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Climate Change Affect Coffee Leaf Rust (*Hemileia vastatrix* Be & Br.) Epidemics in Ethiopia

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Abstract

Arabica coffee (Coffea arabica L.*)* is native from Africa, particularly from Ethiopia. Previously of little concern, epidemics of coffee leaf rust (CLR), caused by the fungus Hemileia vastatrix, have become more frequent and severe in Ethiopia accompanying the expansion of commercial plantations and changes in climate variables. Abroad scale survey was conducted in the main coffee-growing regions of Ethiopia in order to update the CLR status and identify factors associated with disease intensity. Disease intensity (incidence and maximum severity) and crop management data were obtained from 405 farms distributed over 27 districts (9 zones) of Oromia and Southern Nations Nationalities and Peoples (SNNP) regions. CLR was present in all farms with mean incidence ranging from 5 to 86.7% (mean = 35.3%). While CLR incidence did not differ among zones or districts based on a mixed model analysis, the effects of all agronomic factors and altitude, tested individually in the model, were significant. There was general trend of decreasing CLR intensity with the increase in altitude, but the agronomic factors overlapped and were confounded with the reduction/increase of CLR intensity at higher/lower altitudes. A multiple correspondence analysis showed the lowest incidence class (< 23%) associated with the use of intensively managed improved varieties grown at highest elevation class under shade. The highest incidence (>43%) was correlated with poorly managed local varieties grown under full sun at the lowest elevation class. Our data confirm CLR as a widespread problem and contribute knowledge for improving CLR management, thus serving as a warning for Ethiopian authorities and coffee growers to act towards a national plan to improve CLR management.

Keywords: Arabica coffee, Hemileia vastatrix, climate change, disease epidemics

Screening of Indigenous Mycoparasities Associated to Coffee Leaf Rust Hemileia vastatrix for Their Biocontrol Potential on the Disease

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Abstract

Coffee leaf rust (CLR), caused by *Hemileia vastatrix* is the worst disease of coffee plantations worldwide. Development of varieties with durable resistance to CLR is lengthy and rendered difficult because of the pathogen variability. The successful strategy of escaping the disease by highland planting used became uneffective, possibly owing to climate change. Chemical control is broadly used but is too costly or inadequate for the organic or low pesticide-residue markets. Its intensive use also provokes worries with environmental impact. Therefore, biological control of CLR is becoming an attractive alternative worth pursuing. The objective of the study was to determine the indigenous biocontrol agents and to test antagonistic potential of mycoparasites agenaist CLR using genrmination inhibition and leaf disc inoculation methods. Based on the result in Ethiopia we found 110 mycoparasites which is highest diversity. From biocontrol agents the highest germination inhibition and efficacy percent (reducing the disease severity index) on coffee leaf discs were recorded with mycoparasitic antagonistic fugal isolates of Digitopodium sp. (ET568), Digitopodium sp. (ET567), Pleurodesmospora sp. (ET544), Lecanicillium sp. (ET651), Lecanicillium sp. (ET669), Phoma sp. (ET622), Lecanicillium sp. (ET600), Lecanicillium sp. (ET665), Fusarium sp. (ET642), Fusarium sp. (ET645), Cladosporium sp. (ET566), Cladosporium sp. (ET564), Lecanicillium sp. (ET627) Simplicillium sp. (ET553) and Alternaria sp. (ET614). With this study the best result being obtained with the inoculation of those isolates applied simultaneously. This isolates deserves being further evaluation for use as biological control of H. vastatrix in green house and field condition.

Keywords: Biocontrol, coffee disease, indigenous, Ethiopia, mycoparasites

Characterization of the putative Genome-Wide SNP loci associated with resistance to *Colletotrichum kahawae* (Waller&Bridge) in the variety Hibrido de Timor using GWAS and QTL mapping.

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Abstract

Coffee Berry Disease (CBD) caused by the fungal pathogen *Colletotrichum kahawae*, destroys up to 80% of the developing berries on susceptible *Coffea arabica* cultivars if no control is applied. CBD is still restricted to Africa with a possibility of spreading to other Arabica coffee regions in the world. Resistance to CBD is controlled by three genes designated as T, R that are dominant and the recessive k in varieties Hibrido de Timor (HDT), Rume Sudan (RS) and K7 respectively. The Random Amplified Polymorphic DNA and Simple Sequence Repeat marker for the T-gene were characterized in previous studies. This study aimed to identify the Putative Single Nucleotide Polymorphic (SNP) DNA marker for the T-gene in HDT. The mapping population comprised of 103 F_2 genotypes derived from varieties HDT (resistant) and SL28 (susceptible). The genotypes were assessed for their reaction to CBD using hypocotyl inoculation test on a scale of 1-12 and Chi-square (χ^2) test. The genome-wide SNP markers were obtained through Diversity Arrays Technology sequencing (DArTseq) that were aligned to the *Coffea canephora* reference. 1213 good quality markers that were aligned to the 11 coffee chromosomes were obtained. The population structure was analyzed by both The Principal Component Analysis (PCA) and marker-based kinship Matrix. The genome Genome-Wide Association Study (GWAS) analysis was carried out using both General, Mixed and Compressed mixed Linear model (GLM, MLM &CMLM) in Genomic Association and Prediction Integrated Tool (GAPIT) while Quantitative Trait Loci (QTL) Mapping was carried out using Inclusive composite interval mapping (ICIM). The χ^2 test revealed that the F_2 population conformed to the 3:1 mendelian ratio of segregation hence suitable for mapping of a dominant gene. The PCA and marker-based kinship didn't reveal any population stratification that could lead to spurious association. One SNP markers (100227400|F|0-15:C>T-15:C>T) in coffee Chromosomes 9, was significantly associated with CBD resistance, consistently in GLM, MLM and CMLM at $-Log_{10}$ (P-value) >3 in GWAS. The marker was also detected as significant QTLs at LOD 5 ($P \leq 0.05$), at a distance of 8.5 centi-Morgan (cM) from the gene by QTL mapping. The sequences search was associated with uncharacterized proteins for disease resistance within the NCBI database. The SNP marker 100227400|F|0-15:C>T-15:C>T in Chromosome 9 at a distance of 8.5 cM from the gene, is identified as a putative SNP DNA marker locus that is associated with resistance to CBD in HDT and is recommended for validation and use in Arabica coffee breeding.

Key Words

Coffee Berry Disease, Genome-Wide Association Study, Single Nucleotide Polymorphism, T-gene, *Coffea arabica*

East African Coffee Breeding Hub: Coordinating a regional strategy to accelerate the creation of 21st century varieties

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Abstract

Current coffee varieties were created for the 20th-century coffee sector. We already have significant evidence that they will not tolerate the environmental threats of the 21st century, changing weather patterns, and new disease and insect prevalence. This creates a potentially disastrous decline in supply in the coming decades. By drawing on the latest breakthroughs in coffee genetics, there is a need to accelerate the creation of coffee varieties to meet the challenges of the 21st century. This will lead to the development of the next generation of coffee varieties that will be adapted to various agro-ecological conditions in Rwanda and sustain the coffee industry. New varieties are to be high yielding, excellent cup quality, multiple stress resistance/tolerance, and climate resilience.

The cornerstone of the strategy is the creation of a national coffee breeding hubs. The hub contributes to the results of advanced research, including genes and molecular markers to accelerate molecular breeding approaches, improved breeding populations,

Under the auspices of the World Coffee Research (WCR), The East African Breeding Hub (EABH) is operational since 2018 and is hosted by the Rwanda Agriculture and Animal Resources Development Board (RAB). The hubs serve as a centralized location for East African Countries to access breeding populations, expertise, and materials that can be utilized to create new coffee varieties for the benefit of local producers in each country of the region.

Since its creation, the EABH has achieved tremendous milestones in the above-mentioned endeavor including (i) establishment of genetically diverse germplasm collection, (ii) National performance trials of hybrids, (iii) International Multi locational Variety Trials (iv) integration of molecular breeding tools into national breeding programs and (v) and organization of regular regional breeders' workshop to, collectively, reflect on action items and roadmaps.

The best hope for sustaining the supply of high-quality coffee in the 21st century is to focus on making the coffee plant more resilient. The creation of new, highly adaptable varieties, supported by a vibrant new seed sector, will result in major global productivity and quality gains in the next 10-20 years..

Key Worlds: Breeding, Coffee, Climate resilience, Quality Yield

SNP marker-assisted detection of mislabeling and pollen contamination in a Robusta coffee breeding programme

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Abstract

Mislabeling and pollen contamination in tree crop breeding has significant effect on variety development as it impacts on consistency of field performance of genotypes and has implications for Robusta coffee seed garden and germplasm plot management. The present study used single nucleotide polymorphism (SNP) fingerprinting at 120 loci to examine the diversity, parentage and labeling errors in 400 *Coffea canephora* genotypes assembled over different time periods at the Cocoa Research Institute of Ghana (CRIG). The 120 SNPs used in analysis were high quality SNPs selected based on call rate, minor allele frequency and linkage disequilibrium through validation (using Kompetitive Allele Specific PCR genotyping technology) of two hundred candidate SNPs of *C. canephora* selected from a published data source. The probability of identity among siblings (probability of two individuals having the same multilocus genotype), based on all 120 loci was 1.8×10^{-19}, indicating that the chance of finding two individuals with the same genotype in the population is almost null. Additionally, a high total exclusion probability of 99.997×10^{-2}, indicates that the set of markers reported here are sufficient for parentage assignment in Robusta coffee. Of the 400 genotypes analyzed, both synonymous (trees with same SNP profiles but different names, 12.8%) and homonymous (trees with same name but different SNP profiles, 5.8%) mislabeling were identified in addition to trees with unique genotype. This implicates pre-planting labelling errors and introduction of synonymous clones with different names. A principal coordinate analysis separated the coffee germplasm collection at CRIG into three main populations ($F_{ST} > 0.10$ between populations), with the first two coordinates accounting for 36.7% of the total variation. In the parentage analysis, of 12 progenies derived from controlled crossing, only 4 had parentage corresponding to breeders' records. Six out of the remaining 8 had female parents correctly identified. This anomaly may be due to mislabeling, pollen contamination or extraneous seeds in the seed lot prior to sowing. For 20 progenies derived from open pollinated bi-clonal seed garden, only 6 had one parent correctly identified. The data suggests mislabeling of some of the clones used in the seed garden and pollen contamination from more distant coffee plots. This has significant implications for isolation distance in the establishment of Robusta coffee seed gardens. This study demonstrates the utility of SNP markers to detect mislabeling in Robusta coffee germplasm collections. The impact of mislabeling on Robusta coffee breeding is discussed.

Key words: Robusta, Breeding, SNP markers, mislabeling, pollen contamination

Determination of field establishment and early bearing potential of half-sib Robusta coffee families in Ghana

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Abstract

Assessing the level of genetic variation that exist in any breeding population, particularly for traits during establishment phase is important as this has significant implications for selection of genotypes with superior early growth performance and establishment. The present study was aimed at determination of genetic variation among half-sib Robusta coffee genotypes during field establishment, determine relationship among field establishment traits and cluster the families based on establishment traits. Twenty-four Robusta coffee families including 21 locally derived half-sib families, 2 recently introduced half-sib families and 1 hybrid variety were evaluated. Families differed significantly for all traits evaluated, except for chlorophyll fluorescence. Significant correlations were observed among the traits assessed with the highest significant correlation ($r = 0.89$, $p < 0.001$) observed between number of primary branches and stem diameter. Of all the traits assessed, canopy diameter was the most strongly associated ($r = 0.54$; $p < 0.001$) with percentage bearing trees 1 year after field planting which was used as a proxy for earliness to bearing. All families evaluated in the present study had at least 20% of trees bearing 1 year after planting, although no family had more than 50% of trees bearing after the first year of field planting. Broad-sense heritability ranged from 0.03±0.001 (percentage bearing) to 0.39±1.00 (canopy diameter). Cluster analysis grouped the 24 Robusta coffee families into three major clusters with a clear distinction among the local families. However, there was a lack of clear distinction of the newly introduced half-sib families from most of the locally derived half-sib families as well as the hybrid variety, E139 × C134. This suggests the need to introduce more diverse germplasm in the efforts to improve Robusta coffee, particularly for field establishment in Ghana.

Key words: Half-sib Robusta, genetic variation, chlorophyll fluorescence, germplasm

Sustainable Coffee Production Challenges in Developing Countries, the case of Ethiopia Coffee Production

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Abstract:

Coffee is the second largest trade commodity and is the sustaining force behind the economies of 80 developing countries and 125 million people's livelihoods. However, number of challenges currently creates sustainability of coffee production. This paper aimed at assessing the key challenges for sustainable coffee production in producing countries and suggest the possible solutions. In the course of the study, data collection was conducted from selected key players in coffee sector like coffee farmers, cooperatives, associations, local governmental offices, higher learning institutions, marketing players and NGOs. Data collection was done through questionnaires, focus group discussions and secondary sources review. The results have shown that the key challenges for sustainability of coffee production in three categorical issues namely; economical, social and environmental. Key economical issues are low price of coffee to cover production cost thus replacement of coffee with other cash crops, volatility of coffee price, high living cost, shortage labour and high labour cost, high input cost, aging of coffee tree and low productivity, unfair value chain, lack of market information and access, limited access to insurance and hedging instruments, poor extension services. The key social issues are ageing of coffee producing communities, migration of young people by leaving coffee farm, lack of pension and social security for coffee farmers. The environmental issues are soil fertility degradation, deforestation, loss of biodiversity, degradation of water quality and supply, evolving coffee pests and diseases, weather volatility and climate change. To tackle these challenges establishing coffee producers' alliance among coffee producing nations may help with the following objectives. Enable growers to improve coffee production in a sustainable way, enhance coffee quality through improved practices, improve coffee marketing performance of producers thru value addition and efficient linkage to marketing, empower coffee growers to participate in and benefit from coffee supported inventions, supporting smallholder farmers towards acquiring entrepreneurial skills that enable them to become profitable, initiate, implement and scale-up best practice projects. Moreover, all coffee industry key players have to come together for equitable distribution of benefits to all stakeholders as for growers, roasters, exporters and retailers and agree on what is essential and the top most priority for the sustainability of the coffee industry as a whole.

Keywords: *coffee producers' alliance, economical, environmental, social, issues*

Différenciation en racines et tiges feuillées à partir de feuilles cotylédonaires du caféier robusta. Possibilité de reproduction des plants de caféier atteints par la Rhizoctoniose (fonte de semis).

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Summary

Coffee tree multiplies naturally by its seeds. This method of propagation is very often used by planters, since vegetative propagation is very expensive. Sprouting coffee seedlings are often prone to crown rot (damping off) disease caused by a fungus *Rhyzoctonia bataticola* (Taub). The attack manifests itself at the crown by a very marked necrosis interrupting the nutrition of the plant. After observing fortuitously that a cotyledonous leaf of the coffee tree *Coffea canephora* Pierre, cut by a locust, developed a seedling in natural conditions, a study was conducted at the National Coffee Research Program at INERA Yangambi, to assess the ability of cotyledonary leaves taken from healthy seedlings and that of cotyledonary leaves taken from seedlings affected by crown rot, to regenerate plants under ambient conditions in the nursery. It was shown that the cotyledonary leaves still alive, transplanted have an ability to regenerate coffee plantlets. This gives the farmer an advantage to recover coffee plantlets affected by damping-off and thus reduces the additional cost of purchasing seeds to replace lost materials.

Key words: fitness, regenerate, crown rot, cotyledonary leave**s**

Stabilizing income in small scale coffee farming systems through crop diversification. The case of coffee banana intercropping practice.

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Abstract

With the emerging global coffee price volatility and climate change effect on coffee productivity, crop diversification features in many countries as one of the promising adaptation options. Coffee and banana being high-value crops for Sub Saharan Africa, the profitability of intercropping both crops in the framework of crop diversification for farm income stabilization in the small scale farming systems was assessed in two purposively different trials conducted by the Rwanda Agriculture Board (RAB). The first attempt was to establish coffee (trees) and banana (mats) simultaneously with varying population densities per hectare: (i) 2500 coffee in monocrop, (ii) 2500 coffee + 1000 banana; (iii) 1000 banana mats in monocrop; (iv) 1250 (coffee) + 1000 banana and, (v) 1250 coffee + 500 banana. The second attempt consisted of varying the populations of banana mats (500, 625, and 833) per hectare into a fixed number of coffee trees per hectare (2,500). Both trials were laid in randomized complete block design with each treatment replicated 3 times. The analysis of variance of the first trial on three years, revealed no significant differences between treatments on coffee productivity for 2 years (2014 and 2016) while a significant effect was obtained in 2015. The highest cherry yields per tree (around 9 kg) were obtained with coffee in monocrop, the mixture of 500 banana mats with 2500 coffee trees, and the mixture of 1250 coffee trees with 1000 banana mats respectively.
The analysis of variance of the second trial led to a significant difference between treatments. Hence, growing 500 and 625 banana mats into 2500 coffee trees yielded higher than coffee in monocrop (4; 3.8 and 3.9kg per tree respectively) for three consecutive years. The effect of intercropping also was translated on quality attributes as the highest bean size (0.58 cm), the weight of 1000 beans (23.6 gr), and the overall score (85%) were obtained on coffee trees under 500 and 625 banana mats. Rust scores were significantly higher in coffee monocrop (12 spots per leaf) than in the intercropped plots. From the economic perspectives, the cost-benefit analysis revealed a positive comparative advantage of mainstreaming coffee banana intercropping into the coffee farming systems as the Cost-benefit Ratio was higher in intercrop (1.61) than the monocrop (1.15). Regarding the global coffee price volatility intercropping coffee with banana would be inevitably a sustainable crop intensification systems that would lead to improved livelihoods of small-scale farmers.

Key words: Coffee, Banana, Intercropping, Income, small-scale farmers

Investissement de base et coût de production du café vert robusta au Togo

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Summary

Coffee production is a labor intensive activity. With the revaluation of the guaranteed minimum interprofessional wage (SMIG) in Togo, the production costs of green coffee have changed. The objective of this study is to update the investments required in the establishment of a new plantation and the production costs of green coffee in Togo. Semi-structured interviews were conducted with key informants in twenty (20) locations selected in a reasoned way in the coffee production area. The primary information obtained was crossed with the available secondary data. The budgeting approach was used to develop the income statement. The results show that the establishment of a hectare of coffee plantation requires an investment of 2,310,000fcfa spread over a period of 4 years as follows: i) 33.4% in the first year (i.e. 771,000fcfa including 502,000fcfa basic investment and 269,000 CFA francs for operating expenses), ii) 15.2% in the second year, i.e. 351,000 CFA francs for operating expenses, iii) 25.5% in the third year, or 589,000 CFA francs for operating expenses 'operation and iv) 25.9% in the 4th year or 599,000 CFA francs of operating expenses. Operating expenses are made up of 75% labor and 25% inputs. Family labor accounts for 65% of labor expenditure. With an average yield of 560 kg / ha, the cost price of a kg of robusta green coffee without the valuation of family labor is 548fcfa / kg. Taking into account the opportunity cost of family labor, the cost price of green coffee is 1069fcfa. Compared to the average purchase cost of green coffee (600fcf / kg), production is at a loss. This loss can be eliminated by improving the yield or the purchase price.

Keywords: green coffee, opportunity cost, production cost, investment, Togo

Qualités sensorielles de cafés de nouveaux hybrides Robusta pour une utilisation optimisée pa l'industrie

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Summary

The sensory qualities of 84 coffee samples from 84 varieties, including 74 hybrid progenies in selection and 10 popularized clones were evaluated. The sensory profiles of these coffees were produced according to 13 characteristics. A hedonic test on tasters' preferences for different coffees was also carried out. The results obtained showed a very highly significant difference between the varieties for most of the typicities analyzed. Principal component analysis revealed high variability between coffees. These fall into four distinct sensory groups. Coffees with neutral tastes and scents were also highlighted. This diversity offers breeders the opportunity to improve these traits through selection. It also enables optimized use of these coffees by industry, by conquering niche markets according to consumer tastes.

Keywords: hybrid descent - clone - coffee - sensory profile - typicality.

Une nouvelle méthode pour prédire le fonctionnement et la production du caféier : le modèle GreenLab

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Summary

The selection of coffee trees and the creation of new ideotypes adapted to climatic and environmental challenges require the consideration of plant architecture as one of the key and essential points. Indeed, many components of the architecture of the coffee tree are indicators of productivity and are highly hereditary. A study was carried out to optimize the prediction of coffee production and the selection of genotypes, by modeling the architecture. The GreenLab plant structure-functional model (FSPM) has been calibrated in a field environment in six African coffee species, including the species *Coffea canephora*. The results showed that the architectural parameters calculated by this model, such as stem development, plant branching and branch development, were not significantly different between the six species. On the other hand, the hidden parameters of the model such as organ sinks, production surfaces and the resistance of leaves to transpiration are different from one species to another, showing that each species has its own growth pattern and of development. All these parameters calculated by the GreenLab model made it possible to successfully simulate the plant architecture and the biomass production of the six coffee tree species, based on the interactions between the structural dynamics, the external resources and the physiological processes that govern organs. This study provides coffee breeders with a new tool to create new ideotypes in a short time. It is also a fundamental analysis of the development, growth and distribution of biomass in coffee trees.

Keywords: Coffee tree, Architecture, Biomass production, GreenLab.