An Investigation on the Relationship Between Mineral Nutrition of Lemon and Rumple

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HIGHLIGHTS

- Fruit development stages are extremely important for Lemon and Rumple.
- The nutrient content of the fruit rind is also highly important for Lemon and Rumple.

Abstract

This study investigated the relationship between Rumple and tree crown parts regarding direction, fruit development stages and fruit rind nutrient content. A Lemon orchard on which Rumple disorders have shown severely were chosen among Erdemli and Silifke region where the majority of grown lemon cultivar is Kütdiken. In this orchard, from healthy and contaminated trees samples were taken from the South and West half parts of crown and the North and East parts of the crown separately. Also, fruit samples were taken at four fruit development stages which were hazelnut-sized fruit, end of fruit enlargement, the beginning of maturation and fully mature fruit stages. The rind of samples fruit was analyzed, and their content of N, P, K, Ca, Mg, S, Mn, Fe, Zn, B, Cl and Na was determined. PCA was used to analyze these data. Biplot scheme of the 2nd Sampling from the part one-half of the trees which includes the South and West directions, that is, from the Healthy (G2S) and Rumple signed trees (G2B) taken were examined. The increase in K, Zn, Fe, Ca, and Mg is associated with Na, P and Cl concentration reduction. Besides this, in this period, it was observed that fruit rind has higher N, S, Mn and B content which were taken from part one, that is, the South and West sides, of healthy plants. The relationship identified here is important because Rumple's symptoms become visible after this stage.

Keywords: Lemon, Citrus, Rumple, Mineral Nutrition

1. Introduction

This rind disorders damage the external layer of lemon fruit. It is given different names in different countries and by different researchers. For example, Russo and Klotz (1963) called "Wrinkle Rind", Knorr (1963) called "Rumple", Salerno (1963) called "Raggrinzimento Della Buccia", Özbek et al. (1974) Çöküntü, Benek and Çopur. Rumple does not affect fruit flesh and juice, but it causes fruit to lose its market quality and value. Rumple was described first in Florida in 1956 by Knorr (1958). Later, it is detected by Russo and Klotz (1963), by Salerno et al. (1968) in Italy, Florida, Korsika and Cyprus. Moreover, it is detected by Chapot and Bahcecioglu(1969) and by Chapot (1971) in Turkiye, Cyprus, Lebanon and Ethiopia, respectively. Chapot ve Bahçecioğlu (1969) reported that Rumple was found in Antalya, Mersin Adana and Hatay (Arsuz) in the years 1960-1961.

Rumple damage rate has shown differences according to years and region. Knorr (1963) 10-14%, Salerno (1965) 30%, Knorr and Koo (1969) 38% have reported damages rates. Besides these, some extremely high damage rates, like 77% in Florida, 75% in Turkiye have been detected (Knorr 1963; Knorr and Koo1969; Chapot and Bahçecioğlu 1969; Chapot 1971; Klotz et al. 1972). In Spain, in Murcia and Alicante, citrus-grown regions, Rumple affected to Primofiori and Fino's lemon cultivar-grown orchards, where the damage rate was 20-80% (Pinilla 1991).

Rumple damage resembles *Oleocellosis* on fruit rinds. Fat sacs maintain their normal shape, but the surrounding tissues lose their normal appearance (Knorr 1963). The first symptoms of the collapse began in the early period when the color of the fruits begins to change. The change in lemon peel manifests itself as a slight color change. Subsequently, the affected areas gradually spread unevenly and increase in size. Gradually, their color starts from dark green on a yellow background darkens to chestnut-brown and finally turns into a dark brown-black color. Parallel to these macroscopic changes, essential oil glands undergo a series of similar discolorations and eventually collapse. The factors causing the collapse and the occurrence of damage to the fruits were investigated with numerous field trials, but no reliable results could be obtained.

The first scientific studies were carried out in Florida in 1958, on its relationship with genetic structure. (Knorr 1958,1963; Knorr and Koo 1969). The relationship of fungi, bacteria, aphids, worms, and pesticides with the sediment was investigated and negative results were obtained (Knorr 1963; Salerno et al. 1968; Knoor and Koo 1969). It was investigated assuming that it could be associated with virus disease or citrus petrification disease and negative results were obtained (Knorr 1963; Chapot and Bahçecioğlu 1969; Knorr and Koo 1969; Chapot 1971). Studies on the relationship between Rumple and water balance and irrigation were initially promising, but later satisfactory findings could not be obtained (Russo and Klotz 1963; Salerno 1968, 1965; Scaramuzzi 1965; Knorr 1965, 1966, 1967; Salerno and Continella 1967; Salerno et al. 1968; Knorr and Koo 1969). Knorr (1965), Knorr and Koo (1969). Considering that the collapse is a physiological disorder, they applied GA3 and anti-transpirant applications to prevent cracking and splitting of the bark and to preserve the fruits on the tree, but the results were not as they expected. Mechanical effects were also investigated, and reliable results could not be obtained (Knorr et al. 1963; Knorr and Oberbacher 1964; Knorr and Koo 1969).

Turkey produces around 1,188 thousand tons of lemon (TUIK 2020). The amount of production is more than 1.8 times the consumption of our country. In other words, the consumption of lemon should be increased, expanded, spread throughout the year, and more importantly, some of it should be exported. In addition, since lemon production is concentrated in certain months of the year, it is necessary to increase the supply time to the market and to store it to meet the demand of the market. In addition, to ensure price stability, it is necessary to supply enough products to the market regularly and stably. This is only possible if the product is of storable quality and can be stored. Kütdiken is the most widely grown lemon variety in our region due to its superior quality and long-term storage properties. Unfortunately, in our region, Kütdiken is the lemon variety that was the most affected by Rumple and the market value of the fruit in fresh consumption completely be destroyed too. This study investigated the relationship between Rumple and tree crown parts regarding direction, fruit development stages and fruit rind nutrient content.

2. Materials and Methods

As a result of the literature review and interviews with experienced producers, the gardens in Erdemli and Silifke districts of Mersin, where almost all the Kütdiken Limon variety is grown, have been scanned. A garden was selected on the eastern bank of the Göksu River, 600 m away from the river, in the Göksu Delta of the Silifke district, which was believed to have the most intense Rumple. As a result of the information received from the producer and depend in on observation, 6 infected lemon trees showed collapse in their fruits and 3 healthy lemon trees were selected and marked.

The tree crown is divided into two parts with a line length from northwestern to southeastern regarding sunlight exposure. Part, one included the east and west directions, and part two included the north and east direction. This was done to determine the direct effect on Rumple. (Figure.1)
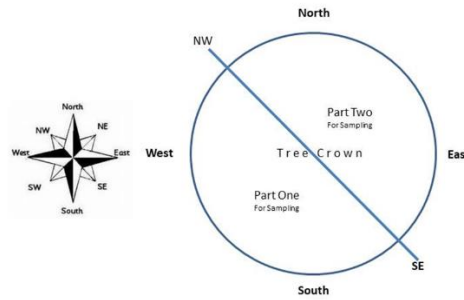

Figure 1. Tree Crown

In 2018 and 2019 years, fruit samples were taken from crown parts, at four fruit development stages which were hazelnut-sized fruit (1. Sampling stage), end of fruit enlargement (2. Sampling stage), the beginning of maturation (3. Sampling stage) and fully mature fruit stages (4. Sampling stage).

The fruit skins of the samples taken were peeled, dried, and prepared for analysis. The total N contents of the samples were determined by the Kjeldahl method. (Macz et al. 2001). To determine the P, K, Ca, Mg, S, Mn, Fe, Zn, B, Cl and Na amounts, the ground plant samples were burned in nitric acid: perchloric acid (HNO3:HClO4) (4:1) mixture, the final volume was made up to 100 ml with bi-distilled water, and the readings were made in ICP-OES (Hong et al., 2019).

3. Results and Discussion

As a result of the evaluation of these samples collected at the Gevne Valley (Alanya- Hadim-Taşkent) in 2019-2020, 11 species were identified belonging to the genera: *Adoxomyia*, *Pycnomalla* (Clitellariinae), *Lasiopa* (Nemotelinae), *Chloromyia* (Sarginae) and *Oxycera*, *Oplodontha* and *Stratiomys* (Stratiomyinae). The list with all specimens and species found is presented below.

The parameters obtained from the samples taken at different growth and maturation periods of lemon were subjected to Principal Components Analysis (PCA) (Tablo 1). As a result of PCA, the study was explained as high as 86.6% in two components. Studies reported that the first two components must be explained in more than 25% of the study to use the PC analysis (Mohammadi and Prasanna 2003; Mozafari et al. 2019; Seymen et al. 2019). It is obvious that a strong explanation of PCA will yield important results regarding the usability of this analysis and the parameters looked at.

As a result of PCA, the first component (PC1) explained a very high rate of study at 75.7%. N, K, Ca, Mg, S, Mn, Fe, Zn and B parameters were explained high in the positive direction, while Cl, P and Na were the parameters explained in the negative direction.

The second component (PC2), on the other hand, explained 10.9% of the study. And parameters such as N, P, S, Mn, B and Cl were explained high in the positive direction and Zn was the parameter that was explained high in the negative direction. Especially Cl showed a very high positive value.

Table 1. PC1 and PC2 eigenvalues and eigenvectors

Components	PC1	PC2
Eigenvalue	9.0873	1.306
Varyans Ratio	75.727	10.883
Total Varyans	75.727	86.611
Eigenvectors		
N	0.28712	034319
P	-0.31312	0.21631
K	0.31365	-0.02166
Ca	0.31678	-0.09476
Mg	0.30604	0.00224
S	0.29132	0.33707
Mn	0.29538	0.30693
Fe	0.31042	-0.1061
Zn	0.27018	-0.29875
B	0.27054	0.34605
Cl	-0.19913	0.61154
Na	-0.26983	0.15464

Principal Components (PC): Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulfur (S), Manganese (Mn), Iron (Fe), Zinc (Zn), Boron (B), Chlorine (Cl), Sodium (Na)

Using PC1 and PC2 components, a Loading Plot Chart was created to examine the relationship between the nutrient content of fruit samples taken from different sides of the crown of healthy and infected trees at different developmental stages (Figure 1). It has been reported that if the angle between the vectors in the figure is <90°, there is a positive relationship, if it is >90°, there is a negative relationship, and if the angle between the vectors is 90°, there is no significant relationship (Yan and Kang 2003). When the figure is examined, it is seen that there is a high positive correlation between the fruit peel nutritional elements content parameters (N, K, Ca, Mg, S, Mn, Fe, Zn and B) explained in PC1. (Cl, P and Na) elements, on the other hand, showed a positive relationship with each other in a negative direction. The element group (Cl, P and Na) exhibited a highly negative relationship compared to the element group (N, K, Ca, Mg, S, Mn, Fe, Zn and B). The first signs of collapse disorder generally begin to appear at the beginning of ripening (3rd sampling period). In this respect, it can be said that at the end of fruit enlargement, which is the second sampling period, the mineral content of the fruit peel is very important in the emergence of Rumple. Therefore, it has been evaluated that Principal Components Analysis (PCA) can provide important information in the 2nd sampling period. According to PCI, in the 2nd sampling period, it was determined that the changes in the K, Mg, Ca and Fe contents of the fruits taken from part one and part two with Rumple and the trees without Rumple were different. While the contents of K, Mg, Ca, and Fe were higher in the peels of fruits taken from part two in the 2nd sampling period from healthy trees compared to those taken from Part one. These elements were found to be higher in the peels of the fruits taken from part one of the infected trees than those taken from part two. In addition, the contents of K, Mg, Ca, and Fe in the fruits taken from part one of the trees with Rumple were higher than those of the fruits taken from part one of the trees without Rumple. Again, in this period, it was determined that the N, S, Mn, and B elements were higher in the peel of the fruit samples taken from part one of the trees that did not show any Rumple symptoms. In addition, in the 2nd sampling period, it was determined that the peels of the fruits taken from part one of the trees without Rumple had higher P content than both the peels of the fruits from part two of the trees without Rumple and the peels of the fruits taken from the part one and part two of the trees with Rumple.
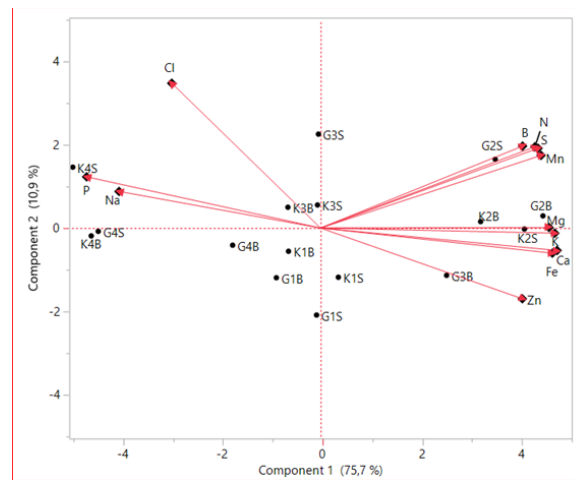
Figure 2. Biplot graph

Abbreviations K1S: First sample from part two, healthy trees, K1B: First sample from part two, infected trees, K2S: Second sample from part two, healthy trees, K2B: Second sample from part two, infected trees, K3S: Third sample from part two, healthy trees, K3B: Third sample from part two, infected trees, K4S: Fourth sample from part two, healthy trees, K4B: Fourth sample from part two, infected trees, G1S: First sample from part one, healthy trees, G1B: First sample from part one, infected trees, G2S: Second sample from part one, healthy trees, G2B: Second sample from part one, infected trees, G3S: Third sample from part one, healthy trees, G3B: Third sample from part one, infected trees, G4S: Fourth sample from part one, healthy trees, G4B: Fourth sample from part one, infected trees

4. Conclusions

When the figure drawn by the biplot method is examined (Figure 2). An increase in the concentrations of N, S, Mn and B elements in the fruit peel and a decrease in the concentrations of Na and P elements were observed in the sample taken from part one of the G2S tree at the end of the fruit enlargement period. Biplot also shows that the K2B, G2B and K2S samples are associated with the increase in Mg, Ca, Fe and Zn concentrations, and has negative relation with the decrease in the concentrations of Cl, Na and P elements. The relationship identified here is important. Because the Rumple symptoms seen on the peel of the fruits become visible symptoms for the first time after this stage. Biplot also showed the differentiation of healthy and defective fruits at the beginning of the maturation period of fruits, in part one of the tree crown (G3S and G3B). Comparing G3S and G3B, it was seen that G3B was associated with an increase in Zn, Fe, Ca and Mg and a decrease in Na, P and Cl concentration. According to the findings, it can be thought that the differences and irregularities in the distribution of minerals such as K, Mg, Ca, and Fe in the tree are effective factors in the formation of Rumple. We believe that promising results can be obtained if new studies are conducted on the negative correlations observed in the concentrations of K, Fe, Ca and Mg groups and Na, P and Cl groups occurring before the beginning of maturation in fruits with Rumple in part one.

In addition, it would be helpful to determine and correlate the mineral content of the leaf and the mineral content in the fruit peel to make a healthier evaluation.

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