RESEARCH ARTICLE

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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Maharashtra government reported 10,000 Core production loss of Pomegranate every year, due to incidence of Telya disease. The present study was aimed to analyze physical properties, chemical properties, available micronutrients and macronutrients in soil of pomegranate orchards infected with Telya disease at Nasik, Maharashtra. 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%) was recorded in Sompur village whereas maximum incidence (74.40%) and severity (68.70%) was recorded in Daswel and Mangitungi village respectively. pH (7.5-7.9) and free lime concentration (7.4-9.4%) was exceptionally very high for all test and control villages. 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 case of mock orchards all the parameters were in accordance with reference values. Statistical analysis of data declared that there was significant difference among parameters of tested groups (P>0.05) while for control fields there were no significant differences (P<0.05). Further, positive correlation between macro-micronutrients (Na, Ca, N, P, K, Mn) and incidence of disease was recorded which concludes that imbalance in nutrients promotes growth of pathogen and increases susceptibility of plants towards pathogenic attack. Further, balancing of nutrients through fertilizers or foliar spray could be an effective strategy of integrated pest management system.

Key Words: *Integrated pest management; Pomegranate; Telya; Soil nutrients*

INTRODUCTION

Pomegranate is one of the most preferred table fruit crop has a place with the family Lythraceae [1]. 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, flavanoids and minerals. These compounds are responsible for many biological and pharmacological applications such as, antimicrobial, anti-inflammatory, anti-diabetic, anti-cancer, and antioxidant activities [2]. It is economically developed in tropical and sub-tropical locales of the world. Due to winter hardy, drought tolerant and long duration of storage properties India has become one of the largest producer and exporter of pomegranate in the world. In India, this economically and nutritionally important plant mainly concentrated in Maharashtra followed by Karnataka, Gujarat, Andhra Pradesh, Madhya Pradesh, Tamil Nadu, and Rajasthan [3]. 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 axanopodispvpunicae) affect pomegranate production among which epidemic proportion of Telya disease leads to 60-80% crop loss [4]. 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 [5]. Moreover, the plant is also susceptible to various abiotic stresses viz.; environmental conditions, nutritional quality of soil, ripening, storage, and post-harvest treatments [6]. Among all soil acts as a medium for plant growth and regulates supply of nutrients, water, gases and heat to the crop. Even the presence of different microbes interfere physical and chemical properties of the soil, which ultimately affects crop productivity. Therefore, soil composition ought to be reasonable for the germination of the seeds and development of the roots [7]. Moreover, timing of seeding, crop rotation, mulching, tillage, seedbed preparation, irrigation, and application of mineral nutrients, liming and organic amendments are major factors of occurrence and extremity of plant diseases. Among all nutrient deficiencies and toxicities contribute more in disease severity [8]. There are 18 nutrient elements; grouped as primary macro-nutrients (N,P, K), secondary macro- nutrients (Ca,S,Mg) and micronutrients (B, Cl, Mn, Fe, Zn, Cu, Mo) can affect the development of a disease by acting on host or pathogens [9]. These supplements can change 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 [10]. In addition, nutrients present in the soil naturally and incorporated in the soil artificially as fertilizers both have impact on soil climate which eventually influence the pathogenicity of the microbe [11]. Effect of nutrients on growth and development of the pathogen varies with kind of pathogen e.g. in 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.) [12]. other side many researches supports that application of nutrients can control disease severity and develop resistance in plant or host. So, it is not essential that application of particular nutrient which increases severity of one disease may decrease the severity of another disease for same host or different host [13]. For instance incidence of Pyrenophora tritici-repentis on wheat is inversely proportional to the concentration of potassium. Furthermore, incidence and severity also affected by types of fertilizers as ammonium-based fertilizers escalate the occurrence of Phytophthora root rot, Fusarium wilt, Fusarium crown rot, root rot like diseases, whereas, nitrate-based fertilizers inverse the effect [14]. Various strategies are used to control pest and diseases viz; cultivation of less susceptible or resistant varieties, biological control, chemical control,

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management by improvising cultural practices and control through plant nutrition. Although, function of plant nutrition in disease management is well understood yet sufficient utilization of mineral nutrients to control any infection is not in standard practice [15]. Considering the connection between soil supplements and disease extremity, present investigation was intended to ascertain the soil nutrient status in pomegranate plantations tainted with telya disease. The findings here can be utilized to oversee infection by adjusting mineral sustenance as an integrated pest management system.

MATERIALS AND METHODS

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 Dhule locale (Table 1). Northern Part of Nasik district is portrayed by sub- tropical environment having an average yearly temperature of 32°C, precipitation of 175-200 mm- coupled with 80%-90% humidity. The trees of selected orchards were 3-5 years old, placed at the distance of 4 m*4 m apart and drip irrigated with four emitters per plant. Before starting of season (Bahar) pruning was done to train the tree in proper shape [16]. 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.

Assessment of disease incidence and severity

Roving survey of disease incidence and severity was conducted amid of Mrig bahar (June- January) and Ambe bahar (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 distinct scale created by Huber [17], using 0-5 scale rating. Where, rating description was as follows; 0=No symptoms; 1=1-10% Disease infection (Initial oily spot), 2=11-25% Disease infection (Initial and dark spot), 3=26-50% Disease infection (Y shaped crack), 4=51-75% Disease infection (middle stage), 5=>75% 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 following formula;

% incidence=(Number of infected)/(total number of observed plants)*100

However, for assessment of disease severity index 20 fruits per plant were randomly selected and graded as per the scale developed by Sharma. Further, %DSI was calculated by using formula adopted from Lakshmi.

%DSI=Sumofalldiseaseratings $(\Sigma n\times v)$/(Numderoffruitsexamined(N)×Maximumdiseasegrade(Z))*100

Where, 'n' and 'v' represents number of samples in each numerical rating and grade in each numerical rating respectively.

Collection and processing of soil

The pattern soil samples, 20-33 cm profundity, from 7-8 distinct sites of field were collected, prior to beginning of bahar treatment. All samples were mixed completely in the wake of eliminating surface litter and weighed upto 1 kg. 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 disease was reported. Samples were air dried in shade, ground, and passed through 0.2 mm and 2 mm strainer. Afterward, stored in plastic bags and transferred to Shejami laboratories, Satana, Nashik (funded by Agriculture department of Maharashtra) for additional assessments.

Soil analysis

Determination of chemical properties, physical properties, availability of macronutrients and micronutrients were done by adopting methodologies from Huber and Graham [18]. In order to determine physical properties of soil like Bulk density and hydraulic conductivity clod coating and constant head method was followed respectively. Soil pH and electrical conductivity were estimated in a 1:5 w/v aqueous solution. Soil organic carbon and free lime were assessed through wet oxidation method [19] and acid neutralization method separately. Available N was determined by alkaline permagnate method [20]. For assessment of Available P Olsen's extractant method was followed. For exchangeable sodium and available potassium flame photometer method was adopted. The DTPA- extactable micronutrients (Fe, Mn, Zn, Cu) were assessed by using atomic absorption spectrophotometer (USA make Analyst 400) method from Lindsay and Norvell.

Statistical analysis

The complete randomized 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 relation between physico-chemical properties of soil and disease severity, Pearson's correlation analysis was performed among soil parameters and disease incidence and severity, for all selected villages at correlation coefficient of 0.01 and 0.05 using SPSS V27 software.

RESULTS

The survey conducted amid of Mrig bahar and Ambe bahar shown that telya disease on all plant parts of pomegranate is common in all selected villages of north Nasik district. The outcomes uncovered that maximum DSI 68.71% 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 (Figure 2). The disease incidence significantly varied ($P>0.05$) where as there is no significant difference in disease severity of villages surveyed ($P<0.05$). Disease incidence and severity were positively correlated ($r_{DS}=0.790$. $r_{DN}=0.413$; $r_{ML}=0.635$ and $r_{SM}=0.519$) for all territories except MangiTungi village ($r_{MT}=0.011$) at P0.05. There are a few variables which fundamentally affect disease incidence and severity such as climatic parameters (Temperature, rainfall and humidity), irrigation process, type and rate of fertilizers used, agricultural practices, bahar timings and presence of inconstancy in pathogen [21].

TABLE 1

Geographical location and climatic characteristics of year 2014-15 of surveyed villages of Nasik district, Maharashtra

S.No.	Village Name	Longitude W	Latitude N	Rainfall (m.m.)	Humidity (%)	Temperature (oC)
1	Mangi Tungi	20.834	74.094	99.6	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	103.6	69.49	25.40

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*

Remarkable differences among physical properties, chemical properties, availability of macronutrients and micronutrients were observed in all soil samples of pomegranate orchards. Average Water holding capacity and density of all soil samples were accordant with the standard values which showed that soils of study area were less dense with high permeability reasonable for pomegranate crop creation [22]. The pH of tested soil samples ranged in between 7.0-8.5 and the average pH was 7.7 for all locations except Mangi Tungi village that was 7.9. The soil pH in all orchards was basic and in support of findings of Lima [23]. 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 is 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; rFreelime=0.987). Electrical conductivity estimates the salinity of 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 2). It was observed that 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 village which is 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 2. Results of current study revealed that average available content of Na and Ca was in scope of standard limit for all villages where as soil samples from orchards of Mangi Tungi 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 function of plant membranes [24]. 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, resistance and tolerance capacity of crop plant towards any disease might be affected. In case of macronutrients all orchards showed deficiency of N and K whereas measure of P was in favor of Pomegranate crop. Similarly, incidence of Panama disease of banana (Fusarium oxysporum f. sp. cubense) and leaf spot of coffee (Cercospora spot) increased at lower concentration of N reported by Maity, et al. [25-28]. Conversely, high N supply increases the incidence of bunch rot of grape wine occurred due to Botrytis Cinerea [29]. There are several factors responsible for these distinctions such as; the form of N supplied as fertilizers (ammonium based or Nitrate based), type of pathogen (Obligate or facultative), development phase of plant when N is provided, plant species and plant growth conditions [30].

Various combinations of macronutrients (N:P:K:10:26:26, 00:34:52, and 19:19:19) 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 high concentration of N upgrades the vegetative development of plant so proportion of young tissue which is more susceptible towards pathogenic attack, increases as compared to developed tissues. Moreover, activity of key enzymes of phenol metabolism might be diminished in presence of high N which leads to aggregation of phenolics and amino acids. These low molecular N compounds acts as substrate for the germination and growth of conidia thus growth of pathogen increases [31,32]. Likewise, Zn insufficiency promotes high membrane permeability which leads to high N supply [36] yet deficiency and negative correlation was observed in between both nutrients in present study. Deficiency of K content and high disease incidence in current investigation was in support of findings of 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 [33,34]. Like high N supply lack of K decreases the synthesis of high molecular weight compound which results into deposition of low molecular weight compounds which act as substrate for parasite development. Moreover, P is applied in the form of PO43- in soil which suppress disease incidence by inducing resistance in host plant reported previously [35].

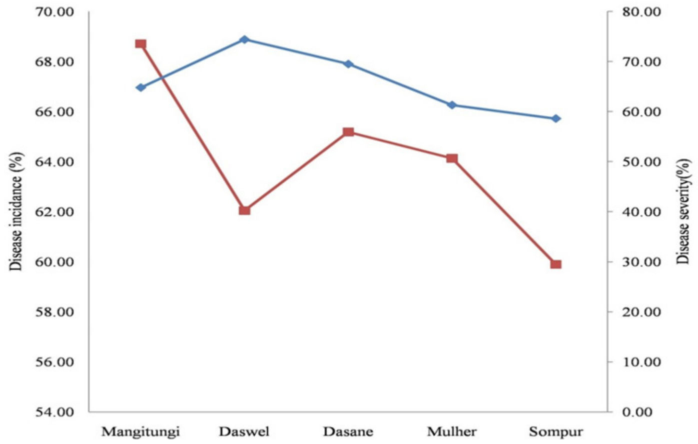

Figure 2) *Disease incidence and severity of Telya disease of Pomegranate of studied orchards. Data presented here is the mean of incidence and severity of ten fields per location*

Among all micronutrients Mg concentration was in acceptable limit for all surveyed orchards. Additionally, Soil samples from Dasane, Daswel, Mulher and Sompur had adequate amount of Fe, Mn, Cu whereas, insufficiency was observed in soil samples of Mangi Tungi village. Similar to essential macronutrients, micronutrients are also involved in suppression of disease severity by affecting physiology and biochemistry of plant. Inadequacy of micronutrients can be overwhelmed by direct foliar splash than provided in soil as lesser amounts is required to fulfill their role. These micronutrients have 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 methylesterase which promotes fungal growth and degrades host cell wall respectively. Other side, Mn activates the enzyme responsible for biosysnthesis of lignin and suberin. These biomolecules act as barriers to fungal pathogen invasion [36]. Junior was reported that 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 [37]. In present investigation, soil samples of DS, DN, ML showed deficiency of Zn which could have effect on disease incidence and severity. This is because during infection generation of free radicals induces permeability of low molecular weight compound which ultimately leads to pathogenesis [38]. 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 [39]. Role of Cu in disease resistant is not well studied yet. Foliar spray of Cu as fertilizer required 10-100 times higher than amount required naturally by the plants, yet it did not affect the extent of infection [40]. It was observed that physical properties, 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.

TABLE 2

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	K	Ca	Mg	Fe	Mn	Zn	Cu	DI	DSI
Density	1																	
WHC	-0.535	1																
pH	-.929*	0.361	1															
EC	-0.177	.925*	0.023	1														
OC	0.093	-0.561	-0.07	-0.598	1													
FL	-.970**	0.453	.987**	0.108	-0.047	1												
Na	.946**	-0.364	-.945**	0	0.202	-.941**	1											
N	.874*	-0.193	-.880*	0.173	0.167	-.860*	.977**	1										
P	.886*	-0.2	-.980**	0.149	0.04	-.948**	.955**	.931*	1									
K	-.868*	0.597	.885*	0.335	0.015	.921*	-0.743	-0.596	-0.781	1								
Ca	-0.778	0.738	0.644	0.526	0.084	0.747	-0.542	-0.376	-0.499	.895*	1							
Mg	-0.4	0.585	0.567	0.545	-0.409	0.536	-0.368	-0.204	-0.452	0.705	0.495	1						
Fe	0.544	0.001	-0.761	0.199	-0.373	-0.717	0.524	0.446	0.735	-0.772	-0.497	-0.596	1					
Mn	.933*	-0.256	-.954**	0.116	0.078	-.943**	.990**	.978**	.977**	-0.741	-0.521	-0.327	0.598	1				
Zn	-0.594	-0.029	0.414	-0.317	0.586	0.496	-0.479	-0.506	-0.433	0.376	0.5	-0.391	-0.256	-0.537	1			
Cu	-.819*	0.114	.849*	-0.214	0.453	.869*	-0.744	-0.693	-.832*	.823*	0.696	0.269	-.825*	-.809*	0.733	1		
DI	0.327	0.289	-0.159	0.526	-0.221	-0.186	0.404	0.549	0.281	0.136	0.083	0.701	-0.204	0.434	-0.736	-0.285	1	
DSI	-0.404	-0.063	0.695	-0.223	-0.259	0.573	-0.606	-0.608	-0.748	0.44	-0.003	0.617	-0.667	-0.627	-0.21	0.393	0.14	1

Note: 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.

DISCUSSION

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, causal agent of disease reported here is fungal pathogen (data not shown) in this way; reasons referenced above may act as primary source of inoculums. Although application of nutrients through fertilizer can attain the required concentration for resistance of disease but several approaches like crop rotation, green manuring, intercropping, soil tillage can imbalance the optimum nutrient concentration [41]. 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 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 Mangi Tungi village this is due to application and timings of fertilizers through foliar spray. In a detailed study of depicted that to limit the entry of pathogen to the plant; ideal utilization of chemical fungicides ought to be applied at young expanding tissues, including fruits, leaves and flowers. Similarly, disease severity of Dasane, Daswel and Mulher village was near to Mangi Tungi, this could be attributed to environmental factors and overhead irrigation process which aids successful colonization of the pathogen [43].

CONCLUSION

The outcomes of current study showed that soil available nutrients are correlated with 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 micronutrient was recorded less when contrasted with standard values. Imbalances in nutrients would influence the development of pathogen as well. Level of disease incidence and severity was less in Sompur taluka as analyzed to other locale, concludes that rate and seriousness relies upon the unbalancing of supplements as well as sanitization measure, 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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