DOWNLOAD PDF PUCCINIA GRAMINIS LIFE CYCLE

Chapter 1 : Basidiomycota_Pucciniomycotina - Plant_Evolutionary_Diversity

In this article we will discuss about the life cycle of puccinia graminis with the help of suitable diagrams. Dikaryophase in the Life Cycle of Puccinia: This phase in the life cycle of Puccinia is confined to the primary host which is wheat.

Pucciniomycotina Introduction The subphylum Pucciniomycotina presently include an array of fungi that include yeasts, rusts, smut-like and jelly-like fungi, with approximately species. Some of the larger orders that are recognized in this subphylum are: Septobasidiales Pucciniomycetes is a group of fungi that are associated with scale insects, with approximately species Alexopoulous, et al. It is uncertain whether this relationship is one in which the fungus parasitizes the insect or if the relationship is one of mutualism. Couch hypothesized that the relationship of Septobasidium is mutualistic because the fungus covers the colony of scale insects with a mycelial mat that protects it from any external, unfavorable conditions, as well as protecting them from predators Fig. However, members of the colony are parasitized and rendered sterile by the fungus. Microbotryales Microbotryomycetes is a group of smut-like fungi, with approximately species that were formerly classified in the Ustilaginomycotina, along with the other smut fungi. However, utilization of molecular sequences, recent ultrastructural studies and biochemical data have led to the conclusion that they are more related to the Pucciniomycotina despite their superficial smut-like appearance Fig. Pucciniales Pucciniomycetes is by far the largest group of fungi in this subphylum, with approximately species. These are commonly called the rust fungi and are economically important as pathogens of various species of cereals as well as forest trees. The common name is due to the rust-colored sori of the urediospore stage of the fungus Fig. We will use the rust fungi as representative of the Pucciniomycotina. They formerly only included the rust fungi. Mycelial mat covering scale insects that are being parasitized. Microbotryum violaceum teliospores on anthers of Silene sp. Rust colored sori on stems and leaves of wheat plant.. Pucciniales Rust Rust diseases of grains have probably been observed by mankind since the onset of agriculture. The earliest reference of what is believed to be rust disease was in The Bible, Genesis In this story, Joseph had interpreted the dream of Pharaoh to mean that God had revealed to him that there would be seven good years where the wheat crops would flourish, followed by seven years in which the wheat would be "blighted" causing famine. Agrios , Carefoot and Sprott and Large interpreted the blighted wheat to be a rust disease and Hudler even named three species of rusts, Puccinia graminis, P. Regardless of whether this particular story is true or not, rust diseases, especially Puccinia gramminis Black Stem Rust , have caused tremendous hardship in civilizations throughout the world. Because of the economic significance of this species, a great deal of research has been carried out in this species. Thus, we will use the life cycle of this species to illustrate the life cycle of a rust. Puccinia graminis Black Stem Rust The rusts, as a whole, have unique life cycles. Unlike most parasitic fungi, or fungi in general, the rusts do not have only one or two spore stages and a single host, but have at least two and may have as many as five spore stages, and may have two hosts. Puccinia graminis is an example of a species that is macrocyclic, five spore stages and is heteroecious, requiring two hosts. The 5 spore stages for this species is as follows: Urediospores in uredia sing. Teliospores in telia sing. Basidiospores on basidia sing. Receptive hyphae Spermatia [sing. Aeciospores in aecia sing. The basidiospores are not borne on either hosts, and is the transitional stage that initially infects the barberry host. During the early spring, the dikaryotic aeciospores will infect the wheat plant. Infection of the wheat occurs in both the stem and leaves. Entry into the host occurs when the spores germinates and enters the plant through openings called stomata. Stomata are pores on the surface of the herbaceous parts of plants that allow for gas exchange to occur. However, these openings also provide an avenue for pathogens such as the rust fungi to enter. Once entry into the wheat plant has been accomplished, mycelium will grow and begin to absorb nutrient from the plant. The wheat plant is initially infected by the aeciospore stage during the early spring. The aeciospore is dikaryotic and give rise to dikaryotic mycelium in the host plant that will give rise to clusters of urediospores that will also be binucleate. Each cluster is referred to as a sorus, called the uredium. As the urediospores develop, they will burst the epidermis, exposing the characteristic, rusty-colored urediospores on the surface of the plant Figs. This stage is a "repeater stage" and is the most damaging stage to the wheat. The urediospore can infect other wheat plants throughout the spring and early summer. During late summer, just before fall, the uredium gradually converts into the telium and begin to produce the two-celled, thick-walled teliospores Fig. The conversion is readily observed as the rusty-orange uredium becomes black as the teliospores are borne. Rusty pustules of uredia on leaf from: Urediospores as seen through microscope from http: Black pustules of telia on stem. Teliospores as seen through microscope. The following spring, meiosis will occur as each cell germinates to produce haploid basidia and basidiospores Fig. What happens next is unique to species of some rust fungi, including P. Instead of infecting the wheat plant, again, the basidiospores, instead, must infect the alternate host, the barberry where spermogonia Figs. Each spermogonium consists of what is interpreted as female receptive hyphae and male spermatia. These structures are interpreted as sex organs and is the only group in the Basidiomycota in which sex organs occur. Puccinia graminis is heterothallic and the spermogonia are arbitrary designated as A1 and A2 mating strains. In order for the life cycle to continue, the spermatia of the A1 mating must be deposited on the receptive hyphae of the A2 mating strains or vice versa. The movement of spermatia to receptive hyphae is carried out by flies that visit spermogonia because of a sweet sugary exudate that is produced in the spermogonium that attract flies. When compatible strains come in contact, plasmogamy will occur and the dikaryon is reformed. Unless the flies carry the spermatia to compatible receptive hyphae, aeciospores, the next spore stage, will not form. The cluster of aeciospore, the aecium, will grow towards the lower surface of the leaf and eventually burst the lower epidermis, exposing the aceiospores Fig. The aeciospore stage will then reinfect the wheat plant and the cycle then starts again. Teliospore germinating to produce basidium from http: Spermogonium on upper surface of Barberry leaf and Figure Spermogonium section with receptive hyphae and spermatia from http: Aecium on lower surface of Barberry leaf and Figure Aecium and aeciosporessection with aeciospores from http: Summary of Puccinia graminis life cycle from http: Also, since the urediospore stage of black stem rust was the most recognizable stage of the life cycle, it will be seen that it would be the only known stage for centuries. Following the Fall of the Roman Empire, the growing of wheat expanded to Northern Europe where it was free of black stem rust until the 8th-9th Century when the barberry was also introduced and established as more travel between Europe and Middle East, where black stem rust is thought to have first become established with wheat as an agricultural plant. Over time, farmers began to realize that there was an association between barberry and black stem rust. However, it would be several centuries before this knowledge would be acted upon Barberry and An Answer to Eradication of Black Stem Rusts? At some point in time farmers observed that black stem rust was often worst when there were barberry bushes were nearby. By , in France, the first law was enacted to control black stem rust by eliminating the barberry, even though there was not any tangible evidence connecting the two Littlefield, ; Schumann, However, this practice proved to be successful in control black stem rust. This was followed later by other European countries and this practice was also followed as America was being colonized. Even though the practice of eradicating barberry continued in Europe, the Europeans settling in the New World, nevertheless, brought barberry plants with them since its wood was used as a source of tool handles and yellow dyes, and its fruits for jellies and sauces Schumann, However, even if they did not, black stem rust would still be a problem since there are two native species of Barberry, in North America. Despite this discovery, it would be a long and difficult path to discover the five spore stages in the life cycle of the wheat and would require literally the efforts of thousands of researchers, starting in the 18th Century before this great mystery would become unraveled. Microscopic examination of the rust pustules, in , by the Italian naturalist, Felice Fontana, revealed to him that the pustule was composed of what he called "small parasitical plants". He also noted that the pustule was actually composed of two kinds of "bodies". One was the rusty orange color that was expected and the other was black. Fontana concluded that this represented two species of fungi that were named by Persoon as Uredo linearis and Puccinia graminis, respectively. Because the two "species" always were together, even in the same pustule, eventually led to the hypothesis that the two spores were derived from the same fungus. Anton de Bary would later observe that this hypothesis was correct in his observation that the uredia stage would eventually become the telia stage. It was finally the Tulasne brothers who turned their attention to the rust fungi in and concluded that there were five and only five spore stages and that different numbers of these spore stages could be found in different species of rust fungi. But what was the connection between the wheat host and the barberry? However, he was unable to reinfect the wheat with the basidiospore stage. After numerous attempts to reinfect the wheat, de Bary believed, though he thought it was rather far fetched, that perhaps another plant was required. Even though there was a history of the wheat plant with barberry in this disease, the connection was not made immediately. However, it was made, and soon after discovered that it was the aeciospores of aecia stage that reinfects the wheat host. With that de Bary had solved all but but the function of spermogonium, which would remain a mystery until when when a Canadian plant pathologist, John Craigie, determined the function of this part of the life cycle. The discovery that Barberry is the alternate host for black stem rust was a rather important discovery in trying to control the disease. If we remove the Barberry plant, the teliospores may be produced and survive the winter, but the basidiospores will not have an alternate host to infect. The urediospore cannot survive a harsh winter and will also die. Thus, the black stem rust disease is ended. There was a program that was developed, in the United States, in , and continued for decades, to eradicate the Barberry. This program was started to destroy black stem rust, but also was used as a means of employing large number of people during the Great Depression, in the s.

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Chapter 2 : Puccinia Graminis Life Cycle - Green Algae - 78 Steps Health Journal

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Trajectory taken by Ug99 since and its possible future paths. Although wheat stem rust is not the most common rust disease of wheat rust, with wheat leaf rust being the most common, it certainly currently is the most dangerous Signh, et al Wheat resistance to stem rust was largely believed to be held in the gene Sr31 Pretorious et al. After running studies for the resistance in wheat for stem rust, it was found that a new strain of stem rust had mutated, making the resistance to stem rust that was found in Sr31 obsolete. This new strain of stem rust was name Ug99 due to its country of origin and the year it was discovered. Not only does Ug99 carry virulence to gene Sr31, but overtime it has also mutated to be resistant against most variations of stem wheat rust resistance that originated in wheat itself Singh et al. Due to this fact, genetic engineering has started to be employed in order to try and find resistance genes in species closely related to wheat. These genes could then be transferred to wheat and give it resistance against the different variations of Ug99 as well as other different races of wheat rust. It is extremely important to find a way to stop the expansion of Ug Although the exact route of expansion of the Ug99 strain is unknown, models have given it the trajectory to reach India, whose wheat production is one of the highest in the world Figure 1. Disease Cycle Figure 2: A barberry bush which is a common host for Puccina graminis. These two distantly related species that stem wheat rust requires are wheat and barberry plants Schumman and Leonard, Barberries are a type of shrub that is either deciduous or evergreen, and it can be found in temperate and subtropical regions Figure 2. While the best mode of reproduction for P. The life cycle of the stem wheat rust starts by the introduction of either an aceciospore or a urediniospore to a wheat plant. The spores can either come from a distant region carried by the wind, from barberry, the alternate host, or from the wheat plant itself if it is already infected. The pathway cycle that the disease will take depends on the region where the wheat is being grown. Temperate regions mostly only grow wheat during the springs since the winters are too cold for wheat to grow. So the plants in temperate regions may either be exposed to aeciospores from barberry or from uredinospores being carried by the wind from the south, where wheat is grown year-round or just at an earlier time than the wheat in the north Schumann and Leonard, The complete life cycle of Puccinia graminis can be seen on the figure below Figure 3. Disease Cycle with Barberry Figure 3: The complete life cycle of Puccina graminis. Due to this fact, the stem wheat disease that includes barberry mostly happens in the temperate regions where the cold temperatures of winter allow the teliospores to germinate Schumann and Leonard, Once the growing season is over in the temperate regions, the barberry acts as a host for P. After the winter is over, the barberry can pass on the disease to wheat. Towards the end of the growing season, diploid teliospores are produced. Teliospores appear as thick black stripes on the stems of the wheat. Once the winter is over, teliospores then germinate in the spring to haploid basidiospores, which appear to have no color and have really thin walls unlike the teliospores. These haploid basidiospores are the one that infect the barberry Schumann and Leonard, In order to infect the barberry, the basidospores have to germinate and produce haploid mycelium. These haploid myceliums then infect the surface of the leaves of the barberry. Once on the leaves, the haploid mycellims are able to produce Pycnia. Once on this form, the fungus is able to infiltrate the leaf. Inside the leaf, the pycnia produces receptive hyphae and pycniospores. The pycniospores of an individual plant can only be fertilized by the pycniospores of a different host plant Schumann and Leonard, The production of pycniospores is important since it allows cross-fertilization to happen. The pycniospores are spread thanks to the insects that are attracted to the honeydew that is produced alongside the pycniospores. Cross-fertilization between plants produces dykaryotic mycelium. This is one of the most important steps in the life cycle of P. Once the barberry is infected, only a few days have to pass in order for aecium to grow from the dikaryotic mycelium through its leaves. The dikaryotic myselium is able to produce aeciospores, which can infect wheat or other grass hosts. Once the wheat is infected, P. Once the growing season ends, teliospores are formed again on the stem of the wheat in order to start the cycle all over again. Since the winter is too cold for the spores to survive, uredinospores from other regions need to be donated. The uredinospores from the warmer Great Plains of the south can then be introduced to the northern Great Plains by northward blowing wind. Since wheat is usually planted on the south earlier than on the north, there always seems to be a fresh batch of spores just waiting to be picked up by the wind. The disease ends once the wheat season of the north is over Schumman and Leonard, It is worth noting that the cycle starts again on the south by having uredinospores that were produced by the wheat planted for the fall infect the wheat seedlings planted for the winter. In the south, P. The infected winter wheat then infects the summer wheat crops and the spores from those crops eventually find their way north again Schumman and Leonard, Symptoms, Dispersal, and Environmental conditions Symptoms Figure 4: The appearance of uredinia on the stem of wheat. Most of the time the symtoms start to be noticeable after 7 to 15 days have passed Schumann and Leonard, After those few days, uredinia start to appear. Uredinia appear as little red dots on the stem or leaves of the wheat They sometimes appear to be slightly crystallized Figure 4. Once the end of the season is nearing, the uredinia start to decrease and the teliospores start to form Figure 5. The appearance of teliospores on the stem of wheat. The appearance of pycnia on the surface of barberry leaves. In the spring, before the wheat is present, pycnia starts to form on the surface of the leaves Schumman and Leonard, The infection starts to be noticeable a little earlier than on wheat, since the infection starts to be noticeable after 5 to 10 days. After that time, the aeciospores break open through the bottom of the leaves Figure 6 Dispersal and Environmental Conditions There are three modes of transportation that the uredinospores can take. One of them is long distance dispersal by a single event as well as assisted dispersal, the second one being stepwise range expansion, and the third being extinction and recolonization Singh et al. All of these modes of transportations have been observed before, although some of them are more common than others. Dispersal by a single even is the most rare of all the modes. This type of mode includes the movement of the uredinospores across whole continents. Although it has been noted that this type of transportation is extremely rare, it has been recorded before. Brown and Hovmoller report that stem rust spores have moved up to km from the south of Africa all the way to Australia Although these events are rare, the ability for spores the withstand a high range of environmental pressures make these large distance travels completely possible Singh et al. Unlike the previous example, humans mostly cause assisted dispersal. In assisted dispersal, the spores mostly travel on clothing as well as through the trade of infected wheat Unlike dispersal by a single event, the second mode of even travels in smaller distance as well as it takes more time for the spores to travel. Stepwise range expansion does not expand across continents like single event dispersal. This type of transportation mostly spreads at the slightly smaller scale of countries and regions. Out of all the transportation modes, this is the most common one. The current expansion of the stem rust strain Ug99 is an example of stepwise range expansion. The strain first originated in Uganda in , hence getting its name, then migrated into the Middle East, and now has made its way into Asia Singh et al. Although the effects that Ug99 has left in its path are devastating, its slow expansion, taking it 10 years to spread to Asia, are giving scientists time to try and come up with a wheat resistant strain against Ug99 before it reaches India. The third and last mode of dispersal is extinction and recolonization. Although it is generally believed to be a different mode of dispersal, it is much similar to the stepwise range mode of expansion. Both of these modes expand through smaller distances, as well as move much slower than the single event mode. The only difference is that this type of dispersal happens on land that is too stressful for the spores to survive Singh et al. Expansion Control by Genetic Engineering Even though there are many different types of control out there, it is evident that by far, gene manipulation is the most effective way to combat the stem wheat rust gene strain Ug99 Schumann and Leonard. Recently, 50 strains of resistant genes have already been cataloged, although not all of them work with all the different strains that Ug99 displays Singh et al. Only a few genes have been found effective against most of Ug99 variations, including Sr22, Sr26, Sr35, and Sr50 Some of these genes have already been successful in the past, like the Sr26 gene which has already been used in the s, s, and it is even being used up to this day Singh et al. One of the most important facts about this certain gene strain is that it has remained effective even after it has been used in such large scales. The only problem is that this gene has only been used in Australia, so the effect that it would have on other parts of the globe is still unknown.

Sr50, which was introduced to wheat from Imperial rye, has also been deployed in Australia, but no varieties have been released Variations of Ugresistant wheat that were released in eight countries in The level of resistance that they had to the fungus was also recorded. This gene, after being cultured tested in Australia, was found to be virulent to many of the other races of stem wheat rust throughout the world Singh et al. Avirulence to gene Sr28 by Ug99 was found, but that same gene has also been found to be virulent to many other races of stem rust throughout the world The virulence and avirulence on these genes suggest that although some genes might be effective against certain races of stem rust, they might be ineffective against others. These findings should remind us that careful planning should be made when deciding which and where different resistant strains should be planted. The combination of different resistance genes in a wheat plant can also give synergistic effects. There is evidence that genes that on their own only have moderate resistance to Ug99 actually have high levels of resistance when paired with another one. This is certainly the case with gene SrCad and Lr SrCad gives moderate resistance to Ug99 while Lr34, a leaf wheat rust resistance gene, slows the rusting of the leaves Singh et al. There are also genes that display resistance to the Ug99 strain but are linked to undesirable traits in the wheat plant Signh et al.

Chapter 3 : Stem rust - Wikipedia

Life cycle in Wheat â€¢ Wheat is the primary host upon which dikaryophase of the pathogen is completed â€¢ This phase consists of well developed branched, septate, dikaryotic vegetative mycelium and two spore stages namely, uridenial stage and telial stage.

Puccinia graminis Notes on Taxonomy and Nomenclature Top of page Several subspecies and either varieties var. Eriksson, are recognized. According to the nomenclature of Savile , based on the descriptions of Urban , there are three distinct morphological forms: The distinction of subsp. There is, however, less consensus regarding the morphologically based var. Many workers prefer an f. The appropriate taxonomy then becomes P. However, in most current literature, the causal fungi are directly named and the subsp. A range of species, varieties, or formae speciales are reported in the literature, most of which have now been included under either P. An illustration of the first recognized genus of the rusts, Puccinia, named in honour of the lecturer and physician, Thomas Puccini Arthur, is included in this publication. Scientific classification of the rusts began with Persoon , who provided the first binomial for P. The taxonomy of the cereal rusts is complicated by morphological variation and specialization on numerous different hosts. From the morphological taxonomy of Savile and Urban , a cladistic analysis by Baum and Savile separated var. The oat and rye stem rusts have been placed in var. However, not all data support the above separations. In crossing studies, the wheat and rye stem rust fungi show greater genetic compatibility than the oat and wheat stem rust fungi, or the oat and rye stem rust fungi Green, a ; Johnson and Newton, ; Stakman et al. Two-dimensional polypeptide mapping Kim et al. The inclusion of the oat and rye stem rusts into a single variety, separate from wheat stem rust, is questionable and indicates that purely morphological criteria are not adequate to clearly delineate intraspecific relationships in the rust fungi. Modern techniques, Anikster et al. Host range may also be problematic. Tajimi noted that P. Johnson and Anikster put forward a strong case for host specialization as a taxonomic criterion. However, host specialization is complicated by numerous overlapping host compatibilities. For example, the tritici and secali forms are generally recognized by their adaptation to species of Triticum and Secale, respectively, but they also have common hosts including species of Agropyron, Elymus, Hordeum and Bromus. The forma speciales designations have been based either on the host species of the first observation or on the principal host affected. Despite the complexities of host specialization, most workers involved in cereal rust pathology find the f. References to variations in P. As indicated in the previous paragraphs, classification of P. Herbarium specimens currently require a morphological basis for classification, while the control of the disease is based on a host range classification f. Classical genetic evidence for differences in P. Molecular genetics has solved this problem and current data indicates two or three subdivisons or even species within the current P. Current data is similar but not identical to the f. The problem is that the samples are mainly from initially introduced pathogen populations which probably lack the range of variation that exists. Furthermore, genetic data will probably always be lacking for most herbarium specimens. Races, or pathotypes, constitute a taxon below the forma speciales level. Pathogenic specialization has been most thoroughly studied for P. The differential set of Stakman et al. One advantage of this system is that it provides a taxonomic base and a means of comparison and communication. However, the standard differentials are limited and include lines with complexes of several resistance genes. It is, therefore, not possible to define the virulences of fungal populations on a gene-for-gene basis. Although approximately races have been identified using this system, the pathogenic variability within P. Rust fungal populations are highly variable within an ecological zone or in different regions of the world. It is unlikely that an internationally standardized set of differentials will be able to differentiate local virulences satisfactorily; this may have important implications in plant breeding for resistance. Virulence surveys relate the virulences within a rust fungal population to sources of resistance in breeding programmes and allow international communication. The standard set of differentials can be supplemented and entirely new sets of differentials can be devised; these are usually adapted to local requirements. Differentiation and nomenclature have been standardized for races of P. Roelfs , b summarized major race nomenclature systems for f. None of these systems has proved totally satisfactory, but the accumulation of information on the distribution of virulences may help in the design of an internationally usable system in the future. The traditionally used differentials for f. International virulence surveys of f. Description Top of page P. The characteristics and ontogeny of each of the spore stages have been described at the ultrastructural level by Harder The urediniospores of P. The teliospores are two-celled, thick-walled with up to five wall layers and are thickened at the apical end. The formation and characteristics of teliospores are described by Mendgen For further information, see Biology and Ecology. Distribution Top of page The table of geographic distribution does not distinguish between the various formae speciales as they may affect different crops in different regions. Where appropriate, these distinctions are made in the Epidemiology section of the text on Biology and Ecology. Most of the geographic information concerns distribution on cultivated cereals, mainly on wheat. Information on the occurrence on wild grasses is more limited. Detailed surveys of grasses would probably reveal the presence of P. Although stem rust on wheat has largely been controlled worldwide by the use of resistant cultivars Roelfs et al. Most regions of the world have conditions that are normally more marginal for rust development. For further information on the status, likely migration and strategies to mitigate the threat to wheat production from Ugg99, see Singh et al. Consideration of the geographic distribution of the pathogen is complicated by prevailing climatic conditions, the movement of global air masses, geographical features, the availability of alternative grassy hosts or the alternate sexual host, and cropping practices. Geographic distribution must, therefore, be discussed in terms of disease epidemiology see section on Biology and Ecology. Distribution Table Top of page The distribution in this summary table is based on all the information available. When several references are cited, they may give conflicting information on the status. Further details may be available for individual references in the Distribution Table Details section which can be selected by going to Generate Report.

Chapter 4 : LIFE CYCLE AND PLANT BODY OF PUCCINIA GRAMINIS TRITICI - All About Biological Scie

Life cycle of Puccinia graminis Like other Puccinia species, P. graminis is an obligate biotroph (it colonizes living plant cells) and has a complex life cycle featuring alternation of generations.

Occurs worldwide wherever wheat is grown. It is most important where dews are frequent during and after heading and temperatures are warm, C. Damage is greatest when the disease becomes severe before the grain is completely formed. In areas favorable for disease development, susceptible cultivars cannot be grown. Grain is shriveled due to the damage to the conducting tissue, resulting in less nutrient being transported to the grain. Severe disease can cause straw breakage, resulting in a loss of spikes with combine harvesting. Uredinia generally appear as oval lesions on leaf sheaths, true stem, and spike. Uredinia can appear on the leaves if other diseases have not killed them. Uredinia are brick red in color and can be seen to rupture the host epidermis, on the leaves uredinia generally penetrate to sporulate on both surfaces. Infected areas are rough to the touch. Stem rust is favored by hot days C, mild nights C with adequate moisture for night time dews. Wind can effectively disperse urediniospores over great distances. Rain is necessary for effective deposition of uredinospore involved in regional spore transport. Aeciospores from Berberis vulgaris are currently rare, but historically it was an important source of inoculum in northern North America and Europe. Mycelium or uredinia on volunteer wheat, are the most important source of inoculum in tropical and subtropical climates. Windblown urediniospores are usually from earlier maturing wheat from the south in the northern hemisphere, or from the north in the southern hemisphere. Urediniospores and aeciospore germinate when in contact with free water. Infection by penetration through the stoma. Penetration requires at least a low light intensity. Germination optimum is 18 C, latent period varies from 10 to 15 days in the field with temperatures of C. Stem rust can survive as teliospores during winter when aeciospores are a major source of inoculum. It generally survives as mycelium or uredinia on volunteer wheat during the non-wheat growing season. Uredinospore can be spread by wind into disease-free areas. Sporulating uredinia are active in tropical and some subtropical areas throughout the winter. Occasional dormant mycelium may survive beneath the snow pack in more northern temperate regions. Urediniospores and aeciospores are wind borne. Teliospores remain with the straw. Stem rust is generally confined to Triticum species, although naturally infected plants of Secalecereale, Hordeumvulgaris, H. Many genera of the tribe Hordeae are infected when artificially inoculated. Other formae specialis of P.

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The life cycle of the fungi is complex, typically involving five kinds of spores and two unrelated types of host plants. Because Puccinia spores are extremely mobile and can infect host plants in more than one way, the fungi pose a significant threat to garden plants, turf grasses and crops.

The most important of all is P. It is an internal obligate parsite and is found in associated with wheat growing areas. It obtains nourishment by small round or branched haustoria. There is a single central dolipore in each septum for the protoplasmic connection. During the life cycle, two types of mycelia are produced, the monokaryotic, mycelium and dikaryotic mycelium. The dikaryotic mycelium occurs in primary host Wheat and the monokaryotic type is found in alternate host barberry Life Cycle: The mycelium develops in the host intercellular spaces taking nutrition from host cells through haustoria. Soon 1â€"2 weeks after infection they start collecting below the epidermis in clusters called uredosori. When a large number of spores form, they exert pressure on the host epidermis and cause its rupture. This exposes the spores and facilitates their dispersal by wind. This appears as rust or brown colored pustules or lesions on the host. The infection first appears on the leaf then goes to the stem, glumes and awn. Each urediniospore has two germpores where the wall is thin. The urediniospores germinate by forming a germ tube when it comes in contact with a compatible host. The germ tube produces appressoria which in turn develop the infection peg. When fully established, the uredosori are developed again. Urediniospores are the only type of spores which can re-infect the host. Urediniospores spread from one wheat plant to another through wind, thus spreading the infection from plant to plant, and, field to field. This phase can rapidly spread the infection over a wide area. Telia are produced in the same sorus as the uredinia. These are bicelled, black, thick, smooth walled spores. They remain with the straw after harvesting where karyogamy occurs and the teliospores become diploid 2n. The teliospores germinate after a long resting period and exposure to freezing temperature. Germination of teliospores and formation of basidiospores The upper cell of the spore has an apical germpore, while the lower cell has two laterally apical germpores. A thin hypha comes out of the pore and is called the promycelium. The teliospore is the site of karyogamy and meiosis. Before germination the two nuclei fuse and the resultant diploid 2n nucleus of the spore undergoes meiosis producing four haploid nuclei. These nuclei migrate into the promycelium, which then becomes septate. This four celled structure is the basidium. It is a septate, uninucleate phragmobasidium. Each cell produces a single haploid basidiospore on sterigmata. They are usually carried to the alternative host by wind. The pycnia are flask shaped structures. The pycnia look like small orange bumps on the leaf surface. The spermogonia are produced at the tip of short, erect, unbranched hyphae which line the base of the spermogonium. They are formed in large numbers and released from the ostiole in a drop of sticky honeydew which attracts insects. The spermatia function as the male cells. In the neck of the pycnium, long, thin hyphae develop. They grow out of the pycnium through the ostiole and may branch a few times. These are called receptive hyphae. They function as the female gamete. Insects carry spermatia from one leaf to another; splashing raindrops can also spread spermatia. This is the sexual stage of the life cycle and cross-fertilization provides an important source of genetic recombination. These spores have a warty appearance, hexagonal shape, and are formed in chains. The aecidial cup is emergent i. It looks like small orange colored cup like structure on the undersurface of the leaf. The aecidiospores are able to germinate on the cereal host but not on the alternative host. They are carried by wind to the cereal host where they germinate and the germ tubes penetrate into the plant. Within 1â€"2 weeks the mycelium produces uredinia and the cycle is complete.

Chapter 6 : Puccinia Life Cycle | eHow

Puccinia graminis tritici is a heteroclous, i. e., requires two alternate hosts to complete its life cycle; and macrocyclic, i. e., produce more than one type of spores during its life cycle, rust.

In this article we will discuss about the life cycle of puccinia graminis with the help of suitable diagrams. Dikaryophase in the Life Cycle of Puccinia: This phase in the life cycle of Puccinia is confined to the primary host which is wheat. It consists of dikaryotic mycelium and two spore stages, uredineal and telial. It is internal and thus invisible until it is ready to reproduce. The binucleate secondary or dikaryotic mucelium is filamentous, well developed and branched. The hyphal branches, which are septate, ramify in the intercellular spaces of the tissues of the stem and leaves of the host plant wheat Fig. The septal pore is simple. The nuclear membrane is double layered and perforated. Besides the two nuclei, the cytoplasm contains free ribosomes mitochondria, glycogen particles, lipid bodies and other unidentified particles. To obtain nutrition the intercellular hyphae develop intracellular food absorbing organs called haustoria. List of important diseases caused by species of Puccinia: Allen reported that the tips of certain hyphae of the intercellular dikaryotic mycelium come in contact with the cell walls of the host cells and become separated from the remainder of the mycelium by septa. The resultant small, binucleate tip cells swell somewhat and function as haustorial mother cells. At the point of contact, each haustorial mother cell develops a buldge-like thickening which is closely appressed to the host cell wall. A fine pore appears at the point of contact extending through the cell walls of both the pathogen and the host. A delicate infection peg from the haustorial mother cell passes into the host cell through the pore. After penetration, the infection peg elongates to form the haustorial neck. A wall is formed around it by the fungal pathogen. The plasma membrane of the host invaginates as the developing neck elongates. The latter eventually ceases to elongate. Its apical portion expands to form the body region of the haustorium. Dickinson , stated that the formation of haustoria by the infection hyphae is induced by contact stimulus. The intercellular mycelium probably by enzymatic degradation enters the host cells. The haustoria may be knob-like or finger-like, rarely convoluted. Rykenberg and Truter reported that the intracellular saccate or extensively lobed body of the haustorium is connected by a narrow penetration tube or the stalk to the extracellular haustorial mother cell. The hyphal wall and the plasma membrane of the haustorial mother cell are continuous along the entire length of the penetration tube and haustorial body constituting the haustorial wall and haustorial membrane respectively. A collar-like structure attached to the host cell wall and made of the same material is produced by host cell in response to the presence of the penetration tube. It surrounds the penetration tube at its proximal end. The haustorial body is binucleate. On the outer face of the hyphal wall or haustorial wall in the body region only is formed an electron dense sheath matrix consisting of a granular amorphous material. The sheath matrix is also designated as the extrahaustorial sheath. Since the fungus obtains nutrition from the host the infected wheat plants exhibit stunted growth. Despite the serious damage that the rust causes the host plant never succumbs completely. The yield of wheat crop is, however, reduced. Each cell of the fungus mycelium has a pair of nuclei dikaryon. The transverse septa between the cells have each a central pore without a dolipore parenthesome complex. The clamp connections, however, have not been reported on the dikaryotic mycelium. The mycelium is generally localised. It grows and ramifies near the point of infection extending only short distance into the host tissue. The fully developed dikaryotic mycelium enters upon the reproductive phase. Reproduction in Puccinia Graminis: The dikaryotic mycelium of Puccinia graminis reproduces by sporulation. The spores produced are of two kinds, the uredospores and the teleutospores or teliospores. They are produced near the surface of the host tissues. When mature they break through in slits or pustules called the sori. The mature spores are thus seen externally. Prior to uredospore formation, the hyphae of the dikaryotic mycelium begin to aggregate near the surface of the infected organ such as stem, leaf, leaf sheaths or glumes to form a hyphal mass which surrounds isolated host cells B. The mycelial hyphae then produce masses of cells subepidermally. These are called uredia. From the uredia arise vertically growing slender, stalk-like hyphae arranged in a close palisade-like layer. The tip of each hyphal stalk or uredospore mother cell swells to form a single binucleate oval uredospore or uredeniospore. The uredospores are thus formed in groups. Each such group is called a uredosorus or uredinium B. The developing uredosori are seen in the wheat leaf as pale streaks. They exert pressure on the overlying epidermis which is, at first, lifted but finally ruptured in the form of slits or blisters A. It is through these slits that the rusty coloured masses of uredospores are seen externally. They are stalked, unicellular, oval, binucleate structures C. In masses the uredospores appear rusty red in colour. The uredospore wall is thick. It is differentiated into three layers: The outermost layer pellicle is faintly echinulate and generally with four equatorially arranged thin areas on it. These thin areas on the otherwise thick wall are called the germ pores. Harder et al however, consider the uredospore wall to probably be composed of 5 layers including the pellicle as the outermost layer. The uredospore wall contains silica deposits. The binucleate uredospores function as conidia and are capable of germination as soon as they are produced. They are carried in the air to healthy wheat plants which they infect immediately. The uredospores thus serve as dispersal agents of rust rapidly multiplying the dikaryophase during the growing season. However, unlike the conidia of Ascomycetes, the uredospores are binucleate. They are able to infect wheat plants only and not the alternate host barberry. Germination of Uredospores and infection of the host Fig. On falling on another wheat plant and under suitable conditions the uredospore germinates within a few hours. The endosporium comes out in the form of a slender tube through the germ pore B. More than one germ tubes may be produced by the same uredospore. They emerge through different germ pores. The germ tube by elongation grows over the surface of the host leaf till it reaches a stoma where its tip swells to form an appresorium C. The two nuclei and the protoplasm of the germ tube migrate into the appresorium. The appresorium is then cut off from the empty germ tube by a septum. Both the germ tubes and the appresoria walls are composed of 2 layers and appear to be coated with mucilaginous-like substance. A peg-like outgrowth, the infection peg arises from the centre of the free end of the appresorium. It enters the stomatal aperture. Reaching the substomatal cavity the tip of the infection peg swells up into a vesicle. The contents of the appresorium pass through the infection peg into the sub-stomatal vesicle. Infection hyphae, one or more in number, then develop from the vesicles, grow towards the neighbouring host cells and ramify in the intercellular spaces between them. The hyphae grow vigorously and form the new dikaryotic mycelium between the mesophyll cells of the host tissue. In a few days time the new mycelium produces a new crop of uredospores. This repeated cycle recurs several times in a single growing season. As a result the disease spreads in a few days from plant to plant and field to field over a large area provided the environmental conditions are favourable. Temperature and humidity are the two climatic factors which facilitate infection and thereafter the development of the dikaryotic mycelium of black stem rust of wheat. The source of hymidity may be the dew drops, guttation drop, light rainfall or irrigation water. For maximum infection a definite sequence of temperature, humidity and sunlight is required. Late in the growing season another kind of spore begins to develop from the uredia in the uredosori. It is the teleutospore. The teleutospores are, at first, developed among the uredospores in the same sorus Fig. They are of dark brown or black colour. Gradually as the season progresses more and more teleutospores are produced whereas the number of uredospores is reduced. Finally the sori contain only the teleutospores B. These sori are called the teleutosori. The teleutospores in the teleutosorus exert pressure on the overlying epidermis which is at first lifted but finally ruptured.

Chapter 7 : 5 Stages in Life cycle of Puccinia | Plant Science 4 U

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An epidemic in caused the loss of 14 million bushels in the United States and million bushels in Canada. In , 60 percent of the crop was lost in Minnesota and the Dakotas; in other areas, the loss was near total. In to , the loss was more than 80 percent in the same area. In Roman times, it was thought that damaged wheat was a visitation upon wicked persons. For hundreds of years it was known or suspected that the common barberry plant was in some way involved; yet not until did it become known that wheat rust is caused by a fungus. German mycologist Heinrich DeBary is credited with working out the details of Figure Basidiospores are most commonly formed on a club-shaped hypha, but also can take the form shown at left. In the lower right-hand corner, the fusion of nuclei to create the diploid condition, which is then followed by meiosis to produce haploid basidiospores. The details are complicated, with five different kinds of spores being produced in the complete cycle see figure The infection of the wheat plant in spring shows a rust-red zone, which, on examination with the microscope, reveals a cluster of sporangia. The cluster is called a sorus, and the spores that are produced here have two nuclei. These are called uredospores. Air currents carry the uredospores, thus spreading the infection to other wheat plants. In late summer, the nuclei fuse to create a diploid cell. These nuclei then divide, and a cross wall forms, thereby creating two cells at the end of a stalk. In this stage, the sorus becomes black, and the spores are called teliospores. Teliospores are thick walled and generally do not germinate until the following spring. They remain Figure Dictyophora, a stinkhorn. Its odor makes it attractive to flies, which perch on the top. The fungus was formerly used to make a salve for the treatment of rheumatism. Illustration by Laurette Richin Figure stinkhorn. Phallus impudicus, another on the straw and may germinate in the field or, perhaps, the manure pile. Germination produces an elongated basidium partitioned by walls. The process involves meiosis yielding four haploid basidiospores. As shown in figure , the basidiospores are suspended on the ends of pointed projections called the sterigmata sterigma. There are two types of basidiospores: There is only one place that a basidiospore can germinate: The infection is highly host specific; there is no other place that it can grow. It is so specific, in fact, that it is able to grow only on the upper surface of the leaf. A mycelium is produced in the tissue of the leaf. After a time, pockets are formed on the upper Receptacle Figure End wall perforation surface. These pockets are called spermogonia or pycnia , and spermatia are produced in them. Two kinds of spermatia are produced from the plus and minus teliospores: At left, a redstage sorus occurring in spring, b The binucleated spores are haploid uredospores. At right of the red-stage sorus, the black-stage sorus c occurring in the fall. Diploid, 2n, teliospores are formed. At far right, a teliospore germinates to produce basidiospores, d. Figure Puccinia graminis wheat rust infection on the wheat plant. Although plus and minus spermatia are thereby paired, nuclear fusion does not occur. The cells fuse, but the nuclei do not; a dikary- otic condition thus results. The dikaryotic cells then produce cup-shaped aecia aecium on the underside of the barberry leaves. Binucleated aeciospores are then produced in these aecia chains. These aeciospores are the agents able to infect the wheat plant, and they mark the end of the life cycle. Recall now that the early-season infection of the wheat produces binucleated uredospores, and that nuclear fusion is long delayed. The nuclei do not fuse until late summer, when the black sorus stage occurs and teliospores are produced. Note also that there is an alternation of generations, an alternation of haploid cells and diploid cells, and an alternation of hosts, called heteroecism. Although some species of rust fungi are able to complete the life cycles by parasitizing a single host, large numbers of rusts require two hosts. The white pine blister rust Cronartium ribicola, responsible for the loss of Figure Puccinia graminis infection on barberry leaf. On the upper surface of the leaf, spermogonia with spermatia, which grow from teliospores. Uninucleated spermatia become paired without nuclear fusion, producing aecia on the lower surface of the leaf. The aeciospores are binucleated. Some measure of control has been attained by eradicating gooseberry and current plants in regions where white pine is an important lumber. In the same way, barberry eradication has met with modest success in controlling wheat rust.

Chapter 8 : Life Cycle of Puccinia Graminis | Fungi

Life cycle of Puccinia graminis Like other Puccinia species, P. graminis is an obligate biotroph and has a complex life cycle featuring alternation of generations. The fungus is heteroecious, requiring two hosts to complete its life cycle - the cereal host and the alternate host. [4].

The loss in yield is attributable to several factors associated with colonization of Pgt on its poaceous hosts. These include competition with the fungus for nutrients, lodging due to weakened stems, and reduced metabolic efficiency. Telial host range includes wheat, Triticum aestivum , barley Hordeum vulgare , goatgrass Aegilops spp. Aecial host range includes common barberry Berberis vulgaris , additional Berberis spp. Prolific spore generation, wind-borne dispersal, and viability of spores over thousands of miles are characteristics that have made this an efficiently destructive pathogen 3. Until the late s, successful mitigation of the disease was largely attributable to deployment of wheat resistance genes 11 and alternate host eradication programs 9. In , observations revealed a virulent form of Pgt on wheat lines armed with the Sr31 resistance gene in Uganda. It may be noted that although often referred to as such, Ug99 is not a race but rather an individual of the TTKSK race. The significance of the new pathogen on global wheat production was underscored with a report 4 that laid the foundation for international collaborative efforts addressing the threat of Pgt-Ug99 7. Since , Pgt-Ug99 has rapidly altered genetically, giving rise to eight known variants, and has migrated deeper into the African continent as well as the Middle East 5. Due to the highly mobile nature of the fungus, Ug99 stem rust is expected to arrive in North America, although as of April there have not yet been reports. Anticipation of its arrival has been the impetus of current research objectives and development of action plans 6. Symptoms and Signs Early symptoms of the disease on poaceous crops include chlorotic specks and blisters. However, it is the signs of the pathogen that are more often visualized. Blisters on the plant tissue rupture to reveal oval-shaped, elongated pustules of red-orange urediniospores on the stem, leaf sheath, both abaxial and adaxial sides of the leaves, and spikes. As telia develop, the reddish-orange pustules darken into black lesions On the alternate host, symptoms include chlorosis and blisters. Signs of the pathogen on barberry are observed as aggregated cup-shaped, orange-pink aecia on leaves, petioles, flowers, and fruit Ecology and Spread This pathogen is a heteroecious rust i. In presence of the alternate host, genera Berberis, Mahoberberis, and Mahonia, the pathogen spreads to wheat as aeciospores formed on barberry, which infect wheat. In the absence of the alternate host, the fungus infects the plant in the form of urediniospores formed on wheat, which infect wheat. Disease inception and progression occur similarly whether introduced as aeciospores or urediniospores: The disease cycle continues as the fungus produces the pycnia. Upon mating between different pycniospores, aeciospores are developed in aecia, which infect the grass hosts and complete the life cycle As the wheat growing season progresses northward, the pathogen also follows the host along this northbound path. Perpetual cycles of urediniospore generation, coupled with wind-born dispersal, is the primary cause of localized wheat stem rust epidemics In the milder climate of the southern United States, the pathogen can overwinter as uredinia. In less favorable climates, the pathogen can overwinter as telia near the end of the wheat harvesting season and develop into basidiospores ready to infect the alternate host when environmental conditions are favorable. For both spore types, an environment conducive to disease progression is characterized by warm, wet weather. Free water on leaf surfaces for six hours, in addition to light, is critical for infection. The first generation of urediniospores occurs between one and two weeks. Subsequent generations of urediniospores form every 4â€”7 days. Symptoms become progressively more severe as the growing season continues due to maintained environmental conditions favorable to disease. Although spores can be spread by wind and rain, wind dispersal is the primary mechanism. Splash range of spores is relatively short distance, at less than 0. Management The primary form of managing this disease has historically been development of stem rust resistant cultivars of wheat. However, durable resistance to Pgt-Ug99 has been elusive due to the rapid genetic shifting of the pathogen 2. Removal of alternate hosts is still highly recommended in order to curtail sexual reproduction of the pathogen and subsequently slow the rate of new virulent genotype generation 2. Although fungicides have been approved for use against the stem rust pathogen, efficacy of this chemical method is debatable due to: Diagnostic Procedures This fungus is an obligate pathogen; it cannot be cultured on media. Differentiating Wheat Rusts Macroscopically- Characteristics that differentiate stem rust from leaf rust or stripe rust include the shape and color of pustules and which plant parts are affected. Stem Black Rust Puccinia graminis f. All aerial parts of the plant during wheat growing season Pustules: Stems at late stages in wheat maturity Leaf Brown Rust Puccinia recondita f. Leaf blades and sheaths Stripe Yellow Rust Puccinia striiformis f. Round, yellow, aggregate to form straight lines Tissue: Leaf blades 1 Microscopically- Key characteristics that distinguish stem rust from leaf rust or stripe rust include fresh urediniospore shape and protoplasm behavior when mounted in Leaf Brown Rust Puccinia recondita f. Stripe Yellow Rust Puccinia striiformis f. 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Chapter 9 : Wheat Rust - Puccinia graminis - Details - Encyclopedia of Life

The Borlaug Global Rust Initiative Presents: The Life Cycle of Wheat Stem Rust. This educational animation details the complex and amazing life cycle of Puccinia Graminis (Wheat Stem Rust).

In this article we will discuss about Puccinia Graminis. After reading this article you will learn about: Habit and Habitat of Puccinia Graminis 2. Habit and Habitat of Puccinia Graminis: It effects wide range of hosts including wheat, barley, oats and rye. Grass hosts include Agrostis, Dactylis and Agrophyron. Poacae and Barberry Berberis vulgaris fam. The wheat plant is called the primary host and the barberry plant is secondary or alternate host. In Northern India the black rust appears after March, but in South India, the rust may appear as early as in the fourth week of November thus, causing great loss to wheat crops. Symptoms of Puccinia Graminis: The symptoms of the disease appear as large, elongated and brown pustules uredosori on the stem, leaf, sheath and leaf Fig. Later on these brown pustules change into black coloured large pustules teleutosori, Fig. Grains of the infected plants are shriveled, much lighter in weight and thus reducing the yield. The pathogen shows a balanced host parasitic relationship. Even in the severe infection, the parasite does not cause much serious damage except that the growth of the plants may be somewhat retarded and the granis may be of reduced size and of poor quality. Infection first starts on the dorsal surface of the leaf in the form of minute, dark coloured and flask shaped pycnia which appear as yellow spots Fig. Beneath Pycnia, on the ventral surface, appear cup like projections of aecia Fig. Vegetative Structure of Puccinia Graminis: The mycelium is dikaryotic each cell of the mycelium bears two nuclei on primary host wheat and monokaryotic each cell of the mycelium bears only one nucleus on the secondary or alternate host barbery. The monocaryotic mycelium is also called hapiomycelium or primary hyphae and the dikaryotic mycelium is called secondary hyphae. The mycelium is well developed, branched, septate and does not spread throughout the host, but is localised to isolated patches. It is either intercellular or intracellular, with the former producing bulbous, branched or knotted haustoria into the cells for obtaining nourishment. The transverse septa are present or long intervals between the cells. Each septum contains a simple central pore. In contrast with many Basidiomycetes the dolipore parenthesome complex is completely absent Cell wall is made up of fungal cellulose. The cytoplasmic membrane surrounds the granular cytoplasm and reserve food material remains in the form of glycogen bodies and oil globules. Life Cycle of Puccinia Graminis: Puccinia graminis is long cycled rust macro cyclic. At the time of reproduction it produces five distinct stages in a regular sequence. These are as follows: Spermogonia bearing spermatia and receptive hyphae. Out of these five stages, Uredo stage, Teleuto stage are produced on the primary host wheat and remaining two stages, spermogonial and aecial stages are produced on the secondary host i. Stages on Primary Host Wheat: Both the spores are bi-nucleate and on germination, produce a germ tube on wheat leaf. The germ tube grows over the surface of the epidermis of the host and on reaching a stoma its tip swells up and forms a vesicle like structure called appressorium Fig. The protoplasm of the germ tube migrates into the appressorium. Now it is cut off from the germ tube by a septum. The appressorium produces a narrow hypha. It enters inside the sub-stomatal chamber through stoma. Its tip again swells up and forms a sub-stomatal vesicle. The contents of the appressorium migrate to vesicle through narrow hypha. A hypha of the dikaryon two nuclei cells develops from this vesicle Fig. It branches and produces hyphae which spread in between the cell intercellular but occasionally produce hausotria. Within days, the mycelium absorbs sufficient food from the host. It begins to aggregate near the surface of the infected organs and forms a compact mass. These are called uredia. From these uredia arise vertically a layer of bi-nucleate parallel cells known as basal cells. The basal cells elongate vertically and divide transversely into a lower cell foot cell and an upper cell uredospore mother cell. The upper cell divides again and its upper daughter cell swells to form a single, bi-nucleate, oval, uredospore or uredinospore, while the lower daughter cell matures into a stalk Fig. They are double walled, echinulate, binucleate the two nuclei belonging to opposite strains and possess four equatorially arranged germ pores Fig. A uredospore can infect only a wheat plant. After falling on a suitable host it germinates within a few hours and produces a dikaryotic mycelium. Thus, these spores cause several successive infections during the season, and spread the fungus and the disease from field to field provided the environmental conditions are favourable sufficient moisture. Teleutospores or Telial Stage: Now uredosori produce another kind of spores called teleutospores. This stage is known as the black stage and hence the name black rust is given to the disease Fig. The teleutospores are dark brown or black in colour. They are bi-celled and spindle shaped structures Fig. Each cell of a teleutospore has a single germ pore and two nuclei one of plus strain and the other of minus strain, Fig. As the teleutospores reach towards maturity, karyogamy takes place and the two nuclei fuse to form a diploid nucleus Fig. At this stage the teleutospores undergo a period of rest. During resting period they lie on the ground or still attached to the host. These are the dormant cells and are capable of tiding over unfavorable period. After the renting period, the teleutospores germinate during the early part of spring. They germinate in situ and either one or both of its cells give rise to a germ tube. The promycelium together with the teleutospore cell is called basidium. However, many authors prefer to call the teleutospore cell as the hypo-basidium and the promycelium as the epibasidium Fig 6 A-C. The diploid nucleus of the teleutospore migrates into the promycelium and divides meiotically into four haploid nuclei Fig. The septa appear between the nuclei and divide the promycelium into four haploid cells. Each haploid cell of the promycelium produces a slender, short, lateral, tube-like structure known as sterigma Fig. The sterigma swells up at the end to form a spore like cell. The haploid nucleus from each promycelium cell migrates into this developing spore cell through its respective sterigma. Thus, at the tip of each sterigma, a minute spore is formed. This spore is called basidiospore Fig. Each cell of promycelium produces a single basidiospore. Thus, from a single cell of teleutospore four haploid, unicellular, uninucleate basidiospores are formed. In this method a liquid begins to collect in the form of a droplet at the base of the basidiospore. This droplet gradually attains a bigger size and suddenly pushes off the basidiospore forcibly into the air to a short distance. The basidiospores are carried away by wind. They are capable of germinating only on Barberry plants Berberis vulgaris available on hills. They perish soon if the alternate host is not available. Stages on Barberry Plant: The basidiospores, which fall over the upper surface of barberry leaf start germinating soon. They germinate by giving out a germ tube which penetrates through the epidermis. The germ tube elongates and divides inside and develops into hyphae. These hyphae grow between all the cells lying in between the lower and upper epidermis. Several basidiospores of different strains may infect the same Berberis leaf. Spermogonial or Pycnidial Stage: This stage is also known as Pycnial or spermatial stage. After about four days of the infection, the haplomycelium collects and forms dense mats both beneath the upper and lower epidermis. The mycelial mats beneath the upper epidermis are known as primordium of spermogonium while the mats beneath the lower epidermis are known as primordium of aecidium or protoaecidium. In 7 to 10 days after infection, each primordium of spermogonia matures into a small flask shaped structure called spermogonium or pvcnidium. The pycnidia appear as minute yellowish specks on the upper surface of the leaf Fig. A vertical section through these specks reveals that each spermogonium opens on the upper surface of the host leaf through a pore like structure known as ostiole Fig. Its wall consists of three kinds of hyphae: The ostiole is surrounded at the fringe by the long, delicate, sterile hyphae known as periphysis. They develop near the ostiole from the spermogonial wall and project from the ostiole. They also arise from the lateral wall of the spermogonium. They are slender, delicate, cylindrical, septate, simple, branched or un-branched with blunt ends.