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HEAD AND SEED INFECTION OF SUNFLOWER BY *Albugo tragopogonis*

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SUMMARY

Albugo tragopogonis is associated with leaf spots, petiole greying and grey stem spot of sunflower. With this study, the fungus is also associated with heads of sunflower. In addition to oospores of *A. tragopogonis* that formed on involucral bracts and the base of receptacles, sexual structures were also produced at the base of floral disks. In these instances, oospores were observed in disk bracts, receptacles and in the pericarp of seeds, but not in disk flowers and pappuses. These infections appeared to take place in the absence of stromata. The incidence of seed transmission of *A. tragopogonis* is expected to be low.

Key words: ***Albugo tragopogonis*, seed, sunflower**

INTRODUCTION

Albugo tragopogonis (DC) S.F. Grey is responsible for white rust of sunflower (*Helianthus annuus* L.) (Zimmer and Hoes, 1978). The disease is known in most countries where sunflower is cultivated, but has not been considered to be economically important. Typical symptoms of the disease are small, yellow chlorotic spots on the upper (adaxial) surface of leaves (Zimmer and Hoes, 1978). On the opposite (abaxial) surface, white pustules with sporangiospores, representing the asexual stage of the fungus, are formed beneath the epidermis.

Unusual symptoms associated with the sexual stage of *A. tragopogonis* were first observed on sunflower in Australia in 1980 (Allen and Brown, 1980). Lesions in which oospores of the fungus were formed on petioles resulted in the death of leaves. Since then, oospore infections of stems (grey stem spot), petioles (petiole greying), receptacles and involucral bracts of sunflower were reported from Argentina (Delhey and Kiehr-Dehley, 1985), South Africa (Van Wyk *et al.*, 1995; Viljoen

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and Van Wyk, 1996; Viljoen *et al.*, 1996) and France (Penaud and Perny, 1995). In South Africa, grey stem spot resulted in severe lodging of sunflower (Van Wyk *et al.*, 1995). Extensive colonization of heads of sunflower by *A. tragopogonis* was also recently observed in field trials and breeding nurseries. The objective of this communication is to report the importance of this new manifestation of white rust and discuss the possibility of seed transmission of the fungus.

MATERIALS AND METHODS

Sunflower heads were inspected in commercial fields, breeding nurseries and white rust trials for the presence of symptoms suggesting infection by *A. tragopogonis*. These symptoms were most commonly white blister-like pustules or greyish subepidermal lesions. Samples of such symptoms were brought to the laboratory for positive identification of sporangiospores and oospores of *A. tragopogonis*.

Heads of sunflower lines and hybrids were hand-sectioned, and inspected for colonisation of the receptacles at the base of the disk flowers by the fungus. Infected tissue was dissected from the head and examined microscopically. Developing and fully developed seeds were hand-sectioned, stained with fuchsin acid and examined for the presence of hyphae and oospores of *A. tragopogonis*. In addition, seeds from material without obvious symptoms, and commercially available seeds, were also examined for infection by the fungus.

RESULTS

White rust pustules, typical of those that are formed on the lower or abaxial side of sunflower leaves, were produced on the involucral bracts (Figure 1). Sporulation was restricted to the abaxial side of bracts, but the adaxial side did not display the typical yellow chlorotic lesions that are characteristic of white blister rust. Oospores were present in the involucral bracts, and were also produced on the receptacles.

Greyish localized lesions resulting from oospore formation could be seen on the base of most sunflower heads (Figure 2). The oospores were formed subepidermally, and the infected area extended 3-5 mm into the receptacles. These infections did not appear to negatively affect the size of heads or seed production and quality. On breaking open the heads, oospores were sometimes found at the base of the floral disks and developing seeds of certain breeding lines (Figure 3). This oospore-infested tissue appeared to develop independently of lesions found at the base of sunflower heads. In some instances, however, greyish lesions on the basal side of very thin receptacles extended through the heads to the bases of the seeds. Microscopic examination revealed extensive colonization of disk bracts and receptacles with oospores (Figure 4). Oospores were not observed on disk flowers and pappuses.

Longitudinal sectioning of mature seeds that developed on sunflower heads infected with *A. tragopogonis* revealed internal colonization of seeds by the fungus. Oospores were produced in the pericarp near the funiculus (Figure 5) and in the testa of developing seeds. No oospores or hyphae were observed in the embryo. Colonization of sunflower seeds by *A. tragopogonis* was found only in a few lines, and always in association with internal colonization of the head. No heads or seeds of commercial hybrids were found to be infected with *A. tragopogonis*.

DISCUSSION

White rust develops in newly planted sunflower fields following infection by soil-borne inoculum from a previous crop, or wind-borne inoculum from infected plants in surrounding fields (Kolte, 1985). The occurrence of *A. tragopogonis* in sunflower seeds would provide an important new means whereby the disease could be introduced into new areas. Seed-borne oospores of *Albugo candida* (Pers. ex. Lev.) Ktze. were previously identified as a possible cause of primary infections of turnip rape (*Brassica campestris* L.) (Petrie, 1975) and radish (*Raphanus sativus* L.) (Petrie, 1986). Circumstantial evidence indicates that seeds colonized with oospores of *A. tragopogonis* might be a likely source of infections of sunflower in fields or countries where the disease has not been observed previously. Systemically infected seedlings, which have been observed in the field before (Van Wyk *et al.*, 1995), may be indicative of primary infections by seed-borne inoculum. Also, white rust has appeared dramatically on relatively weed-free fields on which the crop had not been grown previously, and which were planted out of season many miles from other sunflower fields (Potgieter, personal communication). The seeds used in these specific fields were harvested from plants heavily infected with *A. tragopogonis*.

There are two potential ways in which white rust can develop following seed infection. The first is by means of systemically infected seedlings, and the second is by the primary infection of cotelydons or new leaves by oospores in the seed hull. Mixing of oospores of *A. candida* with seeds of turnip rape prior to sowing has resulted in significant increases in local (foliar) infection and systemically infected plants in field plots (Verma and Petrie, 1980). However, efforts to prove such infections on sunflower seedlings in the greenhouse by planting seeds containing oospores, and seeding of oospores of *A. tragopogonis* with seeds, were unsuccessful (Viljoen, unpublished data). A possible explanation is that these experiments were hampered by the lack of knowledge required for germination of oospores of *A. tragopogonis*.

Albugo tragopogonis is closely related to *Plasmopara halstedii* (Farl.) Berl., the causal organism of downy mildew of sunflower. Both these organisms belong to the family Peronosporales, and infect their host by releasing motile zoospores in the presence of free water (Alexopoulos and Mims, 1979). *Plasmopara halstedii* has been widely distributed by the seed trade, and now occurs in all sunflower-produc-

Figure 1: White rust pustules on involucral bracts of sunflower

Figure 2: Subepidermal oospore formation on receptacles of sunflower

Figure 3: Lateral section through sunflower head showing grey lesions caused by oospores of A. tragopogonis at the base of floral disks and developing seeds

Figure 5: Oospores of Albugo tragopogonis in the pericarp of sunflower seeds

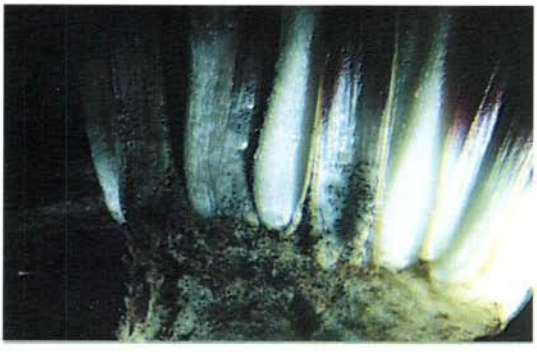

Figure 4: Disk bracts and receptacles infested with oospores of Albugo tragopogonis

ing countries except Australia (Gulya *et al.*, 1997). Although seed-borne inoculum of *P. halstedii* is the primary means of introduction to new areas, it results in low percentages of systemically infected plants (Kolte, 1985). Zoospores of *P. halstedii* infect rootlets, primary roots and hypocotyls of emerging sunflower seedlings by encysting and penetrating host cells in the zone of elongation of the primary root, while those of *A. tragopogonis* encyst in stomata of stems and leaves of sunflower before penetration (Kolte, 1985). The occurrence of sunflower seedlings systemically infected with white rust in the field (Van Wyk *et al.*, 1995) suggests that the possibility of root penetration, although unlikely, should therefore not be ignored.

Primary infection of the cotyledons by oospores in the seed hull provides a likely chance of seed transmission of *A. tragopogonis*. Oospores can either germinate to release their zoospores directly onto the cotyledons of seedlings immediately after emergence, or they can be released in the soil and infect sunflower seedlings in following seasons. The importance of infected seed, therefore, may lie in the introduction of the pathogen to soil where the fungus can persist for more than 5 years (Saharan and Verma, 1992) rather than in the infection of the new seedling.

In all species of *Albugo*, sporangiospores and oospores germinate to release biflagellate zoospores. These zoospores then encyst and form a germ tube which enters the host through stomata (Saharan and Verma, 1992). The present study, however, suggests that colonization of the receptacle can take place even in the absence of stomata. Attempts to reproduce head and seed infections by artificial inoculation were unsuccessful, probably because of the absence of the very specific environmental conditions required for such infections. The possibility exists that sporangiospores are deposited by wind onto sunflower heads. After zoospores are released, they encyst in the cavities between the disk flowers where they germinate and enter host tissue. Since *A. tragopogonis* only colonized the endocarp of seeds on the adaxial side of the receptacle, we believe that the fungus enters the seeds through the micropyle and perhaps funiculus after colonization of the heads and floral bracts. In contrast to systemic infection of seeds by *P. halstedii* (Novotelnova, 1976), infections by *A. tragopogonis* develop locally (Kruger and Viljoen, unpublished data). Lesions that develop on the base of receptacles probably do not contribute to seed infections, unless the receptacle is very thin.

This study has shown conclusively that seeds can be infected with and possibly act as carriers of *A. tragopogonis*. To ascertain whether infected seeds pose a danger as a source of infection, extensive field and greenhouse experiments will be required.

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INFECCIÓN DE CABEZA Y SEMILLA DE GIRASOL POR EL HONGO *Albugo tragopogonis*

RESUMEN

Albugo tragopogonis es ligado con la apariencia de manchas de hoja, coloración gris de peciolo y manchas del tallo de girasol. Por este estudio, el hongo es ligado con la cabeza de girasol. Ademas de ooesporas del hongo *A. tragopogonis*, que se formaron a las hojas corneas de involucro, las estructuras sexuales del hongo se desarrollaban también en la base del disco floral. En este segundo caso, las ooesporas eran encontradas a las hojas corneas de cabeza, al peciolo y al pericarpio de semilla, pero no a las flores tubulares y papuses. Parece que estas infecciónes se hacian en ausencia de stromata. Suponese que la posibilidad de translación del hongo *A. tragopogonis* por semillas es pequena.

INFECTION DE LA TETE ET DE LA SEMENCE DU TOURNESOL PAR L'*Albugo tragopogonis*

RÉSUMÉ

L'*Albugo tragopogonis* est associé à l'apparition de taches sur les feuilles, à l'apparition progressive de couleur grise sur les feuilles et à celle de taches grises sur la tige du tournesol. Cette étude a en outre pu montrer que le champignon touche aussi la tête du tournesol. En plus d'oospores d' *A. tragopogonis* qui se sont formées sur les bractées involutives, des structures sexuelles du champignon se sont développées à la base des disques floraux. Dans ce cas, des oospores ont été observés dans la bractée, le réceptacle et le péricarpe des semences, mais pas dans les disques floraux ou les corolles. Il semble que ces infections soient apparues en l'absence de stromas. On suppose que la possibilité de transmission du champignon *A. tragopogonis* par la semence est réduite.