FIELD SCREENING OF ARABICA COFFEE GENOTYPES AGAINST COFFEE WHITE STEM BORER *(Xylotrechus quadripes)* AND LEAF RUST *(Hemileia vastatrix)* INFESTATION IN KASKI, NEPAL

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ABSTRACT

Twenty-three coffee (Coffea arabica) genotypes were evaluated for relative resistance against coffee white stem borer (Xylotrechus quadripes) and coffee leaf rust (Hemileia vastatrix) at Horticulture Research Station, Malepatan, Pokhara during three consecutive years from 2016 to 2019. The monthly observation on the emergence of this borer showed that coffee genotypes "Yellow caturra" and "Tekisic" were highly infested with coffee white stem borer as compared to the other genotypes. However, no infestation was observed in genotypes Catimor, San Ramon, Indo Tim-Tim, Ketisic, Pacas, Syangja special and both Vermelo and Amarillo groups in Catui and Caturra acessions. Similarly, genotypes Catimor, Indo Tim-Tim and San Ramon were determined to be resistant to coffee leaf rust. While coffee germplasm-Ketisic was also recorded as relatively resistant against coffee leaf rust. These results have important implications for the development of coffee white stem borer and leaf rust resistant high yielding coffee variety in the future.

Keywords: Germplasm, infestation, pest, resistance, scoring

INTRODUCTION

Coffea Arabica L. is the most disease and pest susceptible coffee species (Van der Vossen,2001). It's tetraploidy and autogamy nature combined with narrow genetic base multiplied through inbreeding would have led to genetic homogeneity (Lashermes *et al*., 1996) and consequent vulnerability to pests (Anonymous, 1972). Within the *Coffea Arabica* species, natural hybrids are relatively scarce due to a high degree of self-pollination which is about 85-95%.*Coffeaarabica* is a self-compatible amphidiploid (2n=4x=44), whereas other *Coffea species* are diploid (2n=2x=22) (Lashermes *et al*.,1999).Comparatively larger genetic base of *Coffea robusta* under cultivation, primarily due to its obligate out-breeding nature and hence tolerance to pests (Ram *et al*., 1994).So, the commercial coffee varieties have developed by crossing *Coffea arabica* and *Coffea robusta* using different plant breeding techniques.

Coffee white stem borer, *Xylotrechus quadripes* Chevrolat (Coleoptera: Cerambycidae) is a major pest in commercial plantations of coffee, *Coffea arabica*, in Nepal (Acharya & Dhakal, 2014).Immature grub bores to the plant usually attacks on

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the main stem and thick primary branches of *Coffea arabica* in severe case leads to death of the plant. Nearly 1 to 1.5 years of boring inside trunk, under favorable condition, it emerges as adult out of the trunk by making an exit hole (Gichuhi *et al.*, 2017).A study by National Entomology Research Center found that coffee white stem borer is number one threat causing yield loss up to 70% in Nepal (ED, 2007).Complete tolerance to this pest is not known to exist in *Coffea arabica*, but is much less prevalent on *Coffea robusta* and many other diploid species of coffee (Guerreiro-Filho, 2006).

Coffee leaf rust is new disease of coffee in Nepal. It was identified and reported by National Plant Pathology Research Center, Khumaltar, and Lalitpur, Nepal in April, 2015 (PPD, 2015). It is one of the serious challenges of coffee cultivation caused by the fungus *Hemileia vastatrix* Berk. It was a major problem in south Asia during late nineteenth century where it forced the abandonment of coffee production in large areas (McCook, 2006). Its infestation in the new world began in the 1980s (Fulton,1984) where it rapidly spread to all coffee growing areas but did not reached the devastating levels in earlier days in south Asia(Vandermeer*etal.*,2009).The basic biology of the coffee rust is weather dependent. The fungal spore 'uredospore' germinate within a drop of water on the underside of the leaf and penetrate the leaf through stomata, grow extensively in intercellular space forming a haustoria. Production of fruiting bodies on the underside of the leaf forming yellow rust texture which get spread by rain splash or wind to neighboring leaves and plants up to 150 km (Schieber,1972). It affects mainly matured leaves and on severe stage can also infect young leaves causing leaf drop results to loss in production. Normally, yield losses per year due to coffee rust range from 30 to 90% depending on the environmental conditions during a given year (Sera *et al*, 2005), especially if not controlled by fungicide spray. The economic damage to world Arabica coffee production due to coffee rust has been estimated to be between $(US) 1 billion and 2 billion per year (Van der Vossen, 2001) due to crop losses of 20–25% (Prakash *et al.*, 2004).

The gene S_H3 conditions resistance against coffee white stem borer and coffee leaf rust is believed to be transferred from *Coffea liberica* by a process of natural introgression (Rodrigues and Bettencourt, 1965).The plant Hibrido de Timor (HDT) is a todays' widely used leaf rust resistant donor genotype developed by crossing *Coffea arabica* with *Coffea robusta*(James *et.al.*, 2019). Catimor is the cross between Timor hybrid and Caturra accession; Catuai, the high yielding coffee resulting from a cross between Mundo Novo and Caturra;Mundo Novo, a natural hybrid between Typica coffee and Bourbon coffee and Bourbonamarillo and Bourbon vermelo are developed by the spontaneous mutation of coffee type Bourbon (WCR, 2016). Ketisicis also an improved Bourbon genotype (WCR, 2016).

The coffee production in Nepal is extensively organic in nature. So, farmers are not using any chemical pesticide, fungicide and weedicides. So, selection of coffee genotypes on the basis of susceptibility or tolerance to coffee white stem borer and coffee leaf rust is essential for varietal development and dissemination to farmers. Therefore, this study aims to assess the genotypes relative resistance to white stem borer and leaf rust which ultimately aids in the organic pest management.

METHODOLOGY

STUDY AREA

The present study was conducted in Horticulture Research Station, Malepatan, Pokhara, Nepal (28^{O}13' N to 83^{O}58' E) from 2016 to 2019. The station lies in the elevation of 838-848 meter above average sea level (masl). The field experiments were done in thelitchi-coffee shade system planted at the ratio of 1:4. All intercultural operations and fertilizer application were done as per the recommendation.

SCREENING AGAINST COFFEE WHITE STEM BORER

Each variety of coffee have their own growth pattern i.e. branching and leaves pattern which determine the extent of stem exposure and hence to borer infestation. The coffee white stem borer surveillance was done in 23 coffee genotypes of 9 years' old each with 16 plants. The grub of beetle bores into the trunk from top to the bottom of the tree, boring near the surface makes characteristic bulging out of bark phloem tissue. During hot sunny days adult emerges out making a small circular hole from bark, each exit hole indicates the emergence of one adult specimen. The variety wise extent of infestation and damage by coffee white stem borer was recorded monthly from January, 2016 to December, 2018. Stems were thoroughly examined for stem bulging out or exit holes by white stem borer. The noted monthly data were averaged for further analysis and drawing conclusion.

SCREENING AGAINST COFFEE LEAF RUST

Twenty-three *Coffea arabica* L. accessions were evaluated for their response to coffee leaf rust under field conditions of HRS, Malepatan during the month of June during 2017 to 2019. The severity of leaf rust infestation was scored in numeric scale of 0 (most tolerant) to 9 (most susceptible)(Eskes and Toma-Braghini,1981). Scale value 0 indicates the absence of visible symptoms, 1 to 9 variation show the intensity of rust sporulation and damage. Coffee leaf rust infection was assessed from the 23 genotypes subjected to similar field conditions when disease pressure was at peak.

STATISTICAL ANALYSIS

The raw data were entered in MS-Excel, averaged and presented in bar diagram. The cluster analysis of coffee germplasms based on coffee white stem borer and coffee leaf rust infestation were done according to Ward (1963) in past.03 software. Cluster analysis was done to objectively divide the germplasms into groups based on number of sample plant infested using Euclidean distance paired group method. The cluster representation was done with dendrogram progressively dividing the accessions into smaller groups.

RESULTS AND DISCUSSIONS

VARIETAL SCREENING OF COFFEE AGAINST COFFEE WHITE STEM BORER

The given bar graph (Fig. 1) elucidates that among the twenty-three coffee genotypes evaluated for coffee white stem borer infestation, highest level of infestation (18.75%) was found in the coffee germplasms Yellow caturra and Tekisic followed by Arghakhachi local (12.5%). Ten genotypes namely Selection 10, Mundo Novo, Chhetradeep, Hawaii Kona, Pacamara, Kaski local, Indonesia, Bourbon amarillo, Bourbon vermeloand Puranchaur local showed same level of borer infestation (6.25%). While, remaining ten germplasms were observed to be free of coffee white stem borer infestation.

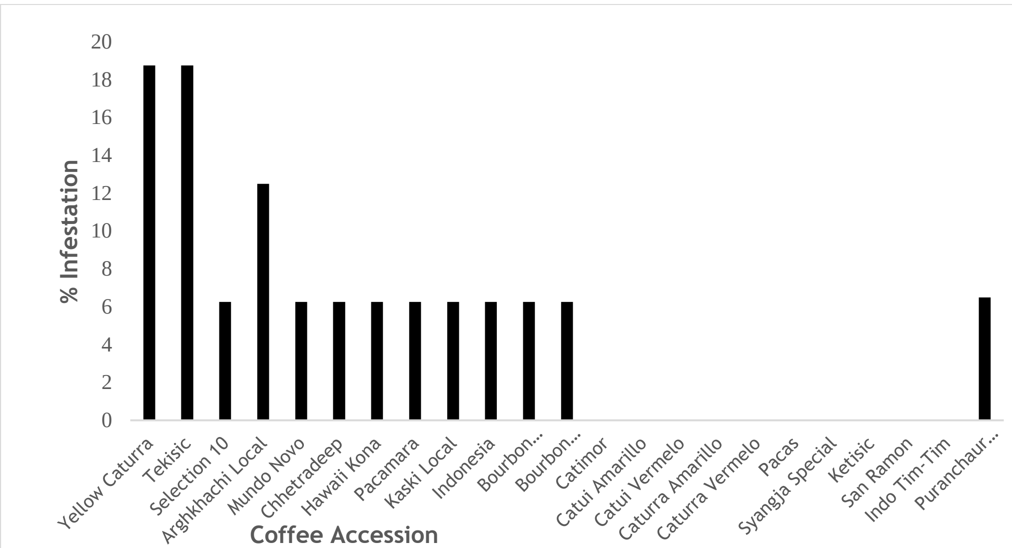

Figure 1. Percentage of coffee white stem borer infestation in different coffee genotypes

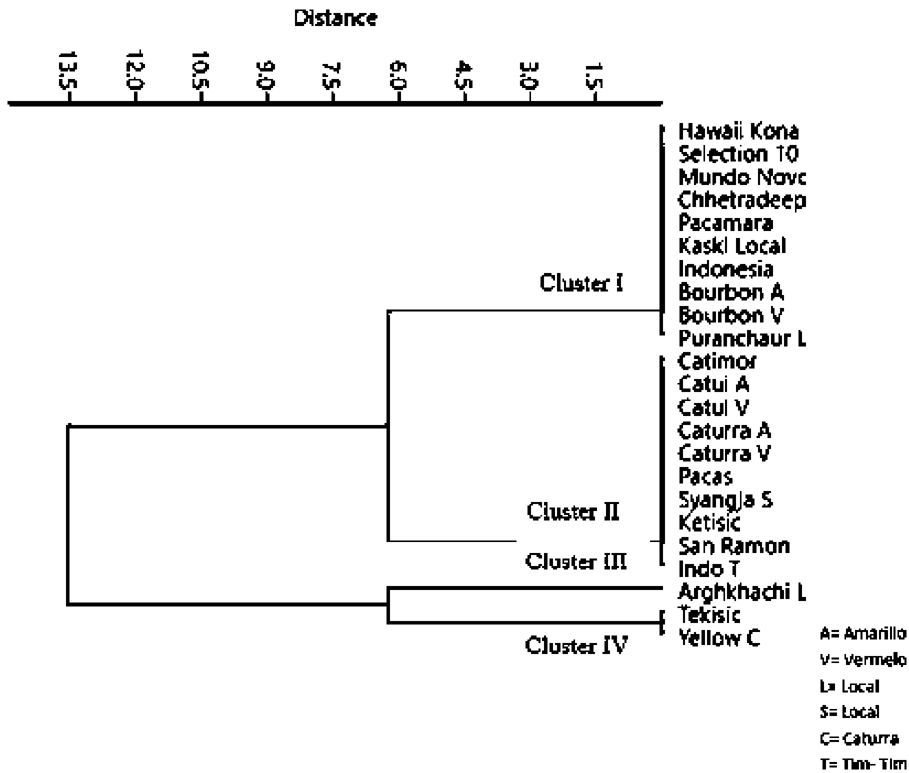

Figure 2. Similarity of coffee genotypes against coffee white stem borer infestation in Horticulture Research Station, Malepatan

Cluster analysis shows the four clusters of coffee genotypes based on the coffee white stem borer infestation (Fig. 2). The cluster II consisted of the 10 genotypes with no coffee white stem borer infestation while cluster I consisted of 10 genotypes with very few infestation (1 infested from 16 sample plants). Genotype namely Arghakhachi local located in the separate branch making cluster III which showed some level of borer infestation (2 infested from 16 sample plants) securing single lineage. Likewise, two genotypes Tekisic and Yellow caturra (3 infested from 16 sample plants) showed distinct but the highest infestation by stem borer among 23 coffee genotypes in cluster IV. The genotypes Ketisic, Yellow caturra and Arghakhachi local have thin and upright branching habit which may expose stem to insect attack but, genotypes Catimor, San Ramon and Indo Tim-Tim have horizontal and comparatively short branching habit might result to less borer attack (ARS, 2014). A similar study in India selected a new Arabica cultivar named 'Chandragiri' with good yield potential and a high tolerance to coffee white stem borer. The drooping branches of Chandragiri plants cover the entire main stem and act as a barrier against borer attack (Jayarama, 2007).Rajus*et al* (2021) found that antennae of CWSB female responded significantly to 18 chemical compounds found in coffee leaves. He concluded that the variable borer infestation to different genotypes is due to their host selection behavior based on plant volatile and the visual clues. Moreover, Morewood et al. (2004) reported the evidence of three different forms of resistance in hard wood tree species against Asian longhorned beetle- *Anoplophoraglabripennis* (Motschulsky) (Coleoptera: Cerambycidae) as antixenosis (lack of cues as a potential host), antibiosis (affect growth and reproduction) and tolerance (no damage). The same mechanism may exist in coffee against coffee white stem borer because of their similar nature of damage and same family characteristics (Coleoptera: Cerambycidae). Additionally, Magalhaes (2005) evaluated the influence of volatile compounds found in coffee leaves on oviposition preference of leaf miner, observing the positive correlation with the concentrations of p-cymene and negative with the concentrations of beta cymene. The result might be comparable with the coffee white stem borer infestation in coffee genotypes.

VARIETAL SCREENING IN COFFEE AGAINST COFFEE RUST

There was notably different level of variation in resistance to coffee leaf rust among the germplasms. The bar graph (Fig. 3) shows that three germplasms 'Catimor', San Ramon and Indo Tim-Tim reacted exceptionally high resistance against coffee leaf rust. While, Arghakhachi local and Yellow caturra found to be most susceptible coffee genotypes to leaf rust followed by Tekisic, Indonesia, Catuai and others. Similar study showed that the varieties Hibrido de Timor (HDT) and Catimor showed high levels of resistance to all Coffee leaf rust isolates, whereas Bourbon was highly susceptible genotype (Rodrigues *et al.*, 2000; Silva *et al.*, 2006).

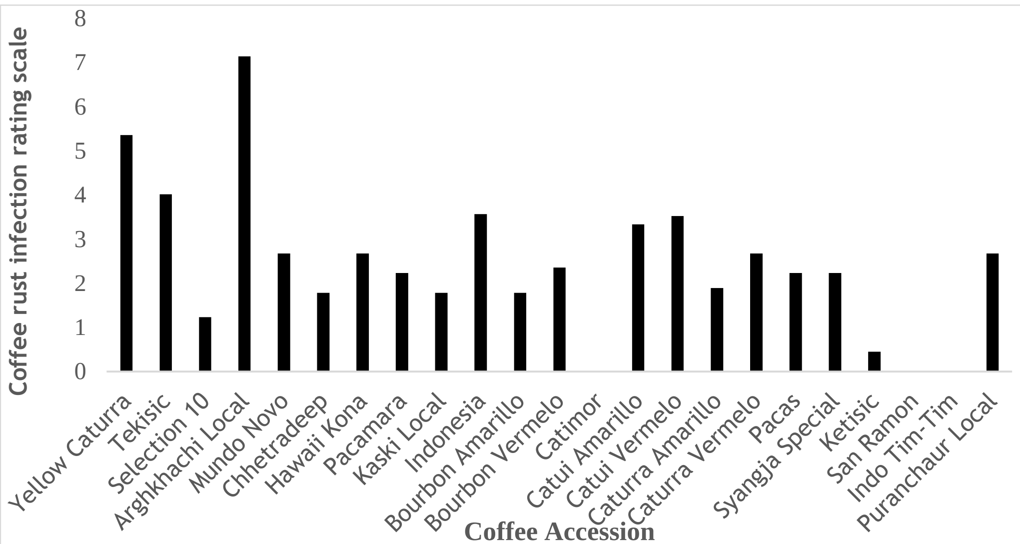

Figure 3. Response of coffee genotypes to coffee leaf rust

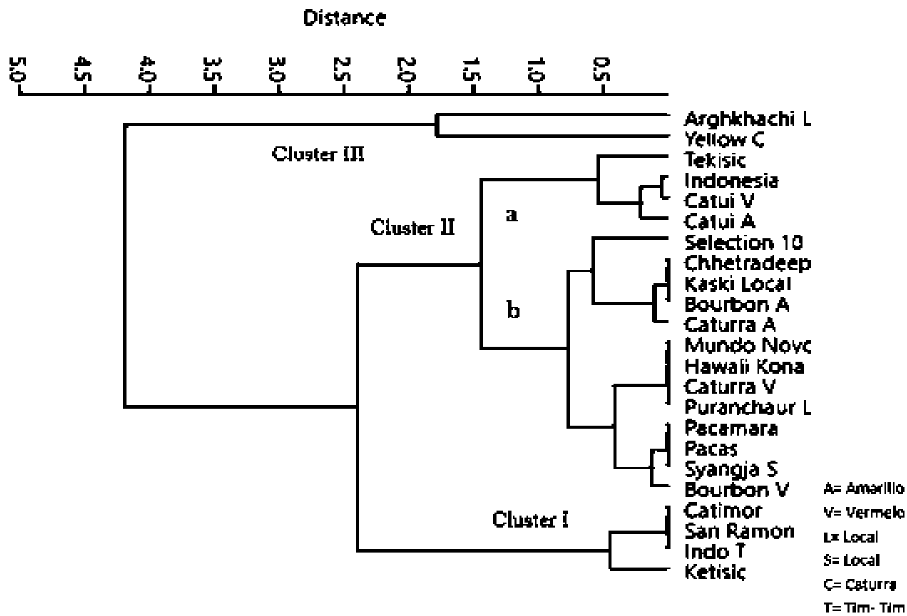

Figure 4. Variation in severity of coffee leaf rust symptoms scored by numeric scale 0 (resistant) to 9 (susceptible) at HRS, Malepatan. (The horizontal axis scale of the given dendrogram) represents the distance or dissimilarity between each cluster of coffee germplasm. The vertical axis represents the name of coffee germplasms)

The graph provides the information on similarity and differences among genotypes by clustering of coffee genotypes based on coffee leaf rust infestation. The horizontal position of the split, shown by the short vertical bar, gives the distance (dissimilarity) between the clusters of genotypes. Looking at this dendrogram, we can see the three clusters as three branches that occur at about the same horizontal distance. The cluster I consisted of the 4 genotypes including Catimor, San Ramon (dwarf variety) and Indo Tim-Tim with no leaf rust infestation and Ketisic with very low level of infestation. Similarly, cluster II comprise of further two clusters IIa and IIb, both of which again give branching to 4 and 13 genotypes, respectively with some level of infestation. Cluster III consists of 2 genotypes namely Arghakhachi local and Yellow caturra which showed distinct but highest infestation by coffee leaf rust among 23 coffee genotypes in Malepatan, Kaski condition. This indicates that most of these genotypes contained quantitative rather than qualitative kind of resistance/susceptibility. The term 'quantitative' is used when differences between genotypes are not easily distinguishable while 'qualitative' is used when different genotypes show easily distinguishable phenotypes (Eskes, 1983).This is due to most of the genotypes seems to be similar in appearance and the difference in resistance might be due to presence of resistance gene or some compounds present in the coffee plants. The genotype Catimor is the progeny of rust resistant Timor hybrid and Caturra genotype (WCR., 2016). Dwarf accession of San Ramon is produced by incorporating rust resistant gene SH3 to original accession in India (Ram, 2006).Similar phenomenon of leaf rust in wheat (caused by *Pucciniarecondita f. sp. tritici*) is caused by the presence of Lr13 and Lr34 genes singly or together (Kolmer, 1996). The differences in resistance in all coffee genotypes might be due to occasional crossing and blending of resistant genes from genetically resistant accessions.The rust resistant gene SH3 in some accessions is suggested to have been derived from *Coffea liberica* and incorporated into *C. arabica* by the way of spontaneous hybridization and natural stabilization (Prakash *et al*, 2004).

CONCLUSIONS

The present study attempts to evaluate the response of various coffee accessions available in Horticulture Research Station, Malepatan, Pokhara, Nepal to the coffee white stem borer and coffee leaf rust under field conditions. The study successfully identified some genotypes with high resistance to stem borer and leaf rust to the area. The observation on the emergence of this borer showed that coffee genotypes "Yellow caturra" and “Tekisic” were infested heavily (18.75%) followed by Arghakhachi local (12.5%) followed by other ten genotypes. However, no stem borer infestation was observed in genotypes Catimor, San Ramon, Indo Tim-Tim, Ketisic, Pacas, Syangja special and both Vermelo and Amarillo group. Similarly, genotypes Catimor, Indo Tim-Tim and dwarf variety San Ramon were observed to be resistant against coffee leaf rust. Coffee germplasm- Ketisic was also recorded as relatively resistant against coffee leaf rust. The results obtained from this study will be useful to enhance the lineage determination and improvement of coffee varieties particularly to develop high yielding rust and borer resistant variety with further multi-location tests and molecular analysis for resistant gene or isolation of chemical compounds involved.

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