and development of the pathogen varies with kind of pathogen e.g. in the case of obligate parasite *(Puccinia graminis and Erysiphe graminis),* severity of infection increases with high N supply whereas, reverse effects have been observed in presence of facultative parasite (*Alternaria, Fusarium and Xanthomonas* sp.).[8,21] Other side many researchers support that application of nutrients can control disease severity and develop resistance in plants or hosts. So, it is not essential that the application of a particular nutrient that increases the severity of one disease may decrease the severity of another disease for the same host or different host.[22] For an instance incidence of *Pyrenophoratritici-repentis* on wheat is inversely proportional to the concentration of potassium.

Furthermore, incidence and severity are also affected by types of fertilisers as ammonium-based fertilisers escalate the occurrence of Phytophthora root rot, Fusarium wilt, Fusarium crown rot, root rot like diseases, whereas, nitrate-based fertilisers inverse the effect[34]. Various strategies are used to control pests and diseases viz; cultivation of less susceptible or resistant varieties, biological control, chemical control, management by improvising cultural practices and control through plant nutrition.[55] Many authors have reported the effect of nutrients on plant growth, and plant disease defense yet, sufficient utilisation of mineral nutrients to control any infection is not in standard practice.[22,56-58]

Considering the connection between soil supplements and disease extremity, the present investigation was intended to ascertain the soil nutrient status in pomegranate plantations tainted with telya disease. The findings here can be utilised to oversee infection by adjusting mineral sustenance as an integrated pest management system.

2. METHODOLOGY

2.1 Location of Study Area

The study was driven in the potential pomegranate-producing towns of Nasik regions, Maharashtra in February-March 2015. Five sample villages; MangiTungi, Daswel, Dasane, Mulher and Sompur in various stature zones ranging from 10-25 kilometers were selected for the study. All towns are around 125-140 km a long way from Nasik City and 100-130 km from the Dhule locale (Table 1). The Northern Part of the Nasik district is portrayed by a sub-tropical environment having an average yearly temperature of 32°C, precipitation of 175-200 mm- coupled with 80-90 per cent humidity. The trees of selected orchards were 3-5 years old, placed at a distance of 4m*4m apart and drip irrigated with four emitters per plant. Before starting of the season (Bahar) pruning was done to train the tree in proper shape. The soil surface of this zone ranges from sandy to sandy topsoil which is penetrable, has low water retentive capacity, and generally experiences water deficit during summers.

2.2 Assessment of Disease Incidence and Severity

A roving survey of disease incidence and severity was conducted amid of Mrigbahar (June - January) and Ambebahar (January- August) in 2014-15 at five selected villages. From each village, ten commercial pomegranate fields were selected and designated as MT1-10, DS1-10, DN1-10, SM1-10 and ML1-10. Assessment of the disease symptoms was made with the assistance of the

Table 1. Geographical location, and climatic characteristics of year 2014-15 of surveyed villages of Nasik distirct, Maharashtra.

S. No.	Village Name	Longitude W	Latitude N	Rainfall (m.m.)	Humidity (%)	Temperature (°C)
1	Mangi Tungi	20.834	74.094	99.60	72.27	24.20
2	Daswel	20.816	74.121	102.27	68.47	23.80
3	Dasane	20.605	74.573	76.96	70.42	25.00
4	Mulher	20.763	74.056	91.52	65.14	24.60
5	Sompur	20.802	74.177	103.60	69.49	25.40

distinct scale created by Sharma and Kolte[45], using 0-5 scale rating. Where, rating description was as follows; 0= No symptoms; 1= 1 per cent -10 per cent disease infection (Initial oily spot), 2= 11 per cent - 25 per cent disease infection (Initial and dark spot), 3= 26 per cent - 50 per cent disease infection (Y shaped crack), 4= 51 per cent - 75 per cent disease infection (middle-stage), 5= > 75 per cent disease infection (Final stage) (Figure 1).

To evaluate percent incidence 20 plants from four corners and 20 plants from focus were arbitrarily chosen, resulting in 100 plants for each field. Evaluation of percent incidence was done by using the following formula; given by Masyahit, *et al.*[32]

$$\%incidence = \frac{Numberof\ \inf ectedplants}{Tota\ln umberrofobservedplants} \times 100$$

However, for assessment of the disease severity index 20 fruits per plant were randomly selected and graded as per the scale developed by Sharma and Kolte Loc. cit. Further, % DSI was calculated by using a formula adopted from Lakshmi *et al.*[26]

$$\%DSI = \frac{sumofalldiseaseratings \sum n \times v}{Numberoffruitsexa\min ed(N) \times \max imumdiseasegrade(Z)} \times 100$$

Where 'n' and 'v' represent the number of samples in each numerical rating and grade in each numerical rating respectively.

2.3 Collection and Processing of Soil

The pattern soil samples, 20-33 cm profundity, from 7-8 distinct sites of the field were collected, before beginning of bahar treatment. All samples were mixed completely in the wake of eliminating surface litter and weighed up to 1kg. Besides, this assortment technique was completed for each of the 50 test fields of chosen towns and 15 control fields (3 fields per location) where no history of the disease was reported. Samples were air-dried in shade, ground, and passed through 0.2mm and 2mm strainer. Afterward, stored in plastic bags and transferred to Shejami laboratories, Satana, Nashik (funded by Agriculture department of Maharashtra) for additional assessments.

2.4 Soil Analysis

Determination of chemical properties, physical properties, availability of macronutrients and micronutrients were done by adopting various methodologies mentioned in Table 2. All values of analysed parameters were compared with reference values (as per the recommendation of NRCP, Solapur, followed by the soil testing laboratory as standard operating procedure).

2.5 Statistical Analysis

The complete randomised block experimental design was used with three replications. Descriptive parameters (Mean, SD) were calculated by Microsoft Excel, 2007. To determine the significant difference among soil parameters one way ANOVA was performed at p value <0.05. To evaluate the relationship between physicochemical properties of soil and disease severity, Pearson's correlation analysis was performed among

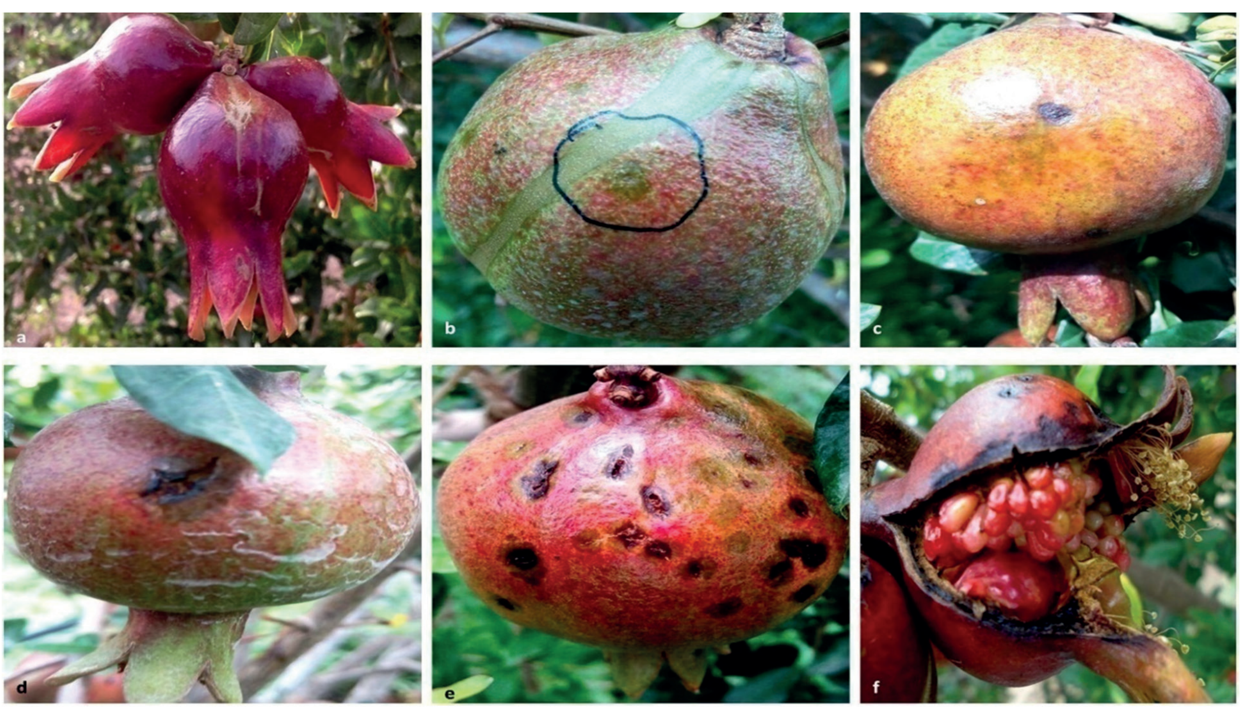

Figure 1. Disease rating scale (0-5) of Telya disease of Pomegranate: (a) Rating 0= fresh fruit; where there is no symptoms of disease, (b) Rating 1= initial oily spot, (c) Rating 2= initial oily spot with dark center, (d) Rating 3= 'Y' shaped or star shaped cracking starts from the dark center; (e) Rating 4 = when infection covers 75% of fruit area and (f) Rating 5= lesions become necrotic and fruits dried up.

Table 2. Methodology used for analyzing physio- chemical properties and availability of Macro-Micro nutrients of different soil samples of Pomegranate orchards

S. No.	Parameters	Methodology Used	Reference values for Pomegranate Orchard	Reference
		Physical Properties		
1	Bulk Density	Clod Coating	>1.5 gm/ml	Black & Hartage[4]
2	Hydraulic conductivity	Constant head method	>50%	Klute & Dirksen[25]
		Chemical Properties		
3	pH	Potentiometry	6 to 7	Jackson[24]
4	Electrical conductivity	Conductometry	> 1	Jackson[24]
5	Organic Carbon	Walkely-Black's Method	0.4-0.6 %	Nelson &Somner[38]
6	Free lime	Acid neutralisation	1.0-5.0%	Jackson[24]
7	Exchangeable sodium	Flame photometry	>250 ppm	Richard[43]
		Macronutrients		
8	Available nitrogen	Modifiedalkaline permanganate	150-250 Kg/ha	Subbiah and Asija[46]
9	Available Phosphorus	Olsen method	15-25 Kg/ha	Watanabe & Olsen[54]
10	Available Potassium	Flame photometry	125-200 Kg/ha	Jackson24
11	Exchangeable calcium and Magnesium	Versenate method	0.2-0.5 % & 0.1-0.2 %	Richard[43]
		Micronutrients		
12	DTPA (Fe, Mn, Zn, Cu)	Atomic Absorption Spectrophotometer	2.5- 4.5 ppm^{Fe} 2.0-4.0 ppm^{Mn} 1.0-2.0 ppm^{Zn} 0.2-0.5 ppm^{Cu}	Lindsay &Norvel[29]

soil parameters and disease incidence and severity, for all selected villages at a correlation coefficient of 0.01 and 0.05 using SPSS V27 software.

3. RESULTS AND DISCUSSION

The survey conducted amid of Mrig bahar and Ambe bahar showed that telya disease on all plant parts of pomegranate is common in all selected villages of north Nasik district. The outcomes uncovered that a maximum DSI 68.71 per cent was recorded for MangiTungi village followed by Dasane (65.18 %), Mulher (64.13%), Daswel (62.04 %) and Sompur (59.90 %). Infection occurrence was maximum (74.04 %) in Daswel village and minimum (58.06 %) in Sompur village (Table 3, Figure 2) (Annexure I). The disease incidence significantly varied ($P>0.05$) whereas there is no significant difference in disease severity of villages surveyed ($P< 0.05$). Disease incidence and severity were positively correlated (rDS= 0.790. rDN= 0.413; rML= 0.635 and rSM= 0.519) for all territories except MangiTungi village (rMT= 0.011) at $P_{0.05}$. There are a few variables that fundamentally affect disease incidence and severity such as climatic parameters (Temperature, rainfall and humidity), irrigation process, type and rate of fertilisers used, agricultural practices, bahar timings and presence of inconstancy in pathogen[3,7.]

Remarkable differences among physical properties, chemical properties, and availability of macronutrients and micronutrients were observed in all soil samples of pomegranate orchards. The average water holding capacity and density of all soil samples were accordant with the reference values. which showed that soils of the study area were less dense with high permeability reasonable for pomegranate crop creation.[50] The pH of tested soil samples ranged in between 7.0-8.5 and the average pH was 7.7 for all locations except MangiTungi village which was 7.9. The soil pH in all orchards was basic and in support of findings of. [40,10,30] There were significant differences of pH among the sample groups ($P> 0.05$).

Basic or alkaline soils are the consequence of the buffering of soil pH by base elements or by the presence of buffering compounds like carbonates. At high pH, the dissolvability of numerous metals and trace elements are diminished, including essential supplements for plants such as Fe, Mn, Cu or Zn. In favor of this the results also showed that pH is positively correlated with free lime, K, Ca, Mg, Fe, Cu. (rK= 0.885; rCa = 0.644; rMg= 0.567; rCu= 0.849; rFree lime= 0.987). Electrical conductivity estimates the salinity of the sample in terms of exchangeable Cl and Na concentration. The investigated soil samples meet with the guideline esteems (>1) of salinity and negatively correlated with the monovalent cations (Table 4) (Annexture II). It was observed that the average concentration of free lime in soil samples of surveyed plantations was 7.78, 6.58, 7.95, 9.70 and 7.54 for Daswel, Dasane, Mulher, MangiTungi and Sompur villages which are exceptionally high contrasted with standard reach (1.0-5.0). Presence of calcium and magnesium carbonates responsible for higher concentration of free lime in soil henceforth pH of the soil increases as documented in Table 3.

Results of current study revealed that the average available content of Na and Ca was in the scope of standard limit for all villages whereas soil samples from orchards of MangiTungi village lacking in Na content. Ca has an important role in disease resistance because this is the important component of cell wall structure which provides stability and regulates the function of

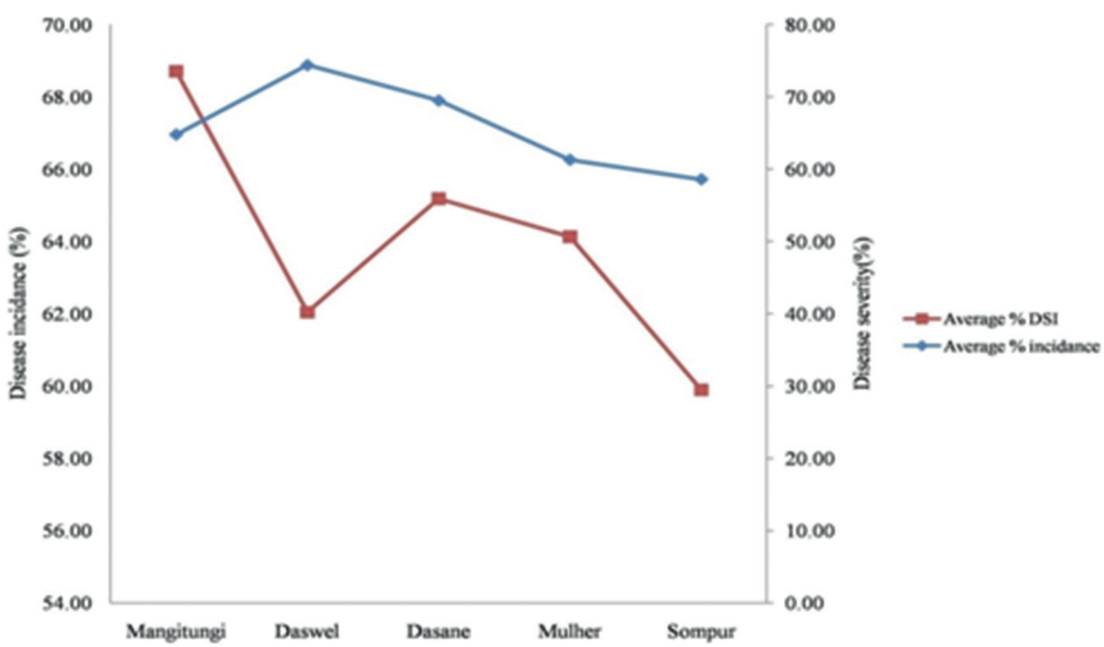

Figure 2. Disease incidence and severity of Telya disease of Pomegranate of studied orchards. Data presented here is the mean of incidence and severity of ten fields per location.

plant membranes.[31] Nutrients can affect plant metabolism straight forwardly and have secondary effects on the development and yield of the crop plants by prompting changes in growth pattern, plant morphology and anatomy or chemical composition. Consequently, the resistance and tolerance capacity of crop plants towards any disease might be affected. In the case of macronutrients, all orchards showed deficiency of N and K whereas the measure of P was in favor of the pomegranate crop. Similarly, incidence of Panama disease of banana (*Fusarium oxysporum* f. sp. *cubense*) and leaf spot of coffee (Cercospora spot) increased at a lower concentration of N reported by.[14,39] Conversely, a high N supply increases the pathogenicity of *Erwinia amylovora* and *Botrytis Cinerea.*[22] There are several factors responsible for these distinctions such as; the form of N supplied as fertilisers (ammonium-based or Nitrate based), type of pathogen (Obligate or facultative), the development phase of a plant when N is provided, plant species and plant growth conditions.[6,22,31]

Various combinations of macronutrients (N:P:K:: 0:26:26, 00:34:52, and 19:19:19) are recommended by Mahatma Phule Krishi Vidyapeeth Rahuri for pomegranate and National research center of pomegranate, Solapur showed that lower concentration of N is required for quality and quantity production as compared to other two nutrients. This is because the high concentration of N upgrades the vegetative development of plants so proportion of young tissue which is more susceptible towards pathogenic attack, increases as compared to developed tissues. Moreover, the activity of key enzymes of phenol metabolism might be diminished in presence of high N which leads to the aggregation of phenolics and amino acids. These low molecular N compounds act as a substrate for the germination and growth of conidia thus growth of pathogen increases.[44,33] Likewise, Zn insufficiency promotes high membrane permeability which leads to high N supply[35] yet deficiency and negative correlation were observed in between both nutrients in present study. The deficiency of K content and high disease incidence in the current investigation was in support of findings of Freitas *et al*.[13] reported that K content was contrarily corresponding to disease severity of *P. Musaein* banana plants. Many investigations showed that increased concentration of K increases the area under incidence progress curve (AUIPC) and area under severity progress curve (AUSPC) for Phoma leaf spot in coffee, Cercospora leaf spot and anthracnose in strawberries and dogwood.[15,36,28,20] Like high N supply lack of K decreases the synthesis of high molecular weight compounds which results in the deposition of low molecular weight compounds which act as a substrate for parasite development. Moreover, P is applied in the form of PO_4^{3-} in soil which suppresses disease incidence by inducing resistance in the host, the plant reported previously.[48,27,41]

Among all micronutrients, Mg concentration was within the acceptable limit for all surveyed orchards. Additionally, Soil samples from Dasane, Daswel, Mulher and Sompur had an adequate amount of Fe, Mn, Cu whereas, insufficiency was observed in soil samples of MangiTungi village. Similar to essential macronutrients, micronutrients are also involved in the suppression of disease severity by affecting the physiology and biochemistry of plants. Inadequacy of micronutrients can be overwhelmed by direct foliar splash than provided in the soil as lesser amounts are required to fulfill their role. These micronutrients have a direct toxic effect on the pathogen not through the plant's metabolism like as; Mn restrains the ability of two significant enzymes; aminopeptidase and pectin methyl esterase which promote fungal growth and degrades host cell wall respectively. Other side, Mn activates the enzyme responsible for bio-synthesis of lignin and suberin. These biomolecules act as barriers to fungal pathogen invasion[31,18,49].

Zanao Junior[54] reported that the severity of spot blotch in Wheat was reduced with increasing Mn content. Zn plays an important role in activation of Cu/Zn-SOD and detoxifies superoxide radicals. In the present investigation, soil samples of DS, DN, and ML showed deficiency of Zn which could affect disease incidence and severity. This is because during infection generation of free radicals induces permeability of low molecular weight compounds which ultimately leads to pathogenesis. Similar to Zn, Fe is an important component of peroxidase enzyme which protects the plant cell wall from oxidative damage at the site of infection.[51] The role of Cu in disease-resistant is not well studied yet. Foliar spray of Cu as fertiliser required 10-100 times higher than the amount required naturally by the plants, yet it did not affect the extent of infection.[16] It was observed that physical properties, the concentration of macronutrients and micronutrients of soil samples from non-infected fields of pomegranate at all surveyed villages were in accordance with standard values, whereas among all chemical parameter pH and concentration of free lime was higher and similar to samples from infected orchards.

Statistical analysis showed significant difference for all parameters among test groups besides Mn ($P<0.05$) whereas there is no significant difference was observed among parameters from mock groups. Available sodium, available calcium, macronutrients (N,P,K) along with two micronutrients (Mg and Mn) showed significant positive correlation with disease incidence (rN= 0.549; rP= 0.281; rK= 0.136; rMg= 0.701; rMn= 0.434) whereas other three micronutrients (Fe,Zn and Cu) were negatively correlated (rFe= -0.204; rZn= -0.736; rCu= -0.285). The disease incidence was high in Daswel, this could be attributed to poor agricultural practices. In this region, farmers did not make sanitation, prune or remove debris of diseased stems and fruits in their orchards. Since the causal agent of disease reported here is fungal pathogen (data not shown) in this way, reasons referenced above may act as a primary source of inoculums.[12] Although the application of nutrients through fertiliser can attain the required concentration for resistance to disease but several approaches like crop rotation, green manuring, intercropping, soil tillage can imbalance the optimum nutrient concentration.[55] Other than this, interaction between nutrients (dilution effect), competition among nutrients at uptake site, timings and amount of application of nutrients, texture and structure of soil may impact disease severity and incidence. Disease intensity and severity were lesser in Sompur village; this could be ascribed to legitimate sterilization. The majority of plantations in this town were generally cleaner than the others. Additionally, the vast majority of the farmers are engaged in the production of export quality of fruit.

Accordingly, farmers are putting forth attempts to more readily deal with their plantations to profit by better selling costs. Pruning improves the infiltration of daylight, which decreased the pre-harvest development of the living beings down the inflorescence and peduncle across the shelter.[42] Other side, disease severity was higher in MangiTungi village this is due to the application and timings of fertilisers through foliar spray.

A detailed study of Wharton and Diéguez-Uribeondo[53] depicted that to limit the entry of pathogens to the plant; ideal utilisation of chemical fungicides ought to be applied to young expanding tissues, including fruits, leaves and flowers. Similarly, the disease severity of Dasane, Daswel and Mulher village was near to MangiTungi, this could be attributed to environmental factors and overhead irrigation process which aids successful colonization of the pathogen.[47]

Additionally, three major types of commercial fertilisers, nitrogen (N), phosphate (P), and potassium (K), play a significant role in satisfying the world's food demand, but they have a variety of negative impacts on soils, including depletion of water holding capacity and imbalanced soil fertility.[59] Microbiological tools, such as bio-fertilisers and biocontrol agents, which are bacteria and fungi capable of producing beneficial impacts on plant development and health, have been designed for several decades to counter this issue. Bacteria or fungi capable of nitrogen fixation, phosphate solubilization, sulphur oxidation, plant hormone synthesis, or organic compound decomposition are characteristics of biofertilizers. Biological control is also a non-chemical approach of controlling plant diseases using microorganisms. Antibiotic substances, fungal cell wall lytic enzymes, and chelate iron from the rhizosphere (production of Siderophores) are all constituents of these biocontrol microorganisms.[60,61] In the presence of *Bacillu*s isolates, 60.26 per cent of the growth of *Colletotrichum*sp suppressed in the dual culture technique. The same *Bacillus* sp. was applied to Pomegranate orchards (selected from the study area) and reduced telya disease severity by 50-60 per cent while increasing plant vigor by 80-85 per cent. (Data not shown). In this regard, Other researchers have found that *Pseudomonas* K–34, *P. fluorescens* 1773/K, *P. trivalis* BIHB 745, and *Bacillus circulans* have the potential to create organic acids and plant hormone (IAA; indole acetic acid) through nutrient cycling to promote optimal plant growth and development. Simultaneously, *Pseudomonas trivalis* strain BIHB 745 can synthesise siderophores, whereas *B. subtilis* and *B. amyloliquefaciens* protect blueberries and lettuce from mummy berry fungus and bottom rot, respectively.[62,63]

4. CONCLUSION

The outcomes of the current study showed that soil available nutrients are correlated with the incidence and severity of Telya disease. The pH and free lime concentration were exceptionally high in test as well as in control plantations. The concentration of essential macronutrients N, K along with Zn micronutrients was recorded less when contrasted with standard values. Imbalances in nutrients would influence the development of pathogens as well. The level of disease incidence and severity was less in Sompur taluka as analysed in other locales, concluding that rate and seriousness rely upon the unbalancing of supplements as well as sanitization measures, pruning timings, bahar plan, timings of foliar spray. As there is no availability of resistant commercial variety of pomegranate to Telya disease, supplementation as a nutrient management practice could be used to reduce the rate and severity of disease. Longer-term monitoring is required to assess the effects of various supplements and make recommendations for improving soil health and crop production with improved organic product quality.

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Annexure 1

Table 3. Physical properties, chemical properties, micro-macronutrients (Mean±SD) of soil and incidence and severity of telya disease of pomegranate orchards at Nasik, Maharashtra

Parameter/ village code	Density	WHC	pH	E.C.	OC	Free lime	Na	N	P
Reference values	> 1.5	> 50%	6 to 7	> 1	0.4-0.6	1.0-5.0	>250	150-250	15-25
Unit	g/ml	%	-	-	%	%	ppm	Kg/ha	Kg/ha
MT	1.12± 0.09[a]	42.7± 13.06	7.9± 0.22	0.05± 0.00	0.41± 0.03	9.70± 1.18[a]	60.02± 67.08	138.6± 1.71	17.20± 1.13
DS	1.29 ± 0.19[a]	47.6± 13.59	7.7± 0.23	0.07± 0.02	0.40± 0.03	7.78± 1.39[a]	179.82± 104.17	145.35± 7.67	17.85± 1.70
DN	1.44± 0.07[a]	36.4± 7.76	7.6± 0.27	0.05± 0.01	0.41± 0.09	6.58± 0.61[a]	212.02± 130.87	145.4± 6.65	17.90± 1.44
ML	1.24± 0.21[a]	44.8± 12.15	7.7± 0.32	0.06± 0.01	0.39± 0.02	7.95± 1.72[a]	114.12± 104.54	140.75± 4.37	17.65± 1.59
SM	1.29± 0.19[a]	39.5± 12.57	7.7± 0.35	0.05± 0.01	0.43± 0.09	7.54± 1.81[a]	167.02± 61.62	143.3± 7.00	17.80± 1.22

Parameter/ village code	K	Ca	Mg	Fe	Mn	Zn	Cu	DI	DSI
Reference values	125-200	0.2-0.5	0.1-0.2	2.5- 4.5	2.0- 4.0	1.0- 2.0	0.2- 0.5	-	-
Unit	Kg/ha	%	%	ppm	ppm	ppm	ppm	%	%
MT	121.04± 141.47	0.41± 0.05	0.12± 0.01	2.03± 1.61	1.02± 1.56[a]	1.16± 1.91	0.84± 0.76	64.85± 11.38[a]	68.70± 3.38
DS	107.20± 51.61	0.41± 0.11	0.12± 0.00	2.72± 1.38	3.87± 2.06[a]	0.89± 0.46	0.44± 0.49	74.40± 9.02[a]	62.04± 13.84
DN	80.60± 47.7	0.32± 0.07	0.11± 0.00	2.79± 0.87	4.30± 1.44[a]	0.77± 0.16	0.29± 0.05	69.51± 7.97[a]	65.18± 13.90
ML	92.88± 43.30	0.36± 0.06	0.11± 0.00	3.17± 1.47	2.55± 1.99[a]	0.97± 0.60	0.36± 0.52	61.32± 13.89[a]	64.13± 9.6
SM	92.65± 40.68	0.38± 0.07	0.13± 0.01	2.87± 1.10	3.29± 2.45[a]	1.31± 1.79	0.58± 0.70	58.66± 14.94[a]	59.89± 8.97

[a] Mean followed by similar letter showed no significant difference within column, $P<0.05$.

(Annexture II)

Table 4. Correlation matrix (Pearson, n) of soil chemical and physical properties, macro-micronutrients, disease incidence and severity in different Pomegranate farm

	Density	WHC	pH	EC	OC	FL	Na	N	P
Density	1								
WHC	-0.535	1							
pH	-.929*	0.361	1						
EC	-0.177	.925*	0.023	1					
OC	0.093	-0.561	-0.070	-0.598	1				
FL	-.970**	0.453	.987**	0.108	-0.047	1			
Na	.946**	-0.364	-.945**	0.000	0.202	-.941**	1		
N	.874*	-0.193	-.880*	0.173	0.167	-.860*	.977**	1	
P	.886*	-0.200	-.980**	0.149	0.040	-.948**	.955**	.931*	1
K	-.868*	0.597	.885*	0.335	0.015	.921*	-0.743	-0.596	-0.781
Ca	-0.778	0.738	0.644	0.526	0.084	0.747	-0.542	-0.376	-0.499
Mg	-0.400	0.585	0.567	0.545	-0.409	0.536	-0.368	-0.204	-0.452
Fe	0.544	0.001	-0.761	0.199	-0.373	-0.717	0.524	0.446	0.735
Mn	.933*	-0.256	-.954**	0.116	0.078	-.943**	.990**	.978**	.977**
Zn	-0.594	-0.029	0.414	-0.317	0.586	0.496	-0.479	-0.506	-0.433
Cu	-.819*	0.114	.849*	-0.214	0.453	.869*	-0.744	-0.693	-.832*
DI	0.327	0.289	-0.159	0.526	-0.221	-0.186	0.404	0.549	0.281
DSI	-0.404	-0.063	0.695	-0.223	-0.259	0.573	-0.606	-0.608	-0.748

	K	Ca	Mg	Fe	Mn	Zn	Cu	DI	DSI
Density									
WHC									
pH									
EC									
OC									
FL									
Na									
N									
P									
K	1								
Ca	.895*	1							
Mg	0.705	0.495	1						
Fe	-0.772	-0.497	-0.596	1					
Mn	-0.741	-0.521	-0.327	0.598	1				
Zn	0.376	0.500	-0.391	-0.256	-0.537	1			
Cu	.823*	0.696	0.269	-.825*	-.809*	0.733	1		
DI	0.136	0.083	0.701	-0.204	0.434	-0.736	-0.285	1	
DSI	0.440	-0.003	0.617	-0.667	-0.627	-0.210	0.393	0.140	1

WHC= Water Holding Capacity; EC= Electrical conductivity; OC= Organic Carbon; FL= Free Lime; DI= Disease Incidence; DSI= Disease severity index.

***Values are different from 0 with a significant level p= 0.05.**

**** Values are different from 0 with a significant level p= 0.01.**