DISEASE MANAGEMENT IN COCOA pdf

1: Untitled Document

Cocoa Pest & Disease Management: Best Known Practices. This page provide notes on the existing "best known practices": from which more innovative IPM methods may be introduced.

White mycelia growth on lesions that appeared several days after infection is the sign for the causal pathogen of black pod disease, which is Phytophthora spp. Black pod disease starts when the infected pod shows some little yellow spots, which eventually turn brown and enlarge to a dark brown or black lesion within five days. The lesion is fast growing and covers the entire pod after eight days of infection. The infection does not only occur on the pod surface, but also invades inside the pod affecting the beans. The growth of white mycelia on black pod is visible after 11 days and the sporulation is initiated. The dispersal of sporangia or zoospores through water, ants and other insects occurs at this stage and will infect other healthy pods nearby. Direct contact of a black pod with healthy pods also leads to the spread of disease. Cankers were identified as one of inoculum sources for black pod disease. Cocoa trees[edit] In the cocoa trees, P. These cankers will often exude a reddish gum reducing the life of the tree, in turn, reducing the yield of the plant. The most devastating place the pathogen attacks is in the flowers as from these flowers is where the cocoa fruit will set. An infected flower will have infected fruit, which will turn black and will be unable to be harvested and processed. Pathogen[edit] Seven different pathogens have been named to cause black pod disease all over the world. All of the pathogens are found in the genus Phytophthora a plant-damaging Oomycetes. The seven species responsible for black pod disease are; P. While all of these pathogens can cause black pod disease the two major pathogens are P. All of these pathogens can present themselves in all parts of the cocoa trees but are most devastating in the fruit itself where it will turn the fruit to a black mummified casing. This fruit is then useless and can no longer be used. Environment[edit] P. The humid weather that is associated with this pathogen and all other black pod disease pathogens is needed as the sporangia forms and starts distributing spores through rainfall, splashing water, and running water. Inoculum dispersal[edit] Soil and litter[edit] The spread of infection to pods above bare soil was shown to be greater relative to pods above litter. However, litter under the tree prevented water droplets from splashing the soil particles as well as the inoculum beneath the litter to the above pods. Further, it was also reported that pods near the ground showed greater infections compared to higher pods due to greater soil was splashed and stick on the lower pods, therefore causes more infections. Air and water dispersal from sporulating pods[edit] The spread of spores through air from infected pods was observed and some assumption regarding this mechanism of dispersion has been made in previous studies, [13] however it is remained uncertain due to unconvincing results from an experiment that collected some spores in the air using the volumetric spore trap, where a small amount of spores were found in the trap. Conversely, the dispersal of inoculum via rain is considered an effective mechanism in spreading the inoculum. It was assumed that under close canopy, less water will reach the sporulating pods to spread the inoculum, however, rain drops from leaves and branches could also splash the inoculum to the surroundings. Infected pods laying on the ground or litter could also spread the inoculum, yet greater infection was observed on pods located under infected pods hanging on the tree compared to pods at the same level of infected pods. It was reported that splash of wind-blown droplets from the infected pods are also able to infect pods on different trees nearby [12] Invertebrate[edit] The dispersal of the disease is also associated with the invertebrate vectors. Tent building ants such as Crematogaster striatula and Camponotus acvapimensis were reported as the primary vector in disseminating the spores of P. Therefore, this ant effectively spread the disease by transporting the spores from the infected pods on the ground or on trees to healthy pods. Several other ant species namely C. Other invertebrates that were reported to be associated with spreading the disease are several species of beetle, snail, caterpillar and millipedes. These invertebrates consume the outer layer of the infected pods and incidentally ingest the mycelium and spores of the pathogen, thus spread the pathogen to other healthy pods. Disease management[edit] There are several methods available in order to control black pod disease such as cultural, chemical and biological control. In addition, the cultivation of varieties that resistant to black pod is an alternative in order to reduce disease incidence. Cultural control[edit] Several cultural practices to manage black pod disease could be implemented in cocoa plantation. This will reduce the level of humidity that is causing black pod disease. The removal of pods with black pod symptom should also be done in favor to eliminate the source of inoculum. In another study, the utilization of litter mulch under cocoa plantation has been reported in Papua New Guinea, which has some negative effect on the population of P. Leaf litter showed rapid decline in pathogen recovery of colonized cocoa tissue after 18 weeks, relative to grass ground cover. In addition, scattered healthy pod on the ground should also be removed, as it will be infected and become the source of inoculum later. Sanitation practices include weed removal, pruning, thinning and removal of infected and mummified pods every two weeks [7] in order to eliminate the source for inoculum. However, increase in disease incidence after raining season was observed to be most likely due to the spread of inoculum from survival site by the rain. The application of fungicide following sanitation is commonly performed for an effective control of disease, as sanitation practice alone would not completely eliminate the source of inoculum and still causes greater black pod incident compared to sanitation followed by at least one fungicide application [7] Chemical control[edit] The application of copper fungicide has been shown to significantly reduce a great number of black pod incidences in Nigeria. Metalaxyl Ridomil and cuprous oxide Perenox were identified to be successful in increasing the number of harvested healthy pod compared to the application of fosetyl aluminium Aliete and control treatment. On top of that, the timing of fungicide application has some positive effect on the final pod yield where this plot produced greater yield than the unsprayed plot. The application was done before August, which is before the main disease epidemic that usually occurs in September and October. However, the adoption of recommended application was very low among farmers in Ghana. However, reduced in fungicide application was shown to be significantly less effective than the recommended standard fungicide application. It was suggested that the understanding regarding the source of inoculum, the amount of infective inoculum production and how the disease is disseminated is important in order to identify the appropriate and economical method in fungicide application as well as for an effective control of the disease. For example, the application of fungicide on the trunk will help farmers to control the spread of the disease up in the canopy, as it is difficult to reach the canopy during fungicide application. This will eventually save more time, labor and cost for disease management. This suggested that the application of fungicide on the trunk would protect pods from infection, therefore reduce primary and secondary infection rate, both on the trunk and in the canopy. In addition, the application of systemic potassium phosphonate with one and double injection 20 ml and 40 ml of fungicide for each injection frequency , and semi-systemic metalaxyl fungicide showed better control compared to contact fungicides copper based fungicide in both locations that were used in the experiment. Hence, more sustainable and environmental friendly method should be established and implemented, such as biological control. Several species of fungi from the genera of Trichoderma was identified to be a beneficial endophyte, to control black pod caused by Phytophthora spp. An isolate of Trichoderma asperellum from soil was observed as a potential mycoparasite for P. Nevertheless, the protection against black pod via biological control is not as effective as the control using chemical fungicides [19] [21] Resistant variety[edit] There is no specific variety of cocoa that shows resistant to Phytophthora infections and the establishment and utilization of resistant variety will be most likely depends on the region. Numerous breeding programs have been established worldwide in order to screen and test for local hybrids for disease resistant of Phytophthora spp. For example, a study in Cameroon assessed the performance of local cocoa cultivars the southern and northern Cameroon cultivar compared to the local and international gene bank cultivars. Based on the information provided by farmers and leaf disc test to assess resistant variety, the local cultivars selected from farmers field showed some resistant to P. Thus, it was concluded that there are some potential resistant varieties available in this area. Importance[edit] The United States chocolate industry consumes 1. Archived from the original PDF on Retrieved 20 November Epidemiology of Phytophthora on cocoa in Nigeria. Commonwealth Mycological Institute, Kew.

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2: The Impact of Plant Diseases on World Chocolate Production

Cocoa breeders boast of genotypes that can produce several tonnes of beans per hectare, however in most countries farmers only average 10% of potential yields, largely because of the cumulative effects of disease, pests and declining soil fertility.

Friday, 01 October Phytophthora causes two-dimensional disease in cocoa as Phytophthora pod rot and Phytophthora stem canker. Phytophthora pod rot is traditionally controlled by sprays of fixed copper fungicide including cuprous oxide. Some aspects of Asian agronomy may pre-dispose cocoa to Phytophthora in both its pod rot and stem canker phases. For instance, in parts of Vietnam, where the cocoa industry is relatively new, durian trees are also infected by the same Phytophthora palmivora pathogen. These trees are shade species of choice for cocoa due to the quick and high financial rewards from durian fruit. A big question is whether the P. Similarly, coconut, long established as a shade tree for cocoa and especially in Asia, is also susceptible to P. Systemic fungicides are widely used on other crops but the economics of cocoa cultivation means relatively little progress has been made with these generally more expensive products on this commodity crop. Most progress with systemic fungicides has occurred in Asian cocoa due to several factors, including more modern and superior cocoa production economics, compared with Africa and South America, and the inherent inventiveness and innovation of Asian cocoa farmers and industries. Copper is a broad spectrum fungicide which hits and disables the microbial metabolism at a number of different points and as such is called a multi-site action fungicide. They are correspondingly called single-site mode of action fungicides and this delivers a much narrower activity spectrum compared with contact multi-site action fungicides like copper. Phytophthora is a member of the Oomycetes. Downside of such specificity is fungicide resistance, two words that still haunt agrochemical manufacturers who saw many new and costly-to-develop systemic products reduced to a fraction of their commercial usefulness and worth in a short space of time. Fungicide resistance is the development and eventual dominance of pathogen populations no longer susceptible to the action of the active ingredient used. The fungicide essentially selects out the resistant non-susceptible mutation which remains unscathed while rest of the pathogen population is destroyed. The resistant strain eventually predominates. Phytophthora species resistant to fungicide actives of the phenylamide grouping began to appear in other crop situations before scientists got around to evaluating the products in earnest on cocoa. Occurrence of metalaxyl-resistant Phytophthora in other crops raised awareness and caution and tailored their use in cocoa accordingly. Phenylamide fungicides were still used but in restricted ways that minimised risk of resistance. Much of the early work was carried out in Papua New Guinea using a range of application strategies for metalaxyl that minimised selection pressure on the Phytophthora pathogen population. These included the use of systemic fungicides in stem injections and canker paint but not as sprays targeted at pods or sprayed over the whole canopy. Sprays were used only when alternated with contact multi-site action fungicides like cuprous oxide or even in spray mixtures with cuprous oxide, the latter providing cover and protection against resistance development to the systemic fungicide. Reasoning behind such strategies is that if resistant populations did start to evolve then they would be destroyed by the broad spectrum multi-site action fungicide in the mixture. This was the rationale. Tree injection damage The phosphonates are another group of systemic chemicals evaluated for control of Phytophthora in cocoa. They do work but sometimes cause considerable confusion in more ways than one. Phophonates is a general term that covers phosphorous acids, neutralised metal alkali salts of the acid e. All three names are found when referring to this group of chemicals which are claimed to demonstrate some classical direct fungicidal action. They control plant pathogens and specifically Oomycetes, to which Phytophthora belongs, but to call them fungicides is an enigma and not only because Phytophthora is no longer regarded as a true fungus. Efficacy of phophonates through direct and indirect action varies widely depending on the particular Phytophthora species and the plant host as there is some direct fungicidal action on the pathogen but how much is not altogether clear. Since they do not act directly on the pathogen, the risk of resistance developing is considered correspondingly low. Phosphonates have been widely evaluated in cocoa and shown to work especially when applied as trunk injections. Some estates have used these chemicals with great success but reports from Indonesia and elsewhere indicate many farmers and estate managers are reluctant to subject their trees to the collateral damage caused by trunk injection. Persistent damage can reduce tree vigour and open the way for other bark infecting pathogens not affected by phosphonates. Basic chemistry indicates cuprous oxide as the most active of the fixed sparingly soluble copper fungicides. It is easy to use and apply as a spray to control Phytophthora pod rot, or in canker paint to control Phytophthora stem canker. No phtyotoxicity, operator hazard or any effect on microbial dynamics of cocoa bean fermentation or the development of flavour during curing fermentation and drying and roasting of the cocoa beans, have been reported in the use of copper fungicide so far. Cocoa producers are aware of the rules framed for the usage of particular pesticides in different countries. For instance there is a long list of pesticides currently used in cocoa around the world which are not approved for use within the EU. Cuprous oxide can be used in organic cocoa production within the limits laid down by the designated organic cocoa certification authority.

3: Cocoa pest and disease management in Southeast Asia and Australasia.

Understanding how to achieve and maintain healthy soils on cocoa farms is fundamental to sustaining higher yields and lower levels of disease. A healthy soil is one that contains high organic matter and plant nutrient content, abundant and diverse microbial activity, good drainage and physical structure.

The World Cocoa Situation, M. In Brazil, the production of cocoa beans has dropped from , to , metric tons in just 10 years, largely as the result of the infection by the fungus, Crinipellis perniciosa. The pathogen also is on the Caribbean islands of Trinidad and Tobago 28, A second fungus, Moniliophthora roreri, causes another very damaging disease, frosty pod rot, that also destroys the cacao beans inside the pods 7, Vast numbers of air-borne spores of the fungus, that give the pods a frosty appearance, will undoubtedly spread the disease to other cacao growing regions The disease that causes the most widespread destruction of cacao worldwide is black pod, which is caused by several species of Phytophthora, a fungus-like microorganism that comes in several forms The most widespread species are found around the world in all cacao growing areas, and cause sporatic losses. Vascular streak dieback, caused by Oncobasidium theobromae, is found only in Asia 30,42 , and swollen shoot virus disease, found only in West Africa 37,38 , are of relatively minor importance compared to the other above-mentioned diseases Many factors contribute to a decline in production of cocoa beans worldwide, including insect infestations, social pressures to grow other crops, economic issues that discourage long-term commitment of small acreage farmers to grow the crop, and societal pressures to destroy rain forest environments. Plant diseases are major components of the decline in production. We as plant pathologists and microbiologists have as our mandate to discover and devise means to reduce disease losses and to save chocolate for the enthusiastic consumers of the world. Cacao tree with healthy pods on the left, and pods with black pod disease on the right click image for larger view. Black pod disease of cacao is an economically serious problem in all areas of the world where cacao is grown Fig. These pathogens are fungus-like microorganisms with a world-wide distribution. Species of Phytophthora are pathogens on most economically important crops grown throughout the world, such as P. Previously, isolates of Phytophthora from cacao were classified as P. This species has been recognized as one of the most important pathogens in the tropics attacking many plantation crops, including cacao, rubber, black pepper, coconut, pineapple, and papaya, as well as citrus, avocado, and many ornamental plants. Early studies of the pathogen revealed some variation in the morphology and types of lesions produced on cacao pods among isolates from different countries. In , isolates of P. Further studies redefined the morphological groups. The MF1 form was considered to be the typical P. The MF3 form was described as a new species, P. Recently, it has been proposed that isolates of P. Phytophthora palmivora is present in most countries and is an important part of the black pod complex, while P. In the major cacao-growing region of Bahia, Brazil, three species have been implicated: Phytophthora capsici appears to be the dominant and most important species attacking cacao in Brazil, and also has been reported to occur in other countries in Central and South America, as well as in the West Indies, Indonesia, and India 6. Phytophthora citrophthora is the least common species found in Brazil, but is the most virulent 17, Phytophthora heveae Thompson also has been found to cause black pod in some countries 6. Although Phytophthora species attacks all parts of the cacao plant, the major economic loss is from infection of the pod Fig. Pods or cherelles immature pods may be infected at any place on the surface, but infection is most often initiated at the tip or stem end. The disease causes a firm, spreading, chocolate-brown lesion that eventually covers the whole pod. The beans inside the pod may remain undamaged for several days after initial infection of the husk, thus frequent harvests may prevent much yield loss. In advanced infections, Phytophthora invades the internal pod tissues and causes discoloration and shriveling of the cocoa beans. Diseased pods eventually become black and mummify. The pathogen also will cause a seedling blight in cacao nurseries as a result of infection of the stem and young leaves Fig. Black pod disease of cacao caused by P. Seedling blight of cacao caused by P. Root infection from residual soil inoculum usually is not an economic concern, however, the pathogen is capable of producing spores on all infected plant parts. Thus, infected roots may serve as a source of inoculum for infection of the pods. Bark and stem cankers may function in the same manner. Once a pod is infected and sporulating, it may then provide a massive source of inoculum to infect other pods. Under humid conditions, sporangia asexual reproductive structures and a source of secondary inoculum may form on the surface of infected roots, cankers, or diseased pods Fig. This type of propagule can be dispersed by rainfall, splashing water, and water moving over the surface of the soil 5. When sporangia are in free water, zoospores are formed inside the sporangia and released into the water Fig. Zoospores are motile spores that actively swim towards an infection site and are the primary infective propagules. Thus, windborne rain is a primary factor in the spread of the disease. Ants also have been reported to transport inoculum. Sporangium and zoospores of P. Control of black pod is difficult because Phytophthora can persist in soil and debris for several years 5. Also, since susceptible pods may be present on the trees most of the year, the pathogen may always be present in the canopy, ready to cause major epidemics when environmental conditions become favorable for sporulation and dispersal Frequent harvesting will lessen the danger of spread of the disease from infected pods Regular pruning to remove infected chupons small suckers at the base of the tree and increase air circulation to reduce the humidity under the canopy is an important disease management tool. Other measures, such as the removal of infected pods and husk piles, may have some effect on inoculum levels. However, under high rainfall conditions, it is difficult to effectively suppress the inoculum to attain good control Chemical control relies on the use of copper and metalaxyl-based fungicides. However, these are not entirely effective, are expensive for the small farmer, and not economically feasible 12, Additionally, there are environmental concerns regarding the heavy use of chemicals in the tropical rainforests, and there may be problems with non-target effects and resistance of the pathogen. At present, there is no acceptable genetic resistance in cacao to control black pod. Active research is underway throughout the world on this important disease of cacao. Control measures being investigated are aimed at integrated pest management IPM strategies, and include biological control microorganisms, genetic and induced resistance, cultural practices, natural products, and limited use of chemicals The disease is initiated by basidiospores produced and released from pinkish mushrooms called basidiocarps Fig. It is estimated that a single basidiocarp can release 80 to 90 million basidiospores. In the presence of free moisture rain and dew and high relative humidity, basidiospores germinate and penetrate young meristematic tissues in vegetative and floral buds through stomata, epidermis, or trichomes. The colonized tissues undergo several physiological and hormonal changes leading to swelling and formation of numerous succulent vegetative branches, known as brooms, within flower cushions Fig. The brooms are usually formed within 5 to 6 weeks following infection. The fungus also infects pods causing necrotic lesions, uneven ripening, and various deformations. Brooms and infected pods become progressively brown and dry, and within 3 to 8 months following broom and pod drying, basidiocarps Fig. Vegetative branches brooms arising from a flower cushion infected by C. A dry broom formed from infection of an apical vegetative bud by C. Basidiocarps pinkish structures formed on a dry broom and pod infected with C. Cacao pod infected with C. Further yield loss is incurred by the prevention of seed formation in pods infected early in their development. If seeds are formed prior to infection they may be unusable depending on the extent of pod colonization by C. The cultivation of cacao has intensified over the years as cocoa has progressively become a global trade commodity. Production environments that encourage the planting of cacao varieties with little genetic diversity ensures a constant supply of susceptible tissue for infection by C. Broadly, there are four major strategies that may be adopted: Phytosanitation, by removal and destruction of diseased plant parts, has been shown to reduce pod loss and delay disease epidemics 32, The development of genetically resistant cacao cultivars is an on-going endeavor in many countries, and it is expected that the use of these cultivars would reduce the incidence of the disease. In Brazil, commercial formulations of T. However, the inconsistent performance of T. Collaborative research efforts by scientists at research institutions in the United States and Central and South America are currently underway to optimize the use of T.

4: Pests & Diseases

of producing an economic management system for witches' broom disease of cocoa. The contributions of the various sponsors, and the roles played by the participating organizations and scientists are described in the introductory chapter.

Though a tropical crop it does not like the sun and grows in the shade of other important crops such as banana, oil palm, and rubber as well as fruit trees such as avocado, breadfruit, guava, mango, orange and coconut. The fruit is an egg-shaped red to brown pod that contains 30 to 40 seeds, each of which is surrounded by a bitter-sweet white pulp. When the seeds are dried and fermented in the sun they are brownish red, and known as cocoa beansâ€"the principal ingredient of chocolate. The first recorded evidence of chocolate as a food product goes back the Mayans and Aztecs who made a drink from the beans of the cocoa tree. After roasting, the beans are crushed in a machine and ground into cocoa powder. It also contains theobromine, an alkaloid closely related to caffeine and phenols and flavenoids, antioxidants that can inhibit cancer and cardiovascular diseases. Cocoa beans are a good source of potassium, magnesium and iron. The crushed shells or pod husks of cocoa beans can be used as a cost-effective, organic fertilizer to help in suppressing weeds, conserving moisture, and minimizing erosion. Production Cocoa is essential to the livelihoods of 40 â€" 50 million people worldwide, including over 5 million smallholder cocoa farmers who grow this valuable crop. Usually, cacao trees start in a nursery bed where seeds from high yielding trees are planted in fiber baskets or plastic bags. The seedlings grow so fast that in a few months they are ready for transplanting. The cocoa pods are unusual in that they grow directly from the trees trunk and major branches. Harvesting With care, most cocoa trees begin to yield pods at peak production levels by the fifth year, which can continue for another 10 years. Ripe pods may be found on cocoa trees at any time, however, most countries have 2 periods of time per year of peak production. A farmer can expect 20 â€" 50 beans per pod, depending on the variety. Major pests and diseases of cocoa Globally, there are many hundreds of insects and pathogens recorded on cocoa. Of these, only a fraction is economically important, and diseases, rather than insects, are the biggest pest problem. Pest and disease management in cocoa has been heavily reliant on chemicals but most farmers cannot afford to treat their cocoa, or make only one or two applications a year. Economics of cocoa The vast majority of cocoa farms are not owned by the companies that make chocolate products or supply cocoa. Cocoa is grown on millions of small ha and medium-sized ha , family-run farms worldwide. It is a highly labor-intensive crop. It is an important cash crop providing income to more than 4. Farmers must contend with severe crop loss due to disease, aging tress, outdated farming techniques, and limited organizational support. Many farmers have virtually abandoned their cocoa trees, only investing the bare minimum of time and money to maintain the crop. This neglect has exacerbated many pest and disease problems such as cocoa capsids, cocoa swollen shoot virus CSSV , and black pod disease. Sustainability and cocoa production Chocolate consumption is growing faster than cocoa production and this has implications for the smallholder farmers who produce the cocoa. In Africa, growth in the cocoa sector has been achieved by increasing the area cultivated rather than by improving yield leading to the near disappearance of the West African rainforest. The challenge today is to enable the farmers to have a viable living whilst protecting the environment. IITA Research and impact Our objectives are to improve the economic and social well-being of smallholders and the environmental sustainability of tree crop systems in West and Central Africa to contribute to agricultural growth. This participatory training approach encourages farmers to make their own discoveries about management practices, to reduce their dependence on costly inputs such as pesticides, and to improve their understanding of crop and pest management. Through the FFS, farmers learn about biological processes and interactions in the cocoa agroecosystem.

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5: Disease Management In Cocoa: Comparative Epidemiology Of Witches' Broom Download

The Monograph deals with the conception, planning, implementation, results and conclusions of the International Witches' Broom Project (IWBP), which was set up in with the aim of producing an economic management system for witches' broom disease of cocoa.

However our ability to sustain even current production levels is threatened by climate change, land degradation, political instability, alternative crops, labour shortages and pests and diseases. Cocoa is affected by a range of co-evolved and new confrontation diseases and pests that can destroy entire crops. Several Phytophthora species cause pod rot, canker and blights wherever cocoa is grown. While the soils of newly-cleared forests are usually fertile and support yields well over a tonne of dry cocoa beans per hectare for a few years, organic matter and nutrients are rapidly exhausted if not replenished by fertilisers, and yield declines steadily after trees reach an age of ten years. For many semi-subsistence smallholder farmers cocoa trees signify land ownership and function like a dependable ATM that can be visited when school fees or hospital bills need to be paid. These farmers depend on their own food gardens or earn an income from other employment. To impoverished farmers the poor and unreliable returns from cocoa do not justify investment, and even if they had the resources farmers frequently lack informed and objective technical or logistic support to decide what investment is needed. Older farmers are risk-averse and less likely to change their farming methods, while more entrepreneurial farmers are lured by alternative, and more lucrative, crops such as rubber oil palm and maize. Supporting these farmers to invest in improved productivity is the key to making sure production continues to meet demand. In Indonesia and Papua New Guinea work funded by ACIAR involving LaTrobe and Sydney Universities in Australia, Hasanuddin University, the Assessment Institute for Agricultural Technology, the Indonesian Coffee and Cocoa Research Institute in Indonesia, and Mars Australia, focuses on working with farmers and local research and extension agencies to identify constraints to production, devising a series of management options for farmers then working with farmers and extension workers to promote the adoption of these options. The first level of improved management aims to stimulate flowering and reduce disease pressure by implementing pruning, sanitation and regular and complete harvesting. The second level is to provide nutrients to support the development of flowers into pods, and the highest level includes the targeted use of pesticides to protect developing pods. Management levels are demonstrated side by side in villages, and are managed by the farmer who was trained to implement each level. That farmer provides advice on the cost and effort provided as well as the increased yield experienced, supported by regular visits from extension workers. Field Days are also used to promote the options, but the choice of management level is made by the farmer. In our experience farmers quickly adopt improved management because they see the results and are able to discuss the effort required with their peers. These management options are based on solid research. The second part of our strategy is to support local scientists to engage with industry stakeholders, including of course farmers, to identify constraints and to develop research that addresses them. Engaging private sector champions in promoting improved management is essential to the sustainability of farmer training. Results from collaborative research activities build local capacity and feeds directly into refining management options for farmers. The key sustaining our chocolate dependency is to improve the sustainability, productivity and viability of smallholder cocoa production by supporting farmers, extension workers and scientists working with the industry. A well-supported cocoa industry is a powerful driver of rural poverty alleviation, and increased yields contribute directly to improved health and living standards, reduced pressure on rainforest clearing and political and social stability.

6: Black pod disease - Wikipedia

Pests and disease management are one of the major problems farmers in Cameroon face due to the impacts of pests and disease infestation which leads to a drop in Cameroon's cocoa production.

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7: Genetic Resources > Flavour - Cocoa Research Centre

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8: Disease management for sustainable cocoa production

Perhaps an optimum disease management strategy would be to identify beneficial microorganisms that persist in the cacao canopy and root systems and provide disease control without regular spray applications.

9: Pest and Disease Management in Cocoa | FARMD: Forum for Agricultural Risk Management in Develop

Data on farm management practices, cocoa and shade tree types and densities, plot sizes, yield, land tenure and labour arrangements for farm operations, disease incidence and profitability of.

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