Food and Agriculture Organization of the United Nations

Reef ريف

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture

Catalogue of coffee diseases, pests and weeds in the Kingdom of Saudi Arabia

(CEF/051/2021/4)

Strengthening MoEWA's Capacity to implement its Sustainable Rural Agricultural Development Programme (2019-2025) (UTF/SAU/051/SAU)

Food and Agriculture Organization of the United Nations

Riyadh, Kingdom of Saudi Arabia

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Acronyms

CABI	Centre for Agriculture and Bioscience International
CBD	Coffee Berry Disease
CLR	Coffee Leaf Rust
ETL	Economic Threshold Levels
FAO	Food and Agriculture Organization of the United Nations
IPM	Integrated Pest management
KSA	Kingdom of Saudi Arabia
MoEWA	Ministry of Environment, Water and Agriculture
NTP	National Transformation Programme
OTA	Ochratoxin A
SRADP	Sustainable Rural Agriculture Development Programme

Glossary

Biological control agent: Natural enemy, antagonist or competitor, or other organism, used for pest control (FAO, 2006).

Control (of a pest): Suppression, containment or eradication of a pest population (FAO, 2006).

Integrated Pest Management (IPM): Careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human and animal health and/or the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms (FAO, 2006).

Natural enemy: Organism which lives at the expense of another organism in its area of origin and which may help to limit the population of that organism. This includes parasitoids, parasites, predators, phytophagous organisms and pathogens (FAO, 2006).

Pest: Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants and plant products, materials or environments and includes vectors of parasites or pathogens of human and animal disease and animals causing public health nuisance. (FAO, 2006).

Pesticide: Any substance, or mixture of substances of chemical or biological ingredients intended for repelling, destroying or controlling any pest, or regulating plant growth (FAO, 2006).

Ochratoxin A (OTA) is a secondary metabolite produced by filamentous fungi of the genera *Aspergillus* and *Penicillium* present in a wide variety of foodstuffs.

Resistance: Naturally occurring, inheritable adjustment in the ability of individuals in a (pest) population to survive a treatment with plant protection product that would normally give effective control (FAO, 2006).

1.0 Introduction

Coffee has been grown in the kingdom for over 300 years, but was not a priority crop. With Vision 2030 and the National Transformation Programme whose main objective is to diversify the economy, coffee has been identified as one of the commodities that will contribute towards achieving this goal.

Food and Agriculture Organization is providing technical and advisory assistance to the Ministry of Environment, Water and Agriculture in the implementation of its initiatives within the context of the National Transformation Program (NTP) 2020. The Ministry of Environment, Water and Agriculture in conjunction Food and Agriculture Organization have developed the project "Sustainable Rural Agricultural Development (SRAD) Programme (2019-2025)". Coffee development is a component of this programme under "Development of coffee Arabica production, processing and marketing". The aim is to enhance the production of quality coffee in the Kingdom for local consumption (reduce coffee imports) and exports particularly to niche markets like organic coffee and geographical indications. It is therefore critical and crucial to identify all the diseases/pests that affect and may affect coffee production in future, their management taking into account environmental, health and market considerations. In Saudi Arabia no survey has been conducted to identify the main pests in the coffee sector and there is therefore no consolidated data or information. Possible new pests and disease that may attack coffee particularly with climate change, change of farming systems by the farmers and more stakeholder interactions, have been discussed. The need for strict quarantine system is also discussed.

2.0 Approach and methodology

2.1 Rationale

2.2 Objectives

This catalogue has been prepared to assist coffee technicians and extension staff at national and regional levels gets equipped in understanding coffee pests and diseases in the Kingdom of Saudi Arabia. They will also learn how to identify the pests/diseases; symptoms of damage caused and are able to apply modern and sustainable management practices. This will be done in consideration to improving coffee productivity and processing without compromising on the environment now and in the future. The manual provides recent information and skills for managing coffee pests and diseases in simple and clear manner, easy for famers to understand and adopt.

This coffee pest and disease catalogue provides useful information to not only produce increased volumes of quality coffee but also sustaining the business into the future for posterity. It will be useful for technicians working in the sector to have a quick reference material to assist in pest identification and recommendations on the control measures.

2.3 Scope

2.4 Methodology

The study employed the following step-wise methodology to ensure adequate data collection from all the relevant stakeholders:

a. Review of global best practices coffee including emerging trends, technologies and practices – this provided a framework for comparison and a bench mark to measure the baseline status.

b. Review of existing relevant secondary information and reports related to the

c. coffee diseases and pests in the Kingdom, distribution and coffee management practices

d. Field visits in the main coffee growing regions in the Kingdom for data collection,

e. observations and triangulation. This formed part of the primary baseline data

f. on coffee pests, diseases and weeds in the Kingdom.

The data collection was at three levels:

i. Key Informant Interviews with MoEWA extension staff

ii. Farmer discussions held in their farms regarding disease, pest and weed problems

iii. Non-interactive observations and photography recording of diseases, pests and weeds as observed in the coffee farms visited

2.5 Limitations

The catalogue is based purely on data and information gathered during the field missions between 2018 and 2021. The COVID 19 pandemic curtailed movement particularly in 2020. Coffee is grown in mountainous regions and the farmers are far apart. This affected the number of farmers that could be visited in a day.

3.0 Disease and Pest Management

3.1 Biological control

Biological control has the potential to keep the pest population below the level of economic damage. When tested and found successful, it becomes self-sustaining and integrated into the normal environment of the control area. However, establishment of the natural enemies to effective populations takes time and is dependent on what goes on in the farm and even the surrounding farms. Even when multiplied in the laboratory, it survival rate in the farm is usually limited. Any pesticides if applied does not discriminate between the target pest and natural enemies and kills both. The use of pesticides should then be carefully considered and only as a last resort.

3.2 Cultural methods

Cultural methods are cost effective and take advantage of the day to day operations in the farm. Regular pruning to remove unwanted growth creates room for air and sunlight penetration an environment not conducive to many pests and disease pathogens. In well pruned open trees, birds assist in feeding on insect pests and the quick elimination of moisture on leaf surfaces affects sporulation of fungal pathogens. The management of the soil PH and proper feeding of the coffee trees reduces drastically incidences of white stem borer infestation. Prevention of bruising the coffee stem mainly while digging irrigation basin will reduce the high incidences of Fusarium disease in all the coffee growing areas of Saudi Arabia. The cultural will be attained when farmers adopt good agriculture practices in coffee production and the extension staff trained on the same.

3.3 Chemical control

Chemical control is when chemicals are used to kill the pests. All these chemicals are referred to as pesticide. They are used to control pests once the infestation is above the economic threshold as determined through routine pest surveillance. Pesticides are also used as a protective measure particularly in the management of fungal diseases. The fungal growth dynamics are greatly influenced by weather patterns with moist and warm conditions favouring sporulation. Fungicides are applied before disease attack and by forming a thin film on the coffee leaf surface prevent sporulation of the fungus spores. This approach is practiced in countries where coffee berry disease and coffee leaf rust are endemic. On the other hand, pesticides to control weeds referred to as herbicides are used when farm labour is needed for other activities like harvesting, on sloppy ground where hand weeding will lead to soil erosion and when there is too much rain to use cultural and mechanical methods. In KSA farmers are greatly encourage to limit the use of chemicals due to the fragile ecosystem and environmental considerations. As such the use of chemicals to control diseases has been limited to IPM approaches and when absolutely necessary. However, farmers may use pesticides for other crops on their farms. As such the farmers are recommended to adhere to safe use of pesticides as enumerated here below: -

If pesticides have to be used for any critical reason, then procedures for their safe use and efficient use MUST be followed. These are shown in Annexes I and II.

3.4 Integrated pest management

Integrated Pest Management (IPM) as the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human and animal health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms (FAO, 2017). FAO promotes IPM as the preferred approach to crop protection and regards it as a pillar of both sustainable intensification of crop production and pesticide risk reduction.

IPM entails combining several pest control methods such as planting of healthy plants raised from healthy seed, application of best agricultural practices, biological control by enhancement of natural enemies, use of biological control agents and application of cultural control methods like stripping all diseased or pest infested berries and destroying them by burning. Chemical or pesticides are only used as last resort and all the principles of safe use of pesticides applied. It is important to avoid unnecessary insecticide sprays in order to conserve the beneficial insects and natural enemies. Pesticides are harmful to the farmer and the environment. Use of unnecessary and unapproved pesticides will also render the coffee produced not legible for labelling as organic or as a Geographical Indication. IPM practices entail a careful combination chemical, biological and cultural control methods.

Biological control or bio control is a method of controlling pests such as insects, mites, weeds and plant diseases using other organisms. The essential difference between biological control and natural control is merely that in biological control natural enemies are encouraged and disseminated by man. It relies on predation, parasitism, herbivore, or other natural mechanisms, but typically also involves an active human management role. In coffee, biological control depends on the area and the natural enemies available. In the coffee growing areas of Saudi Arabia, several natural enemies like spiders, lady birds have been observed predating on insect pests. More work is recommended to identify more natural enemies and the pests they feed on.

In order to take full advantage of IPM practices, pest surveillance and training of both producers and extension staff is crucial. Pest surveillance refers to random survey of to determine pest presence and population levels. It is a critical pest management strategy. For effective pest management, it is important to take into consideration the economic threshold levels (ETL) i.e. the pest population level beyond which if not controlled is likely to cause crop loss which exceeds the cost of control. It will be undertaken by trained personnel. Farmers will also be trained to undertake this activity focussing on pest identification in the field and use of available pest identification tools like the FAO plantix (https://www.fao.org/e-agriculture/news/plantix) which supports farmers to recognize plant diseases, pests and nutrient deficiencies just by sending a picture. The data so collected is used to complete the pest scouting form is shown in Annex 1. On analysis the pest dynamics is determined and the right management strategies put in place.

The following IPM practices are recommended for the coffee farmers in the Kingdom of Saudi Arabia: -

a. Disease management

i. Planting of healthy seedlings raised from identified mother trees or from a recognized nursery;
ii. Never planting the volunteer coffee seedlings that germinate under the coffee trees;
iii. Keeping the coffee trees young (changing the cycle 5-6 years) and well pruned;
iv. Avoid injuring the coffee stem while preparing irrigation basis or allowing goats/sheep into the coffee fields. Animals damage the trees by nibbling and removing the bark. The wounds created become entry points for fungal pathogens mainly;
v. Pruning using a pair of secateurs or pruning saw as the case may require. NEVER remove branches or suckers by breaking with bare hand.

b. Weed management

i. Keeping the fields weed free by removing the weeds before they flower.

c. Pest management

i. Stripping all coffee berries still on the tree after the end of the season. They are dried separately from the other coffee;
ii. Collecting all fallen beans from the ground. They may be contaminated with ochratoxin A and therefore not suitable for human consumption;

iii. Pesticides to be used only when very necessary and as a last resort. When used then the appropriate spraying procedures **must** be followed.

3.5 Influence of Climate Change on pests and diseases

Climate change is any significant change in measures of climate such as temperature, precipitation and persists for an extended period of time (IPCC, 2007) which may be limited to a specific region or may occur across the whole globe It is characterized by frequent and prolonged droughts, floods, hailstorms, landslides, thunderstorms and erratic and unreliable rainfall. These changes in turn affects agricultural systems and productivity. One key aspect is the pest dynamics. The behaviour and life cycle of insects are greatly affected by temperatures. A change in temperature would therefore affect the dynamics of some of the insect pests or disease pathogens with some increasing in number and voracity, some minor insect pests becoming major while some may be wiped out. This was the case of coffee leaf rust in Central and south America where the attack almost become reached pandemic levels. The kingdom is targeting to plant over 10 billion trees and some of these may turn out to be alternate hosts of pests and pathogens. Rigorous pest surveillance is key in ensuring that the disease and insect pest damage is kept below the economic threshold.

Climatic risk	**Effect on coffee tree**	**Effect on diseases and pests**
High temperature	Create stress on the tree due to high evapotranspiration	Faster life cycle of insect pests; Prolific production and dispersal disease spores
Sporadic rains	Continuous flowering	Possible increase of some diseases; Post-harvest drying difficulties and mould formation
Heavy rains	High vegetative growth	Increased habitat for pests and disease pathogens Rewetting of drying coffee leading to mould formation

3.6 Plant Clinics

Smallholder coffee farmers in Saudi Arabia rely on crop production for income generation. Their ability to generate sustainable incomes is often threatened by pests and diseases that not only reduce yields but also quality. Farmers require various options for addressing pest and disease, maintaining and updating information on the types of pest and diseases and how to address them is difficult (American Institutes for Research, 2018). Plant clinics offers such a new extension method that offers one to one extension services to farmers more so on pests and diseases. They are located in meeting places like local markets/centres, community centres and cooperatives where farmers with plant disease problem can take samples of their sick plants to trained plant health extension officers (for diagnosis and recommendations on how to manage the problem. They offer regular services to the farmers in a similar way to human clinics that offer health services to the community. Farmers take along the diseases or infested plant or part of the plant. After the diagnosis by the extension officer also known as plant doctor, the farmer is issued with recommendations on how to manage the disease/pest problem and if the use of pesticides is recommended then a prescription is provided (Tambo et al., 2020). The plant clinics are designed to systematically collect information on the crops and associated pests and diseases reported by farmers (American Institutes for Research, 2018). This become a source of additional information to assist in designing new training for the farmers and extension staff as well as aiding input

suppliers on which agro inputs to stock for both prevention and protective. Information regarding the prevalence of new pests, diseases and emerging issues due to climate change and or introduction of planting materials is gathered during the plant clinics. Over the years plant clinics have been established mostly in the developing countries and online apps developed.

4.0 Coffee growing in the Kingdom of Saudi Arabia

The Kingdom of Saudi Arabia lies between latitudes 16° and 33° N, and longitudes 34° and 56° E. It has a total area of approximately 215 000 km^2. It is bordered in the north by Jordan, Iraq and Kuwait, in the east by the Persian Gulf with a coastline of 480 km, in the southeast and south by Qatar, the United Arab Emirates, Oman and Yemen, and in the west by the Red Sea with a coastline of approximately of about 2 000 m.

Coffee Arabica is grown in south-western region of the Kingdom comprising of Jazan, Aseer and Al-Baha regions (Figure 1). This area is mountainous with steep slopes ranging 1 000-3 000 m above sea level. The area receives between 200 to 600 mm annual rainfall compared to the national average of 150 mm per year. It has mild temperatures in both summer and winter averaging 20-35^{0}C moderated by air movements from the Red Sea. These agro- ecological and climatic conditions make the area suitable for coffee cultivation. Coffee Arabica (*Coffea Arabica*) has been grown in this area since 1450 AD (853 AH).

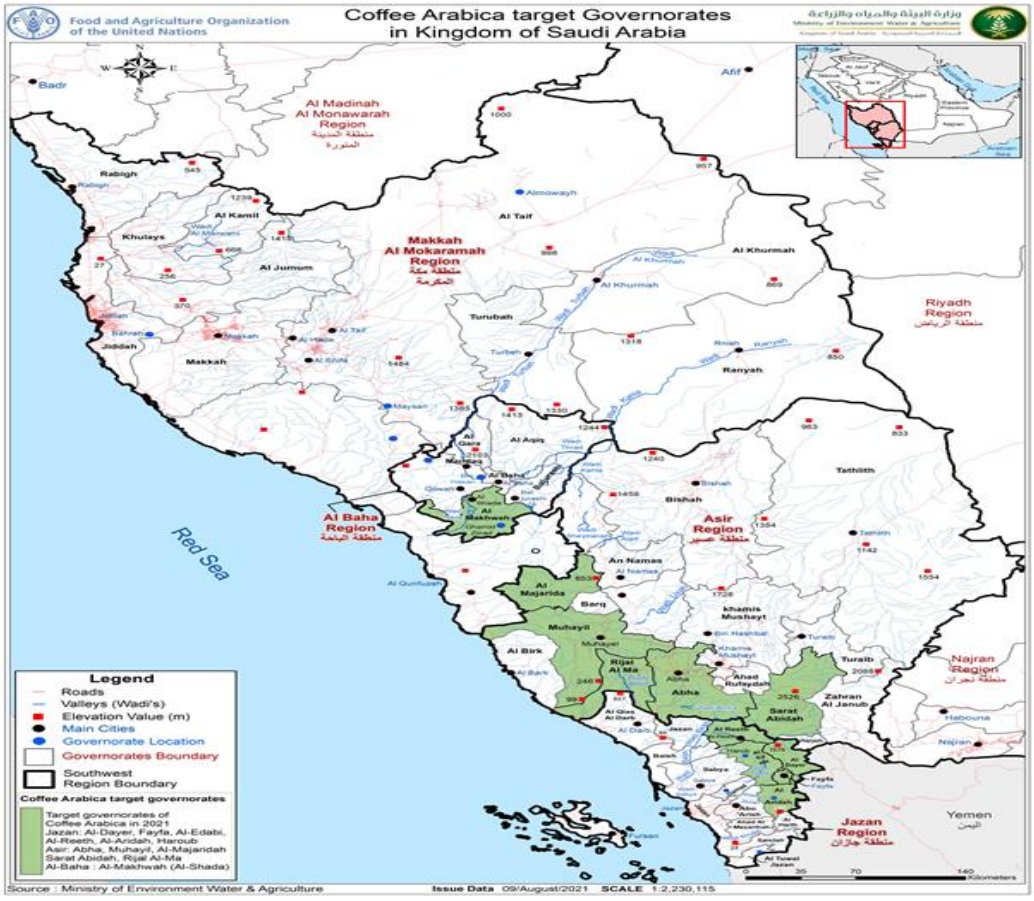

Figure 1: Coffee Arabica growing areas of Saudi Arabia

Arabica coffee is the most important species in term of economic production since it is responsible for about 60 percent of the world coffee production (Vossen *et al*., 2015). Arabica coffee is a small evergreen tree (not a shrub), capable of reaching 7m in height, with a 3 m spread. Coffee thrives best at altitudes of 1 200-2 100 m above sea level. The optimal temperature range is 15-19ºC and day temperatures should not exceed 30ºC while night temperature should not fall below 15ºC. Above 25ºC photosynthesis is reduced and above 30ºC coffee leaves are damaged leading to drying of the tree together with any berries. However, coffee has been found growing and producing at areas with either higher or lower temperatures than this mainly at the "higher latitudes" within the tropics. This is the case with Saudi Arabia where coffee thrives at 17-18^0 N but at high

altitudes of 700-2 200m above sea level. Unlike the humid tropics where coffee is grown, the conditions in Saudi Arabia are not very favourable to pests and disease pathogens (hot and dry) and hence there is limited disease and pest incidences. With climate change and increased coffee cultivation the scenario is likely to change requiring continuous pest surveillance and strict quarantine measures to bar introduction of new pests and diseases to the Kingdom.

5.0 Main Coffee Diseases in KSA

5.1 Coffee Leaf Rust

Cause: Among the most serious diseases of the coffee is coffee leaf rust caused by a fungus *Hemileia vastatrix*, which attacks leaves leading to defoliation, beans drying on the tree and eventual death.

Distribution: Globally, coffee rust epidemics, with intensities higher than previously observed, have affected a number of countries. In KSA some sporadic cases have been reported in Jazan.

Symptoms: The disease is characterized by pale yellow patches on the lower surface of leaves. The colour then changes in one or two days to yellow orange powdery mass (Figure 1). The whole leaf then becomes infected and drops off the tree. This leaves the coffee tree bare of leaves and dry berries on the tree. It may take more than one year for the tree to recover.

Life Cycle: The spores germinate on the underside of the leaf and produce mycelium which enters the plant through the stomata openings. The mycelia feed on the plant sap and start to produce spores appearing as rust lesions on the underside of the leaf (Figure 2). The lesions enlarge over a period of 2 to 3 weeks and produce spores (seed) for a period of 3 to 5 months.

Figure 2: Coffee leaf rust

Management:

In countries where it is endemic, the disease is controlled by

Cultural

- Keeping the trees open and well pruned
- Planting of disease tolerant varieties of which a number exist in Eastern Africa (Kimemia, 2010), Central and South America

Chemical

- Spraying with protective fungicides recommended by the relevant authority

Genetic

- Development and promotion of disease resistant varieties

5.2 Fusarium bark diseases

Cause: Fusarium bark disease caused by a fungus *Fusarium stilboides* that enters the plant through injures on the stem or branches.

Distribution: This disease is prevalent in all the coffee growing araes of Jazan, Aseer and Al Baha and has caused the death of many coffee trees. Fusarium fungus has also been reported in Saudi Arabia attacking date palms (Saleh *et al*., 2017).

Symptoms: The disease infects and weakens the stems which may break during picking while root rot attacks the root system thus slowing down the nutrients and water uptake resulting in reduction of production and quality of coffee. The fungus grows beneath the bark layer that becomes flaxy resulting in bark scaling the clearest symptom of the disease (Figure 2). Affected trees develop pale yellow leaves the slowly die off.

Source: Kimemia, 2021

Figure 2: Fusarium bark disease on mature coffee trees Al Baha

Life cycle: Fusarium fungi occur naturally in most soils particularly in hot weather conditions, areas with poor soil and nutrient imbalance. It can remain in the soil for a long time. The disease enters the coffee plants through wounds on damaged stems caused on the stump when slashing weeds or by poor change of cycle. Poor cultural practices mainly plucking of coffee tree branches by hand, damaging the stem while digging water holding basins contribute significantly to the proliferation of the disease Figures 3.

Management:

Cultural

- Uprooting and destroying the infected plant preferably by burning. The hole left by uprooting should be allowed to be scorched by the sun for at least two (2) months so that all the fungal spores and mycelium are destroyed.

Figure 3: Proper use of the pruning saw and damaged tree stump.

5.2 Fungal moulds

Cause: The moulds are caused by fungus, the main being *Penicillium verrucosum*, *Aspergillus ochraceus*, *Aspergillus niger* and *Aspergillus carbonarius*. There are fungi (moulds) in the soil that produce a poisonous toxin known as Ochratoxin A (OTA).

Distribution: Ochratoxin A (OTA) producing moulds have been reported in KSA (Alkhalifah, 2013) and were observed on drying cherry in Aseer. However, presence of moulds does not mean that automatically the coffee is contaminated by OTA but is a good guide.

Symptoms.: White mass growing on the coffee dry cherry (Figure 4**).**

Life cycle: The fungi occur naturally in a variety of plant products such as cereals, coffee beans, beans, pulses and dried fruit all over the world. In coffee moulds usually grow due to poor drying, handling and storage. Moulds lower coffee quality and are also been classified as carcinogenic. Ochratoxin A (OTA) is not destroyed by roasting and therefor, OTA contaminated is NOT safe for human consumption.

Management:

Cultural:

- Coffee if poorly processed and stored at the farm and warehouse can be attacked by moulds.
- While picking, processing and storing coffee, farmers should ensure that it does not get into contact with the soil.
- The coffee cherries must be dried on the raised drying beds.
- Coffee in the store awaiting sale should **NEVER** be allowed to come into contact with any form of moisture.

Figure 4: Mouldy dry coffee cherry, Aseer.

6.0 Main Coffee Pests in KSA

Arabica coffee is attacked by a large number of pests from the nursery up to the bean. The pests may affect the whole or parts of plant leading to low or total loss of yield and quality. Serious insect damage may render the coffee unmarketable. It is therefore critical and important to manage and control these pests.

6.2 Coffee leaf miner (*Leucoptera coffeella)*

Distribution: The pest is prevalent in all the coffee growing areas of Jazan, Aseer and Al Baha. The coffee leaf miner was originally found in Africa and it has probably been introduced to other countries through nursery materials. It is considered to be the principal pest to coffee especially in hot and dry climate (Dantas, et al. 2020).

Life cycle: The adult moth lays eggs on the upper leaf surface of the coffee plants. The eggs hatch into larvae hatch after about 7 to 12 days. The feed on the palisade parenchyma of the coffee leaf. The larvae stage varies from 9- 40 days depending on the weather conditions. The larvae are not able to move from leaf to leaf and therefore remains feeding on only one leaf. After about 40 days the larvae pupates on the underside surface of the leaf. The adult moth emerges from the pupa after 2-3 weeks and starts the cycle all over again. The month lives for about 2-3 weeks. This creates continuous overlapping generations hence the prevalent damage observed on the coffee plants throughout the Kingdom at all times.

Symptoms of damage: The insect, owes its name to the galleries or tunnels formed in the epidermis of the leaf, as a consequence of destruction of the palisade tissue used by the caterpillars for food (Figure 5).

Management:

Cultural

- Prudent pruning,
- use of shade trees
- Development of resistant varieties

Chemical

- As the larvae live inside tunnels under the leaf surface, they are sheltered from direct sun heat and spraying with pesticides will not be effective.

Genetic

- Efforts are under way led by Brazil to develop a leaf miner tolerant coffee variety

Figure 5: Coffee leaf miner infestation and a larvae

6.3 Green scales ***(Coccus viridis)***

Distribution: Green scales are of Brazilian or African origin but now spread all over the tropics. In KSA, they are present in all the coffee growing regions of Jazan, Asir and Al Baha. Scales also attack other crops fruit trees, vegetables and ornamentals.

Life cycle: The scales are small flat oval shaped feeding along the tips of young shoots and main leaf vein (Figure 6a). The mature female lays whitish oval eggs and keeps them underneath her body to protect them. Eggs hatch in anything between a few minutes and a few hours. The newly hatched crawlers settle on a leaf or near the tip of a green shoot and start feeding. Both nymphs and adults suck sap from the host plant.

Symptoms: The scales sap juice from the plants and excrete a sticky honey dew. Moulds then grow on the honey dew and give the characteristic black soot on the leaves (Figure 6a). The honey dew also attracts attendant ants that feed on it and their presence on a tree is a confirmative indicator of scale infestation.

Management: The black soot reduces the leaf area available for photosynthesis thus reducing yields. The cause much damage to young coffee trees after transplanting.

Biological

- Scales are predated by a small yellow with black spots beetle known as ladybird *Coccinellidae* (Figure 6b). To protect their honeydew, the ants attack ladybirds and expel them from the coffee tree. By stopping the ants from accessing the coffee tree and expelling the ladybirds, these natural enemies are able to effectively manage the scales. To prevent the ants from climbing the coffee tree a 15cm band of a suitable and safe insecticide is applied around the base of the tree. All branches touching the ground are pruned to remove any alternate ladder to the tree. This is a classic case of integrated pest management (IPM).

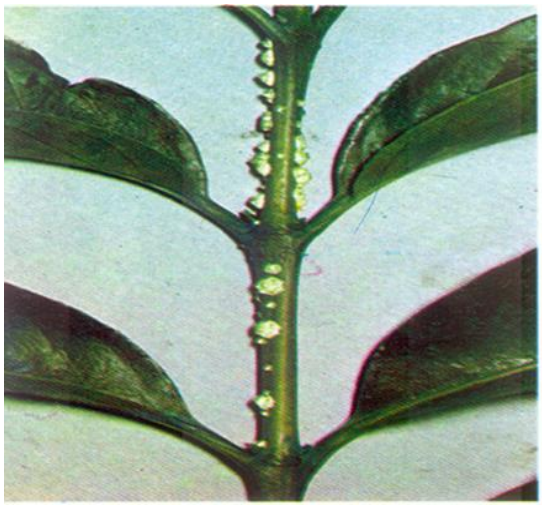

Figure 6: a) Scales on a coffee shoot b)Adult ladybird *Coccinellidae*

6.4 Thrips (*Diarthrothrips coffeae*)

Distribution: Thrips are common in the coffee growing areas Jazan, Asir and Al Baha.

Life cycle: Thrips have 5 developmental stages the egg, two feeding stages also known as larvae, two non-feeding stages (pupae) and the adult. The durations of each stage vary depending on species, host, and temperature.

Symptoms of damage: Thrips sap water from the under surface area of the coffee leaves and green shoots. This causes irregular grey or silvery patches covered by numerous minute black spots on leaves, berries and young shoots (Figure 7). It causes excessive leaf fall resulting to the berries drying up and consequently a loss in yield and quality. If uncontrolled the defoliation can lead to subsequent death of the coffee tree.

Management:

Cultural

- Thrips are managed by cultural practices that reduce moisture stress to the plant like mulching, shading and irrigation.

Chemical:

- Spraying is difficulty as they hide under the underside part of the coffee leaf.

Figure 7: Thrips feeding on a coffee leaf and advanced damage

6.5 Coffee berry moth (*Prophantis smaragdina*)

Distribution: Coffee berry borer is common coffee pest in coffee farms with no shade trees. It is endemic in all the coffee growing areas of Saudi Arabia. It is prevalent in Yemen where infestation very high (Ba-Angood and Al-Sunaidi, 2004).

Life Cycle: The eggs which are laid on the green berry are small, white and scale-like. It hatches to a larva in 3-4 days. The larvae then bore into the berries and feed on the seed before moving out to feed on other berries. As it moves across the berries on a cluster they spin a web of silk, joining the cluster together in the characteristic spider web. The larvae then drop down on the ground to pupate after 14 days. It pupates between two leaves neatly stuck together. The adult emerges after 6-42 days and has a life span of two (2) weeks.

Damage symptoms: The larva is the destructive stage. It bores into the berries and destroy the seed from within making it difficult to control by pesticides. The symptoms include berry clusters webbed together, one or more berries being brown, dry and hollow. Its presence is visually characterized by a **spider like web** joining several berries together and **an entry hole at the base** of the coffee berry (Figure 8).

Figure 8: Berry moth web on a berry cluster

Management:

Cultural

- Removal of all the affected clusters of berries and destroying them by burning or deep burying.
- All berries that have dropped to the ground must be collected and burned. Pesticide spraying may not be effective as the borer resides inside the berry.

Biological

- The moth is attacked by a parasitic wasp prevalent in most coffee growing countries. Its presence in Saudi Arabia has to be confirmed through surveillance surveys.

6.6 Coffee berry borer (***Hypothenemus hampei***)

Distribution: Coffee berry borer is a serious pest in many of the major coffee-producing countries in the world. It is prevalent in the coffee growing regions in Saudi Arabia

Life Cycle: The female beetle bores through the berry into the bean and lays eggs in the tunnel. The eggs hatch in 5–9 days. And the larvae feed on the bean for about 10–16 days. The rate of growth and reproduction of the larvae is favoured by high temperatures. The life cycle of the coffee berry borer takes 28–35 days from egg-laying to the mature beetle depending on the prevailing air temperature.

Damage symptoms: It attacks and damages both Arabica and Robusta coffee. The beetle bores into the berry through the scar left by the stigma and feeds on the bean from inside. The entry is clearly visible on an infested cherry. On maturity, the coffee berry may appear red ripe but on hulling the whole bean had been destroyed by the borer. This drastically reduces the yields. The entry hole also becomes an avenue for fungus and bacteria that do infect the coffee bean further lowering production and quality (Figure 9). The borer on the other hand is known to feed on the fungus creating a symbiotic relationship.

Figure 9: Berry borer damage on green berries and bean.

Management

Cultural

- Regular pruning
- Practice field hygiene by collecting infested fallen berries to avoid the berries becoming breeding reservoir for CBB
- Strip all the remaining berries at the end of the harvest season. If infested, bury or burn them
- Avoid over-shading (self-shading or bushiness) in order to enhance searching capacity of natural enemies on the pest

Chemical

- Ensure timely spraying twice at 3 weeks' interval (15th and 18th week from the main flowering (blossoming) using any of the MoEWA registered insecticides. This to apply where infestation was severe (above 5%) in the previous season.

Integrated method

- Use of pheromone traps (Brocap traps) – traps laced with a suitable insecticide are used to attract and kill the males (Figure 11).

Figure 10: A simple pheromone trap, Jazan.

6.7 Antestia bug ***(Antestiopsis spp)***

Distribution: This is a major pest of Arabica coffee. Sporadic cases have been observed in the coffee growing areas of Jazan, Aseer and Al Baha.

Life Cycle: The adult bug is shield-shaped, about 6 to 8 mm long and strikingly coloured dark brown with orange and white markings (Figure 12). They hide in berry or flower clusters. Females lay eggs in groups on the underside of the coffee plant leaves. Nymphs resemble the adults in colour but have a more rounded shape and lack functional wings.

Damage symptoms: Both adults and nymphs are known to cause severe damage to green berries by feeding and indirectly by the transmission of a fungus *(Nematospora coryli*), which causes rotting of beans. The bug also attacks flower buds and shoots causing blackening of flower buds and consequently no flower/fruit set. Attacked branches grow side shoots developing a fan branching structure. No visible surface marks / scars or wounds are noticeable on berry. However, on hulling the dry cherry, a characteristic zebra stripes are observed on the bean (Figure 12). These zebras stripped beans produce poor quality coffee. The antestia bug is recognized by a foul lingering smell when touched with bare hands. This foul smell is passed on to the bean and coffee cup rendering the coffee undrinkable.

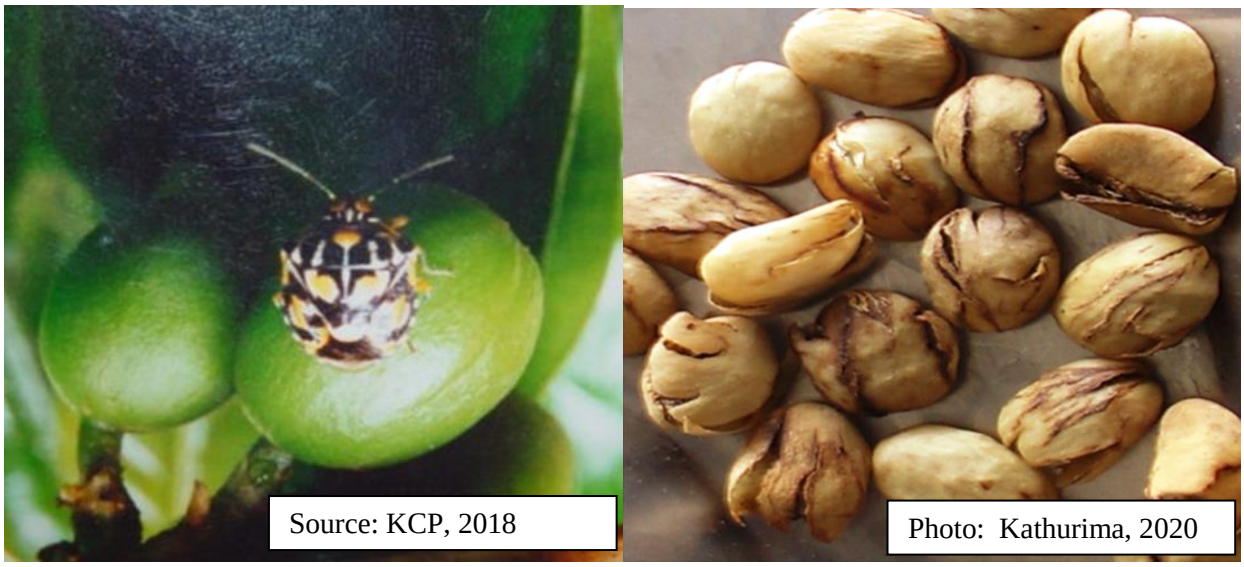

Figure 11: Antestia bug on a green cherry damage (zebra striped beans)

Management

Cultural control

- Timely pruning, handling and de-suckering

Chemical control

- Spray when the pest population reaches 2 bugs per tree using any of the MoEWA registered insecticides

6.8 Mealy bugs (***Planococcus spp***)

Distribution: Most of the coffee growing countries. The coffee mealybugs have wide range of alternate hosts and has been found attacking many different species of plants. It is also widespread in the coffee growing areas of Jazan, Aseer and Al Baha.

Life Cycle: The female coffee mealybugs give birth to live young nymps which undergo nymphal stages before becoming adults. The males have wings while females are wingless.

Symptoms: The symptoms manifest as mealy white masses between clusters of berries and flower buds or on top of suckers (Figure 12). They feed mainly on mainly on leaves, stems and on fruits but has also been recorded on roots. The mealybugs are attended by ants in a mutually benefical association. Mealybug colonies flourish and spread when the sticky honeydew produced is removed and the cast skins and dead mealybugs are cleaned up by the ants (CABI, 2019)

Management:

Figure 12: Coffee mealy bug crawlers

6.9 White Stem Borer (*Xylotrechus quadripes*)

Distribution: This is a major pest in the low altitude coffee growing areas with poor and shallow soils. In KSA it is widespread in the low altitude (below 700m above sea level) areas of Jazan, Asir and Al Baha.

Life cycle: The adults are slender, elongate beetles of about 2-2.5cm in length. The forewings are black with characteristic white bands. The female beetles lay eggs in the cracks and crevices of the bark and under the loose scaly bark of the main stem and thick primaries, thus preferring old coffee trees. The larvae (2-3 cm long) on hatching feeds on the bark then enters the hard wood and make tunnels extending all the way into the roots. The tunnels are filled with excreta of the larvae. The larvae pupate after about 10 months and the pupal stage is about 3-4 weeks.

Symptoms: The adult remains in the stem and emerges out by cutting a characteristic round exit hole (Figure 13). Wood shavings are extruded by larvae when burrowing into the stem which acts as quick diagnosis for the presence of white stem borer. The symptoms of the damage yellowing of foliage and eventual death of the tree.

Source: Bandar

Figure 12: Characteristic round hole created by emerging beetle Photo:

Management: The pest burrowing in the stem is well protected from pesticides. It is therefore best managed by an integrated pest management (IPM) approach. These include: -

Cultural

- Planting shade trees to provide light shade that modifies the temperatures;
- Improving soil fertility through application of manure and compost;
- Identifying infested trees, uprooting and burning them preferably before the adult beetles emerge out from the stem and starts laying more eggs;
- Scrubbing the stem to remove the loose scaly bark of the main stem and thick primaries using a coarse material to reduce the cracks and crevices in which the eggs are deposited. Sharp objects **MUST NOT** be used as they may injure the stem and create entry points for fungus that causes fusarium bark disease;
- Use of pheromone traps installed in the coffee field to attract and kill the adult male beetles (Figure 11).

Chemical

- Spraying with 10% lime (spray lime at 1.0 kg in 10 litres of water) on main stem and thick primaries to prevents the females from eggs on the stem and thick primaries. This best done after scrubbing the stem to remove all the flaked bark.

6.10 Coffee Bean Weevil (*Araecerus fasciculatus*)

Distribution: This is a storage pest found in all the coffee growing regions in the Kingdom

Life cycle: Eggs are laid singly in the parchment coffee or dried cherry. The larva is a white, legless grub, similar to many weevil larvae. It initially feeds on the pulp but later perforates the bean. The larval stage lasts 33-40 days then pupates for 5-11 days. The adult is 3-5 mm long, dark brown in colour.

Symptoms: This weevil damages stored beans, especially old coffee kept at high humidities. The adult perforates the dried coffee bean and lays eggs and then the larvae develop inside and destroy the bean completely. The main loss is the contamination of the stored coffee, which considerably reduces the quality (The American Phytopathological Society, 2015).

Management: This is a pest of coffee beans and hence use of pesticides is not recommended.

Cultural control

- Drying the coffee cherries to a moisture content of about 12%
- Stored coffee should not be exposed to moisture
- Sun drying the coffee may kill the weevil and this method will be very effective in KSA

7.0 Common weeds in coffee farms

Introduction:
Weeds are defined as plants growing where they are not wanted. Weeds in coffee farms compete for moisture and nutrients leading to production of small beans, low yields and quality, and after prolonged weed infestation, yields drop to zero and subsequent death of the coffee trees. Weed seeds contaminate green beans and if not removed by sorting affect the cup quality. Weeds also act as alternate hosts to insect pests and diseases. A number of weed species are common in the coffee farms depending on elevation and soil fertility. The weeds grow together and require similar approaches to their management. It is therefore to describe each weed separately. During the farm visits weeds were not identified by the farmers as a serious problem that could affect yield and quality. However, lack of labour for weeding purposes was reported to a serious threat to coffee cultivation. Some of common ones found growing in all the coffee growing regions are shown in Figure 14. The weeds were identified using Picture This App https://apps.apple.com/us/app/picturethis-plant-identifier/id1252497129.

Classification
Weeds are classified either as annual or perennial weeds.
Annual weeds are those that complete their vegetative cycle within one year and are easy to control e.g. gallant soldier (*Galinsoga parviflora*), jimson weed (*Datura stramonium*), devils beggarticks (*Bidens frondosa*), Mexican marigold (*Tegetes erecta*), golden crownbeard (*Verbesina encelioides*), pale Mexican pricklywood (*Argemone ochroleuca*), prickly lettuce (*Lactuca serriola*), horseweed (*Erigeron canadensis*), black nightshade (*Solanum nigrum*), cheeseweed mallow (*Malva parviflora*) among others.
Perennial weeds are those that persist over seasons and are usually difficult to control as they are deep rooted and hardy. These include most grass weeds like nut grass (*Cyperus rotundus*), feathertop grass (*Cenchrus longisetus*), Bermuda grass (*Cynodon.* Other perennial weeds observed in the farms were woodsorrel (*Oxalis dillenii*), field bindweed (*Convolvulus arvensis*), common purslane (*Portulaca oleracea*),) among others. Examples of common weeds found growing in coffee fields are shown in Figure 14.

Management:
Effective weed control depends on timely application of the control methods that should be done before: -

- Weeds get too big and the root system makes them difficult to pull out;
- Weeds start seeding adding to the weed problem;
- Fertilizer/manure/compost is applied which would otherwise be taken up by weeds

Weed management in coffee can be achieved through mechanical, cultural, chemical or a combination of any two or more strategies referred to as Integrated Weed Management (IWM).

Mechanical
This involves: -

- Hand hoeing - done shallowly to avoid damaging root hairs by using a hoe
- Slashing - Care must be taken not to injure the trees as this would predispose them to Fusarium infection.
- Motorized cultivator – this is economical particularly when there is labour scarcity as is the case in the coffee growing regions

Figure 13: Weed species in coffee farms
(From top right, common thistle (*Conchos oleraceous*), nut grass (*Cyperus rotundus*), Buffel grass (*Cenchrus ciliaris*), woodsorrel (*Oxalis dillenii*), mixture of Mexican marigold (*Tegetes erecta*) and black nightshade (*Solanum nigrum*) and horseweed (*Erigeron Canadensis.*

Cultural

This involves use of production practices such as mulching, close spacing and use of cover crops where and when possible.

Chemical

This entails use of MoEWA registered herbicides. Farmers are encouraged to reduce use of chemicals due to the fragile ecosystem and environmental considerations. As such use of herbicides to control weeds in coffee to be recommended on case basis.

Integrated Weed Management

This is a combination of any two or more of the methods mentioned above. It is most effective, cost friendly and efficient as it is directed by the weed spectrum present in a particular coffee farm.

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Compendium of Coffee Diseases and Pests [Editors Gaitan, A.C, Marco, A.C, Narthar L.C.C, Carlos, A.R & Gabriel, C.G]

Annex I: Safe use of pesticides

a. Reading the label carefully and strictly follow the instructions on the label (available in both Arabic and English);
b. Pesticides must be purchased from authorized dealers only;
c. Farmers to avoid using pesticides borrowed from other farmers;
d. Expired chemicals or those without labels must never be purchased or applied. Farmers must be trained to always read the expiry date on the container/label;
e. Always using protective clothing while handling chemicals. This are overall/apron, rubber boots, rubber gloves, goggles, respirators/ facemask, hat and a face shield;
f. Spraying should always be towards the wind direction and never against the wind;
g. Spraying is best carried out in the early part of the morning before the pests start feeding and is not windy;
h. Red flags or any other visible markers are used as labels to indicate plots where chemicals have been sprayed as warning;
i. Eating, drinking or smoking is **prohibited** while spraying or handling pesticides;
j. A thorough body wash is recommended after using pesticides;
k. Left-over pesticides and hand/sprayer washings **must** be disposed of safely by pouring into a deliberately dug disposal hole. The disposal hole must be at least 100 meters away from *wadis*, water wells and houses. In a hilly area, the hole should be on the lower side of the homestead or water well. The hole **must** be well covered;
l. Card board, paper and cleaned plastic containers must be buried in the disposal pit
m. Empty containers **must** be multiple punctured and thrown into the pesticide disposal hole
n. Pesticide containers should never be used for storing food and water for human beings or animals;
o. Pesticide containers **must never** be disposed in the homestead disposal pit or compost pit.

Annex II: Efficient use of pesticides

a. Water for used for spraying has to have a PH 5 – 6.5 for most pesticides.
b. Clean water as dirty water with clays or sediments will inactive the product
c. Targeting of the spraying as most insects are located under the leaves
d. Check the label and ensure that the correct dosage and the maximum number of applications per crop cycle is adhered to;
e. The sparing equipment must be adjusted to the proper pressure setting. A very fine drop is what is desired and spraying equipment must be set at high pressure during the whole spraying time
f. Proper use of the correct product for specific pest or disease. Not all insecticides will kill all types of insects and not all fungicides will control all kind of fungus).
g. d) Use of spreader sticker helps to adhere and keep the product liquid longer. This should be done with recommendations from MoEWA

Annex III: IPM Scouting Form

Farmer…… Region…….

Governorate……. Village……

Geographical coordinates: Lat…… Long……. Alt…….

Name of Scout…….

Date……. Time……. (24 Hour format)

Weather: Hot…. Cloudy Partially cloudy Windy Rainy

Soil Condition: Wet Moist Dry

Field…… Crop (s)…… ……. ……. ……..

Coffee Plant Status: Vegetative Flowering Green berries Red ripe

Pest	**Count**	**Economic Threshold Level**	**Control measures (if any)**	**Remarks**

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