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How Does N: P: K Fertilizer Applications in Different Levels Affect The Nutrition of Anatolian Chestnut (*Castanea sativa* Mill.) ?

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Abstract

The sweet chestnut has provided the fuel, shelter, and nutrition needs of mankind for centuries. However, it was mostly accepted as a forest tree. This study aims to determine the effect of chestnut leaves of fertilizers containing nitrogen, phosphorus, and potassium on nutrient elements and to create a macro fertilization program for the chestnut tree. In this context, nitrogen (0, 110, 220, 330, 440 lb N ha^{-1}) phosphorus (0, 55, 110, 165, 220 lb P ha^{-1}), and potassium (0, 110, 220, 330, 440 lb K ha^{-1}) fertilizers were applied to chestnut trees for two years in different levels. While nitrogen applications increase N, Zn, and Cu concentrations in chestnut leaves; It reduced Fe and Mn content, and no statistically significant effect was found on P, K, Ca, and Mg concentrations. However, increasing phosphorus applications increased N, P, and Cu concentrations in chestnut leaves, but decreased K, Ca, and Mg content, and no statistically significant effect was detected on Fe, Zn and Mn concentrations. This research, which is among the very limited number of studies related to the nutrition of chestnut, maybe a guide for future studies. Keywords: Chestnut (*Castanea sativa* Mill.), plant nutrition, interaction, macronutrients, micronutrients.

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1.Introduction

Chestnut (*Castanea sativa* Mill.) is one of the most important tree nuts in the world (Ertan et al., 2015). Many species of the genus Castanea are grown in several parts of the world for timber and/or edible nut production (Portela et al., 2007). However, some herdsmen also cut down wild fruit trees to enlarge their meadow area, leading to the disappearance of the primary wild chestnut forest (Ercişli et al., 2009). According to the Food and Agriculture Organization Statistical Database (2019), worldwide chestnut production is 2.327.500 tons. Chestnut fruits are highly regarded and widely consumed throughout Europe, America, and Asia. In addition, chestnuts

are one of the most popular nuts in the oriental world. Chestnuts are mainly cultivated in China 1.879.000 ton, Bolivia 84.800 ton, Turkey 64.750 ton and the Republic of Korea 56.200 ton.

Since nutrient management is a critical aspect of crop production, nutrient recommendations have been developed for several fruit and nut species. Sufficiency or survey ranges for individual nutrients are routinely used by soil and plant testing facilities as a basis for providing fertilizer recommendations. The sufficiency range, used for foliar testing, indicates the values at which the tissue is at the optimal nutritional status, as determined by field testing (Bryson et al., 2014).

However, there is limited scientific data on chestnut management, in particular in the field of

mineral nutrition and crop fertilization (Portela et al., 2007).

In the past, this species was not fertilized, the soil only being amended when farmyard manure was available. Regular application of mineral fertilizers is a recent introduction (Arrobas et al.,2017). However, studies done with young potted plants have shown that the crop responds to the application of mineral nutrients (El Kohen et al., 1992; Laroche et al., 1997), and therefore it is expected that a positive response to fertilization may also occur in the field. Pérez-Cruzado et al. (2011), used wood-bark ash, a product rich in Ca, K, Mg, and to a lesser extent P, as a fertilizer in a young chestnut orchard. They recorded an increase in the diameter and height of the trees and also an improvement in the nutritional status of the plants in terms of K, Ca, and Mg. In the world, there are very limited data and researches to determine the need for chestnut fertilization and plant nutrients.

This study was carried out to determine the change of plant nutrient elements in the chestnut plant with nitrogen, phosphorus, and potassium fertilizer applications.

2.Material and Methods

2.1. Climate Data of Research Area

The region is located in the Marmara and the Aegean climate transitional zone. In the chestnut vegetation period (from March to October), the total amount of rainfall was 333.8 mm in the first year and 396.3 mm in the second year. The average temperature in the period of the research is consistent with the average temperature long term years, and the total rainfall is consistent with the total rainfall long term years. Climate data for the experimental sites and periods are shown in Figure 1.
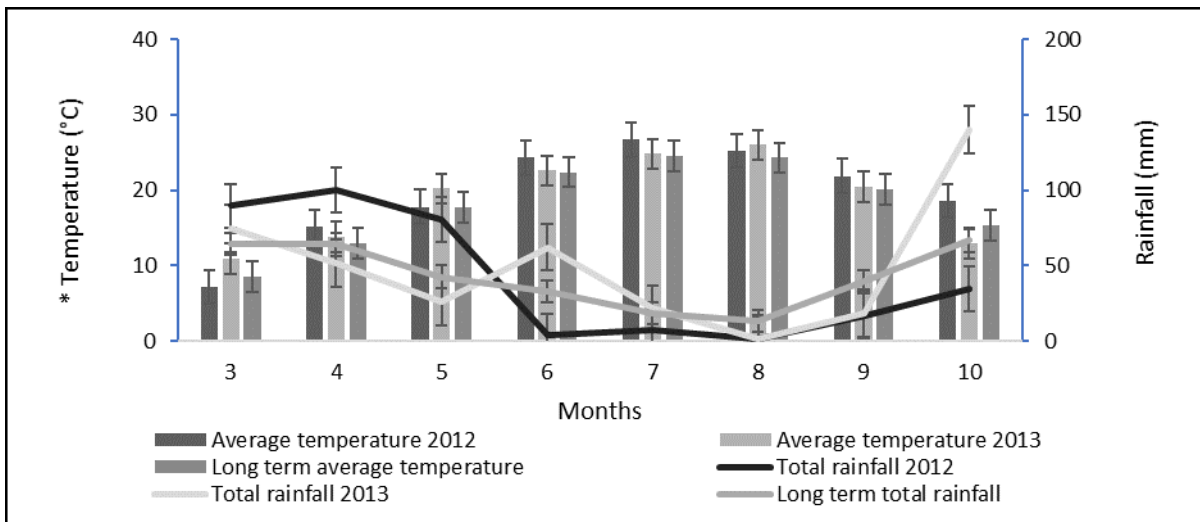
Figure 1. Climate data at the research area over two years (2012 and 2013). The values are shown (bars or symbols) are means ± standard deviation (SD).

2.2.Experimental Design

The study was conducted consecutive years (2012-2013) in İnegöl district of Bursa province in Southern Marmara section of Turkey. For this purpose, chestnut orchard (three zone for N, P, and K fertilizer applications) was chosen in commercial farms planted with Sarıaşılama sweet chestnut cultivars. The trees (three trees for each plot) were selected from different points of the orchard (three zones) each 1 ha fertilizer application zones had 100 chestnut trees (10 m x 10 m planting design).

The research was planned as a randomized plots design with three replications. In the study,

nitrogen, phosphorus, and potassium fertilizers were applied in 2012 and 2013. Nitrogen fertilizer applications were adjusted to be N_0 (Control): 0, N_1: 110, N_2: 220, N_3: 330, N_4: 440 lbN ha-1, phosphorus fertilizer applications, P_0 (Control): 0, P_1: 55, P_2: 110, P_3: 165, P_4: 220 lbP ha^{-1} and potassium fertilizer applications, K_0 (Control): 0, K_1: 110, K_2: 220, K_3: 330, K_4: 440 lbK ha^{-1}.

However, support fertilizers were applied for nitrogen application treatments as 165 lb P ha^{-1} and 330 lb K ha^{-1}, for phosphorus application treatments as 330 lb N ha^{-1} and 330 lb K ha^{-1}, for potassium application treatments as 330 lb N ha-1 and 165 lb P ha^{-1}. All fertilizers (treatments and

support) were applied to under the crown diameter of a chestnut tree in April mixed in 0-30 cm soil depth. In the experiment, urea (CH_4N_2O) was used as a nitrogen source, triple superphosphate $Ca(H_2PO_4)_2.H_2O$) as a phosphorus source, and potassium chloride (KCl) as a potassium source.

2.3. Soil Characteristics of Research Areas

The soil samples of chestnut orchard was taken in March. Soil samples were taken from four subsamples with stainless steel shovel at each plots and brought to the laboratory in plastic bags after mixing. Soil samples were air-dried and prepared by sieving 2 mm for analysis. The pH of the soil samples in a mixture of 1 / 2.5 of soil pure water with pH meter; $CaCO_3$ with calcimetric method; salt, conductometric method in saturation sludge; organic matter, according to the Walkley and Black titrimetric method; changeable K, Ca, Mg, Na photometric according to 1 N ammonium acetate method; availeble P, colorimetric according to Olsen method with 1.5 M sodium bicarbonate; Fe, Mn, Zn, Cu were spectrophotometrically analyzed by DTPA (Kacar 1995).

The classification and interpretation of soil analyzes were done according to Kellog (1952), Forth and Jacobs (1964), U.S. Soil Staff (1954), Evliya (1960), Schlincting and Blume (1966), Kovancı (1969), Pizer (1967), Loue (1968), Viets and Lindsay (1973).

2.4. Plant Analysis

Chestnut leaf samples were taken between 15 July and 15 August (Toprak and Seferoğlu, 2013). The samples were taken from the shoots on four sides of the tree and the leaves in the middle size. Leaf samples taken from the chestnut orchard was brought to the laboratory in paper bags, washed with sterile distilled water, and dried at 65 °C for 24 hours in the oven. The dried samples were grounded in the steel mill and had been made ready for the analysis (Kacar and İnal, 2008). Total N analysis was performed according to the Kjeldahl distillation method by using grounded leaf samples. Phosphorus, potassium, calcium, magnesium, iron, copper, zinc, and manganese were determined at leaf samples. The samples were weighed into 0.25 g microwave tubes. By adding 10 ml of the HNO_3 mixture containing 20% $HClO_4$, the weighted samples were digested for 30 min. The liquid

resulting from digestion was completed to 50 ml and the elements were determined by ICP-OES (Optima 8000, Perkin Elmer, USA). Results were given as % dry matter for P, K, Ca, Mg, and mg kg^{-1} in dry matter for Fe, Cu, Zn, Mn.

2.5. Statistical Analysis

Data were subjected to analysis of variance (ANOVA). Data were analyzed by using SPSS (Ver. 25.0) statistical program and significant differences among means were compared with DUNCAN multiple comparison test. In the study, the Pearson method was used in correlation effect analysis to determine the interactions between nutrients and application treatments.

3. Results and Discussion

The physical and chemical soil properties of the chestnut experiment orchard is shown in Table 1. Soil was determined that the physical structure of the soil was loamy, the pH was slightly acidic, organic matter contents were insufficient. Also, the macro and micronutrient contents were found to be insufficient in the soil.

N, P and K fertilizers were found to synergistic and antagonistic effects on macro and micronutrient element concentrations in leaves. The effects of nitrogen, phosphorus, and potassium applications on macronutrient content of chestnut are shown in Figure 2.

N applications significantly increased the N concentrations of the leaves as expected. The highest foliar N concentration was determined for T_3 or / N_3 treatment (330 lb N ha^{-1}) in 2012 and 2013 as 2.78 % and 2.77 %, respectively (N application zone). Chestnut trees averaged 2.38% and 2.41% foliar N in 2013 to 2015 when an annual application of 308 or 370 lb $ha-1$ of soilapplied N was applied and a nut yield response was recorded (Warmund, 2018).

The leaf N concentrations were positively affected by P treatments but the difference between the P levels was not significant for the N concentration in the leaves. Although the foliar N concentrations in the leaves did not respond to K applications in the first year, significant differences were determined between the K doses in the second year. Synergistic interactions are well known for N x K and N x P interactions (Aulakh and Malhi, 2005). They are not only important for the yield but also help to explain their combined effect on root growth, and the relevance for synchronized applications of, for

example, N and K, during the growing season (Aulakh and Malhi, 2005). Despite there were significant differences in the foliar P concentrations in the first year of N fertilization, these differences were not found the second year. In a study in apples, it was found that increasing N levels did not make a difference in the foliar P concentrations (Raese and Drake, 1997).

Table 1. Selected properties of the soil sampled shortly before the experiment started at a depth of 0–30 cm

Soil properties	Values	Soil properties	Values
Sand (%)	59.20	Available Fe (mg kg^{-1})	46.10
Clay (%)	12.20	Available Zn (mg kg^{-1})	0.43
Silt (%)	28.60	Available Cu (mg kg^{-1})	0.81
pH	5.79	Available Mn (mg kg^{-1})	52.10
$CaCO_3$ (%)	0.44	Exchangeable K (mEq 100 g^{-1})	0.35
Total salt (%)	0.02	Exchangeable Ca (mEq 100 g^{-1})	4.85
Organic matter (%)	1.46	Exchangeable Mg (mEq 100 g^{-1})	0.62
Total N (%)	0.07	Exchangeable Na (mEq 100 g^{-1})	0.08
Available P (mg kg^{-1})	6.96	CEC (mEq 100 g^{-1})	5.89

CEC: Cation Exchangable Capasity

K applications were found almost no contribution to the foliar P concentrations in this study (Table 2). On the other hand, P fertilizers applied increased the foliar P concentrations with significant statistical differences. The highest foliar P concentration was determined in T_3/ or P_3 treatment (165 lb P ha^{-1}) (first year: 0.38% and second year: %0.43) at the P application zone. These values were above the limit value (2.5 g kg^{-1}or/ 0.25%) for the chestnut leaf P concentration indicated by Arrobas et al. (2017). K fertilizers applied with increasing levels significantly increased the foliar K concentrations.

Figure 2. The effect of nitrogen, phosphorus, and potassium application on the foliar macronutrient in the chestnut. The values are shown (bars or symbols) are means ± standard deviation (SD). N, P, and K letters are fertilizer application zone in the chestnut research area (*: P≤0.05). There was no statistical difference between the treatments not shown with letters. T0: $N_0+P_3K_3$, T1: $N_1+P_3K_3$, T2: $N_2+P_3K_3$, T3: $N_3+P_3K_3$, T4: $N_4+P_3K_3$= for N application zone, T0: $P_0+N_3K_3$, T1: $P_1+N_3K_3$, T2: $P_2+N_3K_3$, T3: P_3+N_3K3, T4: $P_4+N_3K_3$= for P application zone, T0: $K_0+N_3P_3$, T1: $K_1+N_3P_3$, T2: $K_2+N_3P_3$, T3: $K_3+N_3P_3$, T4: $K_4+N_3P_3$ = for K application zone.

The highest K content was recorded as 1.47% in the first year and 1.51% in the second year for T$_4$ or / K$_4$ treatment (440 lb K ha^{-1}). These values were above the limit value (11 g kg^{-1} or/ 1.1%) for the chestnut foliar K concentration indicated by Arrobas et al. (2017). Although the foliar K concentration in European chestnut and other nut trees is 2.1-2.2 (Toprak and Seferoğlu, 2013), it has low K concentrations (0.5-0.6%) due to the lack of application of fertilization in trees grown in Missouri (Warmund, 2018). While the P applications significantly reduced the foliar K concentrations in the first year, the K concentrations of the second year remained stable in the leaves. An antagonistic relationship was determined between P levels and foliar K contents.

However, the N doses applied in both application years affected the K concentrations of the leaf in a positive via, and a synergistic relationship was recorded between N and K (Table 2). Especially in plants with high K requirements, N and K were found to be positive in different culture plants (Mengel and Kirkby, 1987; Hakerlerler, 2000). Although the foliar Ca concentrations were not affected by the N levels applied, it was statistically affected negatively by the contents of P and K. In other words, the antagonistic relationship was found between foliar Ca concentrations with increasing phosphorus and potassium levels. The excess of phosphorus can also cause Ca, B, Cu, and Mn deficiencies (Aktaş and Ateş, 1998).

The increasing K levels did not affect the foliar Mg concentrations in the first year but decreased in the second year. The increasing K applications reduce the foliar Ca and Mg concentrations (Yağmur, 2009). Although increasing K levels did not affect the leaf Mg concentrations in the first year, a decrease in Mg content was determined in the second year.
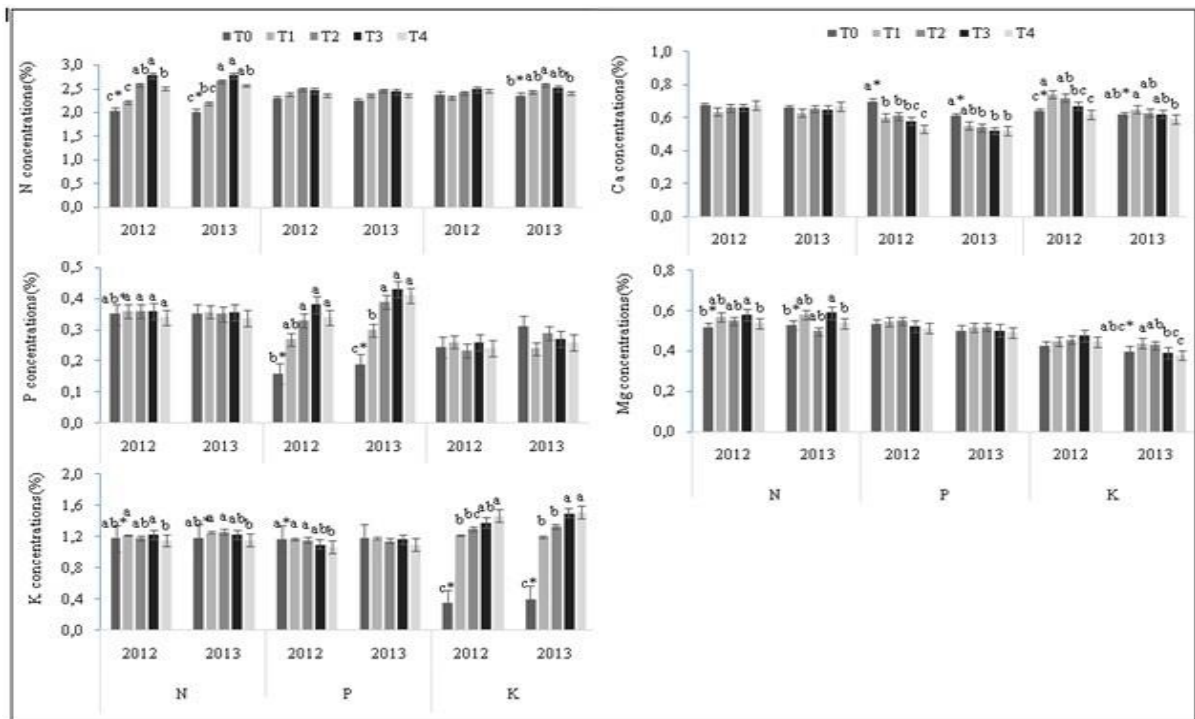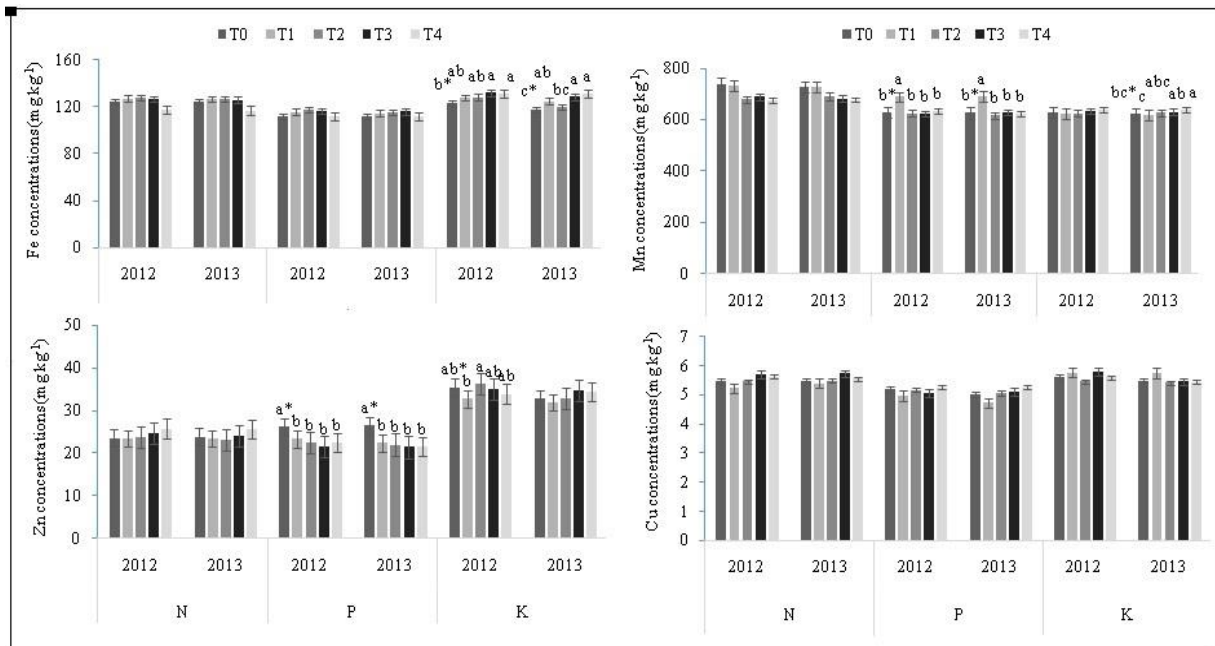

Figure 3. The effect of nitrogen, phosphorus, and potassium application on the foliar micronutrients in the chestnut. The values are shown (bars or symbols) are means ± standard deviation (SD). N, P, and K letters are fertilizer application zone in the chestnut research area (*: P≤0.05). There was no statistical difference between the treatments not shown with letters. T0: N$_0$+P$_3$K$_3$, T1: N$_1$+P$_3$K$_3$, T2: N$_2$+P$_3$K$_3$, T3: N$_3$+P$_3$K$_3$, T4: N$_4$+P$_3$K$_3$ = for N application zone, T0: P$_0$+N$_3$K$_3$, T1: P$_1$+N$_3$K$_3$, T2: P$_2$+N$_3$K$_3$, T3: P$_3$+N$_3$K$_3$, T4: P$_4$+N$_3$K$_3$ = for P application zone, T0: K$_0$+N$_3$P$_3$, T1: K$_1$+N$_3$P$_3$, T2: K$_2$+N$_3$P$_3$, T3: K$_3$+N$_3$P$_3$, T4: K$_4$+N$_3$P$_3$ = for K application zone.

High K concentration causes Mg and Ca deficiencies in leaves (Aktaş and Ateş, 1998). Increasing K concentrations in leaves cause a decrease in Ca and Mg content due to the antagonistic effect between these elements (Kacar and Katkat, 2009). The increasing P levels decreased the foliar Mg concentrations compared to the first year in the second year. Moreover, significant statistical differences were determined between the increasing N doses and the Mg content of the leaves. Ceylan et al. (2001) reported increasing N applications significantly influenced foliar P, K, Ca, Mg, Fe, Zn, Mn, and Na concentrations. The highest Mg concentration

was recorded for T_3 / or N_3 treatment (330 lb N ha^{-1}) as 0.58% in the first year and 0.59% in the second year (Figure 2). In European chestnuts, macroplant nutrient contents such as N, P, K, Ca, and Mg were determined as 2.81%, 0.18%, 2.18%, 0.30%, and 0.48%, respectively (Toprak and Seferoğlu, 2013).

The effects of nitrogen, phosphorus, and potassium applications on macronutrient elements are shown in Figure 3. The N treatments applied to the soil were not statistically significant on the foliar Fe concentrations and were stable in both years (Average: 124 mg kg^{-1}). In a study conducted in pear, researchers determined that increasing nitrogen levels do not show a linear increase or decrease in foliar Fe concentrations (Uysal and Akçay, 2015). However, applied P doses were statistically no significant in the foliar Fe concentrations in both years (Figure 3). The Fe content of the leaves remained generally stable (Average: 114.9 mg kg^{-1}). On the other hand, K applications increased the Fe content of the leaves with statistical significance. As the K levels increased, the foliar Fe concentrations increased, and a synergistic relationship was determined between them. Yağmur (2009) reported that increasing K levels increased foliar Fe content in anise. The foliar Zn concentrations were decreased consistently with increasing P levels, and a statistically antagonistic relationship was determined between both of them.

Using an excessive amount of P fertilizers gives rise to microelement deficiencies such as Zn and Fe (Aktaş and Ateş, 1998). Although increasing N levels increased the foliar Zn content compared to the control, no significant difference was found between the treatments. In contrast, Raese and Drake (1997) stated that the increasing amounts of N applied to the apple reduced the foliar Zn content. Yagmur (2009), although K applications did not have a significant effect on leaf Zn content in anise plant, potassium levels were siğnificantly effective in foliar Zn concentrations. The foliar Zn concentrations were determined as 33.65-33.34 mg kg^{-1} (first year and second year, respectively) in the K experimental zone. The foliar Mn concentrations were recorded in the first and second year of N, P, and K experimental zones, an average of 703 and 701, 639 and 636, 630, and 626 mg kg^{-1}, respectively. These foliar Mn concentrations are much higher than the amount (average 150 mg kg^{-1}) determined by researchers (Arrobas et al., 2017). Increasing P levels reduced the foliar Mn

concentrations in an attitude similar to the N application zone. A significant antagonistic relationship was determined between the Mn and P concentrations in the leaf (Figure 3 and Table 2). This decrease is thought to be due to antagonistic relations between P and some microelements (e.g. Fe, Cu, and Mn) (Kacar and Katkat, 2009).

However, in 2012, the K applications did not significantly affect the foliar Zn contents, but this data changed in 2013. The N, P, and K fertilizers applied in all research zones not caused a statistically significant difference in the foliar Cu concentrations (Figure 3). But, the synergetic impact was determined between Cu concentration and N, P in leaves (Table 2). On the contrary, an antagonistic interaction was found between Cu and K in chestnut leaves (Table 2). The highest Cu content in the leaves was recorded in the first and second year of the K experimental zone as 5.65 and 5.52 mg kg^{-1}, respectively. These foliar Cu concentrations are much less than the amount (18- 24 mg kg^{-1}) determined by some researchers (Toprak and Seferoğlu, 2013). In this research, some antagonistic and synergistic effects on nutrient concentrations of chestnut leaves of nitrogen, phosphorus, and potassium fertilizers were determined, and the differences in some nutrient concentrations were statistically significant among the rates of application.

3.1. Correlations Effect Test Between Nutrients And Applications

As expected, in N: P: K fertilization, a strong positive effect was found in foliar N, P, and K concentrations according to Pearson's Correlation model (Table 2). The strongest positive correlations were found as Zn and Cu in nitrogen applications, N and Cu in phosphorus applications, N, Fe, and Mn in potassium applications. The strongest negative correlations were recorded as Fe and Mn in nitrogen applications, K and Ca in phosphorus applications, and Zn in potassium applications.

4. Conclusions

According to the results of the study, the amount of N, P, and K to be applied in the chestnut (Sarıaşılama variety and 20 years old) orchard was determined as 330, 165 and 330 lb ha^{-1}, ($N_3P_3N_3$ or / 2:1:2 ratio) respectively. Fertilizers should be applied every year in the

middle of April and under the tree crown   diameter and mixed in the soil.

Table 2. Correlations effect test between plant nutrients and N, P, and K applications in chestnut leaves

Plant Nutrients	NF	Significant	PF	Significant	KF	Significant
N	+0.813	**	+0.531	*	+0.522	*
P	-0.059	ns	+0.867	**	-0.253	ns
K	-0.277	ns	-0.856	**	+0.853	**
Ca	+0.280	ns	-0.871	**	-0.331	ns
Mg	+0.150	ns	-0.477	*	+0.083	ns
Fe	-0.528	*	+0.040	ns	+0.799	**
Zn	+0.796	**	+0.296	ns	-0.811	**
Mn	-0.903	**	+0.238	ns	+0.839	**
Cu	+0.647	**	+0.530	*	-0.204	ns

*: 0.05; **:0.01; ns: not significant, NF: Nitrogen fertilization, PF: Phosphorus fertilization, KF: Potassium fertilization.*

Besides, according to applied nitrogen, phosphorus and potassium fertilization, the optimum amounts of required plant nutrients in the leaves of a 20 years old sweet chestnut tree for its healthy nutrition; N: 2.5-2.8%, P: 0.35-0.45%, K: 1.2-1.5%, Ca: 0.50-0.80%, Mg: 0.40-0.60%, Fe: 110-140 mg kg^{-1}, Zn: 25-35 mg kg^{-1}, Mn: 600- 800 mg kg^{-1}, Cu: 5-7 mg kg^{-1} can be considered as limit values.

According to the results of the Pearson correlation analysis of the study, the application of nitrogen fertilizers increased the N, Zn and Cu concentrations in the leaf (strong synergism), decreased the Mn and Fe content (strong antagonism), and did not cause a significant change in the P, K, Ca and Mg concentrations (zero interaction).

Phosphorus fertilization significantly increased the N, P, and Cu concentrations (strong synergism) of the leaves, decreased the K, Ca, and Mg content (strong antagonism), and remained in zero interaction with the Fe and Mn contents. Potassium fertilization increased foliar N, K, Fe and Mn concentrations (strong synergism), however, reduced leaf Zn contents (strong antagonism), and low and nonsignificant interaction determined between P, Ca, Mg and Cu concentrations and K concentration (zero interaction).

This research, which is among the very limited number of studies related to the nutrition of chestnut, maybe a guide for future studies. Finally, further studies on the plant nutrition of chestnut are needed in the future.

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Wheat: Biotrophic Fungi and Resistance Genes

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Abstract

Nowadays, biotrophic diseases such as fungi in wheat fear farmers since they cause serious losses of income. Wheat has been adapted to diverse climatic conditions, for instance, grown over a range of altitudes and latitudes under irrigated, dry, and wetter conditions. Expectedly wheat plant cultivation will reach sixty percent to cover human food necessity in coming decades. However, biotrophic fungi, for instance, *Puccinia graminis* f. sp. *tritici*, *Puccinia striiformis* f. sp. *tritici, Puccinia triticina,* and *Blumeria graminis* f. sp. which are obligate parasites weaken the plant structured plant framework and out coming in poor plant health and minimized grain fill. Therefore, this review has moved forward to answer the main three research questions as **RQ1:** How genetic resistance affects wheat crop? **RQ2:** What are the damages that cause via biotrophic fungal on the wheat? **RQ3:** What are the diversity and the area distribution of the "Ug99" pathotype. In addition, the result of this observational study will be expected to be beneficial for several areas such as in cultivation, production, education, and moreover in research.

Keywords: Rust resistance, Adult plant resistance (APR), Powdery mildew.

1. Introduction

Recently, agricultural diseases which have affected the majority of food crops diversity were documented as causing 15% pre-harvest yield loss (Cerda, R, 2017; Randhawa et al., 2019). Therefore, based on these crops, barley and wheat are critical staple foods providing 20 percent of calories and 25% of protein consumed by human (Hubbard et al., 2015). Farmers and big producers seek to ensure high-quality products via improving their production conditions such as by fertilization. Likewise, wheat cultivation is a significant group in cereals that could easily be cultivated on a large scale being third in the production area across the world (Gargouri-Kammoun et al., 2014; Abdullah and Atroshi, 2016). Wheat has improved itself to adapt to diverse climatic conditions, for instance, a range of altitudes and latitudes under irrigated, severe drought, and wet conditions. 735 million tons of wheat remained manufactured universally, worth approximately US$ 145 billion in 2015 and 2016. Agricultural Organization of the UN indicates that the existing wheat crop may cover food necessities (Vos and Bellǔ, 2019). Similarly, as declared by Singh et al., (2016) the wheat crop outcomes on a per-hectare percentage basis will be required to increase the region of five tons ha^{-1} from the existing three tons per/hectare (Randhawa et al., 2019). In fact, wheat represents 19% percent of the global major cereal crop production. Consequently, wheat products are heavily dependent on imports to meet their food safety in some countries like East and North African Countries. Therefore, the demand for wheat in the world continues to rapidly enhance the cultivation with increasing population growth development. It is statistically, predicted that the worldwide population will surpass eight billion by 2025 therefore the demand is expected to rise to 760 million tons in 2020 and exceed 880 million metric tons by the 2050, (Dixon et al., 2009), consequently, the required production needs to increase at least by 50% based

on the year of 2025 (Yadav et al., 2017). Even though the scale of disease has been impacted which can vary from one period to another; diseases are always active as an important challenge if they attack only by certain plant fragments. Furthermore, all plant parts are prone to diseases, regarding multiple diseases which can occur on the same plant. In addition, multiple diseases can occur in several plant species', depending on environmental conditions and the susceptibility of host cultivars, therefore, crop production throughout the world is reduced via biotic and abiotic stresses. On the other hand, infections were dramatically minimized to around 14% of the agricultural production area. Also, prominent infections of wheat crops that contribute to these losses such as rusts, blotches and head blight / scab. Supplementary, in recent times, emerged unnoticed diseases, for instance, wheat blast and spot blotch, correspondingly, threaten grain production (Figueroal et al., 2018). Mobasser et al., (2012) reported that the genetic diversity enhanced cultivars resistance and pathogen emergence during diseases storms. In the same way, plant pathogens or agents may affect storage, vigor, germination, marketability, yield, seed appearance, and toxins during the storage. When infected seeds are planted, the pathogens are distributed throughout the field and contaminate the land. It is important to know what levels of pathogens are in or on the seed. When levels of disease are high, it may be important to seek a different source of seed for planting. It also may be very helpful to know the present pathogens, to choose a good treatment. Many pathogens can persist in soil or on crop trash and become a problem for many consecutive years.

What's more, as reported by Singh et al. (2016) and Figueroal et al., (2018) wheat is susceptible to numerous pathogens including stem rust (SR) initiated via (*Puccinia graminis* f.sp. *tritici,*) leaf rust (LR) caused via (*P. triticina)*, and yellow rust (YR) initiated via (*P. striiformis)* (Martinez et al., 2012). While some pests such as bacteria, viruses, insects, fungi, etc. can persist in seed, stubble in soil in the coming term, others require green plant material to surviving, which is termed as **'green bridge'**. Therefore, the lifestyles, self-sown volunteer of wheat crops ''**the green bridge''** important in enabling the survival of the pathogens from one cropping cycle. Consequently, destroying the green bridge is an important component of the integrated control of these pathogens. (Park et al.,

2015). Moreover, the utilization of resistant wheat varieties has reduced the damage together with the reduction of green bridge (Park, 2016). This observational research study, in short, has moved forward to answer the main three research questions which are RQ1: How genetic resistance affect wheat crop? RQ2: What's are the damages that cause via biotrophic fungal on the wheat? RQ3: What is the diversity and the area distribution of "Ug99" pathotype.

1.1. The Required Questions in the Research

1.1.1. RQ1: How Genetic Resistance Affect Wheat Crop?

Rational$_1$: The characteristic of the host plant resistance gene(s) that in any way limits damage. Furthermore, various levels of resistance vary amongst the varieties. Moreover, the level of protection from economic damage afforded by durable resistance is the most significant feature of the resistance.

1.1.2. RQ2: What's the Damages that Cause via Biothrophic Fungal on the Wheat?

Rational$_2$: In fact, pathogenic fungi varieties represent a constraint to wheat production. Furthermore, prominent diseases of wheat crops that at present contribute to these losses include the rusts disease and powdery mildew (PM). Moreover, the optimal answer can be observed from the literature review; and also, the answer to this question is presented in Table.1.

1.1.3. RQ3: What is the Diversity and the Area Distribution of "Ug99" Pathotype?

Rational$_3$: In fact, the Worldwide Wheat and Maize Improvement Center (CIMMYT) has drastically minimized and examined against "Ug99" races in Kenya. Furthermore, the progress of virulence against *Sr31* with the emergence of "Ug99" led to susceptibility to SR in wheat crops grown varieties around the world. Especially in Uganda, Ethiopia eastern and southern African nations Yemen, Iran, Egypt, and the Americas, Europe, and Australia.

1.2. Literature Review

1.2.1. Biotrophic Fungi Diseases of Wheat Crop

Biotrophic fungi varieties are obligate parasites which survive on living plants to obtain the nutrients for their survival. Consequently, weakening the plant system and outcome in poor plant health and grain fill (Singh et al., 2016; Randhawa et al., 2019). Among the rust diseases affecting wheat, stripe rust was the most destructive (Hovmoller et al., 2011). The income of the farmers has reduced due to these diseases (Ali et al., 2017). Singh et al., (2016) has announced that the causal pathogens have distinct strains otherwise physiological races, which a strong-minded evaluation reveal diverse resistance genes.

Scientifically, the rust diseases are identified as brown rust, yellow, and leaf rust, which all caused by Basidiomycete order (McIntosh et al., 1995; Figueroa et al., 2018). Among biotrophic disease, rust fungus and powdery mildew (PM) continue to decrease the world's wheat production. In the same way, biotrophic fungi has attacked only living plant crops and affect universal diseases of wide distribution are brown, yellow, and stem rust as well as powdery mildew (Table.1 and Figure. 1.1). Additionally, Singh et al., (2015); Huerta-Espino et al., (2011) have mentioned that wheat rusts and powdery mildew have been a major focus of several experimental studies because of breeding concerns, deployed race-specific resistance genes in a short duration, which in turn cause the phenomenon called as "Boom and Bust". Because their biotrophic lifestyles, self-sown volunteer wheat crops which is termed as green bridge are significant in enabling the survival of these pathogens from one cropping cycle (Park, 2016). In West Asia and North African nations, severe epidemics of septoria leaf blotch have occurred, in a specific condition in some countries such as Morocco, Tunisia, and Turkey (Saari, 1974). In addition, isolates of the pathogen have been identified in diverse regions, along with their specificity for durum and bread wheat.

1.2.2. Powdery Mildew (PM)

Blumeria graminis f. sp. *tritici* is the causal agent of (PM) with wider distribution in dry, warmer and cool climatic conditions (Table.1). Furthermore, (*Blumeria graminis f. sp. tritici)* has great significance in some nations, for instance, China, Europe, and South America. Consequently, wheat cultivation varieties which have been cultivated in South Asia is highly prone to (*Blumeria graminis* f. sp. *tritici*) if over-sensitive varieties are grown in a conducive environment. In contrast with rusts wheat, powdery mildew conidia do not disseminate to distant locations, however, do evolve at a fast percentage. Therefore, the outcome losses attributable to powdery mildew (*Blumeria graminis* f. sp. *tritici*) vary with the seasons around locations a record high of 20% in the UK, also, (10 to 15%), below 10% in Western Europe; (5 to 17%) in North Carolina, on the other hand, sometimes reaching (30 to 35%) to in Russia, up to 62% in Brazil, equally, (30 to 40%) in China during heavy epidemics. (PM) has international distribution in regions with dry and cool climates, together with China, Europe, and Southern Cone of South America (Beddow et al., 2015). In the same way, epidemics of (PM) and economic losses of wheat are enhanced via high plant density, heavy usage of nitrogen fertilizers, and irrigation conditions (Cowger et al., 2012; Mehta, 2014; Savary et al., 2019). Largely, yield decreases of higher than 40% are infrequent, on the other hand, early infections might lead to the death of seedlings otherwise tillers that eventually fail to producing seeds infection via (PM) which was documented on the wheat plant after the tenth day of pollination (Aranyi et al., 2014). Symptoms of (PM) have been reported on all the above-ground parts. However, the leaves are the main issues on which symptoms occur. Consequently, fungicides, for instance, triadimefon, are often applied on the above-ground parts to control (PM) when susceptible cultivars are grown, or the host resistance cannot provide sufficient protection from the disease (Johnson et al., 1979; Li et al 2016; Li et al., 2020) However, PM-resistant cultivars are preferred via wheat crop cultivators for the sake of waste in the line process of the production costs and better environment-friendly (Johnson et al., 1979).

1.2.3. Stem Rust (SR)

According to Roelfs et al., (1992) the most damaging fungal diseases of wheat which has been found in warmer, humid wheat-growing regions is (SR) which has been caused via *Puccinia graminis* f. sp. *tritici* (Pgt). (SR) is widely distributed all over the national domain, even though less common than

the other two wheat rusts varieties (Singh et al., 2015). Furthermore, Kolmer (2005) has documented that symptoms of stem rust infection on the plant parts, for instance, leaf sheaths, stems, glumes, and awns of susceptible plants are masses of dark red urediniospores (Figueroa et al., 2018). Stem rust causes the outcome of loosening through a reduction of wheatquality. In severe epidemics, producers will lose their total harvest returns if susceptible cultivars are grown in rust hot spot zones. Moreover, in the last century the CIMMYT put serious efforts on Stem Rust (Figueroa et al., 2016). Stem rust has gained significance as new virulence traits have evolved in (SR) populations, and broadly utilized wheat cultivars across the globe (Singh et al., 2015). Similarly, (SR) has turned out to be a significant pathogen, since a highly aggressive (SR) race of *P. graminis* f. sp. *tritici*. Such as the "Ug99" race TTKSK including *Sr31, Sr21, Sr24, Sr36* and *Sr9h* were detected before 22 years in Uganda (Singh et al., 2015; Figueroa et al., 2018). (SR) is the most devastating rust disease which has wide distribution globally in some countries, for instance, Africa, America, Europe, and Australia (Singh et al., 2012; Singh et al., 2016). Archaeologically, it caused losses of (19.3 to 28.4%) in the US from the 1910s to 1950s. Later, however, stem rust has been under satisfactory control condition later by the year (1954). The longer adoption of resistant cultivars is associated with the removal of barberry, the alternative host of the (SR) fungus (Singh et al., 2015). Epidemics remained low internationally for the last 30 years except for major epidemics in Ethiopia; in the period amongst (1993-1994) on Enkoy, which carries resistance gene *Sr36*. In the same way, (SR) rematerialized in the form of the "Ug99" race, which cause economic losses (Singh et al., 2012). Likewise, extra "Ug99" unrelated races have appeared in various parts of the world, decreasing the efficacy of the sources of resistance. Additionally, the 'Digalu' race caused a devastating epidemic in Ethiopia amongst (2013 - 2014) which is similar to race that has been registered in Germany and severe stem rust epidemics in the southern wheat production region and the epidemics continued into the 2014 crop season (Olivera Firpo et al., 2015). Race analyses of samples from the epidemic regions detected race TKTTF to be the causal race behind these epidemics. Race TKTTF is highly virulent to the widely grown 'Digalu' wheat, which possesses resistance gene *SrTmp* that is effective against the "Ug99" race group and ineffective against TKTTF. This race has been known from Turkey since (2005) and it is widely distributed in the Middle East region. It is being increasing detected across a wide geographic distribution area. Currently, it has been confirmed in nine countries such as Turkey, Iran, Lebanon, Egypt, Ethiopia, Georgia, Azerbaijan, Eritrea and Yemen; with two countries such as Germany and Denmark; detecting TKTTF-like variants in 2013. The German and Danish isolates differed by having virulence on four additional: *Sr33, Sr7a, SrTt-3, Sr45* (Olivere Firpo et al., 2015). By the year 2016, the broadly virulent race that has been detected in recent time, the (SR) subversive 10.000 of hectares in an outbreak in Sicily. What's concerning is that (GRRC) experimental examinations has suggested that fungi can infect dozens of lab-developed strains of wheat crops, containing hardy varieties that remained reported highly resistant to disease (Bhattacharya, 2017).
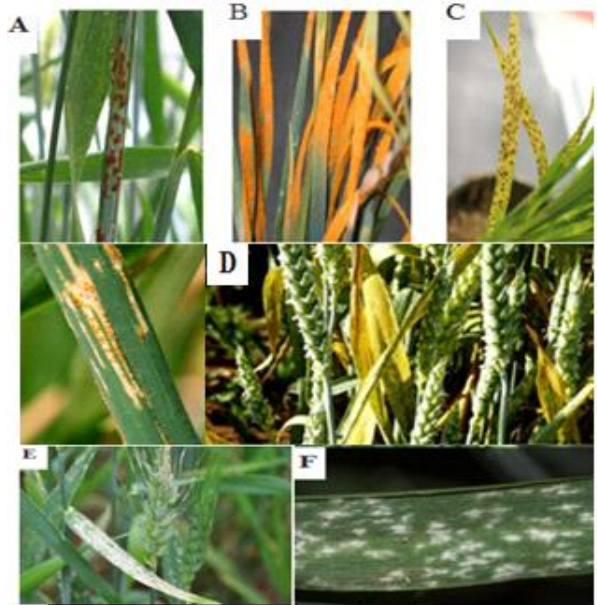

Figure.1.1. The wheat rust diseases symptoms which are affected via *(Puccinia graminis* f. sp. tritici) **(A),** (*Puccinia striiformis* f. sp. *tritici*) **(B)** and (*Puccinia triticina*) **(C)** adapted from (Figueroa et al., 2018) and **(D)** Mature symptoms of stripe rust that has turned out to be brown, dry (Martínez-Espinoza et al., 2009) and symptoms of PM on wheat- flag leaf and head infection via (*Blumeria graminis* f. sp. *tritici*) **(E, F)** (Wicker et al., 2013)**.**

Table. 1. Biotrophic fungi pathogen on wheat

Fungial pathogen	Name patho	Type of wheat	Climate	Pathogen distribution	Reference
Puccinia triticina	wheat leaf rust (also known as brown rust)	(*Triticum turgidum* ssp. *durum*), wild emmer (*Triticum dicoccoides*), domesticated emmer wheat (*Triticum dicoccum*), and *triticale*.	Warmer region	Americas, Europe, South, Central, and North Asia, South and North Africa, and Australia	(McCallum et al., 2012); (Singh et al., 2016)
Puccinia striiformis f. sp. tritici	wheat stripe rust (also known as yellow rust)	On tetraploid durum wheat *Triticum turgidum ssp. Durum Triticosecale Triticum aestivum L*	Warmer region	United States and Australia represents the introduction of a single lineage and including Asia and Europe	(Khanfri et al., 2018); Singh et al., 2015); (Singh et al., 2016); Sharma et al., 2016)
P. graminis f. sp. tritici	wheat stem rust (now known widely as 'Ug99)	Durum wheat, emmer wheat,triticale (*Triticosecale*)	Aggressiveness and adaptation to Warmer temperature	Especially in Africa Uganda, Ethiopia eastern and southern African countries Yemen, Iran, Egypt, and the Americas, Europe, and Australia	Rodriguez-Algaba et al., 2014); (Singh et al., 2016); (Singh et al., 2015)
Blumeria graminis f. sp. tritici	wheat powdery mildew	*Triticum* spp.	especially important in regions with dry and cool	including China, Europe, and the Southern Cone of South America	Singh et al., 2016; Mehta, 2014)

1.2.4. Leaf Rust (LR)

Scientifically, leaf rust is widely adapted fungal pathogen based on wheat crops on an international basis. Its main epidemic regions are spread throughout some registered documentation nations such as America, Europe, South Asia, Central North Asia, South, and North Africa, and Australia, affecting various levels of damage (McCallum et al., 2012). In the US, the disposable income of trade and industrial losses of $350 million in total remained attributed to (LR) in the period of (2000-2004). Huerta-Espino et al., (2011) has demonstrated that in China, annual outcome losses because (LR) is estimated at 3 million tons. In the last decades, it remained also a devastating fungal pathogen in Mexico and South Asia, on the other hand, has turned out to be negligible in recent decades for the reason that cultivars protected via low rusting resistance genes (Figueroa et al., 2018).

According to Bolton et al., (2008); Huerta-Espino et al., (2011) the pathogenic (*Puccinia triticina* (Pt) has affected (LR) is widely distributed of the three rust fungal pathogens. Furthermore, environmental conditions such as modest temperatures which is linked with moist has affected wheat-growing areas. Likewise, as an outcome, the main factors that have affected the outcome losses has been decreased in some plant areas, for instance, seed size, seed weight, besides several numbers of grains per spike. Moreover, in the period (2000-2004), the total

monetary financial losses in the USA is US$ 350 million in total attributable to (LR) remained estimated (Huerta-Espino et al., 2011). Murray and Brennan, (2009) have presented that, in Australia, yield losses in AU$ was 12 million ascribed to leaf rust. As a final point, leaf rust is a problematic fungal pathogen since the pathogen displays high diversity. (McCallum et al., 2016).

1.2.5. Yellow Rust (Stripe rust)

Stripe or yellow has conventionally occurred on wheat crops besides the fungal pathogen survives in wheat crops as dormant mycelium in cooler climates and wetter regions, regarding the region of Asia and Europe (Martinez et al., 2012). Environmentally, disease development of (YR) is mostly rapid in low temperature which is raged (from 10 to 16 °C). Therefore, urediniospores are spread via wind to healthy plants where they can initiate new infections. Heavy dew or intermittent rains can accelerate the spread of the disease. Infection tends to cease when temperatures, consistently, exceed 21 - 23°C (Martinez et al., 2012). However, new aggressive races that have been adapted to warmer climates have spread to other continents and caused severe losses in several countries in the meantime, 2000 (Ali et al., 2014). Furthermore, (YR) commonly causes yield reductions of 5 to 50%, depending on the region, along with the conditional developmental stage of wheat crops. Based on the

current valuation, annual yield reductions of 5.47 million tons of wheat crop are attributable to this disease, which is equivalent to annual losses of $979 million (Beddow et al., 2015). In Australi, the damage of stripe rust disease, causing average annual economic losses of AUD$127 million (Beddow et al., 2015). Therefore, the pathogen (*Puccinia striiformis* f. sp. *tritici* (Pst), is prevalent in cooler wet wheat conditions. Moreover, (YR) is considered the most significant pathogen fungal disease because its potential to the effect of total out came losses in susceptible wheat cultivars, because its frequent which is a wide occurrence. Based on the latest estimations, the international annual losses affected via (*Puccinia striiformis* f. sp. *tritici* (Pst) are US$ a billion in total. According to Chen et al., (2014) the genetic diversity has been specified of (*Puccinia striiformis* f. sp. *tritici)* populations in some countries such as Europe, Australia, and North America, although significant levels of diversity prevail within several fungal pathogen populations. As declared by Ali et al., (2014) YR populations in western China, Himalayan, nearby regions and Central Asia are pathogen diversity, where sexual recombination appears to be commonly happened (Hovmøller et al., 2016; Hubbard et al., 2015).

1.3. Resistance Biotrophic Fungal

Scientifically, the resistance has been identified as whichever genetically detected characteristic of a host plant that in whichever way limits damage along with yielded via disease. Furthermore, the term resistance can vary amongst apparent immunity and extreme susceptibility. Consequently, the stage of protection from economic damage afforded besides the time is a significant feature of resistance (Park, 2016). In the same way, in genetic is termed as oligogenic, which is starting controlled via one or few genes of individually small phenotypic effect. Functionality, resistance is recognized centered on epidemiological, for instance, low rusting and rate-reducing (Aktaş and Zencirci, 2016). Basically, Periyannan et al., (2017) has declared that resistance gene to rust infection by fungal pathogen has been recognized as either race-specific which is also identified as a seedling, or qualitative resistance or non-race-specific resistance. Therefore, more than 70 genes are labelled resistance genes of yellow rust which is had been presented to condition reactions to Pst

(McIntosh et al., 2014; McIntosh et al., 2017). On the other hand, all over the world, (YR) virulence was documented for all most of these genes. In contrast, most (PM) besides rust resistance genes are expressed during the life of the wheat crops all-stage resistance (ASR), as well termed to seedling, while others stand expressed only at post seedling growth stages termed as adult plant resistance (APR), which is mentioned to as minor gene resistance (Martinez et al., 2012; He et al., 2018; Park, 2016). In the same point, yield loss researches have commonly presented that (APR) will protect against an important yield loss. For instance, several researches in which the protective value of (YR), (APR) gene *Yr18* were assessed utilizing near-isogenic paired lines with and without *Yr18* demonstrated yield losses of seventy-four to ninety-four percent in the line lacking *Yr18*, however, (31 to 52%) in the line carrying *Yr18* (Park, 2016). In fact, (APR) genes has been presented by several researchers and switched on at diverse growth stages, after seedling growth stages in addition to others not until flag leaf emergence. Growth stage resistance genes are expressed which are an important consideration in ensuring adequate protection from diseases. McIntosh et al., (2014); Singh et al., (2016) has declared that wheat germplasm has high genetic diversity for its resistance to several diseases, which is numerous race-specific and a specific durable resistance gene which is has been characterized. Moreover, this diversity has been enriched via methodically transferring several resistance genes from various species and genera related to wheat through cytogenetic interventions. On the other hand, resistance expression initiates at later growth stages. What is more, the magnitude of resistance conferred via these genes varies to a great extent, ranging from immunity to only small reductions in disease symptoms. Even though several race-specific rust and (PM) resistance genes has been recognized by matching virulence's in the fungal pathogen population, opportunities to enhance their longevity exist via pyramiding multiple, undefeated genes through marker-assisted selection (MAS). Furthermore, in Western Australia in the earlier stage of an experimental test domain has been detected a breakdown in (PM) resistance, for instance, (*Pm4b, Pm7, Pm24* and *Pm28*) in less than four years (Golzar et al., 2016).

Thus, Li et al., (2014) and Burdon et al., (2014) have approved that the lifespan of race-specific resistance approaches based on gene stacking with a range of (PM) genes together, regional allocation based on temporal deployment of resistance-gene was recommended for durable breeding. Consequently, durable resistance is conferred via quantitative trait loci (QTLs), which have small to intermediate, however, additive effects, and the accumulation of multiple QTLs can lead to a high level of (APR0 approaching near immunity (Brown et al., 2015; Kang et al., 2020; Singh et al., 2016). Even though several QTLs were recognized to confer resistance to rusts and (PM) (Periyannan et al., 2017), three pleiotropic multi-pathogen resistance genes are identified, of which (*Lr34; Yr18; Sr57; Pm38*) concerned with (*Lr67; Yr46; Sr55; Pm46*) are cloned which is detected to confer resistance through novel mechanisms (Moore et al., 2015; Singh et al., 2016; Li et al., 2014; Yu et al., 2014). Up to the current time, McIntosh et al., (2014); McIntosh et al., (2017) has reported that more than 200 rust resistance-genes which categorized and formally designated in wheat plant otherwise wild families; the majority of these confer race-specific-resistance at least sixty are designated as (SR) resistance-genes (McIntosh et al., 2017). Another example, (*Sr31*) remained one of the major widely utilized race-specific (SR) resistance genes; on the other hand, in Kenya "the International Maize which is associated with Wheat Improvement Center (CIMMYT)" that has been drastically reduced the exanimating against "Ug99" races (Singh et al., 2016; Randhawa et al., 2019). Furthermore, the measurements of virulence against (*Sr31*) with the emergence of "Ug99" led to susceptibility to (SR) in a huge number of the sorts of wheat plant cultivation around the world. What's more, according to Figueroa et al., (2018) and Olivera Firpo et al., (2015), new races in the "Ug99" lineage is related to numerous genes, for instance, (*Sr21*; *Sr24; Sr36; Sr38* and *SrTmp*). At the present time, Singh et al., (2015) has presented that the genes, for instance, (*Sr2; Sr23; Sr25; Sr33; Sr35; Sr45; Sr47and Sr50*) are most valuable ones for protection against newly evolved races. In contrast, numerous (YR) resistance-genes are considered as (seventy-eight) have been categorized which is ceremoniously termed in formal (Anh et al., 2015). On the other hand, in several parts of the world a huge number of these genes have been rendered

ineffective with the emergence of virulent races, an effective worldwide except for a few combinations, for instance, (*Yr5* and *Yr15*). Equally, Dakouri et al., (2013) has documented that 70 (LR) resistance-genes have been genetically and frequently deployed in wheat cultivars, for instance, (*Lr1*; *Lr3; Lr10* and *Lr2* 0) (Ellis et al., 2014; Randhawa et al., 2019). In consequence, it has been well acknowledged in the registration section through cloning of eleven race-specific genes in wheat plant, for example, (*Sr22; Sr33; Sr35; Sr45*; *Sr50; Yr5; Yr10; Lr1; Lr10; Lr21;* and *Lr22*) that these genes encode nucleotide-binding site– leucinerich repeat (NBS-LRR) proteins (Steuernagel et al., 2016; Thind et al., 2017; Marchal et al., 2018). Therefore, markers linked to several (SR) resistance-genes such as (*Sr2; Sr22; Sr24* and *Sr26; Sr32; Sr38; Sr43; Sr45; Sr55*) (Moore et al. 2015), (*Sr56*, and *Sr57*) have been reviewed and published. In the same direct, (Randhawa, 2015) has documented that (YR) resistance several genes, for instance, (*Yr1; Yr5; Yr10; Yr15; Yr17; Yr18; Yr26; Yr28; Yr6; Yr50; Yr51; Yr57; Yr59; Yr61; Yr64;* and *Yr65*). Similarly, (LR) resistance gene marker has been reported by Schachermayr et al. (1994; 1997) as (*Lr1; Lr9; Lr10; Lr19; Lr24; Lr26; Lr28; Lr34; Lr35; Lr37; Lr51; Lr67* and Lr68) (Moore et al., 2015). In the same context, these markers can be advantageously used for the selection of desirable gene combinations along with phenotypic assays. Likewise, procedures for recognized markers requirement to being optimized and validated before used in the selection of plants carrying the respective genes. In the same way, the DNA of the donor is included in the PCR reactions of markers to avoiding any error. On the other hand, race non-specific rust resistance-genes offer durable resistance, as the pathogen fungal cannot without difficulty overcome them, termed as adult plant resistance (APR). Furthermore, confers quantitative resistance against wheat plant rusts (Periyannan et al., 2017) has the characteristic partial resistance phenotypes limit inoculum build-up besides the likelihood of the occurrence of epidemics. According to Ellis et al., (2014) examples of this sort of resistance contain (*Sr2; Lr34; Lr46; Lr67; Lr68* and *Yr36*). Similarly, cloning of *Yr36* revealed the role of a cytoplasmic protein kinase in mediating resistance (Figueroa et al., 2018). Besides, *Lr34, Lr67* both are encoding an ATP-binding (Dodds and Lagudah, 2016; Moore et al., 2015). Furthermore,

the cloning gene such as (*Pm38; Lr34; Yr18*; *Sr57*) encodes a protein in terms of resembling adenosine triphosphate binding cassette transporters of the pleiotropic drug resistance sub-family. Additionally, the gene is more strongly expressed at later growth stages, consistent with its action as an (APR) gene. Consequently, breeding resistance cultivars International Centre for Wheat and Maize Improvement (CIMMYT), breeding can targeted for smallholder agriculturalists in Asia, Africa, also Latin America, strongly emphasizes selecting high-yielding wheat germ-plasma that possesses high levels of rust resistance based on diverse combinations of multiple pleiotropic resistance genes and other QTLs with significant progress made for all 3 rusts (Singh et al., 2015; Moore et al., 2015). Furthermore, deployment of CIMMYT derived wheat cultivars with (APR) in Mexico, Asia, and Africa have stabilized (LR) fungal populations for more than two decades in contrast to other regions, for instance, South America where race-specific resistance genes remained utilized (Singh et al., 2015; Guo et al., 2015). Similarly, high-yielding cultivars with resistance to the old Chinese cultivar Sumai 3 is a breeding challenge based on progress in breeding has been relatively slow development. Moreover, a combination of numerous minor genes of moderate-to small effects leads to resistance durability. Up to the present time, (89) meta-QTLs have been recognized; on the other hand, specific (QTLs) are mapped at or near identified genes, in a specific condition (Stb6), which remained present in several sources of resistance (Brown et al., 2015). Likewise, new broad-spectrum resistance to (STB) derived from synthetic hexaploid wheat plant remained identified (Brown et al., 2015) also breeding semi-dwarf, high yielding wheat germ-plasma accumulation of both major and minor genes trace to diverse origins. In addition, commonly finding high yield lines that combine high levels of resistance to rusts and (STB) under high disease pressures in several countries, for instance, Mexico, Ethiopia, and other targets environmental worldwide (Singh et al., 2016; Kang et al., 2020).

2. Conclusion

This paper has reviewed the current knowledge of biotrophic pathogens of four fungal diseases, such as (*Blumeria graminis* f. sp *tritici*); (*Puccinia triticina)*; (*P. striiformis* f. sp*. tritici*) and (*P.*

graminis f. sp. *tritici*); that affected wheat crops, for instance, (powdery mildew, leaf rust, yellow rust and stem rust); respectively, need resistance genes. Furthermore, wheat improvement has been made by documents and the utilization of new adapted sources of disease resistance and wheat varieties with high yield potential to increase the quality of the manufacturing production sector. In fact, disease resistance which is to increase wheat yields varieties by using molecular methodologies ability in conjunction with broad phenotypic evaluation provides opportunities to harness genetic diversity. This research study has acknowledged that there are various other diseases which will be studied further in the future, these fungal pathogens are labeled as the blotch diseases varieties, that correspondingly threaten wheat production, for instance, *Septoria tritici* blotch, *Septoria nodorum* blotch, Tan spot, scab disease development, wheat blast, take all, eyespot, bare patch and crown rot, etc.

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