PHYTOPATHOLOGY

BLACK STEM RUST OF WHEAT

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Black Stem Rust of Wheat:

- Most destructive wheat disease
- Severe grain shriveling.
- Masses of pustules (blisters) on leaves & stems containing brick red spores.
- Rust infested plants transpire much more water than normal.
- Most important disease of wheat, globally.
- Drastically reduces growth and yield, up to 70%.
- Brittle stems can fall over or "lodge" hampering mechanical harvest

Significance:

- Wheat is the sixth most important crop.
- World trade in wheat is greater than for all other crops combined.
- Major disease of wheat and, therefore a potential threat to the world food supply.

EPIDEMIOLOGY (MODE OF SPREAD)

- Stem rust is favored by hot days (25-30°C/ 77-86°F), mild nights (15-20°C/ 59-68°F), and wet leaves from rain or dew. Spores require free water for germination. Infections occur through stomata.
- **Recurrence of Black/stem/rust of wheat**
- The pathogen are air borne. The pathogen **pass their life cycle on two different hosts, wheat and barberry**.
- **Barberry plants** are abundantly found in hilly region.
- The summer heat in the plains that follows the wheat harvest kills all the uredospores of rusts.

Symptoms on wheat plants

Disease symptoms appear mostly on leaves and stems. The infected regions appear dry, rusty orange or yellow coloured spots that rupture the epidermis (outermost surface).

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.ars.usda.gov%2Fmidwest-area%2Fstpaul%2Fcereal-disease-lab%2Fdocs%2Fcereal-rusts%2Fwheat-stem-rust%2F&psig=

BLACK STEM RUST OF WHEAT PATHOGEN: *PUCCINIA GRAMINIS* F. SP. *TRITICI*

- ☐Stem rust affects parts of plants that are above ground.
- ☐In wheat it results in formation of brown to black elongated pustules.
- ☐In Barberry yellowish orange coloured spots at dorsal side and yellowish orange circular spots on ventral side of barberry leaves.
- ☐Infection of P. graminis results in retarded growth and reduced seed size in wheat.
- ☐In north India it appears in March while in south it appears at the end of November.

- **SYMPTOMS:**

- Reddish brown pustules

Occur on both surfaces of leaves, on the stems and on the spikes.

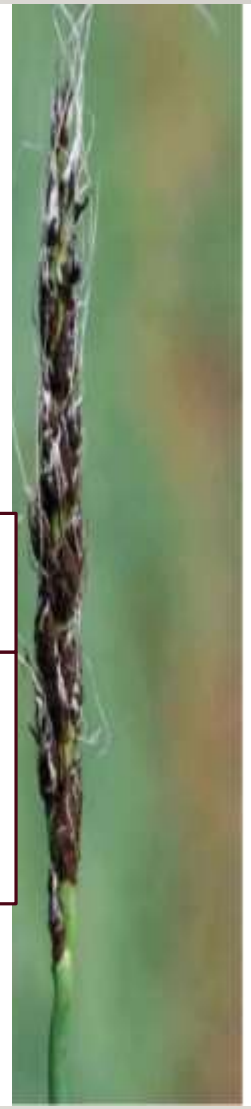
- Infected parts bursting to expose a mass of brown uredospores

- **SYMPTOMS:**

❖The black telial pustules are usually formed on the dorsal side of leaves

later in the season

The stems become dry and cracked and most severely attacked.



➢SYMPTOMS:

- Can only be seen at the time of flowering though the plants are infected right after seed germination.
- Ears of infected one emerge early than healthy one.
- and transformed into black powdery mass
- Whole ear is covered by delicate silvery membrane.
- Resulting in formation of very dark olive brown powdery mass

https://pt.slideshare.net/agp115/ppt

SYMPTOMS -ON WHEAT:

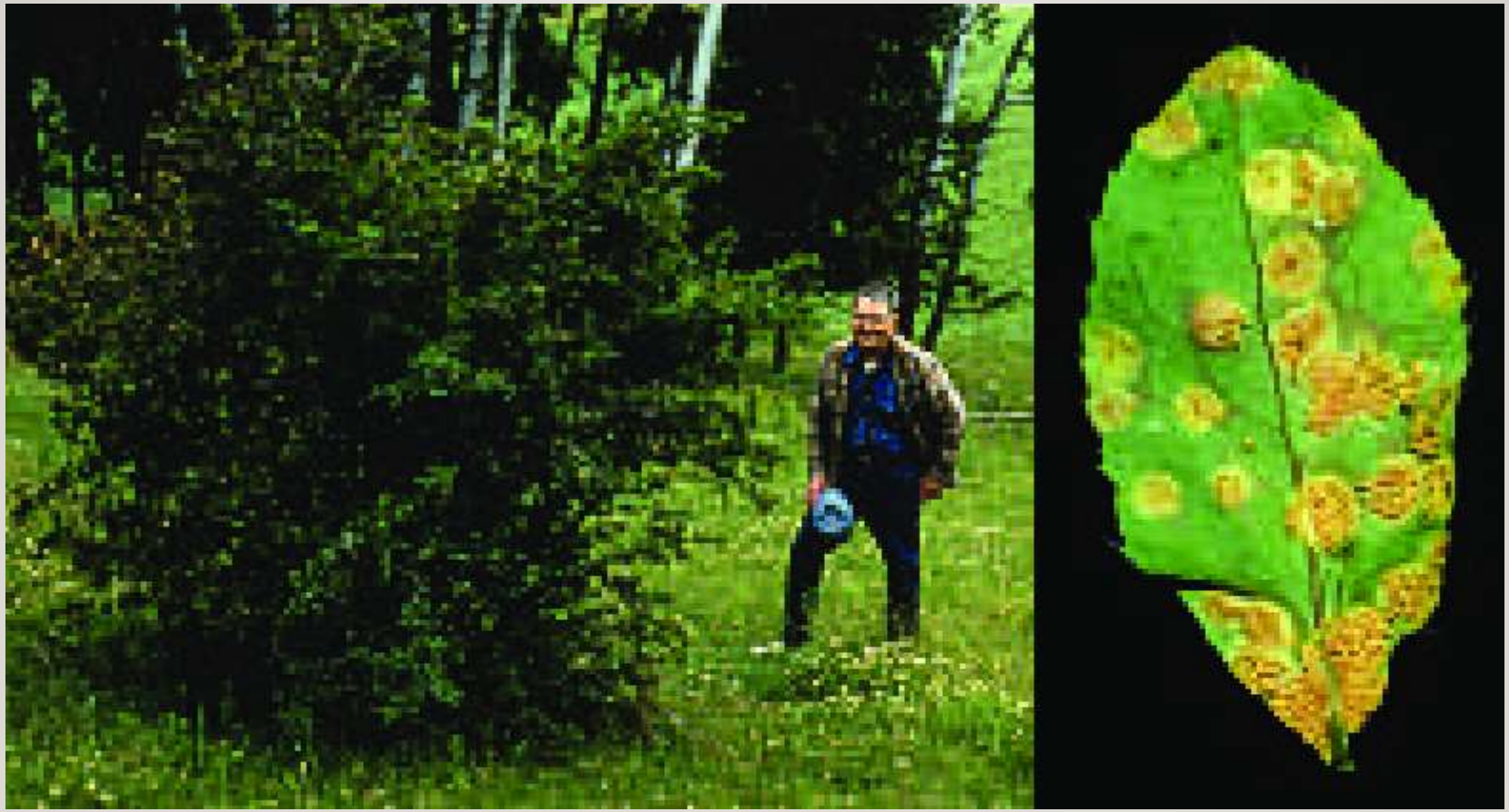
- **Black rust is first marked by an eruption of elongated brown pustule (raised spots) on the stems, leaf sheaths and leaves.**
- These oval pustules (uredinia) on both leaf surfaces and stems very soon burst, exposing a brown powder consisting thousands of brick-red uredospores which break through the epidermis.
- Microscopically, these red spores are **covered with fine spines, single celled and dikaryotic (n+n).**
- **Later in the season, pustules of black teliospores begin to appear in infected wheat plants**. Microscopically, **teliospores are two celled and thick walled**. The teleutospores are often produced in the same sorus as the uredospores and as they are darker in colour, one can see the pustules gradually changing from brown to black as the season advances.

https://www.ars.usda.gov/midwest-area/stpaul/cereal-disease-lab/docs/barberry/barberry-image-gallery/

Barberry leaf underside with aecia

Symptoms on Berberry plant

Barberry is the alternate host for wheat Stem Rust. The picture on the right shows an infected leaf with pycnidia. The top right picture shows a barberry leaf underside with aecia. The bottom right picture shows barberry leaves and berries as they normally appear in the fall.



Barberry bush and infected barberry leaf with symptoms and signs of wheat stem rust. Photos courtesy of USDA-ARS Cereal Disease Laboratory.

PATHOGEN/CAUSAL ORGANISM/ (ETIOLOGICAL AGENT): *PUCCINIA GRAMINIS* F. SP. *TRITICI*

- ***Puccinia graminis*** **is an obligate parasite of wheat causing stem rust disease.**
- **It is heteroecious fungi that require two unrelated host plants, such as Wheat – Primary host Barberry – Secondary host, to complete their life cycle.**
- ***Puccinia graminis*** **is macrocyclic, producing all five spore stages: basidiospores, pycniospores (spermatia), aeciospores, urediniospores (uredospores), and teliospores.**
- **In the absence of living host tissue, they only survive as spores. In most rust fungi, only the teliospores are adapted to survive apart from a living host plant for more than a few months under field conditions.**

SPORE STAGES IN *PUCCINIA*

- **Uredospore:** Dikaryotic containing two un-fused, haploid nuclei in one cell; formed on individual stalks ; spiny and brick-red; the only type of spores in the rust fungus life cycle that are capable of infecting the host on which they are produced
- **Teleutospore**: Dark brown or black; stalked, two – celled; spindle shaped; with thick, black and smooth wall; the only form in which Puccinia graminis is able to overwinter independently of a host; undergoes karyogamy and meiosis.
- **Basidiospore**: haploid products of meiosis; thin-walled and colourless; cannot infect the cereal host, but can infect the alternative host
- **Pycnidiospore or spermatia**: pycniospore can fertilise a receptive hypha of the opposite mating type, leading to the production of a dikaryotic mycelium
- **Aecidiospore**: Dikaryotic, Round, yellowish red, unicellular, binucleate, thick walled, produced in chains; able to **germinate on the cereal host but not on the alternative host**

Source: https://en.wikipedia.org/wiki/Stem_rust

SPORE STAGES ON WHEAT

- **Uredo Stage (Rust stage):**

✓ Formation of single celled, binucleated uredospores on stalks and leaves.

✓ Uredospores apply pressure on epidermis breaking it and forming uredinia or Uredosorus.

✓ Uredospore germinate and forms mycelia.

- **Telial Stage (Black stage)**

✓ Teleutospores are formed from uredospore in unfavourable condition of growth.

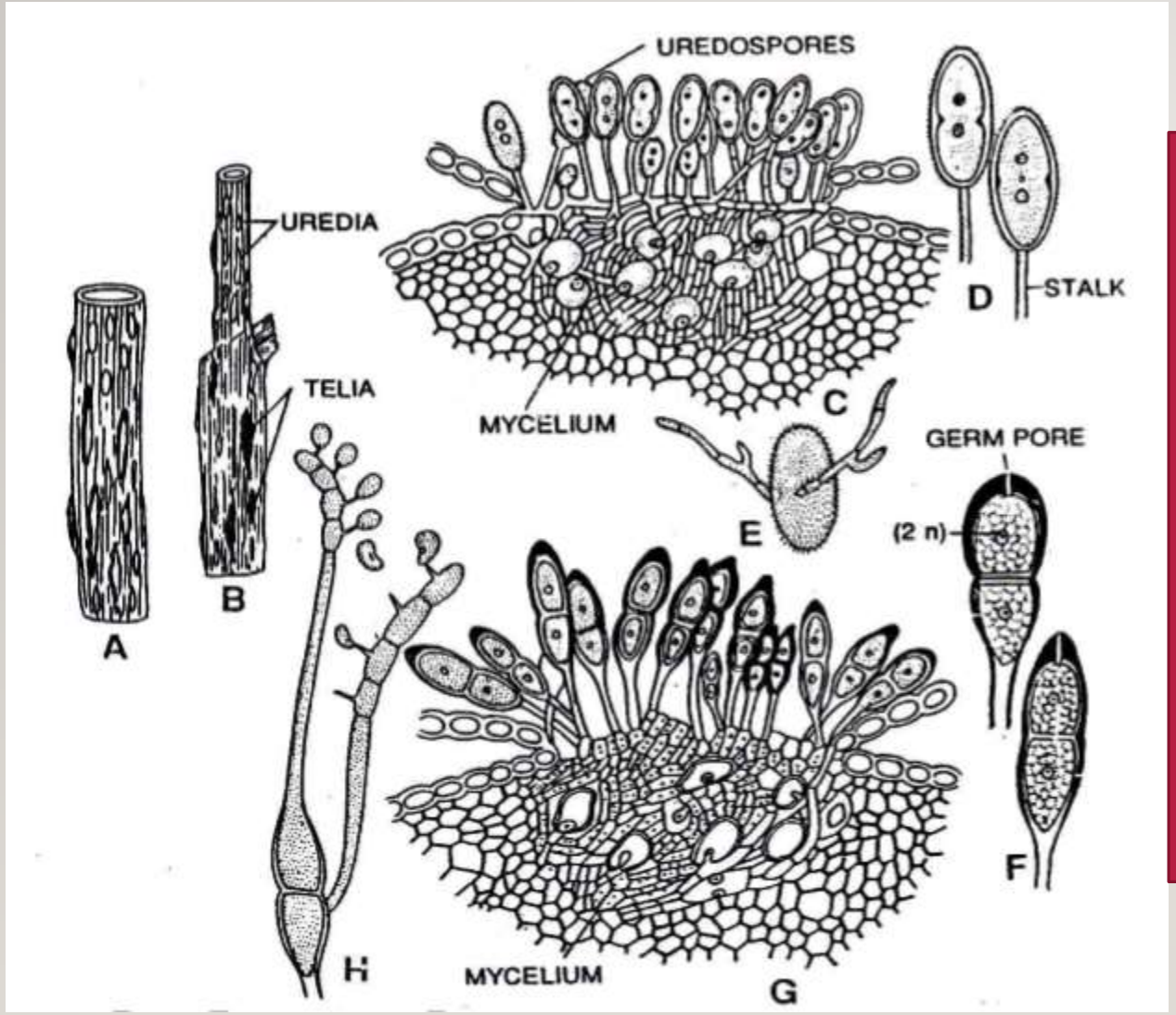
✓ Two celled; Each cell has two nuclei. **Karyogamy leads to formation of diploid nucleus. Spores rests until favourable condition.**

- **Basidial Stage**

✓ Formation of haploid basidiospores by meiosis.

✓ Ejection of spores that are carried out by wind to secondary host (Barberry plant).

✓ Infects barberry forming haploid mycelia.



(B) SPOTS ON STEM AND LEAF WITH UREDINIA/UREDOSORUS AND TELIA /TELEOSORUS

C) UREDO STAGE; (D) SINGLE UREDOSPORE

(G) TELIAL STAGE; (F) SINGLE TELEUSPORE;

(H) TELEUSPORE GERMINATE TO PRODUCE 4 BASIDIOSPORES

https://agriculturistmusa.com/black-stem-rust-rust-of-wheat/

SPORE STAGES ON BERBERRY

Pycnidial Stage

- ✓ Specialised flask shaped **Pycnia** or spermatia appear on leaves of barberry plants in the spring, usually in the upper leaf surfaces. They are often in small clusters and **exude pycniospores in a sticky honeydew**.
- ✓ Pycnia produces haploid pycniospores and receptive hyphae.
- ✓ Dispersed by insects, Pycniospores (n) fertilise receptive hyphae (n) of another plant forming dikaryotic (n+n) mycelia.

Aecial stage

- ✓ Five to 10 days later, **cup-shaped structures (Aecia) filled with orange-yellow, powdery aeciospores** break through the **lower leaf surface of the same barberry plant**.
- ✓ The **aecial cups are yellow** and form dikaryotic (n+n) aeciospores from mycelia.
- ✓ Chain like aeciospores are carried by wind to infect cereal host or wheat plants.

DISEASE CYCLE

- The disease cycle of wheat stem rust starts with the exposure of each new wheat crop to spores of *Puccinia graminis* f. sp. *tritici*, which are the primary inoculum.
- **In warm climates**, wheat is planted in late fall and harvested in early summer. The **first spores to infect the young wheat plants in the fall are uredospores. They generally come from infected volunteer wheat plants**. (Seed spilled in the field or on roadsides at harvest time often sprout and produce scattered volunteer plants. These plants can become infected from spores produced on late-maturing wheat plants still in the field. The infected volunteer wheat plants serve as a bridge that carries *P. graminis* f. sp. *tritici* through the summer to the next fall-sown crop of wheat.)
- The **first rust spores** to infect wheat in the spring **in temperate regions** may be **aeciospores from barberry, the alternate host, or urediniospores from infected wheat in distant regions with milder winters.**

DISEASE CYCLE, WITH BARBERRY

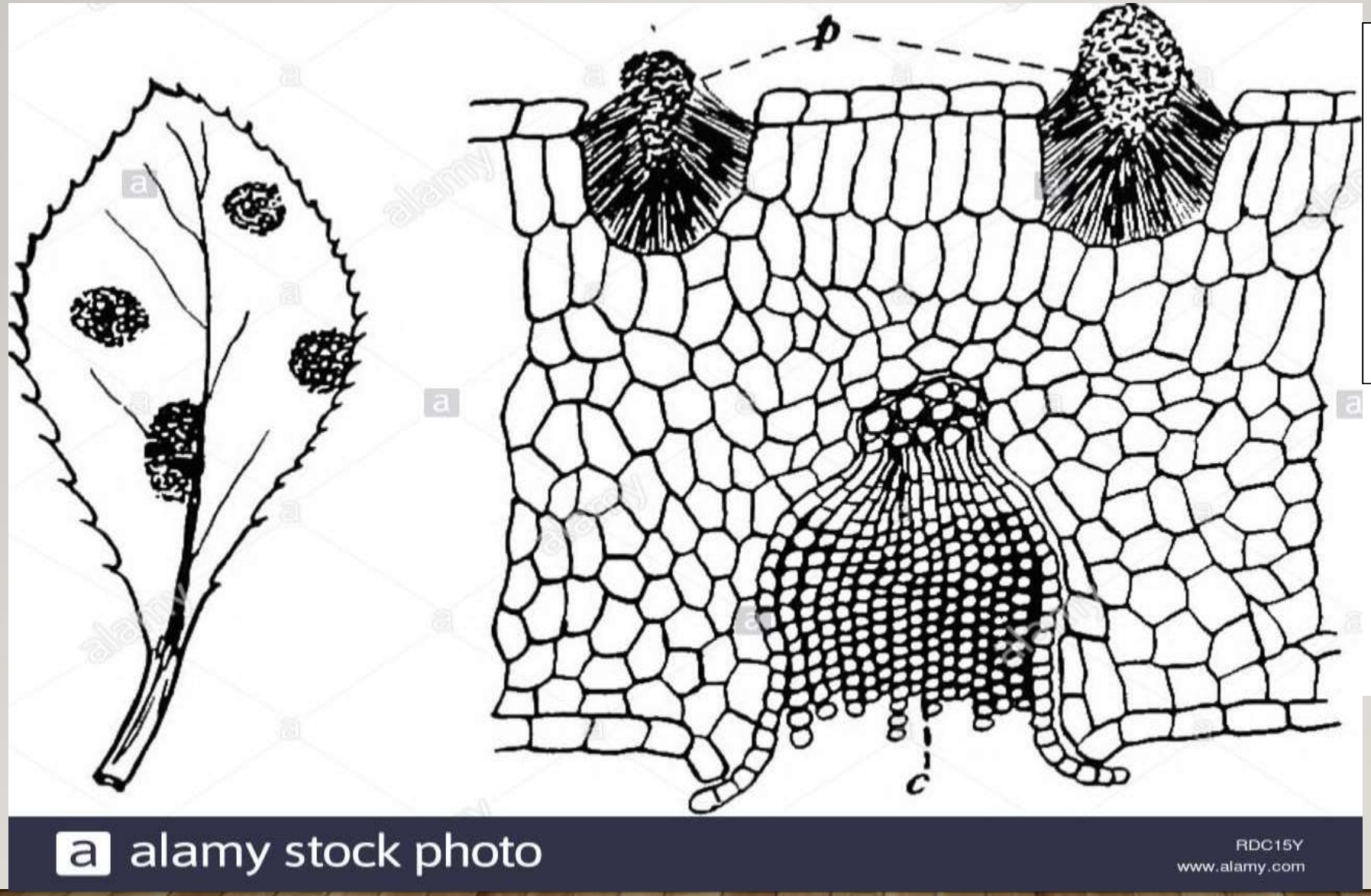
- **Barberry is the** most dangerous **source of primary inoculum** of stem rust in **temperate regions**. If barberry grows near wheat fields, it will be a consistent source of aeciospores for the earliest infections of wheat in the spring
- ***Puccinia graminis* overwinters as black, thick-walled, diploid teliospores that are produced on wheat or other grass hosts toward the end of the growing season. Karyogamy** (fusion of two haploid nuclei to form a diploid nucleus) **and meiosis** (reduction division to produce four haploid basidiospores) **take place in the teliospore.** Teliospores are produced in a telium or teleutosorus.
- **In the spring, each teliospore germinates to produce thin-walled, colorless, haploid basidiospores. Basidiospores infect the alternate hosts such as common barberry.**

ON BERBERRY

- **Basidiospores germinate and produce a haploid mycelium which colonizes the leaf tissue in barberry. From this mycelium, pycnia are formed** inside the leaf but **with the tops extending through the surface**, usually in the upper surface, **of barberry leaves**.
- **Pycnia produce receptive hyphae and pycniospores**. No further development will occur until **the receptive hyphae in the pycnium are fertilized by pycniospores from a pycnium of a different mating type**.
- (**Pycnia and pycniospores are referred to as spermagonia and spermatia** by some authors, but the former are the preferred terms of rust specialists.)

ON BERBERRY….

- Pycniospores are produced in a sticky honeydew that is attractive to insects and helps ensure that successful cross-fertilization occurs.
- **Insects carry pycniospores from one pycnium to another** as they forage across the leaves feeding on the honeydew. **Splashing raindrops also disperse pycniospores and aid in cross-fertilization.**
- **Fertilization of pycnia** is critical in the rust fungus life cycle, because it **gives rise to the dikaryotic mycelium**. After **the nucleus of the pycniospore joins that of the receptive hypha, the paired, haploid nuclei (dikaryon) divide in tandem in the mycelium** throughout the remaining stages of the life cycle**.**
- All stem rust infections of wheat or other grasses involve dikaryotic spores and dikaryotic mycelium.

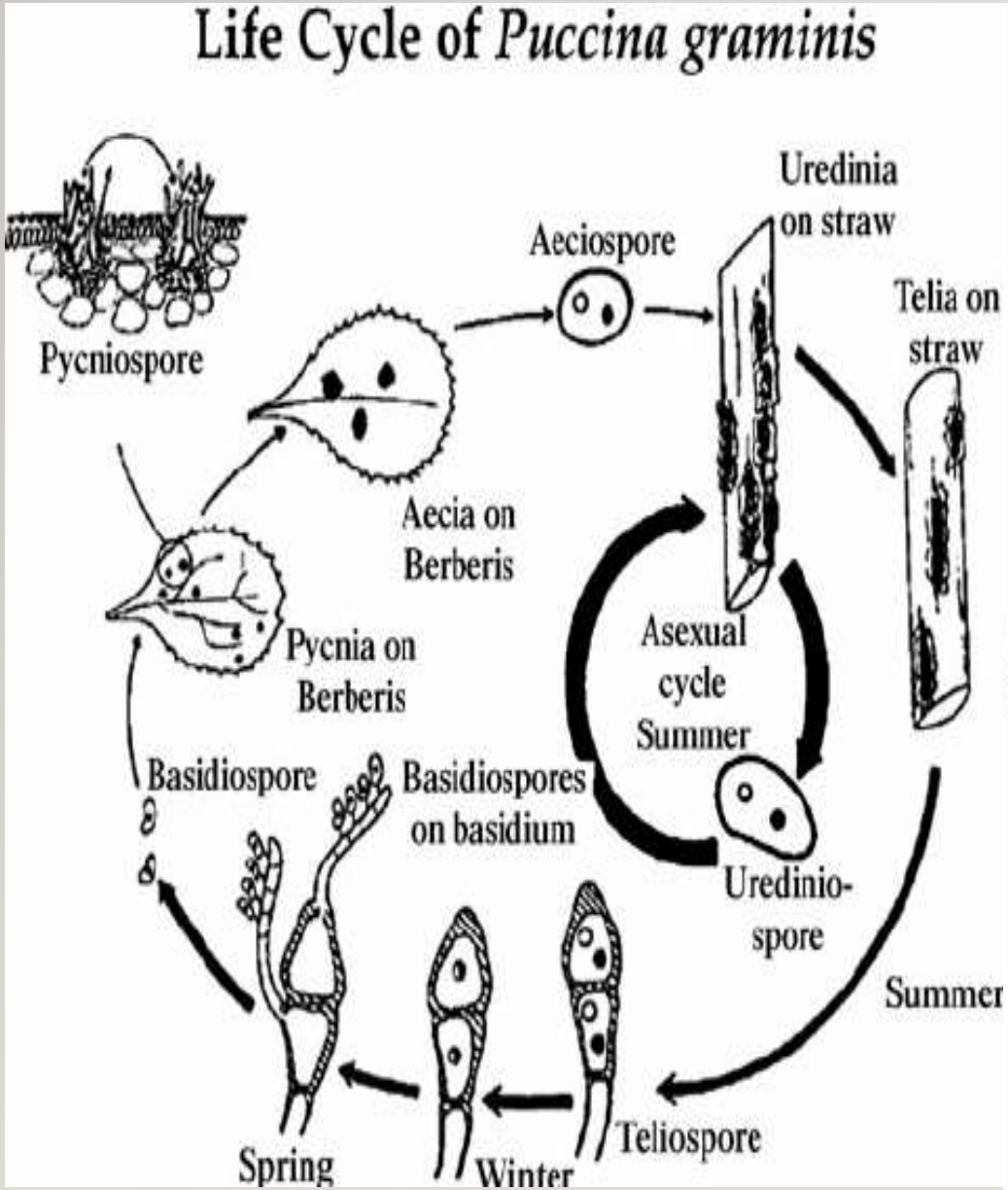


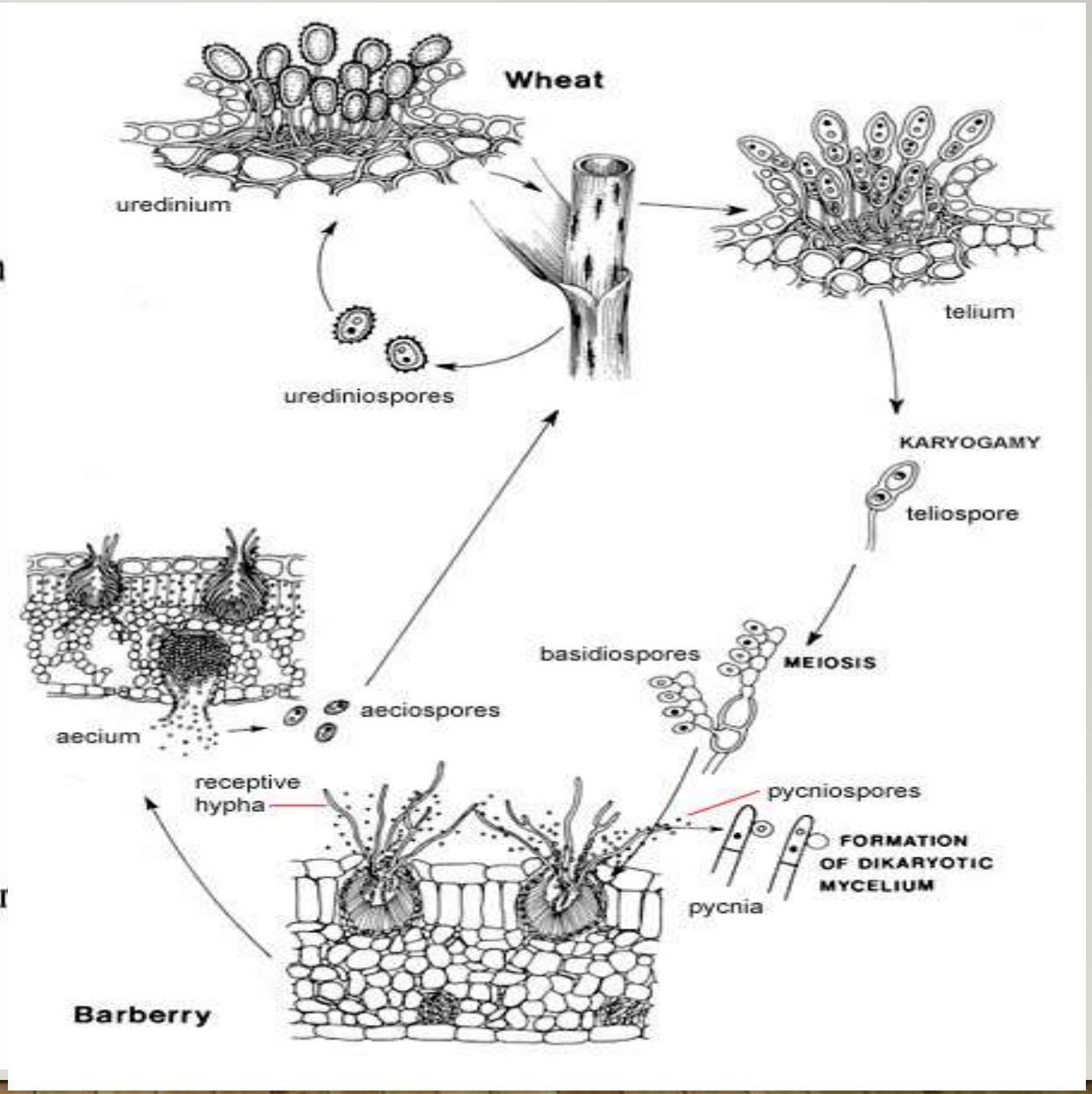
Flask shaped Pycnidia (n) on upper surface and **Cup shaped aecia** (n+n) on lower surface of Berberry plant leaves.

✓**Aeciospores (n+n)**, although produced on barberry plants, **can infect only wheat or other grass host** of *P. graminis*.

FROM BERBERRY TO WHEAT

- **On wheat, aeciospores germinate**, the germ tubes penetrate into the plants, and the **fungus grows as dikaryotic mycelium**.
- **Within 1 to 2 weeks, the mycelium in each infection produces a uredinium (uredosorus)** filled with brick-red, spiny, **dikaryotic urediniospores/uredospores that break through the leaf or stem epidermis.**





https://www.researchgate.net/figure/Life-cycle-of-Puccinia-graminis-Wikimedia-commons_fig5_224008581

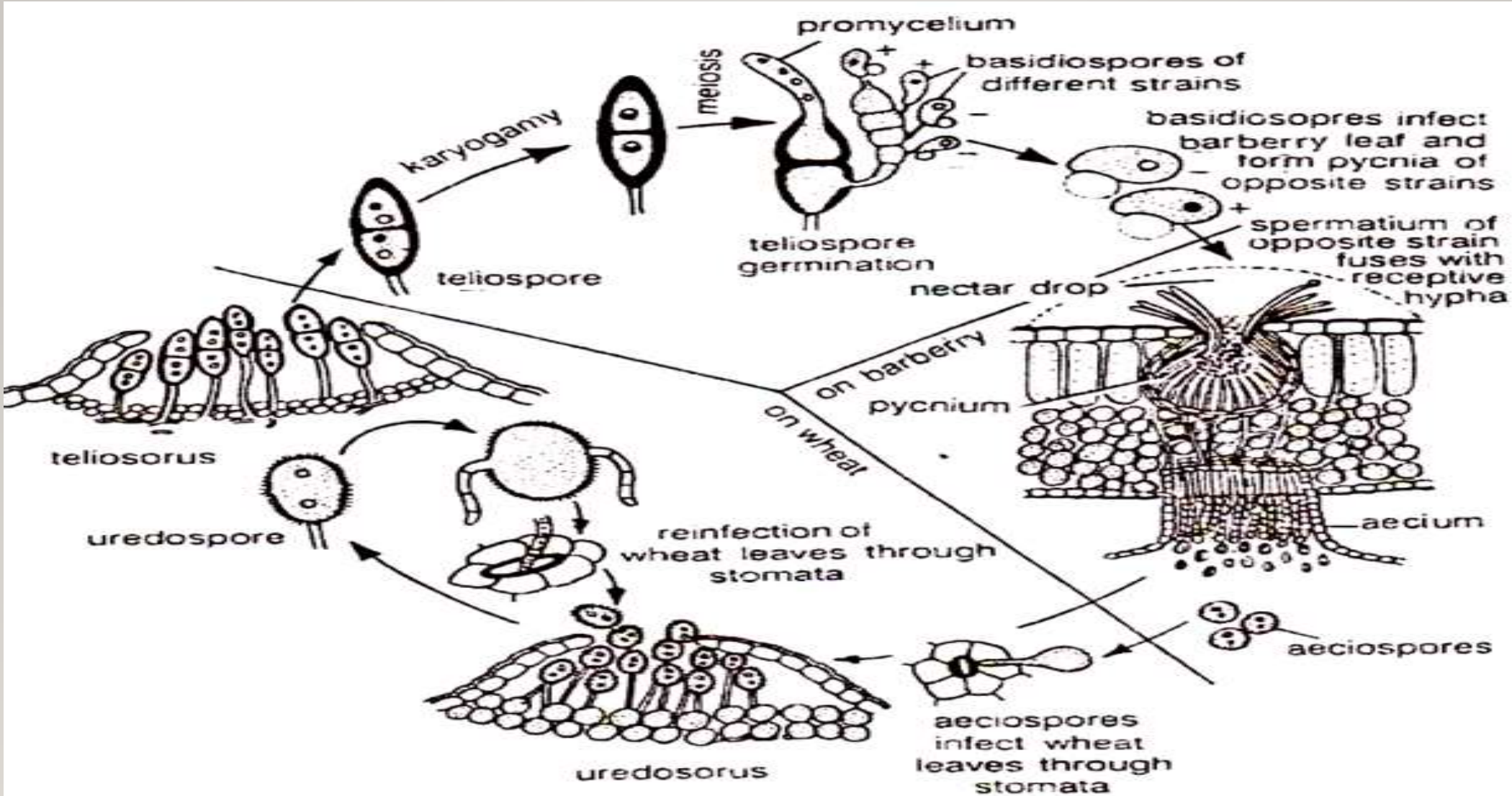


Fig. 11. Diagrammatic life cycle of *Puccinia graminis tritici*

http://comenius.susqu.edu/biol/205/day-8/laboratory

REPEATING STAGE- UREDOSPORE STAGE

- In heteroecious rusts, **uredospore spore stage** is called the **"repeating stage," because uredospores are the only rust spores that can infect the host plant on which they are produced**. Under favorable environmental conditions, multiple, repeated infections of the same wheat plant and neighboring wheat plants can result in explosive epidemics.
- Toward the end of the growing season, **black overwintering teliospores are formed in telia**, and the life cycle is completed. Because **karyogamy and meiosis** take place in the **teliospore**, this spore stage is an important source of genetic recombination in addition to its role as a **survival spore**.

FORMAE SPECIALES :PUCCINIA GRAMINIS F. SP. *TRITICI*.

- Although stem rust is caused by a single species of fungus, *Puccinia graminis*, there is considerable genetic variation within the species. In 1884, Eriksson discovered **host-specific subspecies or "special forms" of the fungus. Each special form is designated in Latin as a *forma specialis* or "f. sp."** All of the *formae speciales* have an identical appearance, but vary in host range. The pathogen that causes stem rust of wheat (*Triticum aestivum*) is *Puccinia graminis* f. sp. *tritici*.
- *P. graminis* f.sp. *secalis*, causal agent of stem rust of rye (*Secale cereale)*, and *P. graminis* f.sp. *avenae*, causal agent of stem rust of oat (*Avena sativa*).

MANAGEMENT

- i. Growing rust-resistant varieties.
  ii. Avoidance of late sowing and late maturing varieties.
  iii. Use of excess amount of nitrogenous fertilizer should be avoided.
  iv. Removal of barberry plant from crop field.
  v. Spraying of Zineb or Mancozeb 75 WP.