THE POSSIBILITY OF BIOLOGICAL CONTROL OF DODDER, *CUSCUTA* SPP. IN AUSTRALIA

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Summary. Ten species of parasitic dodders, *Cuscuta* spp., occur in Australia. *Cuscuta compestris* is particularly important as a crop pest. The possibility of the biological control of this species is discussed with particular reference to studies in Pakistan and Kazakhstan. The fly, *Melanagromyza cuscutae*, and the weevils, *Smicronyx* spp., are sufficiently damaging and specific to be used as agents. The fungus, *Alternaria cuscutacidae*, could be used as a bioherbicide. However, it is recommended that surveys for agents be carried out in the U.S.A. where *C. campestris* originated.

Dodders, *Cuscuta* spp., are parasitic plants evolved from the Convolvulaceae and are placed there or in the related monogeneric Cuscutaceae (10, 19, 32). Evolutionary reduction due to parasitism has been very great. On germination the seeds produce a twining vine. This roots briefly, just until a plant host is contacted. The almost chlorophyll-less vine, with rudimentary scale-like leaves, then produce haustoria which attach frequently and which invade the host leaves and stems. Flowering occurs later, as the dodder starts to smother its host (19). *Cuscuta* evolved mainly in the Northern Hemisphere (19, 30). *Cuscuta* spp. are most important as parasites of lucerne, clover, other legumes, flax, sunflower, truck crops and many ornamentals. Their biologies and control methods have been comprehensively reviewed (2, 9, 33). The twining vines deprive the host plant of nutrients and inhibit growth and fruiting. They also transmit viral and mycoplasma diseases. In Australia they infest both native and exotic plants and crops (7, 25, 31) and considerable amounts of herbicide are used to control them (23).

Ten species of *Cuscuta* occur in Australia (Johnson, pers. comm. 1985). Five of these; *C. campestris*, *C. suaveolens*, *C. epithymum*, *C. europaea* and *C. planiflora*, have been inadvertently introduced, of the native species two; *C. australis* and *C. chinensis*, are widespread Asian/Australasian species and three; *C. tasmanica*, *C. tatei*, *C. victoriana* are Australian only (34). *C. australis* and *C. epithymum* were once considered to be important crop pests in Australia (25, 31) but recently *C. campestris*, has been identified as the main crop pest in south-eastern Australia (23, L. Smith, pers. comm. 1986). This species originated in western U.S.A. but it is now widely distributed (34). *Cuscuta* spp. can be divided into a thick-vined group, which parasitizes shrubs and trees, and a thin-vined group, that include *C. campestris*, which infests herbaceous plants (18).

BIOLOGICAL CONTROL STUDIES

The possibility of controlling *Cuscuta* by biological means has been reviewed (3, 11). The main surveys for and studies of biological control agents have been carried out in Pakistan (4) but agents have also been studied in Kazakhstan (22), Hungary (13) and Yugoslavia (21). No surveys have been made in the U.S.A.

As dodders lack roots and have rudimentary leaves, only the vines and fruits are available as feeding niches. Because *Cuscuta* is related to the Convolvulaceae, sweet potato, *Ipomoea batatas*, would be the critical test plant for potential agents. Only the agents which have been studied in detail are considered here. Of these, the tortricid moth, *Herpystis cuscutae*, was

not specific enough to be used as an agent (6, 8).

Melanagromyza cuscutae, an agromyzid fly studied in Pakistan and Kazakhstan, is specific to *Cuscuta* (5, 15, 16). Adult flies will only mate and develop eggs after feeding on the sap of a *Cuscuta* plant. Eggs are laid into dodder vines and the larvae bore and pupate in them. The vines gradually dry up and die. A generation takes about 24 days. The flies destroy *Cuscuta* vines in spring and autumn in hot regions and during summer in cooler regions. In Pakistan the fly was common on thick-vined *C. reflexa* but it has been recorded from thin-vined *C. europaea* in Germany (27) but not from *C. campestris* *M. cuscutae* is a relatively easy organism to manipulate. In Kazakhstan, fruits and vines of *Cuscuta* spp. infested with fly pupae have been stored over winter. In spring, emerging adults are used to augment the natural occurring populations (15, 16). *M. cuscutae* from Pakistan was introduced to Barbados and released against two local *Cuscuta* spp. but it did not establish (11).

Smicronyx spp. weevils have co-evolved with *Cuscuta* (1) and in each region of the world where *Cuscuta* occurs there is a group of *Smicronyx* spp. adapted to the local species of dodder (1, 12, 13, 14, 18). Although in North America many *Smicronyx* spp. are restricted to *Cuscuta*, some occur on other herbaceous plants, mainly Compositae, which are, or were, hosts of *Cuscuta*. In the Old World, the parasitic plants *Orobanche* and *Striga* are also hosts for *Smicronyx* weevils (1).

Smicronyx spp. have been studied in Pakistan (3, 18), in Kazakhstan (26, 28) and Hungary (13). In all these regions the weevils have several generations a year infesting successively one or more species of dodder. Adults feed on the vines and their larvae feed in the vines and/or the fruit or produce galls on the vines. The attack either destroys the *Cuscuta* plants or seriously reduces fruiting. In Pakistan, seven *Smicronyx* spp. were found on three thick-vined and five thin-vined *Cuscuta* spp., including *C. campestris* and *C. chinensis* (18). Only one weevil was found on both thick and thin-vined dodder. The others occurred only on one type of vine. Only *S. rufovittatus* was recorded on *C. campestris*.

After testing against related plants *S. roridus* (as *S. cuscutae*) was considered specific to *Cuscuta* (3). An additional four *Smicronyx* spp. were tested against Convolvulaceae and cultivated crop plants (18). The weevils are sufficiently host restricted to be used as agents. Subsequently, *S. rufovittatus* was transported from one region and released in another region of Pakistan and successfully established on *C. campestris*. *S. roridus* from Pakistan was introduced to Barbados to control local *Cuscuta* spp. Like *M. cuscutae*, it did not establish (11, 17). However, in Bangladesh *S. roridus* was also introduced to control *C. reflexa* and establishment probably did occur (11).

In Kazakhstan, *S. jungermanniae* has been artificially bred in high numbers and released onto *C. campestris* successfully retarding and destroying that dodder and causing a reduction in parasitisation of its hosts for several years (28). Also emerging adults of *S. tataricus* were collected in southern regions and effectively released in numbers as an agent against *C. campestris* in northern regions of Kazakhstan (26). In Hungary *S. jungermanniae* reduces fruiting of *C. campestris* by up to 40% (13) whilst in Yugoslavia *S. seriespilosus* attacks *C. campestris* (21). The augmentative use of both *S. tataricus* and *S. jungermanniae* indicates that these agents would be relatively easy to manipulate as agents. However, neither *S. tataricus* nor *S. jungermanniae* have been tested to demonstrate specificity to *Cuscuta* spp.

Alternaria cuscutacidae attacks *C. campestris* and *C. cupulata* in southern U.S.S.R. Mass production by fermentation was developed and the fungus employed as a bioherbicide to control dodder infestations on their plant hosts (24). This fungus has been shown to be safe to use on lucerne and sugar beet crops which were unaffected by massive amounts of infective stages. Another fungus, *Colletotrichum destructivorum*, destructively attacks *C. campestris* in Oregon (20).

DISCUSSION

Based on what is known about the damage casued by host-restricted agents on *Cuscuta* spp. in various parts of the world, there is the possibility of biological control of *C. campestris*, in Australia. However, it is now generally accepted by workers in biological control of weeds that agents with sufficient specificity adapted to a particular weed are more likely to be found in the weed's native range. Since the agents in Pakistan are clearly adapted to their native *Cuscuta* spp. most of the studies there could be irrelevant to control of *C. campestris* in Australia. Thus, the first priority would be to survey the regions of the U.S.A. infested by *C. campestris* for suitable agents on the weed there. These would include *Smicronyx* weevils native to the U.S.A. but would not include *M. cuscutae* which is only Eurasian in occurrence.

In the interim, Europe and/or Pakistan could be searched for strains of *M. cuscutae* attacking *C. campestris*. If found, they could be introduced immediately under quarantine to Australia for further testing. Consideration could also be given to the introduction of the fungus *A. cuscutacidae* after adequate additional testing. The introduction of non-obligate pathogens to Australia for weed biological control and subsequent development as bioherbicides has recently been recommended (29).

REFERENCES

1. Anderson, D.M. 1962. Proc. U.S. Nat. Museum 113, 187-372.
2. Ashton, F.M. 1976. Bull. Agric. Expt. Station, Univ. California (College Agric. Sci.) No. 1980, 20 pp.
3. Baloch, G.M. 1968. PANS 14, 27-33.
4. Baloch, G.M., Din, I.M. and Ghani, M.A. 1967a. CIBC Tech. Bull. No. 8, Commonwealth Agric. Bureau. pp. 149-158.
5. Baloch, G.M., Mohyuddin, A.I. and Ghani, M.A. 1967b. Entomophaga 12 (5), 481-489.
6. Baloch, G.M., Mohyuddin, A.I. and Ghani, M.A. 1969. Entomophaga 14 (2), 119-128.
7. Black, J.M. the late 1980. Flora of South Australia. 2nd ed. Part IV. Oleaceae-Compositae. Revised by E.L. Robertson, (Government Printer: South Australia), pp. 685-1008.
8. Bradley, J.D. 1968. Bull. Ent. Res. 57, 615-618.
9. Dawson, J.H., Ashton, F.M., Welker, W.V., Frank, J.R. and Buchanan, G.A. 1984. U.S.D.A. Agric. Res. and Ext. Service. Tech. Bull. No. 2276, 24. pp.
10. Engler, A. 1964. Syllabus der Pflanzenfamilien II Band Angiospermen. (Gebruder Borntraeger: Berlin). 666 pp.
11. Girling, D.J., Greathead, D.J., Mohyuddin, A.J. and Sankaran, T. 1979. Biocontrol News and Information. Commonwealth Agric, Bureau Sample Issue, pp. 7-16.
12. Hoffman, A. 1958. Coleopteres Curculionides. 3 eme Partie. Faune de France No. 62. (Librairie de La Faculte des Sciences: Paris), pp. 1209-1839.

13. Horvath, Z. 1983. Production System of Sunflower, Bacsalmas, Hungary. Novenyvedelem, 19, 501-508.
14. Hustache, A. 1930. Ann. Soc. Ent. France. 99, 81-272.
15. Ivannikov, A.I. 1969. Vest. sel'-khoz. Nauki Alma-Ata 12, 85-88.
16. Ivannikov, A.I. 1972. Kazakhstan Zashch. Rast. 17, 23-24.
17. Julien, M.H. 1982. Biological Control of Weeds; A World Catalogue of Agents and their Target Weeds. CIBC, (Commonwealth Agric. Bureau), 108 pp.
18. Khan, A.G. and Zafar, T. 1981. Biologia 27, 265-273.
19. Kuijt, J. 1969. The Biology of Parasitic Flowering Plants. (Univ. California press: Berkeley) 246 pp.
20. Leach, C.M. 1959. Plant. Dis. Rep. 42, 827-829.
21. Lekic, M.B. 1970. Proc. 1st Int. Symp. Biol. Contr. Weeds 1969. CIBC Misc Publ. No. 1, pp. 21-24 (Commonwealth Agric. Bureau).
22. Marikovskii, P. and Ivannikov, A.I. 1966. Kazakhstan. Zashch. Rast. 11, 27-28.
23. McKenzie 1986. Minutes 3rd Meet. of the Interstate working party on Golden Dodder: Mildura, 3 April 1986.
24. Miusov, I.N. and Bashaeva, E.G. 1968. Vest. sel'khoz Nauki Alma-Ata 11, 87-90.
25. Parson, W.T. 1973. Noxious Weeds of Victoria. (Inkata Press, Melbourne), 300 pp.
26. Shinkarenko, V.A. 1982. Kazakhstan Zashch. Rast. 7, 30-31.
27. Spencer, K.A. 1973. Agromyzidae (Diptera) of Economic Importance. (Junk: The Hague), 418 pp.
28. Tyurebaev, S.S. 1977. Vest. Sel. Skokhoz. Nauki Kazakhstana 20 (3), 116-117.
29. Wapshere, A.J. 1987. J. Aust. Inst. Agric. Sci. 53, (In press).
30. Weber, J.Z. 1981. J. Adelaide Bot, Gard. 3, 187-262.
31. Whittet, J.N. 1968. Weeds. The Farmers Handbook Series. 2nd Ed. (N.S.W. Dept. of Agric.: Sydney), 486 pp.
32. Willis, J.C. the late 1973. A Dictionary of the Flowering Plants and Ferns. 8th ed. (Revised by H.K.A. Shaw). (Cambridge Univ. Press). 1245 pp.
33. W.R.O. (Weed Research Organisation). 1970, 1972, 1976, 1979, 1982. Annotated Biblio. Nos 32, 51, 100, 135, 146. (Commonwealth Agric. Bureau).
34. Yunckers, T.G. 1932. Mem. Torrey Bot. Club. 18, 114-331.