Annotated Bibliography on the Ecology and Management of Invasive Species:

Field bindweed (*Convolvulus arvensis* L.)

prepared by

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Peer-reviewed Journal Articles

Andreev, G., T. S. Gemishev, M. Dimitrova, D. Dragolova, and G. N. Vassilev. 2004. Effect of some growth-regulators on ATP-ase activity in maize (*Zea mays* L.) and meadow rye-grass (*Lolium perenne* L.) coleoptiles and in field bindweed (*Convolvulus arvensis* L.) hypocotiles. Oxidation Communications 27 (4): 979-984.

> Authors' abstract: The pH dependence and the effect of 3-indol acetic acid (IAA), gibberellic acid (GA(3)) and 6-furfurylaminopurine (kinetin) on the ATP-ase activity in nuclear fractions of maize and rye-grass coleoptiles and in field bindweed hypocotiles have been studied. A pH optimum of 7.0-7.5 has been established for the three objects under study. The individual growth-regulators do not exert a significant effect on the enzyme activity in the plants studied.

Austin, D. F. 2000. Bindweed (*Convolvulus arvensis*, Convolvulaceae) in North America—from medicine to menace. Journal of the Torrey Botanical Society 127 (2): 172-177.

> Author's abstract: *Convolvulus arvensis* L. is considered one of the worst weeds in the world by agriculturists and horticulturists; it has at least 84 common names. Bindweed is native to the Mediterranean region of the Old World, where it and a morphologically similar species, scammony (*C. scammonia* L.), both still are used medicinally. Although the first literature on *C. arvensis* referred to medicinal uses, it was also dispersed for ornament and by accident. Herbarium vouchers and literature were used to map the first occurrences of *C. arvensis* in each state. Bindweed was first reported in North America (Virginia) in the 1730s, and was sold commercially by mail in and from Pennsylvania by 1807. Over the decades, the reputation as a medicinal plant became lost. It was not until the 1880s that *C. arvensis* came to be considered a naturalized weed in North America, but efforts to eliminate this twining herb were not made until the early 1900s. Almost 100 years of battling this medicine-turned-pest have failed to effectively control the species.

Berca, M., and C. Chirila. 2004. Perennial weeds in agricultural crops of Romania from 1960-2002 and the relation to the soil type. Journal of Plant Diseases and Protection, Special Issue 19: 91-96.

> Authors' abstract: Out of the 40 perennial weed species present in agricultural crops in Romania, 19 species were considered to be most dangerous, 14 thereof are dicotyledonous, four are monocotyledonous and one is a species of Pteridophyta. *Cirsium arvense* and *Convolvulus arvensis* have a frequency of 70% and *Sonchus arvensis, Lathyrus tuberosis* and *Rubus caesius* 20-40%. All these species are dicotyledonous weeds. Perennial monocotyledonous weeds such as *Sorghum halepense* and *Elymus repens* are rapidly spreading. Some of the species depend strongly on the soil type and soil moisture as e.g. *Symphytum officinale* and *Equisetum arvense*. Others are favoured by the lack of adequate agricultural production techniques and climate

change. This is true for *Convolvulus arvensis, Cirsium arvense, Sorghum halepense, Elymus repens* and *Cynodon dactylon*, which at present are widely spread in Romania's agriculture.

Boldt, P. E., S. S. Rosenthal, and R. Srinivasan. 1998. Distribution of field bindweed and hedge bindweed in the USA. Journal of Production Agriculture 11 (3): 377-381.

Authors' abstract: A survey of weed specialists and herbaria was conducted by mail with telephone follow-up in 1994 and 1995 to determine the distribution, abundance, and economic importance of field bindweed (*Convolvulus arvensis* L.) and hedge bindweed [*Calystegia sepium* (L.) R. Br.] (Convolvulaceae) in the continental USA. Field bindweed occurs at densities regarded as serious (greater than 1000 acres/county) in 957 counties, moderate (between 250 and 1000 acres/county) in 845 counties, and low (less than 250 acres/county) in 573 counties in 47 of the 48 contiguous states. Only Florida and the southern parts of states from South Carolina to Texas do not report its presence. Field bindweed infestations have increased since 1970 in several western states but have decreased in importance in most Great Plains states. Based on detailed crop loss data for 10 states containing 52% of the seriously infested counties, we estimated the value of crop losses due to field bindweed in the USA at more than $377 million/yr. Hedge bindweed occurs at densities regarded as serious in 101 counties, moderate in 1109 counties, and low in 553 counties in 43 states. Although not as widespread as field bindweed, hedge bindweed appears to have increased in abundance since 1969 and continues to be a localized problem in the midwestern and eastern USA.

Boldt, P. E., and R. Sobhian. 1993. Release and establishment of *Aceria malherbae* (Acari: Eriophyidae) for control of field bindweed in Texas. Environmental Entomology 22: 234-237.

Authors' abstract: *Aceria malherbae* Nuzzaci (Acari: Eriophyidae) was imported from Greece to the United States and released in 1989 near Bushland, Texas, as a potential biological control agent for field bindweed, *Convolvulus arvensis* L. (Convolvulaceae). The number of gall mite–infested crowns increased from 2.0/m^2 in September 1989 to 9.5/m^2 in June 1991 but decreased to 4.0/m^2 in June 1992. In September 1991, 76.0% of the crowns were infested, and the gall mites had moved 9.6 m from the plot. Gall mites overwintered on rhizomes 0.1-6.0 cm beneath the soil surface, but 63.1% of those recovered were found in the top 1.0 cm of soil. This represents the first successful establishment of an introduced arthropod for biological control of a crop weed in the United States. The mite is now being released on field bindweed in South Dakota, New Jersey, and Oklahoma.

Boydston, R. A., and M. M. Williams II. 2004. Combined effects of *Aceria malherbae* and herbicides on field bindweed (*Convolvulus arvensis*) growth. Weed Science 52 (2): 297-301.

Authors' abstract: The effects of a gall mite (*Aceria malherbae*) and sublethal doses of either 2,4-DB or glyphosate on field bindweed growth were evaluated under laboratory conditions. Mite feeding reduced field bindweed shoot biomass 37 to 48% and root biomass 46 to 50%. 2,4-DB at 0.07 to 0.14 kg ae ha(-1) or glyphosate at 0.14 to 0.28 kg ai ha(-1) reduced field bindweed root biomass 25 to 52%. Combining *A. malherbae* feeding with either 2,4-DB or glyphosate application reduced root biomass of field bindweed plants more than mites or either herbicide alone. Live *A. malherbae* were present on field bindweed 3 wk after treatment with either herbicide. Combination of *A. malherbae* with sublethal herbicide doses may allow for field bindweed suppression while reducing potential herbicide injury to crops and maintaining *A. malberbae* populations.

Britten, D. C., G. L. Schuster, G. J. Michels, and D. A. Owings. 2003. Using cold-stored or overwintering *Aceria malherbae* Nuzzaci (Acarina: Eriophyiidae), a gall-forming eriophyiid mite, for infestation of field bindweed. Southwestern Entomologist 28 (4): 273-280.

Authors' abstract: Clippings of *Aceria malherbae* Nuzzaci–infested field bindweed, *Convolvulus arvensis* L., were used to successfully infest field bindweed in a greenhouse for up to 70 days after the clippings had been collected and stored at either 2°C or 4°C. Percentage of plants infested was significantly different between mites collected from the two sites (34.5% from Moore County and 16.5% from Carson County, Texas), and the ability of mites to infest plants decreased significantly as the number of days in storage increased. No significant difference in percentage of plants infested was found between years (27.8% in 1999 and 23.2% in 2000) or storage temperature (23.5% at 2°C and 27.5% at 4°C). Overwintering *A. malherbae* from field bindweed rootstock infested 66.7 and 75% of the field bindweed grown in a greenhouse, and it took an average of 24.5 (+/-6.6) and 21.4 (+/-4.5) days for the bindweed plants to begin showing damage symptoms in 1999 and 2000, respectively.

Cao, W. H., M. J. Horak, J. R. Nechols, and R. E. Charlton. 2003. Pheromone of the noctuid moth, *Tyta luctuosa* (Lepidoptera: Noctuidae), a candidate biological control agent of field bindweed. Environmental Entomology 32 (1): 17-22.

Authors' abstract: Laboratory studies were conducted to identify the sex pheromone of *Tyta luctuosa* (Denis and Schiffermuller), a Eurasian noctuid moth that has been imported and released to aid in control of field bindweed*, Convolvulus arvensis* L. Using gas chromatography–mass spectrometry, together with electro-antennogram and wind tunnel bioassays of male moths, two compounds, (Z)-9-tetradecenal and (Z)-11-hexadecenal, were identified as the major pheromone components. Whole-gland extracts contained these components, as well as two other major compounds, (Z)-9-tetradecanol and (Z)-11-hexadecanol. However, the two alcohols were not detected in airborne emissions of calling females. Ratios of Z9-14:ALD to Z11-16:ALD were markedly different for whole-gland extracts and airborne emissions (1:3 and 2:1, respectively). Also, although the total amount of the two compounds varied nearly eight-fold among individuals (22-167 ng, mean 75 +/- 56 ng [SD]) in gland extracts, the Z9-14:ALD/Z11-16:ALD ratio was relatively constant (0.3 +/- 0.15).

On average, calling females released 94 ng of Z9-14:ALD and 45 ng Z11-16:ALD per hour, with a mean ratio of 2.2. In wind tunnel tests, 69% of males exhibited complete upwind flights and touched the stimulus source in response to a synthetic pheromone blend that mimicked the female-produced Z9-14:ALD/Z11-16:ALD airborne concentration and ratio, as compared with 82% and 50% in response to calling females and pheromone gland extracts, respectively. *Tyta luctuosa* adults are vagile, and both adults and larvae are cryptic in the field—factors that make recoveries of released insects unlikely. Therefore, our data will contribute to the development of a pheromone-based monitoring tool to help assess colonization and establishment of this potentially useful weed biological control agent.

Chessman, D. J., M. J. Horak, and J. R. Nechols. 1997. Host plant preference, consumption, growth, development, and survival of *Tyta luctuosa* (Lepidoptera: Noctuidae) oil biotypes of field bindweed and hedge bindweed. Environmental Entomology 26 (4): 966-972.

Authors' abstract: Larval feeding preference, consumption, and development were assessed for the imported noctuid moth *Tyta luctuosa* (Denis and Schiffermuller) on 4 biotypes of field bindweed, *Convolvulus arvensis* L., and on hedge bindweed, *Calystegia septum* L. No preference, either innate or induced, was observed in 4th and 5th instars for any of the plant types tested. The food source of early instars did not significantly affect later instar development. Food plant type also did not significantly affect maximum larval weight or survival of 1st–5th instars. However, prepupal survival was significantly greater on field bindweed biotype 1. Development from the 4th instar to the prepupa was slower on hedge bindweed than on any of the field bindweed biotypes. Delayed development on hedge bindweed may be related to its higher wet/dry weight ratio. Our findings suggest that *T. luctuosa* may feed nonselectively on mixed biotypes of bindweed in the field. They also indicate that these biotypes would be generally, but not uniformly, suitable for the development and survival of *T. luctuosa.*

Dall'Armellina, A. A., and R. L. Zimdahl. 1989. Effect of watering frequency, drought, and glyphosate on growth of field bindweed (*Convolvulus arvensis*). Weed Science 37 (3): 314-318.

Authors' abstract: Greenhouse experiments were conducted to determine effects of watering frequency, drought stress, and a combination of watering frequency and glyphosate on growth of field bindweed. Watering daily, twice weekly, or weekly to field capacity affected field bindweed grown from seed differently than plants grown from root runner segments. Shoot and root dry matter of plants grown from seed increased when plants were watered frequently but dry matter allocated to root runners did not change when plants were watered less frequently. Plants grown from root runner segments increased their shoot and root runner dry matter when watered frequently, but root dry matter was not affected by watering frequency. Plants grown from seed had highest regrowth when watered weekly and plants grown from root runner segments had higher regrowth when watered daily. Drought reduced survival rate and dry matter of surviving plants. Frequency of watering and whether plants began from seeds or root runner segments influenced glyphosate action on field bindweed. No re-growth was observed 6 months after 1.5 kg ai/ha of glyphosate was applied to plants that had been grown for 8 weeks under three different watering frequencies.

Dall'Armellina, A. A., and R. L. Zimdahl. 1988. Effect of light on growth and development of field bindweed (*Convolvulus arvensis*) and Russian knapweed (*Centaurea repens*). Weed Science 36 (6): 779-783.

Authors' abstract: Field bindweed and Russian knapweed were grown from seed or rhizome segments under 520, 325, or 236 .mu.mol .cntdot. m-2 .cntdot. s-1 photosynthetic photon flux density (PPFD) to determine vegetative and reproductive response. Flower production in both species declined with decreasing light level. Leaf area of field bindweed decreased as light level decreased, but Russian knapweed leaf area increased as light intensity decreased from 520 to 325 .mu.mol .cntdot. m-2 .cntdot. s-1 PPFD or from 520 to 236 .mu.mol .cntdot. m-2 .cntdot. s-1. Dry matter of shoots, roots, and rhizomes of field bindweed grown from seed declined as light level decreased, but the only response of plants grown from rhizome segments was complete inhibition of rhizome production. Dry matter of Russian knapweed shoots and roots in plants grown from seed or rhizome segments decreased as light decreased. In both species the total PPFD was more important than whether low or high light level occurred first.

Defago, G., H. U. Ammon, L. Cagan, B. Draeger, M. P. Greaves, D. Guntli, D. Hoeke, L. Klimes, J. Lawrie, Y. Moenne-Loccoz, B. Nicolet, H. A. Pfirter, R. Tabacchi, and P. Toth. 2001. Towards the biocontrol of bindweeds with a mycoherbicide. Biocontrol 46 (2): 157-173.

Authors' abstract: Within the framework of the European COST Action 816, a five-year collaboration between scientists from five European countries has made an important contribution to biological control of field and hedge bindweeds (*Convolvulus arvensis* and *Calystegia sepium*, respectively). A fungus *Stagonospora convolvuli* strain LA39, able to infect both field and hedge bindweed, was found in the UK and its biocontrol efficacy improved by optimizing mass production, formulation and storage techniques. This fungus controlled bindweeds in both a cemetery and in maize crops. Its use fits best in an integrated pest management system where a green cover controls most of the weeds except the bindweeds. DNA marker analyses indicate that the fungus reproduces sexually, which could be used to further improve this mycoherbicide. In addition, the insect *Melanagromyza albocilia,* which itself exhibits biocontrol potential against bindweeds, may be used in combination with LA39 to improve the ability of the fungus to penetrate the stem of bindweeds. Overall, the results suggest that *S. convolvuli* LA39 has promising potential as a bioherbicide for control of field and hedge bindweed.

Degennero, F. P., and S. C. Weller. 1984. Growth and reproductive characteristics of field bindweed *Convolvulus arvensis* biotypes. Weed Science 32 (4): 525-528.

Authors' abstract: Five presumed biotypes were identified among field bindweed clones collected from a field population near Lafayette, Indiana, USA. Consistent variations in leaf morphology, floral characteristics and accumulation of shoot and root biomass were found between biotypes when grown in a controlled environment. The biotypes also differed in their flowering capacity. The earliest flowering biotype formed flowers 23 days before the latest and produced 19 times more flowers per plant, which indicated further differences in seed production potential between biotypes. Pollination studies helped to differentiate biotypes within the population and showed that the presumed biotypes were self-incompatible. Vegetative reproduction potential of the biotypes varied from 1.8 to 74.5% in the number of root buds that developed into shoots. The variability in growth and reproduction observed between these field bindweed biotypes may explain the survival and adaptability of a population of this weed as environmental conditions and control practices change.

Eizenberg, H., Y. Goldwasser, G. Achdary, and J. Hershenhorn. 2003. The potential of sulfosulfuron to control troublesome weeds in tomato. Weed Technology 17 (1): 133-137.

Authors' abstract: There are few efficient and cost-effective methods for controlling weeds in processing tomatoes. Sulfosulfuron is a sulfonylurea herbicide developed for controlling weeds in wheat. In previous studies, we have demonstrated the efficacy of sulfosulfuron in selectively controlling *Orobanche aegyptiaca* in tomato. The objective of the present study was to elucidate the potential of sulfosulfuron to selectively control troublesome, nonparasitic weeds in tomato. In the greenhouse, sulfosulfuron efficacy at 37.5, 75.0, and 112.5 g ai/ha applied preplant incorporated (PPI), preemergence (PRE), and postermergence (POST) was tested. Sulfosulfuron when applied PPI and POST was highly selective in controlling weeds without causing injury to tomato. The weeds that were efficiently controlled, even at low rates of application, included purple nutsedge, black nightshade, mustard, pigweed, and bindweed. PRE application resulted in the most efficient weed control but was phytotoxic to tomato at high rates.

el-Sayed, W., and K. Hurle. 2001. Efficacy of *Phomopsis convolvulus* as a mycoherbicide for *Convolvulus arvensis*. Meded Rijksuniv Gent Fak Landbouwkd Toegep Biol Wet. 66 (2b): 775-789.

Authors' abstract: The purpose of the investigations was to determine the efficacy of different conidia concentrations of *Phomopsis convolvulus* Ormeno on different leaf stages of *Convolvulus arvensis* seedlings and regrowth potential of *C. arvensis* 25 days after inoculation. Furthermore, the potential of *P. convolvulus* on the growth of *C. arvensis* derived from different root lengths was studied. The results showed a great reduction in dry weight of above-ground biomass with more than 80% irrespective of the conidia concentration (1 x 10(6), 10(7) and 10(8) conidia/ml) on plants of the leaf stage 1-3 and 5-7 and gave more than 80% reduction of root biomass with an exception in case of 1 x 10(6) conidia/ml on plants of the leaf stage 9-11. Mortality was reached complete only with 1 x 10(8) conidia/ml on plants of the leaf stage 1-3. Regrowth potential of *C. arvensis* at more developed leaf stages was higher than at early leaf stages. Within the 3 categories of root lengths tested (5, 10 and 15 cm), the 1-3 leaf stage shoots showed the highest susceptibility to *P. convolvulus*. Obtained results illustrate that the application of *P. convolvulus* with 1 x 10(8) conidia/ml at the young leaf stage (1-3 leaf stage) on all treatments gives a great reduction of biomass and adversely affects regeneration of the plants.

el-Sayed, W., A. Kang, and K. Hurle. 2002. Infection process of *Phomopsis convolvulus* as a mycoherbicide for *Convolvulus arvensis* L. Journal of Plant Diseases and Protection 109 (2): 180-192.

Authors' abstract: The fungus *Phomopsis convolvulus* Ormeno has been suggested as a mycoherbicide for the control of field bindweed. Because no information exists about the mechanisms of infection and penetration, the main objective of this study was to investigate these processes. The mode of infection of *P. convolvulus* on field bindweed was examined using light microscopy, scanning electron microscopy and transmission electron microscopy. Germination of conidia began 12 h after inoculation and most conidia had germinated 24 h after inoculation. The germ tube was usually smooth to rugose and most conidia produced a short germ tube. Between 24 and 48 h after inoculation, the germinated conidia developed appressorium either directly after germination or at the end of an elongated germ tube. *P. convolvulus* appressorium formed a penetration peg that directly penetrated the leaf surface, but penetration through stomata was not observed. *P. convolvulus* penetrated the leaf surface by mechanical force and enzymatic softening of the cell wall substances. In some sections, the formation of subcuticular hyphae was observed 2 days after inoculation. Three days after inoculation, inter- and intracellular hyphae were observed in the epidermal and mesophyll tissue. At an advanced stage of colonization, infected cells showed wall thickening and cytoplasmic plasmolysis. Hyphae could be seen in the vascular elements of the leaf and petiole. At nine days after inoculation, affected tissues were severely disrupted. The rapid collapse of the infected host tissues suggests that a toxin might play a role in the infection process of *P. convolvulus.*

Enloe, S. F., S. J. Nissen, and P. Westra. 1999. Absorption, fate, and soil activity of quinclorac in field bindweed (*Convolvulus arvensis*)*.* Weed Science 47 (2): 136-142.

Authors' abstract: Laboratory and greenhouse experiments were conducted to examine the absorption and fate of quinclorac in field bindweed and to assess the importance of quinclorac soil activity for field bindweed control. No foliar absorption of C-14-quinclorac occurred when applied alone, but absorption increased to 24% when quinclorac was applied with 2,4-D, 28% urea ammonium nitrate (UAN), and methylated seed oil (MSO). Quinclorac translocation in field bindweed was limited, as <18% of the total amount of absorbed radiolabeled material translocated out of the treated leaves 168 hours after treatment (HAT). Quinclorac metabolism in the treated leaves was minimal; 95% of the recovered C-14 was intact herbicide 168 HAT. Quinclorac soil activity on field bindweed was demonstrated in preemergence and soil subsurface applications. Preemergence application of 35, 70, 140, or 280 g ha(-1) quinclorac reduced field bindweed shoot growth. Field bindweed shoots exhibited auxinic herbicide symptoms at all quinclorac rates. Subsurface layering of quinclorac below the root system at rates of 35 and 280 g ha(-1) also reduced shoot and root growth. Both herbicide rates induced malformation in root structure with a proliferation of lateral branching, swollen and fused root tips, and malformed root buds. Shoot growth from surviving roots replanted in untreated media was also reduced in both herbicide treatments. These findings suggest quinclorac soil activity may be important for field bindweed control.

Enloe, S. F., P. Westra, S. J. Nissen, S. D. Miller, and P. W. Stahlman. 1999. Use of quinclorac plus 2,4-D for controlling field bindweed (*Convolvulus arvensis*) in fallow. Weed Technology 13 (4): 731-736.

Authors' abstract: Field studies were conducted in Colorado, Kansas, and Wyoming to compare the use of quinclorac plus 2,4-D with picloram plus 2,4-D, dicamba plus 2,4-D, a glyphosate plus 2,4-D premix, and 2,4-D alone for control of field bindweed (*Convolvulus arvensis*) in a winter wheat (*Triticum aestivum*)–fallow rotation. Treatments were applied in late summer or fall each year for two, three, or four consecutive years at the beginning and end of each fallow period. Evaluations were taken 10 to 12 mo after treatment each year. Quinclorac plus 2,4-D and picloram plus 2,4-D consistently performed as well as or better than 2,4-D, dicamba plus 2,4-D, and glyphosate plus 2,4-D. Wheat yields increased when field bindweed was controlled during the fallow period. Strong correlations ($r > -0.85$) were obtained among visual field bindweed evaluation, biomass, and stand count data.

Flint, J. L., and M. Barrett. 1989. Effects of glyphosate combinations with 2,4-D or dicamba on field bindweed (*Convolvulus arvensis*). Weed Science 37 (1): 12-18.

Authors' abstract: Applications of isopropylamine glyphosate at 0.28, 0.56, 0.84, and 1.12 kg ea/ha in combination with the dimethylamine salts of 2,4-D or dicamba at 0.14, 0.28, 0.42, and 0.56 kg ae/ha produced additive or synergistic field bindweed control compared to the herbicides applied alone. Leaf and root growth was inhibited more from herbicide combinations than would be predicted from the effects of the chemicals applied alone at the same rate. The uptake of 14C from glyphosate into the treated leaf and its accumulation in roots increased when 2,4-D or dicamba was combined with the 0.28 kg/ha rate of 14C-glyphosate. The combination of 2,4-D or dicamba with a higher (0.84 kg/ha) 14C-glyphosate rate did not change total absorption of 14C from glyphosate. However, compared to kg/ha of 14C-glyphosate applied alone, less 14C accumulated above the treated leaf and more accumulated in the roots when 2,4-D was added to the glyphosate. The combination of glyphosate with 2,4-D or dicamba generally resulted in both increased uptake of 14C from 2,4-D or dicamba and greater accumulation in the roots. The additive or synergistic field bindweed control observed from mixtures of glyphosate with 2,4-D or dicamba appeared to be due to greater accumulation of the herbicides in the roots.

Gehring, K., and N. Mulleder. 2004. Problem weed species in maize: a comparative assessment of Liberty Link and Roundup Ready systems. Journal of Plant Diseases and Protection, Special Issue 19: 855-862.

Authors' abstract: Weed control efficacy of field bindweed (*Convolvulus arvensis*) and yield responses to Liberty (glufosinate ammonium) and Roundup (glyphosate) over the top treatments were investigated in a side-by-side comparison of Liberty Link and Roundup Ready maize. None of the Liberty Link treatments in their respective herbicide tolerant crops achieved control levels of field bindweed as high as the standard dicamba treatment over a three-year period. Roundup Ready sequential applications reached the level of standard treatments. To some extent the addition of ammonium sulfate fertilizer in Roundup treatments stabilized weed control efficacy. No significant yield response was observed in any of the Liberty or Roundup treatments as compared to the standard dicamba treatment, however a 30% to 40% yield increase was observed compared to the untreated check.

Gelbard, J. L., and S. Harrison. 2003. Roadless habitats as refuges for native grasslands: interactions with soil, aspect, and grazing. Ecological Applications 13 (2): 404-415.

Authors' abstract: The idea that roadless habitats act as refuges for native-plant diversity against exotic-plant invasion has seldom been tested. We examined the effect of distance from roads and its interactions with soil type, aspect, and livestock grazing on native- and exotic-plant diversity in a 130 000 ha inland California (USA) foothill grassland landscape. During spring 2000 and 2001, we measured the numbers of and cover by native and exotic plant species in 92 sites stratified by distance from roads (10 m, 100 m, and > 1000 m), soil type (nonserpentine and serpentine), and aspect (cool, warm, and neutral slopes). In nonserpentine grasslands, native cover was greatest in sites >1000 m from roads (23%) and least in sites 10 m from roads (0%), and the percentage of species that were native was significantly greatest in sites > 1000 m from roads (44%) and least in those 10 m from roads (32%). In addition, the most distant sites had the largest number of native grass species and the fewest exotic forb species. In serpentine grasslands there was no significant effect of distance from roads on the numbers of and cover by native and exotic species. On both soils, two exotic species (*Centaurea solstitialis* and *Aegilops triuncialis*) were at their lowest frequencies, while a native bunchgrass, *Nassella pulchra*, was at its highest frequency, in sites > 1000 m. from roads. On nonserpentine soils only, the exotics, *Convolvulus arvensis* and *Polypogon monspeliensis*, were at their lowest frequency, while a native bunchgrass, *Poa secunda*, was at its highest frequency in the most distant sites. Native species were more abundant on serpentine than nonserpentine soils; on serpentine, natives were more abundant on slopes than flat sites, while on nonserpentine, natives were least abundant on warm, south-facing slopes.

Grazing, soil type, and aspect all significantly interacted in their effects on native and exotic richness and cover. Grazing negatively affected the number of native grass species, but not the number of native forb species on nonserpentine, and positively affected the number of native forb species, but not the number of native grass species on serpentine.

Roadless areas are significant refuges for native species. To protect these habitats from the continued threat of invasion, however, land managers should consider means of preventing construction of new roads, limiting off-highway vehicle access into grasslands with low road densities, identifying a regime of livestock grazing that favors the persistence of natives over the spread of exotics, and monitoring recreational trails and grazing allotments within roadless areas to detect and eradicate new infestations.

Guntli, D., H. A. Pfirter, Y. Moenne-Loccoz, and G. Defago. 1998. *Stagonospora convolvuli* LA39 for biocontrol of field bindweed infesting cotoneaster in a cemetery. Hortscience 33 (5): 860-861.

Authors' abstract: Field bindweed (*Convolvulus arvensis* L.) infests roadsides, hedges, and parks, and is difficult to control with herbicides. In this work, the potential of the mycoherbicide *Stagonospora convolvuli* Dearness and House strain LA39 for use as a biological control of field bindweed was tested in a cemetery, where a groundcover of cotoneaster was extensively infested by the weed. Application of *S. convolvuli* resulted in extensive necrosis of field bindweed leaves within 20 days, and necrosis became more extensive in the 20 following days. Bindweed density decreased continuously to about half of that in the uninoculated control plots within 40 days after application. No effect on emergence of field bindweed was observed in the year following the application of *S. convolvuli*. In conclusion, *S. convolvuli* may be useful as a mycoherbicide for the control of field bindweed in amenity areas but it would need to be applied every year.

Heiny, D. K. 1994. Field survival of *Phoma proboscis* and synergism with herbicides for control of field bindweed. Plant Disease 78 (12): 1156-1164.

Author's abstract: Small plot field tests were conducted in Washington County, Arizona, and Phillips County, Colorado, to determine the efficacy of *Phoma proboscis* conidia in control of field bindweed (*Convolvulus arvensis*) under various temperature and moisture conditions during 1990-1993. Treatments included combinations of conidia with a formulation of 2,4-dichlorophenoxyacetic acid (2,4-D) and 2-(2-methyl-4-chlorophenoxy)propionic acid (MCPP) used at a sublethal dose of 18 g a.i./ha, the surfactants Activate 9-0 or Activate Plus, corn oil, or sodium alginate. Dew periods of less than 6 hr or temperatures less than 10°C or approaching 32°C were inhibitory to the infection process required for field bindweed control. A rate of 10(7) conidia per milliliter in combination with a sublethal dose of 2,4-D and MCPP increased disease to the level achieved with 10(8) conidia per milliliter and controlled field bindweed. The 10(8) conidia per milliliter rate in combination with a sublethal dose of 2,4-D and MCPP killed mature field bindweed tissue during the later part of the growing season (31 July and 4 September 1992) when dew periods were adequate (8-10 hr). Air-dried conidia were as effective as fresh conidia in causing disease. Nylon membranes and field bindweed stems infested with *P. proboscis* were buried at 1-, 10-, and 20-cm depths at the Arkansas field site and recovered monthly during the winters of 1991-1992 and 1992-1993. No significant difference was found in fungal survival due to depth of burial. Higher winter survival frequencies in the second year were associated with 2-4°C lower average monthly soil temperatures relative to the first year. Survival frequency was higher on membranes than on stems.

Heiny, D. K. 1990. *Phoma proboscis:* new species pathogenic on *Convolvulus arvensis*. Mycotaxon 36 (2): 457-472.

Author's abstract: *Phoma proboscis* Heiny pathogenic on field bindweed (*Convolvulus arvensis* L.) is described and illustrated. *P. proboscis* is typified by rostrate pycnidia, eguttulate, occasionally septate conidia averaging 10.5 times 3.5 mu. mol., unicellular, spherical chlamydospores, and optimal growth at 20°C.

Heiny, D. K., and G. E. Templeton. 1991. Effects of spore concentration, temperature, and dew period on disease of field bindweed caused by *Phoma proboscis*. Phytopathology 81 (8): 905-909.

Authors' abstract: Spore germination of *Phoma proboscis* in vitro and resulting disease development were evaluated over a range of spore concentrations and after incubation at nine dew periods at each of five temperatures. Reduced percent germination on water occurred at spore concentrations above 10(7) spores ml-1. Spore germination on agar was optimal at 24°C. High levels of disease occurred on plants that received 12 h or more of dew at all temperatures tested, except 32°C. Fresh weight reduction in shoots and roots correlated well with disease ratings. Disease was enhanced relative to constant temperature treatments when plants from dew period temperatures of 16 and 20°C were maintained at a post-dew temperature of 24°C. The results of these studies suggest that *P. proboscis* has potential for use as a mycoherbicide.

Hoss, N. E., K. Al-Khatib, D. E. Peterson, and T. M. Loughin. 2003. Efficacy of glyphosate, glufosinate, and imazethapyr on selected weed species. Weed Science 51 (1): 110-117.

Authors' abstract: Experiments were conducted to determine the efficacy, absorption, and translocation of glyphosate, glufosinate, and imazethapyr with selected weed species. In the greenhouse glyphosate, glufosinate, and imazethapyr were applied at 0.25, 0.5, and 1 times their label rates of 1,121, 410, and 70 g ha(-1), respectively, on 10- to 15-cm black nightshade, common waterhemp, eastern black nightshade, field bindweed, giant ragweed, ivyleaf morningglory, prairie cupgrass, velvetleaf, and yellow nutsedge. Glyphosate applied at the 1-time rate caused injury greater than or similar to injury from the 1-time rate of glufosinate or imazethapyr on black nightshade, common waterhemp, eastern black nightshade, field bindweed, giant ragweed, prairie cupgrass, and velvetleaf. The 1-time rate of glufosinate injured ivyleaf morningglory and yellow nutsedge more than did the 1-time rate of glyphosate or imazethapyr. Under field conditions glyphosate caused the greatest injury to common waterhemp, prairie cupgrass, and velvetleaf across plant growth stages. Giant ragweed and ivyleaf morningglory injury was more dependent on growth stage, with the 15- and 30-cm growth stages more susceptible to glyphosate than to glufosinate or imazethapyr. Differential response of these weed species may be caused by differences in herbicide translocation. Glyphosate was translocated more in both giant ragweed and ivyleaf morningglory, and these species were injured more by glyphosate than by glufosinate or imazethapyr at the larger growth stages.

Kremer, R. J., and J. M. Li. 2003. Developing weed-suppressive soils through improved soil quality management. Soil and Tillage Research 72 (2): 193-202.

Authors' abstract: Manipulating soil microbial communities using soil and crop management practices is a basic strategy in developing sustainable agricultural systems. Sustainable farming is based, in part, on the efficient management of soil microorganisms to improve soil quality. However, the identification of biological indicators of soil quality that can be used to predict weed suppression in soils has received little attention. We investigated differences in soil microbial activity among various crop and soil management systems to assess: (i) the microbiological characteristics of these soils; (ii) determine whether any relationships existed that might be used in the development of weed suppression. Soil enzyme activity, water-stable aggregates, and the proportions of weed-suppressive bacteria were compared among seven cropping systems and one native-prairie ecosystem in mid-Missouri, USA. Assays of soil enzymes (fluorescein diacetate hydrolase, dehydrogenase, phosphatase) revealed that organic and integrated cropping systems, and the native-prairie ecosystem had the highest levels of soil activity. Weed rhizospheres from these same ecosystems also had greater proportions of bacterial isolates characterized as "growth suppressive" to green foxtail (*Setaria viridis* [L.] Beauv.) and field bindweed (*Convolvulus arvensis* L.): 15 and 10%, respectively. The proportion of water-stable soil aggregates was the greatest in soils with the highest organic matter and was found to be related to higher enzyme and weed-suppressive activity. Selected biological indicators of soil quality were associated with potential weed-suppressive activity in soil when that soil was managed for high organic matter content under reduced tillage systems. This research study provides further evidence that soil quality and sustainable agricultural practices may be linked to integrated weed management systems for the biological suppression of weeds.

Leishman, M. R., G. J. Masters, I. P. Clarke, and V. K. Brown. 2000. Seed bank dynamics: the role of fungal pathogens and climate change. Functional Ecology 14 (3): 293-299.

Authors' abstract: One of the climate change scenarios predicted for the UK is warmer winters and additional summer rainfall, which may favour growth and survival of fungal pathogens. We tested several hypotheses on the fate of persistent seeds in the soil and the role of fungal pathogens under this predicted climate change. We buried seed bags containing fungicide-treated and non-fungicide-treated seeds of four species with persistent seed banks (*Convolvulus arvensis* L., *Lotus corniculatus* L., *Medicago lupulina* L. and *Rubus fruticosus* L.) under control and simulated climate change (winter warming plus supplemented summer rain) conditions, and monitored seed survival over one to two years. Fungicide treatment resulted in a significant increase in the percentage of intact seeds recovered for only two of the four species, *M. lupulina* and *R. fruticosus*. Seeds of *M. lupulina* that were treated with fungicide remained viable in the soil for longer than non-treated seeds. Thus, the effect of fungal pathogens on seed persistence in the soil appears to be species specific.

There was no significant effect of the simulated climate (winter warming plus supplemented summer rain) on seed persistence in the soil, for any of the four species. Neither was a significant climate x fungicide treatment interaction found for any of the four species. Thus, it does not appear that the conditions provided in the simulated climate plots favoured the growth and survival of fungal pathogens affecting the soil seed banks of the four species studied here. The use of fungicides in manipulative experiments and the importance of field experiments that simulate predicted climate change are discussed.

McClay, A. S., J. L. Littlefield, and J. Kashefi. 1999. Establishment of *Aceria malherbae* (Acari: Eriophyidae) as a biological control agent for field bindweed (Convolvulaceae) in the northern Great Plains. Canadian Entomologist 131 (4): 541-547.

Authors' abstract: A European gall mite, *Aceria malherbae* Nuzzaci, was released and established in southern Alberta and Montana as a biological control agent for field bindweed, *Convolvulus arvensis* L. (Convolvulaceae). Populations of the mite survived for up to four years at some sites and caused slight to severe damage to the weed. The establishment of *A. malherbae* in these areas suggests that it could be established throughout the North American range of field bindweed.

MacDonald, R. T., J. C. Hall, J. J. O'Toole, and C. J. Swanton. 1993. Field bindweed (*Convolvulus arvensis*) control with fluroxypyr. Weed Technology 7 (4): 966-971.

Authors' abstract: Experiments were conducted under controlled environment and field conditions to evaluate the influence of growth stage and fluroxypyr dosage on control of field bindweed. In controlled environment studies fluroxypyr effectively controlled 8- to 12-leaf field bindweed. Shoot number, length, and dry weight, and root dry weight decreased as herbicide dose increased. The estimated ED(50) (effective dose for 50% reduction) values for shoot and root dry weight were 50 and 33 g ai/ha, respectively. The ED(50) for shoot length was 98 g ai/ha. Fluroxypyr was applied at rates from 0.2 to 0.4 kg/ha under field conditions to field bindweed at selected stages of growth. Regardless of herbicide dosage, fluroxypyr applied at the late flowering stage of growth controlled field bindweed better than when applied at the bud or early flower stage. Corn grain yield increased as a function of fluroxypyr dose in 1988 but not in 1987. Dry weight of roots and shoots of field bindweed harvested one year after treatment decreased with increasing rates of fluroxypyr. These studies demonstrate the potential of fluroxypyr for the control of field bindweed.

Miller, N. W., J. R. Nechols, M. J. Horak, and T. M. Loughin. 2000. Photoperiodic regulation of seasonal diapause induction in the field bindweed moth, *Tyta luctuosa* (Lepidoptera: Noctuidae). Biological Control 19 (2): 139-148.

Authors' abstract: Field and laboratory experiments were conducted to determine the influence of photoperiod on diapause induction in an Italian population of the moth *Tyta luctuosa* (Denis and Schiffermuller), which has been released as a potential biological control agent of field bindweed in North America. In the laboratory, the percentage of pupae that entered diapause at 25 degrees C was related inversely to photoperiod. Most, and possibly all, instars were sensitive to photoperiod. Sensitivity increased as a function of both the larval stage of development and the duration of exposure to diapause-inducing short day lengths. Soil-inhabiting, late fifth instars and pupae did not respond to photoperiod. All insects underwent diapause when reared in the laboratory at 13.5:10.5 (L:D) h. The critical photoperiod (50% diapause) was estimated to be between L:D 15:9 and 15.5:8.5 h. About 20% of *T. luctuosa* entered diapause under the longest day length (16:8 [L:D] h), indicating a strong tendency for diapause in this population. When *T. luctuosa* was field-reared under natural day lengths and temperatures, a variable but generally high percentage underwent diapause from spring to late summer. Under the shorter day lengths of August and early September, most of the insects entered diapause and the variation was lower. A variable diapause response may represent an adaptation to periods of unpredictable bindweed quality during summers in southern Europe. Our findings have immediate utility for developing mass-rearing and release strategies for *T. luctuosa*. In addition, they will allow better predictions of its phenology and population dynamics if this species becomes established in North America.

Monteiro, A., and I. Moreira. 2004. Reduced rates of residual and post-emergence herbicides for weed control in vineyards. Weed Research 44 (2): 117-128.

Authors' abstract: In 1997 and 1998, five field studies were conducted at four Portuguese wine-growing regions in order to evaluate the effectiveness of the chemical control of vineyard weeds under Mediterranean conditions using either reduced doses of residual herbicides or only foliar herbicides. Amitrole (3440 g a.i. ha(-1)), amitrole + glyphosate mono-ammonium salt (1720 + 900 g a.i. ha(-1)), amitrole (3400 g a.i. ha(-1)), amitrole + diuron (2580 + 1500 g a.i. ha(-1)), amitrole + simazine (2580 + 1500 g a.i. ha(-1)), amitrole + terbuthylazine (2580 + 1500 g a.i. ha(-1)) and amitrole + diuron + simazine (2580 + 1300 + 1400 g a.i. ha(-1)) were assayed and compared with the following reference herbicides: glyphosate isopropylamine salt (1800 g a.i. ha(-1)), amitrole + diuron (2520 + 1680 g a.i. ha(-1)), diuron + glyphosate + terbuthylazine (1275 + 900 + 1425 g a.i. ha(-1)), amitrole + simazine (1900 + 3900 g a.i. ha(-1)) and glyphosate + simazine (800 + 2200 g a.i. ha(-1)). The herbicides were applied during late winter. The results indicated that good control was achieved by the application of foliar herbicides alone or of reduced rates of a mixture of residual herbicides with foliar herbicides for at least 2 months. Three months after application, the efficacy of post-emergence herbicides and lower rates of residual herbicides decreased significantly in clay soils and under heavy rainfall conditions. *Convolvulus arvensis*, a weed that is becoming increasingly significant in Portuguese vineyards, was poorly controlled, even when glyphosate was used. Despite this, it can be assumed that in those regions in which the trials were conducted, it is possible to employ weed control strategies that entail the elimination or a reduction in the rate of residual herbicides.

Morin, L., A. K. Watson, and R. D. Reeleder. 1989. Efficacy of *Phomopsis convolvulus* for control of field bindweed (*Convolvulus arvensis*). Weed Science 37 (6): 830-835.

Authors' abstract: *Phomopsis convolvulus* Ormeno, a fungus, reduced growth and regeneration of field bindweed under greenhouse environments. Field bindweed seedlings at the cotyledon stage were severely injured and killed (95% mortality) with 108 conidia/m^2. Three- to five-leaf seedlings (2 weeks old) were controlled when inoculated with 109 conidia/m^2 (70% mortality; 98 and 89% reduction in dry weight of aboveground biomass and roots, respectively). This inoculum density reduced aboveground and root biomass, and adversely affected regeneration of 4-week-old seedlings and established plants, but few plants were killed. In controlled-environment studies, two inoculations were superior ($P = 0.02$) to one inoculation in reducing foliage aboveground of well-established seedlings (4 weeks old). However, new shoots produced between the first and second inoculation treatments were less diseased than expected.

Navarro-Ainza, J. A. C., R. L. Grijalva-Contreras, and A. Lopez-Carvajal. 2003. Field bindweed (*Convolvulus arvensis* L.) control on drip-irrigated asparagus. Hortscience 38 (5): 785.

Authors' abstract: Field studies were conducted during the 2000 season with the purpose of designing production technology for field bindweed control on a drip-irrigated asparagus plantation. Agricultural drip irrigation systems are being increasingly used in the Caborca area due to water constraints. It is therefore important to find ways of improving the efficiency of this irrigation infrastructure. Treating every 30 days exhibited better field bindweed control than treating every 60 days. Applications to both soil and leaves was also found to be important. Treatment of 150 cc/ha Dicamba and 2,4-D (through drip system) and 200 cc/ha (foliar) resulted in a reduction of 50% and 80% on the field bindweed shoot length and coverage respectively, in relation to the control plot. Caution should be used when applying Dicamba and 2,4-D through the drip irrigation system because this combination is very aggressive. Glyphosate 3% resulted in 35% and 60% higher shoot number per plant than the other treatments. A non-conventional treatment of acetic acid applied at 10% through the drip system, and *Larrea tridentata* juice extracts applied at 15% through the drip system and 20% foliar resulted in reductions of 30% and 40%. The asparagus plants were not affected, but further tests over more growing seasons are required to better determine the performance and effects of this non-conventional product.

Ormeno-Nunez, J., R. D. Reeleder, and A. K. Watson. 1988. A foliar disease of field bindweed *Convolvulus arvensis* caused by *Phomopsis convolvulus*. Plant Disease 72 (4): 338-342.

Authors' abstract: *Phomopsis convolvulus* was identified as the causal agent of leaf spots and anthracnose lesions on field bindweed (*Convolvulus arvensis*). Seedlings (10-14 days old) were killed after spray inoculation with alpha-conidia concentrations of 5 x 10^6 spores/ml or more. Increasing inoculum concentrations from 1 x 10^5 to 5 x 10^6 spores/ml resulted in decreases in foliage dry weight. At 20°C, a dew period of more than 3 hr was required before seedling death occurred or before significant reductions in dry matter were evident. The dew period following inoculation could be delayed for up to 48 hr without significantly decreasing disease ratings. Shoot re-growth occurred, however, when the delay was 24 hr or more. Disease severity and mortality following 24-hr dew periods were greater when dew period temperatures were at 20 or 30°C than when at 10°C. When plants were exposed to various temperatures (10-30°C) after a 24-hr dew period, no differences in disease severity were evident. These results suggest that this fungus has potential as a myco-herbicide.

Pandey, J., and A. K. Verma. 2002. Effect of atrazine, metribuzin, sulfosulfuron and tralkoxydim on weeds and yield of wheat (*Triticum aestivum*). Indian Journal of Agronomy 47 (1): 72-76.

Authors' abstract: An experiment was conducted during the winter seasons of 1997-98 and 1998-99 to find out the effect of four herbicides on weeds and yield of wheat (*Triticum aestivum* L. emend. Fiori and Paol.). Of the herbicides, metribuzin being most potent killer of weeds, eliminated *Chenopodium album* L. and gave excellent control of all other weeds. Only this herbicide paralyzed severely the growth of *Convolvulus arvensis* L. till harvest of the crop. The next best treatment was atrazine. Its effect on *C. album* was similar to that of metribuzin. It gave remarkable control of *Phalaris minor* Retz., but its effect on *Avena ludoviciana* was inconspicuous while vivid on all other weed species. Isoproturon gave good control of *P. minor* and *C. album* and satisfactory control of all other weed species except *C. arvensis*. Sulfosulfuron proved more effective than tralkoxydim in controlling *A. ludoviciana*. Both the herbicides were effective against *P. minor.* Weed population and weed dry weight were significantly lower under weed-control treatments. The lowest was in metribuzin and it proved significantly superior to all other treatments in arresting both weed population and weed dry matter. The next best treatments were hand-weeding and atrazine. Weed competition resulted in significant decrease in wheat plant height, productive tillers/m row length, grains/panicle and 1,000 grain weight and lowered crop yield by 27.2%. All the weed control treatments caused significant increase in yield attributes and yield in both the years. Hand-weeding affected maximum increase in grain yield which proved significantly superior to all other treatments except metribuzin (150 g/ha). No significant difference existed between atrazine (100 g/ha) and metribuzin.

Pfirter, H. A., H-U Ammon, D. Guntli, M. P. Greaves, and G. Defago. 1997. Towards the management of field bindweed (*Convolvulus arvensis*) and hedge bindweed (*Calystegia sepium*) with fungal pathogens and cover crops. Integrated Pest Management Reviews 2 (2): 61-69.

Authors' abstract: The bindweeds *Calystegia sepium* and *Convolvulus arvensis* are difficult to control chemically. *Calystegia sepium* is often a problem in maize or in vineyards, while *Convolvulus arvensis* is an important weed of cereals. The biological control of these weeds with insects or fungal pathogens has been investigated since 1970. More than 600 fungi collected in countries throughout Europe have been isolated in our laboratories. The isolates with the highest and most stable pathogenicity against bindweed belong to the genus *Stagonospora.* In a field trial in maize in 1995, one of these *Stagonospora* isolates stopped the increase of ground coverage by the bindweeds. In response to public concern about environmental problems caused by modern agriculture, new cropping systems are being developed. Underseeding maize with a living green cover achieves good control of a large spectrum of the weed flora typical of conventional tillage systems. However, *C. sepium* and *C. arvensis* remain as problems. The research reported shows that *C. sepium* is partly suppressed by the green cover, but escapes control by climbing the stems of the maize plants; therefore, the application of spores of *Stagonospora* sp. in a maize field underseeded with a living green cover may allow a large or a complete reduction of the herbicide input and promote a more sustainable agriculture.

Pfirter, H. A., and G. Defago. 1998. The potential of *Stagonospora* sp. as a mycoherbicide for field bindweed. Biocontrol Science and Technology 8 (1): 93-101.

Authors' abstract: Field bindweed (*Convolvulus arvensis* L.) is one of the 12 most important weeds worldwide. *Stagonospora* sp. Isolate LA39 was isolated from diseased field bindweed plants collected in Europe. No crop tested was susceptible to the fungus, but disease symptoms were observed on other Convolvulaceae species. On field bindweed, the fungus induces disease symptoms (i.e. lesions) mainly on leaves and less severely on stems. The application of spores in an oil emulsion (10% oil in water) enhanced the disease on field bindweed plants compared with spores suspended in a 0.1% aqueous solution of the surfactant agent, Tween 80. The necrotic leaf area of inoculated plants increased as the length of exposure to 100% relative humidity (RH) and the spore density applied increased. Severe disease developed on plants inoculated with 1 x 10(7) spores/ml in oil emulsion, even in the absence of exposure to 100% RH. A delay of exposure to 100% RH (up to 8 h) did not have a significant effect on disease severity. Field bindweed was susceptible to the fungus at all growth stages tested, but older plants were more susceptible than younger ones. It was concluded that isolate LA39 has potential as a biocontrol agent of field bindweed, especially when applied in an oil emulsion. The oil emulsion maintains the aggressiveness of the pathogen during a dew-free period and provides a favourable micro-environment during the infection process.

Pfirter, H. A., F. Marquis, and G. Defago. 1999. Genetic and pathogenic characterization of different *Stagonospora* sp isolated from bindweed. Biocontrol Science and Technology 9 (4): 555-566.

Authors' abstract: Genetic variation among 38 isolates of *Stagonospora* sp. and 10 isolates of *Septoria* sp. from bindweed was studied using (a) restriction fragment length polymorphism (RFLP) analysis of the internal transcribed spacer (ITS) region, and (b) random amplified polymorphic DNA (RAPD) PCR analysis. RFLP analysis revealed three types of fragment patterns among the isolates. A total of 26 distinct groups, based on common fragment patterns, were identified using cluster analysis of the RAPD-PCR data. When the grouping results of the two methods were compared the fragment pattern types and clusters were generally in agreement. The degree of pathogenicity of six genetically characterized isolates of *Stagonospora* sp. was assessed on three ecotypes of field bindweed (*Convolvulus arvensis*). Disease symptoms were observed with all isolates on all ecotypes, but only *Stagonospora convolvuli* strain LA39, a potential biocontrol agent, showed a high degree of pathogenicity on all ecotypes. A mixture of two *Stagonospora* sp. enhanced the mean necrotic leaf area on bindweed from 33.9 and 39.0% (when applied alone) to 64.9% applied together at the same final concentration of 5 x 10(6) spores ml(-1). Molecular methods were used to identify the two pathogens. Both were present on the same plant when applied together; but never found in the same lesion.

Rodriguez-Alvarado, G., S. Fernandez-Pavia, R. Creamer, and C. Liddell. 2002. Pepper mottle virus causing disease in chile peppers in southern New Mexico. Plant Disease 86 (6): 603-605.

Authors' abstract: The primary pepper producing areas of southern New Mexico were surveyed to identify the viruses causing severe disease in chile peppers over a 2-year period. The survey included weeds commonly found in and around pepper fields. Using indirect enzyme-linked immunosorbent assay (ELISA), Pepper mottle virus (PepMoV) was associated with plants showing mosaic and distortion of foliage and fruit deformation. PepMoV and Cucumber mosaic virus (CMV) were determined based on ELISA to be infecting chile peppers and weeds singly or in combination. Four perennial plant species were infected with PepMoV and CM including *Solanum elaeagnifolium* (silverleaf nightshade), *Convolvulus arvensis* (field bindweed), and *Chamysuraces* sp. (small groundcherry), which had not previously been identified as hosts for PepMoV. Some peppers and weeds surveyed were also infected at a lower level by several other plant viruses.

Rodriguez-Navarro, S., G. Torres-Martinez, and J. Olivares-Orozco. 2004. Biological control of field bindweed (*Convolvulus arvensis* L.) using *Aceria malherbae* (Acari: Eriophyidae) in Mexico. International Journal of Acarology 30 (2): 153-155.

Authors' abstract: Field bindweed (*Convolvulus arvensis* L.) is a serious weed and infests several crops in Mexico. At present, it is controlled by the use of herbicides. An experiment found *Aceria malherbae* Nuzzaci (Acari: Eriophyidae) a potential good candidate for biological control of this weed in Mexico.

Rosenthal, S. S. 1985. Potential for biological control of field bindweed in California USA coastal vineyards. Agriculture Ecosystems and Environment 13 (1): 43-58.

Author's abstract: The possibility of using biological control against field bindweed, *Convolvulus arvensis* L., was studied in four vineyards along the California coast. Field bindweed is a dominant member of the weed community and the principal plant pest in these vineyards. There is considerable insect and mite damage to its foliage during late summer and autumn, but the stress this places on the weed is unknown. The most significant natural enemies of field bindweed are defoliating caterpillars, *Bedellia somnulentella* Zeller, *Chaetocnema confinis* Crotch, and spider mites. None of the natural enemies present appeared to be suitable as biological control agents. However, some arthropods, such as *Noctuelia floralis* (Huebner), associated with field bindweed in Mediterranean Europe and Pakistan, could be useful in the California grape agroecosystem, once cleared for importation and release in North America. Others, unsuitable to release in California because of feeding on closely related native plants, may be of value in other parts of the world

where no such conflicts of interest exist. It would be feasible to use biological control against field bindweed in California's coastal vineyards and, perhaps, also in orchards under present systems of cultivation. Its effectiveness could be enhanced by certain changes in growing practices, particularly the acceptance of some weed growth, and by changes in existing pest controls. Biological control of field bindweed should be considered in the development of pest management programs for such crops in California and wherever this plant is a serious pest.

Rosenthal, S. S. 1978. Host specificity of *Tyta luctuosa* (Lepidoptera: Noctuidae), an insect associated with *Convolvulus arvensis*. Entomophaga 23 (4): 367-370.

Author's abstract: Biological control agents were tested for *C. arvensis* L. A defoliator, *T. luctuosa* (Denis et Schiffermueller), was tested for host specificity in the laboratory and in field cages. There was feeding only on members of the Convolvulaceae. There was complete development only on species of *Convolvulus* and *Calystegia.*

Rosenthal, S. S., and G. R. Buckingham. 1982. Natural enemies of *Convolvulus arvensis* in Western Mediterranean Europe. Hilgardia 50 (2): 1-19.

Authors' abstract: A survey was conducted in Mediterranean Europe on the fauna of *C. arvensis.* A total of 140 spp. of insects, 3 species of mites and 3 pathogenic fungi were found attacking *C. arvensis* and other closely related members of the Convolvulaceae. Most organisms were associated with the leaves, but, considering the amount of root material available, very few were found on the roots. About half of the arthropods are widespread and important *C. arvensis* herbivores, but most are polyphagous and many are known crop pests. None is strictly monophagous on *C. arvensis*. The seasonal progression of plant growth and the presence of the more important arthropods associated with various plant parts are described. After considering literature records of their host specificity and field observations of plant damage and biology, 15 spp. most widespread and damaging to *C. arvensis* were tested for their ability to live on sweet potato. *Galeruca rufa, Erisophyes* sp. and *Spermophagus sericeus* have the greatest potential as biocontrol agents, while six other insects and one fungus may be of value.

Rosenthal, S. S., S. L. Clement, N. Hostettler, and T. Mimmocchi. 1988. Biology of *Tyta luctuosa* [Lep noctuidae] and its potential value as a biological-control agent for the weed *Convolvulus arvensis*. Entomophaga 33 (2): 185-192.

Authors' abstract: The biology of the noctuid *Tyta luctuosa* (Denis and Schiffermuller) (Lep.: Noctuidae), a defoliator of field bindweed, *Convolvulus arvensis* L., was studied in southern Europe. *T. luctuosa* is widely distributed and feeds on both thick stands and scattered host populations growing in a diversity of habitats. It undergoes 2 and perhaps a partial 3rd generation/year in southern Europe and is active during most of the growing season of *C. arvensis*. In the laboratory the total time from egg to adult averages 45.6 days. There are 5 larval instars. Adult females deposit on average over 400 eggs. The larvae being able to feed and develop on native North American *Calystegia* spp. in the laboratory, there are some reservations about its release in North America. However, the moth has potential value as a biological control agent for field bindweed in the western USA where it would fill an almost unoccupied niche.

Rosenthal, S. S., and N. Hostettler. 1980. *Galeruca rufa* coleoptera chrysomelidae seasonal life history and the effect of its defoliation on its host plant *Convolvulus arvensis.* Entomophaga 25 (4): 381-388.

Authors' abstract: Because of interest in the USA in *G. rufa* Germar as a biological control agent for field bindweed *C. arvensis* L., its ability to damage this plant was studied in field cages in Rome, Italy. *G. rufa* was shown to severely defoliate established field bindweed plants and to lower flower production. Substantial *G. rufa* defoliation of field bindweed seedlings killed most of them. *G. rufa* has two complete and one partial generation per year and is well synchronized with its host plant.

Rosenthal, S. S., and B. E. Platts. 1990. Host specificity of *Aceria* (Eriophyes) *malherbae* (Acari: Eriophyidae), a biological control agent for the weed *Convolvulus arvensis* (Convolvulaceae). Entomophaga 35: 459–463.

Authors' abstract: The host specificity of the gall mite *Aceria* (Eriophyes) *malherbae* (Nalepa), from Greece was studied under quarantine conditions at Albany, California USA. Of the species, ecotypes, or strains tested, only *Convolvulus* and *Calystegia* spp. supported gall formation and mite reproduction. Although 2 of the native North American *Calystegia* species that served as laboratory hosts are threatened or endangered species, *A. malherbae* is considered safe for release in the USA as a biological control agent of the weed *Convolvulus arvensis* (L.).

Schoenhals, M. G., A. F. Wiese, and M. L. Wood. 1990. Field bindweed (*Convolvulus arvensis*) control with imazapyr. Weed Technology 4 (4): 771-775.

Authors' abstract: Sixteen applications of imazapyr and other herbicides were made to field bindweed from 1982 to 1986. Control with imazapyr was 89% or more 1 yr after treatment at 0.14 kg ai ha-1 when plants were growing vigorously at application. Only 1 of 16 applications of imazapyr at 0.56 kg ha-1 controlled less than 90% regardless of plant vigor. Control at 0.56 kg ha-1 was usually superior to that obtained with dicamba at 1.1 and 2.2 kg ae ha-1, and 2,4-D at 1.1 kg ae ha-1, as well as combinations of picloram with either 2,4-D or dicamba. All herbicides were less effective when applied to field bindweed with poor vigor. Winter wheat planted in the fall up to 122 days after application was injured 20 to 88% by imazapyr at 0.14 kg ha-1. Sorghum planted the next spring was injured 15% or less by imazapyr at 0.14 and 0.28 kg ha-1.

Sparace, S. A., L. A. Wymore, R. Menassa, and A. K. Watson. 1991. Effects of the *Phomopsis convolvulus* conidial matrix on conidia germination and the leaf anthracnose disease of field bindweed (*Convolvulus arvensis*). Plant Disease 75 (11): 1175-1179.

Authors' abstract: The conidia-free conidial matrix of *Phomopsis convolvulus* contains 6% dry matter which consists of approximately 89% carbohydrate and lesser amounts of protein and free amino acids. Conidia densities of 10(6) per milliliter or greater in the presence or absence of matrix are unable to germinate without dilution. Increasing concentrations from 0 to 5% (v/v) of conidial matrix in water reduces conidia germination from 70 to 11%. Conidia survival in terms of percent germination was greatest (80-100% for up to 9 wk) when conidia were stored at room temperature in the presence of liquid matrix, whereas drying was generally lethal to conidia. The matrix had no effect on the initiation and subsequent development of the leaf anthracnose disease of field bindweed as measured by dry weight accumulation of treated plants. The undiluted conidial matrix of *P. convolvulus* functions to prolong conidia viability and prevent germination of diluted fresh conidia.

Swan, D. G., and R. J. Chancellor. 1976. Regenerative capacity of field bindweed roots. Weed Science 24 (3): 306-308.

Authors' abstract: Lateral roots of a clone of field bindweed (*Convolvulus arvensis* L.) were dug each month for 12 mo., cut into 6-cm long sections and grown in the dark on moist paper at 23°C to determine if regeneration varies seasonally. New shoots and roots were measured after 8, 11 and 14 days. After 14 days, 69%-98% of the sections had produced shoots. The mean number of shoots per section was greatest in April (6.4) and least in Nov. (2.0). The monthly mean shoot length ranged 24-43 mm. Although most sections produced shoots, very few produced roots. In May, 31% of the sections grew roots, but only 2%-16% had new root growth in the other months. For the test period, 83% of the sections produced shoots and only 10% produced roots.

Todd, F. G., F. R. Stermitz, P. Schultheis, A. P. Knight, and J. Traub-Dargatz. 1995. Tropane alkaloids and toxicity of *Convolvulus arvensis.* Phytochemistry 39 (2): 301-303.

Authors' abstract: Horses in a few, localized northern Colorado pastures exhibited weight loss and colic. At post mortem, intestinal fibrosis and vascular sclerosis of the small intestine was identified. The pastures where the affected horses grazed were overrun by field bindweed (*Convolvulus arvensis*). Bindweed from the pasture was found to contain the tropane alkaloids tropine, pseudotropine, and tropinone and the pyrrolidine alkaloids cuscohygrine and hygrine. Laboratory mice readily ate *C. arvensis* and exhibited a variety of abnormal clinical signs depending on the amount eaten. Similar alkaloids have been found in other *Convolvulus* species and cuscohygrine and calystegines (poly-hydroxytropanes) have been previously reported from *C. arvensis* roots. This is the first report of simple tropane alkaloids in *C. arvensis*, a world wide problem weed. Pseudotropine, the major alkaloid, is known to affect motility and might represent a causative agent for the observed cases of equine intestinal fibrosis.

Villamil, S. C., J. R. Nechols, and S. B. Ramaswamy. 2003. The effect of pre-adult and adult temperatures on oocyte development of the field bindweed moth, *Tyta luctuosa* (Lepidoptera: Noctuidae). Journal of the Kansas Entomological Society 76 (3): 442-446.

Authors' abstract: We evaluated the influence of pupal and adult temperatures on oocyte development in the noctuid moth *Tyta luctuosa* (Denis and Shiffermuller) (Lepidoptera: Noctuidae), an imported biological control agent of field bindweed (*Convolvulus arvensis* L.) (Convolvulaceae). Temperature influenced oocyte development in adults but not pupae regardless of whether both life stages were reared at a constant temperature (20 or 27.5 degrees C) or transferred to the higher or lower temperature at emergence. However, the pre-adult temperature experience had an indirect effect on ovarian development. Specifically, oocytes developed and matured faster in moths that experienced an increase in temperature at emergence (20 --> 27.5 degrees C) than those that were reared continually at 27.5 degrees C. Our findings do not support the idea that temperature is related to differences in ovarian development in *T. luctuosa* at emergence. Thus, it is possible that the range of maturation is linked to genetic variation or other environmental factors in this moth species.

Vogelgsang, S., A. K. Watson, A. DiTommaso, and K. Hurle. 1999. Susceptibility of various accessions of *Convolvulus arvensis* to *Phomopsis convolvulus*. Biological Control 15 (1): 25-32.

Authors' abstract: The susceptibility of *Convolvulus arvensis* L. accessions from different geographic locations to disease caused by the fungal pathogen *Phomopsis convolvulus* Ormeno was evaluated. In a postemergence application experiment, single excised plant shoots of *C. arvensis* collected from 11 different regions in North America and Europe were inoculated with *P. convolvulus* conidia. All *C. arvensis* accessions showed similar disease reactions. However, plants originating in Canada (Quebec) and Spain showed significantly greater disease development than

plants from a USA accession (Montana). In a separate preemergence application experiment, plants from two selected accessions originating in Greece and the USA (Montana) were grown from root stock and subjected to a granular formulation of *P. convolvulus* applied to the soil surface. The emerging shoots of both accessions showed severe disease development and the fungal application on Greek and Montana accessions reduced aboveground biomass 83 to 100% and 65 to 86%, respectively. Results of this study indicate that control of *C. arvensis* using *P. convolvulus* might be achieved in various geographic regions.

Vogelgsang, S., A. K. Watson, A. DiTommaso, and K. Hurle. 1998. Effect of the pre-emergence bioherbicide *Phomopsis convolvulus* on seedling and established plant growth of *Convolvulus arvensis*. Weed Research 38 (3): 175-182.

Authors' abstract: The effects of the fungal pathogen *Phomopsis convolvulus* Ormeno on seedling and established plant performance of *Convolvulus arvensis* L. were compared under both controlled and field conditions. Under a controlled environment, a granular barley formulation of the fungal inoculum that had been applied on to the soil surface of pots containing pre-germinated *C. arvensis* seeds resulted in above-ground biomass reductions of up to 87%. However, application of the fungus to established plants that had been cut to ground level produced biomass reductions (43%) that were nearly half of those obtained for seedlings. In a parallel field experiment conducted over two growing seasons, application of *P. convolvulus* resulted in dramatic above-ground biomass reductions for both seedlings and established plants. In one trial, biomass reductions of up to 100% and 98%, respectively, were obtained. *C. arvensis* coverage within field plots was closely correlated with above-ground biomass. Findings in this study indicated that *P. convolvulus* may provide effective control of *C. arvensis* when applied preemergence.

Weaver, S. E., and W. R. Riley. 1982. The biology of Canadian weeds—53: *Convolvulus arvensis* L. Canadian Journal of Plant Science 62: 461-472.

Authors' abstract: *C. arvensis* L., field bindweed, is an introduced weed which occurs in the agricultural regions of all provinces of Canada with the exception of Newfoundland and Prince Edward Island. Its twining growth habit and extensive root and rhizome system make it exceptionally difficult to control. It spreads by both seeds and root or rhizome fragments. Details of its morphology, reproductive biology, response to parasites and methods of control are presented.

Westra, P., P. Chapman, P. W. Stahlman, S. D. Miller, and P. K. Fay. 1992. Field bindweed (*Convolvulus arvensis*) control with various herbicide combinations. Weed Technology 6: 949-955.

Authors' abstract: Dicamba, 2,4-D, picloram, and commercially available premixes of glyphosate plus 2,4-D or glyphosate plus dicamba were evaluated alone and in combination for field bindweed control in a winter wheat–fallow system in Colorado, Wyoming, Kansas, and Montana. Approximately one year after application, herbicide mixtures containing picloram at 0.14 or 0.28 kg ai ha-1 provided the best control. In five of seven locations, the control provided by picloram in herbicide mixtures was greater than the control provided by glyphosate plus 2,4-D, 2,4-D, or dicamba when these products were mixed with picloram. Glyphosate plus 2,4-D or glyphosate plus dicamba premixes, or 2,4-D added to dicamba were less effective for long-term control of field bindweed than mixtures containing 0.14 kg ai ha-1 or more of picloram. Under drought conditions in Kansas in 1988, picloram did not control field bindweed as well as in Colorado, Wyoming, or Montana where rainfall was normal.

Westwood, J. H., and S. C. Weller. 1997. Cellular mechanisms influence differential glyphosate sensitivity in field bindweed (*Convolvulus arvensis*) biotypes. Weed Science 45 (1): 2-11.

Authors' abstract: Biotypes of field bindweed that vary in sensitivity to glyphosate were studied to determine the physiological or biochemical bases for these differences. Studies conducted using whole plants and in vitro cultured shoots identified several potentially important differences between the most tolerant (biotype 4) and most susceptible (biotype 1) biotypes. Biotype 4 plants had greater 3-deoxy-D-arabino-heptulosonate-7-phosphate synthase (DAHPS) activity and higher concentrations of phenolic compounds, indicating greater shikimate pathway activity than biotype 1. This may reflect a higher growth ability of biotype 4, as observed in shoot cultures. 5-Enolpyruvylshikimate-3-phosphate synthase (EPSPS) activity in whole plants increased in all parts of biotype 4 by 7 d after a glyphosate treatment of 1.1 kg ae ha(-1), whereas activities in biotype 1 plants did not increase at any time. However, this may not be the only mechanism of glyphosate tolerance because EPSPS activity in cultured shoots of both biotypes increased equally in response to glyphosate, even though biotype 4 shoots were able to survive and grow on a glyphosate-containing medium that inhibited growth of biotype 1 shoots. We propose that multiple mechanisms operating at a cellular/metabolic level combine to enable biotype 4 to tolerate higher glyphosate rates than biotype 1.

Wicks, G. A., D. H. Popken, G. W. Mahnken, G. E. Hanson, and D. J. Lyon. 2003. Survey of winter wheat (*Triticum aestivum*) stubble fields sprayed with herbicides in 1998: weed control. Weed Technology 17 (3): 475-484.

Authors' abstract: A survey of 174 fields was conducted to investigate performance of herbicides applied after winter wheat harvest on weeds across western and southern Nebraska during August and September 1998. Glyphosate plus 2,4-D plus atrazine was applied on 32%, glyphosate plus 2,4-D or dicamba on 24%, paraquat plus atrazine on 23%, glyphosate on 8%, ICIA0224 plus 2,4-D or atrazine on 10%, and atrazine plus 2,4-D on 3% of the fields. These treatments controlled 85 to 100% of the weeds except atrazine plus 2,4-D, which controlled 30%. The frequency of occurrence of the most prevalent summer annual grasses was as follows: green foxtail, 65%; barnyardgrass, 46%; stinkgrass, 41%; witchgrass, 39%; and longspine sandbur, 36%. The most common broadleaf weeds and their frequency were redroot pigweed, 32%; tumble pigweed, 30%; tall waterhemp, 28%; and kochia, 25%. Virginia groundcherry, 22%; common milkweed, 11%; yellow woodsorrel, 9%; and field bindweed, 6% were the most common perennial weeds. The five most difficult weeds to control were yellow nutsedge, spotted spurge, Virginia groundcherry, common milkweed, and toothed spurge, with control ratings of 0, 3, 17, 26, and 33%, respectively. These weeds were not controlled with glyphosate or mixtures containing glyphosate. Only 35% of the fields were treated before summer annual grasses had headed. Late applications required higher herbicides rates for effective control.

Wiese, A. F., and D. E. Lavake. 1986. Control of field bindweed *Convolvulus arvensis* with postemergence herbicides. Weed Science 34: 77–80.

Authors' abstract: Over 20 experiments comparing glyphosate [N-(phosphonomethyl)glycine], dicamba (3,6-dichloro-2-methoxybenzoic acid), fosamine [ethyl hydrogen (aminocarbonyl)phosphonate], and 2,4-D [(2,4-dichlorophenoxy)acetic acid] for control of field bindweed (*Convolvulus arvensis* L. #3 CONAR) were conducted from 1976 to 1982 at various times of the year and different stages of weed growth. In three of the studies, 1.7, 3.4, and 5.0 kg ae/ha of glyphosate gave 54, 72, and 80% control, respectively, 1 yr after application. Control with glyphosate at 3.4, 2,4-D at 1.1, dicamba at 1.1, and fosamine at 13.7 kg ae/ha in the 20 studies was 71, 55, 57, and 73%, respectively, 1 yr after application. Glyphosate, 2,4-D, and fosamine

gave good control at any time of the year if weed growth was lush. Dicamba gave good control anytime if growth was good and in the fall regardless of growing conditions. Control with mixtures of dicamba and picloram, picloram and 2,4-D, or glyphosate and picloram was higher than with the other herbicides. Dicamba at 1.1 kg/ha, applied after August caused some injury to wheat planted the same fall. Herbicide combinations with picloram at 0.28 kg/ha applied after June injured wheat planted in the fall.

Yerkes, D., C. N. Weller, and S. C. Weller. 1996. Diluent volume influences susceptibility of field bindweed (*Convolvulus arvensis*) biotypes to glyphosate. Weed Technology 10 (3): 565-569.

Authors' abstract: Two biotypes of field bindweed differing in their susceptibility to glyphosate were used to determine if diluent or carrier volume and additional surfactant could overcome differences in intraspecific response to glyphosate. In greenhouse studies, glyphosate (formulated product) was applied at 1.68 kg/ha in three diluent volumes (142, 189, and 237 L/ha), with and without 1% (v/v) additional amphoteric surfactant. Nonparametric and ordinal categorical analyses indicated that field bindweed biotype, diluent volume, and surfactant significantly increased glyphosate phytotoxicity 7 DAT. Only biotype and volume were significant 21 DAT. The tolerant biotype was less injured at the 189 and 237 L/ha volumes than the susceptible biotype. Field bindweed injury was similar at a diluent volume of 142 L/ha for both biotypes. These greenhouse studies suggest that control of field bindweed may be improved with glyphosate by using low spray volume in concert with additional surfactant.

Zhang, W. M., T. M. Wolf, K. L. Bailey, K. Mortensen, and S. M. Boyetchko. 2003. Screening of adjuvants for bioherbicide formulations with *Colletotrichum* spp. and *Phoma* spp. Biological Control 26 (2): 95-108.

Authors' abstract: A study was conducted to determine whether certain surfactants (Tween series: 20, 40, 80, and Tergitol NP series: 9, 10) and adjuvants (sorbitol and gelatin) would be useful components in bioherbicide formulations of *Colletotrichum* (10 isolates) and *Phoma* (5 isolates). The effect of adjuvants on conidial germination and mycelial growth varied with adjuvant, adjuvant concentration (0.01, 0.1, 1, and 5%), fungal isolates, and conidial density (10(5)-10(8) conidia/ml). Tween 20 reduced germination and mycelial growth in some *Phoma* and all *Colletotrichum* isolates, whereas Tween 40 and Tween 80 stimulated germination without detrimental effects on mycelial growth of all isolates. Tween 40 and Tween 80 released conidia from self-inhibition of germination in *Colletotrichum* as compared to the germination of conidia at 10(7) conidia/ml in the absence of the adjuvant. Tergitol NP often reduced germination and mycelial growth. There were no trends in fungal responses to sorbitol. The responses of *Colletotrichum* were highly variable to gelatin, but for *Phoma,* gelatin increased germination and mycelial growth, and also released self-inhibition of germination. In summary, gelatin, Tween 40, and Tween 80 were useful components for bioherbicide formulations to increase conidial germination and mycelial growth of *Phoma*, whereas Tween 40 and Tween 80 were useful for *Colletotrichum*.

Ziska, L. H. 2003. Evaluation of the growth response of six invasive species to past, present and future atmospheric carbon dioxide. Journal of Experimental Botany 54 (381): 395-404.

Author's abstract: The response of plant species to future atmospheric carbon dioxide concentrations (CO_2) has been determined for hundreds of crop and tree species. However, no data are currently available regarding the response of invasive weedy species to past or future atmospheric CO_2. In the current study, the growth of six species which are widely recognized as among the most invasive weeds in the continental United States, Canada thistle (*Cirsium arvense*

(L.) Scop.), field bindweed (*Convolvulus arvensis* L.), leafy spurge (*Euphorbia esula* L.), perennial sowthistle (*Sonchus arvensis* L.), spotted knapweed (*Centaurea maculosa* Lam.), and yellow star thistle (*Centaurea solstitialis* L.) were grown from seed at either 284, 380 or 719 mumol mol(-1) CO_2 until the onset of sexual reproduction (i.e. the vegetative period). The CO_2 concentrations corresponded roughly to the CO_2 concentrations which existed at the beginning of the 20th century, the current CO_2, and the future CO_2 projected for the end of the 21st century, respectively. The average stimulation of plant biomass among invasive species from current to future CO_2 averaged 46%, with the largest response (+72%) observed for Canada thistle. However, the growth response among these species to the recent CO_2 increase during the 20th century was significantly higher, averaging 110%, with Canada thistle again (+180%) showing the largest response. Overall, the CO_2-induced stimulation of growth for these species during the 20th century (285-382 mumol mol(-1)) was about 3X greater than for any species examined previously. Although additional data are needed, the current study suggests the possibility that recent increases in atmospheric CO_2 during the 20th century may have been a factor in the selection of these species.

Other Published Sources

Douglas, G. W., G. B. Straley, D. V. Meidinger, and J. Pojar (eds.). 1998. Illustrated Flora of British Columbia, Volume 2: Dicotyledons (Balsaminaceae through Cuscutaceae). Ministry of Sustainable Resource Management and British Columbia Ministry of Forests, Victoria, BC. 401 pp.

This comprehensive reference has excellent identification keys and detailed technical descriptions of vegetative and sexual morphology. This flora is the taxonomic authority for the invasive species fact sheets (unless otherwise indicated). Douglas et al*.* describe the habitat of *Convolvulus arvensis* as mesic to dry disturbed areas and waste places in the lowland, steppe, and montane zones. Introduced from Eurasia, the plant is now common in southern British Columbia.

Geyer, W. A., W. H. Fick, and J. Carlisle. 2002. Weed management on military storage gravel lots. Transactions of the Kansas Academy of Science 105 (1-2): 66-71.

Authors' abstract: Various commercial chemicals were tested to control visually obstructive weed populations abundant in the graveled storage areas on the Fort Riley Military Reservation. Several herbicides applied at lower amounts than the historical treatment were effective in reducing weedy plants. The chemicals Oust and Telar + Karmex provided the best long-term control. Arsenal could be added to a tank mix to provide greater control of field bindweed and tumble windmill grass. A change to these chemicals as part of the integrated pest management strategy would thus help to meet the United States Department of Defense directive to reduce pesticide usage.

Knight, A. P., and R. G. Walter (eds.). 2004. A Guide to Plant Poisoning of Animals in North America. International Veterinary Information Service, Ithaca, New York.

http://www.ivis.org/special_books/Knight/chap1/chapter_frm.asp?LA=1#Field_Bindweed
http://www.ivis.org/special_books/Knight/chap3b/chapter_frm.asp?LA=1#Field_Bindweed

This website (and associated book) provides an overview of toxic plants including *Convolvulus arvensis*. According to this site, "Field bindweed will accumulate nitrates. It also contains various tropane alkaloids including pseudotropine, tropine, tropinone, and cuscohygrine. Pseudotropine, the predominant alkaloid, is capable of affecting smooth muscle activity. Other nortropane alkaloids (calystegins) present in bindweed (*Calystegia* spp., some *Solanum* spp., and *Ipomoea* spp.) are potent glycosidase inhibitors.

Tropane alkaloids (pseudotropine) with atropine-like action are present in all parts of the plant. Calystegins present in bindweeds (*Calestegia* and *Convolvulus* spp.) inhibit glucosidase enzyme activity and therefore possibly play a role in poisoning animals that eat the plants. The glycosidase inhibitory activity of the calystegins is comparable to that of swainsonine, an indolizidine alkaloid found in locoweeds (*Astragalus* and *Oxytropis* spp.). Mice fed an exclusive diet of bindweed developed severe gastritis and liver necrosis possibly as a result of the combined effects of the toxins present in the plant. Bindweed may also accumulate toxic levels of nitrate."

Lauriault, L. M., D. C. Thompson, J. B. Pierce, G. J. Michels, and W. V. Hamilton. 2004. Managing *Aceria malherbae* gall mites for control of field bindweed. Cooperative Extension Service circular 600, College of Agriculture and Home Economics, New Mexico State University. 14 pp.

Also online: http://www.cahe.nmsu.edu/pubs/

Abstract: The bindweed gall mite (*Aceria malherbae*) shows promise as a biological control of field bindweed (*Convolvulus arvensis*) in low-humidity regions. The mite has been successfully established in several areas throughout New Mexico. Once established, populations are persistent although human intervention is required to expand distribution to new host plants. The mite's life cycle is synchronized to the seasonal growth of field bindweed. Mite feeding can inhibit leaf formation, stem elongation, and flowering by the field bindweed. Infested leaves fold, curl, and fuse along the mid-vein where mites feed (Boldt and Sobhian, 1993). Affected leaves thicken and develop a rough surface, having a yellowish to golden brown grainy or mealy appearance. Stem buds that have been damaged will not elongate but will form a mass of galled leaves that act as a nutrient sink. If infestations are great enough, transfer of carbohydrates to the root system and formation of flower buds can be inhibited (Rosenthal et al., 1988). Root buds that have been fed on during dormant periods either do not grow at all or produce severely stunted roots or stems.

McClay, A. S., and R. A. De Clerck-Floate. 2002. *Convolvulus arvensis* L., field bindweed (Convolvulaceae). Pages 331-337 *in* Mason, P. G., and J. T. Huber (eds.). Biological Control Programmes in Canada 1981-2000. CABI Pub., New York.

Abstract: Field bindweed, *Convolvulus arvensis* L., is a deep-rooted, climbing, herbaceous perennial native to Eurasia that is now widely distributed across North America. *C. arvensis* is a prohibited noxious weed under the Canada Seeds Act. Shoots of *C. arvensis* emerge from root buds when day temperatures reach about 14°C. Flowering occurs from late June to September. Seeds remain viable for up to twenty years in the soil and are the usual means of dispersal into new areas, while local spread occurs through lateral roots and rhizomes. Seedlings only nineteen days old can regenerate from the root when the above-ground portion is removed (Weaver and Riley, 1982).

C. arvensis cannot generally be controlled by chemicals alone. Group 4 growth regulators (2,4-D dichlorophenoxyacetic acid), dicamba, and mecoprop are recommended herbicides in cereal crops. Control can be obtained in summer-fallow by repeated tillage every three to four weeks from June through September for two seasons, or by a combination of cultivation, crop rotation and herbicides. Biotypes of *C. arvensis* vary widely in their susceptibility to glyphosate.

In Canada, two arthropods are approved for control of C. arvensis: the defoliating moth *Tyta luctuosa* and the gall mite *Aceria malherbae* Nuzzaci. *T. luctuosa* is one of the most frequently found insects feeding on *C. arvensis* in southern Europe. During tests, *T. luctuosa* larvae fed on three of five North American *Convolvulus* spp., but reached adult stage only on *C. arvensis*, *C.*

althaeoides (mallow bindweed), and *Calystegia sepium* (wild morning-glory). *T. luctuosa* was released in Canada and the US but, as of 2000, no permanent populations were known to have established. As a defoliator, *T. luctuosa* is not expected to have a significant impact on *C. arvensis*, which can readily regenerate from stored reserves in rhizomes. No further releases of *T. luctuosa* are considered warranted.

The gall mite *A. malherbae* feeds on *C. arvensis* leaves, inducing leaf distortion and galling. *A. malherbae* has shown good potential for effective control of *C. arvensis*. All life stages of *A. malherbae* occur within the folded and distorted leaves. Heavily infested shoots become stunted and deformed. *A. malherbae* overwinters below ground on rhizome buds. Release of this mite in North America was approved following evaluation by Rosenthal and Platts (1990). Host-specificity tests showed that *A. malherbae* will develop on North America *Calystegia spp*., closely related to but much less abundant than *Convolvulus arvensis*. While releases of *A. malherbae* in Alberta and Montana successfully established, three releases in British Columbia between 1992 and 1998 did not establish. Considerable variation exists among sites in level of establishment and host species impact by *A. malherbae*. At some test sites, there was no survival or only a few lightly galled leaves the year after release, while at other sites thriving mite populations and heavy damage were present up to five years after release. Observations suggest that environmental conditions may play a role in variation among sites, with humidity being an important factor for establishment. Further evaluation of *A. malherbae* effectiveness is recommended, with particular focus on the effects of environmental conditions, e.g., humidity, method, and timing of release.

The fungal pathogen *Phomopsis convolvulus* Ormeño-Núñez has been assessed as a possible biological control agent. Infected plants in the field showed rounded to irregular, light-brown leaf spots surrounded by a narrow, light-green zone. The first symptoms in pathogenicity tests were pinpoint foliar lesions, followed by spots on leaves, petioles and stems, anthracnose-like symptoms and dieback of apices. Pycnidia were formed on lower parts of the plant, close to or in direct contact with the soil. A granular barley formation of *P. convolvulus* applied to soil in field plots seeded with pre-germinated seeds or root-stocks of *C. arvensis* reduced biomass by 98-100% (Vogelgsang et al., 1998). In field trials, surface application of the granular formulation was more effective than soil incorporation, although the opposite was observed under controlled environment conditions.

Michels, G. J., D. A. Fritts, and J. B. Bible. 1999. Release and colonization of the bindweed gall mite, *Aceria malherbae*: a field bindweed biological control program for the Texas High Plains. Pages 140-141 *in* Spencer, N. R. (ed.). Proceedings of the X (10th) International Symposium on Biological Control of Weeds, Bozeman, MT. USDA-ARS.

Authors' abstract: *Aceria malherbae* Nuzzaci is a gall-forming eriophyid mite imported from Greece for biocontrol of field bindweed. The mite injures plants by producing galls on leaves, petioles, stems and roots. Infested plants are yellowed, have deformed leaves, reduced vigor, and new growth is killed. The mites can kill whole plants, limit seed production and reduce vegetative spread. *A. malherbae* overwinters on the roots of bindweed, and is present in the spring when bindweed growth begins, where it can quickly build up and suppress new growth. After an initial quarantine period at the USDA-ARS Insect Quarantine Facility at Temple, Texas, *A. malherbae* was released at Bushland, TX, in 1989. Approximately 5,800 mites were released in May and 9,000 mites were released in June. By June 1992, 52% of the bindweed crowns at the release site were infested with mites and the mites had moved 9.5 m from the release site. By July 1996, mites had spread over one km from the release site and reduced the bindweed infestation by 50%. Mites have spread at a rate of about 0.125 km/yr. In 1998, a program was initiated at the US Department of Energy's Pantex plant in Amarillo, TX, to redistribute the mite within the confines of this installation. Initial success has been excellent. The release sites in 1998 were inadvertently

mowed; however, this “accident” proved to be beneficial. Over a period of 83 days, the mites moved 60-164m (0.73-2m/day) from the point of release at the mowed sites. In contrast, the “natural” movement at the Bushland release site averaged 0.35m/day. In essence, the mites’ dispersal was increased by two to six times at the mowed sites. It is thought that since the mites are so small, mite-infested bindweed “clippings” act as good host material for distribution. Releases, redistribution, and monitoring continued throughout 1999.

Province of British Columbia. 2002. A Guide to Weeds in BC. Crown Publications, Victoria, BC. 195 pp.

Also online: http://www.weedsbc.ca/pdf/field_bindweed.pdf

This book provides a good overview of weeds in BC, including *Convolvulus arvensis*. The information includes identification, distribution in BC, impacts and management strategies and is available as a pdf from the website.

Royer, F., and R. Dickinson. 1999. Weeds of Canada and the Northern United States. Lone Pine Publishing and University of Alberta Press, Edmonton, AB. 434 pp.

This book includes a two-page botanical description, reasons why *Convolvulus arvensis* is of concern, and photos. It does not include information on control measures.

Taylor, R. J. 1990. Northwest Weeds: The Ugly and Beautiful Villains of Fields, Gardens and Roadsides. Mountain Press Publishing, Missoula, MT. 177 pp.

This book includes a descriptive paragraph and photos that allow comparison with species with which *Convolvulus arvensis* may be confused. There is no information on control measures.

Unpublished Sources and Websites

California Department of Food and Agriculture. No date. Encycloweedia: Field Bindweed. Sacramento, CA.
http://www.cdfa.ca.gov/phpps/ipc/weedinfo/convolvulus.htm

This website provides information on weed species of California, including detailed botanical descriptions, explanation of habitat preferences and details on control methods.

Center for Invasive Plant Management. 2004. Problem Weeds in the West. Bozeman, MT.
http://www.weedcenter.org/management/weed_mgmt_profiles.htm

This website provides information on prevention and management of many invasive plants. For *Convolvulus arvensis*, a list of key links is provided.

Elmore, C. L., and D. W. Cudney. 2003. Field Bindweed. University of California Integrated Pest Management Online. Davis, CA.
http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7462.html

A description of the identification, life cycle, impact and management of *Convolvulus arvensis*. Suggested management techniques include prevention (not buying seed stock, removing seedlings and removing seeds), cultural techniques (shade, cultivation and black plastic) and chemical applications.

FloraBase. No date. *Convolvulus arvensis*. The Western Australian Flora, Western Australian Herbarium, Western Australia.
http://florabase.calm.wa.gov.au/browse/flora?f=307&level=s&id=6611

This website provides general botanical information about *Convolvulus arvensis,* as well as its specific distribution in Western Australia.

Garden Mosaics. Field Bindweed. Cornell University, Ithaca, NY.
http://www.gardenmosaics.cornell.edu/pgs/science/english/fieldbindweed.htm

A very colourful, accessible site with basic information about *Convolvulus arvensis*. The information can be printed as a pdf file, and includes a crossword puzzle and experimental activities. This site is excellent for teachers or other educators.

Hammon, B. 2004. Managing Field Bindweed with the Bindweed Mite *Aceria malherbae.* Colorado State University Cooperative Extension, Colorado State University, Fort Collins, CO.
http://www.coopext.colostate.edu/TRA/PLANTS/index.html#http://www.coopext.colostate.edu/TRA/PLANTS/bindweedmite.html

This narrative provides background to the biocontrol of *Convolvulus arvensis*, and describes the impact and success of these insects.

Hawaiian Ecosystems at Risk Project. 2001. *Convolvulus arvensis* L. A Global Compendium of Weeds.
http://www.hear.org/gcw/index.html

Basic information on *Convolvulus arvensis*, with links to related references from around the world.

Heiny, D. D. K., and G. E. Templeton II. 1995. Method and compositions for the biological control of field bindweed. Patent Number: US 5391538. Date granted: February 21, 1995. USA Assignee: SANDOZ LTD. Official Gazette of the United States Patent and Trademark Office Patents 1171 (3): 1790.

Hilty, J. 2002-2004. Field bindweed (*Convolvulus arvensis*). Illinois Wildflowers, IL.
http://www.illinoiswildflowers.info/weeds/plants/field_bindweed.htm

This website contains general information on *Convolvulus arvensis*, with an additional interesting section on faunal associations, including bees, caterpillars and beetles.

Hodges, L. 2003. Bindweed Identification and Control Options for Organic Production. Nebraska Cooperative Extension, University of Nebraska, Lincoln, NE.
http://ianrpubs.unl.edu/horticulture/nf585.htm

This website provides an overview of organic control methods for *Convolvulus arvensis*, including mechanical control, biological control and “chemical” methods such as hot, salty water or vinegar.

Hodges, L. 1997. Summary of responses on the organic control of field bindweed. Pest Management at the Crossroads, site sponsored by Benbrook Consulting Services, Sandpoint, ID.
http://www.pmac.net/bindweed.htm

This website outlines suggestions from readers on organic methods for controlling *Convolvulus arvensis*. Methods that are described include vinegar, mulch, black plastic, flaming and plowing.

Invasive Species Initiative. 2005. *Convolvulus arvensis* (Field bindweed). The Nature Conservancy, Arlington, VA.
http://tncweeds.ucdavis.edu/esadocs/convarve.html

This site provides photographs of *Convolvulus arvensis* and a link to the Element Stewardship Abstract (see Lyons, 1998).

Kearsley, M. E. No date. Field bindweed (*Convolvulus arvensis*). University of Idaho, Moscow, ID.
http://www.cnr.uidaho.edu/range454/2003%20Pet%20weeds/field_bindweed.html

An overview of *Convolvulus arvensis* including description, identification, distribution, biology, ecology, impacts and management options.

Klinkenberg, B. 2004. E-Flora BC: Atlas of the Plants of British Columbia. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver, BC.
http://www.eflora.bc.ca/

This site provides information on the distribution of field bindweed in BC as well as information on identification, ecology, habitat and nomenclature, with links to other relevant websites.

Lyons, K. E. 1998. Element Stewardship Abstract for *Convolvulus arvensis* L. Field Bindweed. The Nature Conservancy, Arlington, VA.

This document provides comprehensive information on *Convolvulus arvensis*, including nomenclature, botanical description, stewardship, impacts, global range, habitat, biology and control of this species. Extensive references are cited.

Mallory-Smith, C. A., and B. D. Brewster. 2000. Evaluation of Quinclorac for Field Bindweed Control and Tolerance of Perennial Grasses. Oregon State University, Corvallis, OR.
http://cropandsoil.oregonstate.edu/seed-ext/Pub/2000/21.htm

This website outlines the results of an experiment that investigated Quinclorac as a method of control for *Convolvulus arvensis*. Control 7 months after treatment was 97% with quinclorac and 95% with 3 qt of 2,4-D ester. By 8 months after treatment, control in the 2,4-D plots had fallen to 83%, while that in the quinclorac plots was 93%. No visible injury was noted on the fine fescue, perennial ryegrass or tall fescue, but there was some minor stunting of the orchard grass.

Natural Resources Conservation Service. No date. Plants Profile: *Convolvulus arvensis* L. Field Bindweed. United States Department of Agriculture Plants Database, Washington, DC.
http://plants.usda.gov/index.html

This website provides excellent information including an illustrated description of *Convolvulus arvensis*, alternative nomenclature, distribution by state, the classification system for this species, and the invasiveness and noxious status for each state. The site also provides links to other US websites. Photos and line drawings on this page are not copyrighted, and may be used by acknowledging the author.

NatureServe. 2005. Invasive Species Impact Ranks for the United States. Arlington, VA.
http://www.natureserve.org/getData/plantData.jsp

NatureServe is assessing all of the estimated 3500 non-native plant species that have escaped from cultivation in the US using a new methodology called "Invasive Species Assessment Protocol." This system, developed by NatureServe, the Nature Conservancy and the National Park Service, creates a prioritized list of non-native plants and their impact on biodiversity. The site also includes citations and references used in assessing the species. According to this matrix (January 10, 2005), *Convolvulus arvensis* has a national impact rank of medium/low

NatureServe Explorer. 2005. Comprehensive Report *Convolvulus arvensis*. NatureServe, Arlington, VA.
http://www.natureserve.org/explorer/servlet/NatureServe?init=Species

This website provides a distribution map for *Convolvulus arvensis* in Canada and the US and provides information on the species' status (exotic).

Peterson, D., and P. W. Stahlman. 1989. Field Bindweed Control in Field Crops and Fallow. Kansas State University Research and Extension, Manhattan, KS.
http://www.oznet.ksu.edu/library/crpsl2/MF913.pdf

An overview of *Convolvulus arvensis* in Kansas with particular emphasis on control methods. This document outlines the biology of the plant, and provides data on the effectiveness of herbicide use over time.

Plants for a Future Database. No Date. *Convolvulus arvensis*. Plants for a Future, Chapel Hill, North Carolina.
http://www.ibiblio.org/pfaf/cgi-bin/arr_html?Convolvulus+arvensis

This database provides information on physical characteristics, habitats and locations, edible and medicinal uses, cultivation and propagation. There are also links to numerous other sites.

Sullivan, P. 2004. Field Bindweed Control Alternatives. National Sustainable Agriculture Information Service, Fayetteville, AR.
http://www.attra.org/attra-pub/bindweed.html

Author's abstract: Field bindweed can be a pernicious weed. This publication outlines alternative cultural and physical controls and the use of cover crops and crop rotations to suppress field bindweed. It also discusses least-toxic herbicides and provides a list of resources for supplies and additional information about field bindweed control.

University of Missouri. 2004. Field Bindweed. University of Missouri, Columbia, MO.
http://www.psu.missouri.edu/fishel/field_bindweed.htm

Excellent photos for identification of leaves and seeds.

Weaver, S., and W. R. Riley. 2001. Field Bindweed. Ministry of Agriculture and Food, Toronto, ON. http://www.gov.on.ca/OMAFRA/english/crops/facts/01-007.htm

This fact sheet from the Government of Ontario is fairly comprehensive in describing *Convolvulus arvensis*, outlining its growth characteristics and discussing chemical methods of control.

Weber County Weed Abatement. Field Bindweed. Ogden, UT. http://www.co.weber.ut.us/weeds/types/morningglory.asp

A fairly comprehensive overview of *Convolvulus arvensis* and methods of control (primarily chemical).

Weed Science Society of America. Field Bindweed. Lawrence, KS. http://www.wssa.net/photo&info/larrymitich_info/fieldbindweed.html

This site includes unique information, such as global history of this species and potential uses for the plant. All information includes citations.

Weld County Weed and Pest Division. Integrated Weed Management for Field Bindweed. Weld County, CO. http://www.co.weld.co.us/departments/weed_pest/pdf/FIELDBNDWD.pdf

This pdf document outlines methods of control (cultural, mechanical, chemical and biological) and strategies for integrated weed management.

Wilken, D., and L. Hannah. 1998. *Convolvulus arvensis* L. (Convolvulaceae) Orchard Morning-Glory, Field Bindweed. Santa Barbara Botanic Garden, for Channel Islands National Park, Channel Islands. http://www.usgs.nau.edu/swepic/factsheets/COAR4_APRS.pdf

A comprehensive overview of *Convolvulus arvensis*, including botanical description, distribution and control methods.

Zollinger, R. K., and R. G. Lym. 2004. Identification and Control of Field Bindweed. North Dakota State University Extension Services, Fargo, ND. http://www.ext.nodak.edu/extpubs/plantsci/weeds/w802.pdf

This pdf document outlines the identification and control of *Convolvulus arvensis*, particularly detailed chemical treatment options. The handout also includes a key to discriminating between field bindweed, hedge bindweed and wild buckwheat.

Zouhar, K. 2004. *Convolvulus arvensis*. Fire Effects Information System, US Department of Agriculture Forest Service, Rocky Mountain Research Station Fire Sciences Laboratory. www.fs.fed.us/database/feis/

This site provides an overview of *Convolvulus arvensis*, including distribution and occurrence in the US, botanical and ecological characteristics, fire ecology, fire effects, management considerations and extensive references.

General summaries of basic information, or fact sheets:

- http://www.weedalert.com/weed_pages/wa_field_bindweed.htm
- http://mtwow.org/field-bindweed-ID.html
- http://www.oneplan.org/Crop/noxWeeds/nxWeed08.htm
- http://www.ppws.vt.edu/scott/weed_id/conar.htm
- http://www.agf.gov.bc.ca/cropprot/weedguid/bindweed.htm
- http://www.oznet.ksu.edu/pr_wheat/Weeds/field_bindweed.htm
- http://www.co.shawnee.ks.us/NW/bindweed.shtm
- http://bc4weeds.tamu.edu/weeds/rangeland/fieldbindweed.html
- http://www.ext.colostate.edu/ptlk/2104.html
- http://www.cwma.org/weed_descriptions/bindweed.html
- http://dnr.metrokc.gov/wlr/lands/weeds/field_bindweed.pdf
- http://www.northern.edu/natsource/NOXIOU1/Bindwe1.htm
- http://www.geocities.com/pelionature/Convolvulus.htm
- http://www.weedsbc.ca/weed_desc/field_bind.html
- http://www.accesskansas.org/kda/Plantpest/PestManagement/plant-pestmangement-bindweed.htm
- http://www.lyoncounty.org/Field%20Bindweed.pdf
- http://www.maltawildplants.com/CONV/Convolvulus_arvensis.html
- http://web1.msue.msu.edu/msue/iac/ipm/bindweed97.htm
- http://www.unce.unr.edu/publications/FS04/FS0448.pdf
- http://www.ardentermite.com/2003/pestnotes/plants/pnfieldbindweed.pdf
- http://oregonstate.edu/dept/nursery-weeds/feature_articles/bindweed/field_bindweed_email.html
- http://www.ag.ndsu.nodak.edu/invasiveweeds/fieldb.htm
- http://www.colostate.edu/Depts/CoopExt/Adams/weed/pdf/Field_bindweed.pdf
- http://ipm.okstate.edu/ipm/weeds/FieldBindweedPT.pdf
- http://www.cloudcountyks.org/MV2Base.asp?VarCN=70
- http://www.oardc.ohio-state.edu/weedguide/singlerecord.asp?id=610
- http://www.agr.gov.sk.ca/DOCS/crops/integrated_pest_management/weed_identification_broadleaf_weeds/Fieldbli.asp
- http://www.npwrc.usgs.gov/resource/plants/explant/convarve.htm

Personal Communications

Arnold, John. 2005. *Personal communication*. Supervisor for Woodlands, Government House, Victoria, BC. March 22, 2005.

> Arnold used to use Roundup to treat field bindweed at Government House in Victoria and it was effective, but they have been discouraged from using it. With Roundup, they gathered the vines and leaves in a ball on the ground and sprayed them to minimize overspray effects on nearby natives. They now use Roundup to paint on cut stems (above the roots) of ivy, brambles and other invasives. Another method Arnold has tried is treating cut stems with pure turpentine. He cuts a rooted stem off approximately 8-10 inches from the base of the plant where it comes out of the ground, then dips the cut end into turpentine. The objective is to stop the stem from resprouting.

Arnold has observed that this method is at 50-75% effective and results will be seen in approximately one month. He says that the best time of year for treatment is before the plant starts blooming (midsummer).

Beckwith, Brenda. 2005. *Personal communication*. Ethnoecologist, University of Victoria, Victoria, BC. March 18, 2005.

Beckwith has never observed field bindweed in Garry oak ecosystems, but she predicts that it might be on the fringe between developed residential zones and natural areas. Since this species successfully propagates via rhizomes, it will grow only near a seed or rhizome source, such as dumps or composts. She has noticed that some exotic invasive species spread from households where residents use the edge of Garry oak ecosystems to dump compost and lawn waste, and this may be a source for field bindweed. In her own yard, she has tried using weighted plastic to control field bindweed, without success.

Betts, Michael. 2005. *Personal communication*. Weed Specialist, Ministry of Agriculture, Food and Fisheries, Victoria, BC. March 22, 2005.

Betts considers field bindweed to be a serious concern. His main experience with this species in coastal BC is from an agricultural perspective, although he has also seen it to be a problem in horticultural situations such as nurseries. He has found field bindweed quite invasive and difficult to control, spreading vegetatively through an extensive root system. It is a climber and causes problems in an agricultural situation if it winds onto and is spread by equipment. Because it spreads vegetatively it is a concern for non-chemical weed treatments. He has observed field bindweed to be a problem primarily in corn crops, and has found dicamba 2,4-D mixtures to be quite effective. Weeding it is not effective because it can act like tilling and promote growth.

Boyer, Lynda. 2005. *Personal communication*. Restoration Biologist and Native Materials Manager, Heritage Seedlings Inc., Salem, Oregon. March 21, 2005.

Boyer notes that in the prairie and oak habitats that she has been restoring, field bindweed is present but not dominant. Some of the meadow areas dominated by non-native pasture grasses and weedy forbs such as bindweed were treated with glyphosate to prepare them for native seed reintroduction. After one season of herbicide, the bindweed increased on the site. This species seems to have some resistance to glyphosate and will take advantage of the newly opened ground. After a second season of glyphosate and revegetation of the site with native grasses and forbs, no bindweed has been noted.

If the desire is to selectively remove invasive species from a prairie remnant and field bindweed is one of the problem species, instead of a general herbicide such as glyphosate, she suggests spot-spraying with a broadleaf herbicide such as 2,4-D or perhaps an herbicide containing clopyralid (e.g., Confront). The latter is a broadleaf herbicide that is specific and very effective on composites and legumes but might also be effective for species in the morning glory family. However, clopyralid has a long life in the soil so it should be carefully spot-sprayed. Spot-spraying is preferable to broadcast-spraying, which requires that native composites or legumes not be reintroduced until after one to two years, when the chemical degrades. She and others in the restoration community feel the largest threats to native species persistence on Garry oak prairies are perennial pasture grasses such as tall oatgrass, tall fescue, bentgrass, and velvet grass. However, in some sites, invasive forbs such as field bindweed can also have a negative impact due to their highly competitive nature and lack of natural predators.

Ceska, Adolf. 2005. *Personal communication*. Botanist, Victoria, BC. March 16, 2005.

Ceska has not seen field bindweed much in Garry oak ecosystems. He feels that this species is not a problem in these ecosystems.

Ennis, Tim. 2005. *Personal communication.* Director of Land Stewardship for BC Region, The Nature Conservancy of Canada, Victoria, BC. March 1, 2005.

Ennis describes one site with field bindweed across the street from a 20-acre Garry oak preserve containing the best deep-soiled Garry oak habitat in Canada. The infestation is a sheep farm with few native species and contains field bindweed amongst other non-native plant species. The Nature Conservancy experimented with plowing large areas and turning the soil to expose the roots and allow the sun to burn them. It worked well, even for field bindweed.

Fairbarns, Matt. 2005. *Personal communication*. Plant Ecologist, Aruncus Consulting, Victoria, BC. February 22, 2005.

Fairbarns has observed field bindweed all over BC in dry grassy areas, and has seen it up to the Peace region in grasslands. It tends to invade lawns, roadsides, old fields and abandoned lots. He does not consider this species a problem in most Garry oak areas. Field bindweed seems to do best in areas that are tilled, and he has never observed it in a Garry oak stand or meadow where there isn't disturbance to soil. He has noticed that it is very tolerant of drought and soil compaction, and prefers high levels of light, being strongly associated with open environments. He has never seen field bindweed in very nutrient-poor soils but has observed it in moderately poor to very rich soils. This species doesn't appear to like sites that are wet or saturated during the winter, and he hasn't observed it in hydric or subhydric sites, rarely in hygric and subhygric, and most often in mesic to subxeric soils. He has seen it as a scrambling plant that will grow in grass but also will scramble up old shrubbery, although it doesn't usually get very high. Fairbarns suggests avoiding soil compaction and maintaining natural cover of vegetation to prevent field bindweed from establishing, since once it is in a site, it is quite persistent.

Gayton, Don. 2005. *Personal communication*. Ecosystems Management Specialist, FORREX, Nelson, BC. March 1, 2005.

Gayton has a pressed specimen of field bindweed from the 1940s, so it has been in BC for many decades. He has seen situations where bindweed is like ivy, covering other plants, but he has not seen this occur in BC.

Hebda, Richard. 2005. *Personal communication*. Curator of Botany and Earth History, Royal BC Museum, Victoria, BC. March 16, 2005.

Hebda has noticed field bindweed on roadsides and mowed fields throughout southern Vancouver Island, particularly along the Patricia Bay highway. In weedy sites, this species can be dominant and can be the only plant species to bloom in dry summers. It is a deep-rooted species, so trying to remove it can be difficult. It is possible that field bindweed cannot survive in shallow soils, as he has noted it in relatively deep soils of 30 cm or more. Hebda has not seen this species as much of a problem in Garry oak ecosystems, but he explains that it might be an issue in disturbed sites that are to be restored to Garry oak ecosystems. In these types of sites, it would be difficult to establish native species such as shooting stars or buttercups because, in order to remove field bindweed, all plants would have to be sprayed or the soil would have to be dug deeply. To treat this species chemically, repeated applications of herbicide are required. As with other weed species, Hebda cautions against disturbing the soil, which provides a new seed bed for invasive species.

Lomer, Frank. 2005. *Personal communication*. Naturalist, New Westminster, BC. March 8, 2005.

Lomer has seen field bindweed primarily in cultivated fields and on roadsides, and does not feel that it is a threat to Garry oak habitat. This species is rare on the coast in southwestern BC in Garry oak areas. He has observed that field bindweed prefers drier, sunnier habitat and open ground. He has found that hand-pulling aboveground stems is not effective, and that it is important to dig it out and get rid of the roots. If it is cut back frequently, though, it doesn't come back.

McClay, Alec. 2005. *Personal communication*. Biocontrol Specialist, McClay Ecoscience, Sherwood Park, AB. March 23, 2005.

McClay notes that both field bindweed and *Aceria malherbae* have wide distributions and occur in a wide range of climates. For example, field bindweed is an issue in vineyards in California. McClay believes that *Aceria* would establish in Garry oak ecosystems and related habitats given that the mite is from Greece originally (a Mediterranean climate) and has established in Texas, Alberta and Montana as well as widely throughout the southwestern US. McClay notes that *Tyta luctuosa* is not a promising bioagent because it has never established in North America; also, it only defoliates, which field bindweed can tolerate.

Polster, Dave. 2005. *Personal communication*. Plant Ecologist, Polster Environmental Services Ltd., Victoria, BC. February 21, 2005.

Polster has seen field bindweed all over southern Vancouver Island, although he has never observed it in Garry oak ecosystems. He notes that field bindweed tends to like moister, nutrient-rich sites. He has seen field bindweed regrow rapidly from small pieces, and has observed it strangling and covering plants. He has attempted persistent hand-pulling to control this species but every year it grows back. To dispose of remains, he pulls the cuttings out to the middle of his yard and runs over the pile with a lawnmower, which seems to be effective.

Ralph, Dave. 2005. *Personal communication*. Provincial Weed Technologist, Ministry of Agriculture, Food and Fisheries, Kamloops, BC. March 22, 2005.

Ralph has observed field bindweed throughout the whole southern part of the province, primarily in garden or crop situations or in unused areas (such as along roadsides). He has not seen it much in "wild" situations. The products recommended for chemical control are picloram (e.g., Tordon 22K) or Roundup at high rates since this species needs a translocating herbicide because of its extensive root system. If field bindweed is growing within shrubbery or gardens, a method for homeowners is to use a wipe-on of 25-33% picloram solution mix. This method will provide a selective treatment. For management in cultivated fields, there should not be rototilling (which breaks up and moves root pieces), but rather discing (which cuts and breaks the plants down without dragging them). Caution must be taken not to drag root pieces beyond the infested area. Ralph suggests that if someone is going to till, they chemically treat all the bindweed first and then till and cultivate afterwards. Hand-pulling is another control method, and can work quite effectively in loose soils, but it is difficult. Also, if the soil is being disturbed it may promote growth of any remaining plants. Ralph notes that fertilizers and burning are probably not a very effective control for field bindweed, and that clipping it to reduce seed production has limited effect because it spreads primarily by its roots.

Roemer, Hans. 2005. *Personal communication*. Botanist, Victoria, BC. March 17, 2005.

Roemer notes that field bindweed prefers ruderal habitats such as roadsides and other disturbed sites, and he has never seen this species in Garry oak ecosystems. He notes that a Garry oak ecosystem would have to be tremendously disturbed before bindweed came in and at that point there would probably be about 90% non-native plants by biomass.

Spencer, Fran. 2005. *Personal communication*. Chair, Garry Oak Woodlands Management Committee, Victoria, BC. March 22, 2005.

Spencer has been involved in managing field bindweed at Government House in Victoria for many years. They have been continually trying to get rid of this plant by two methods. In areas where the ground is firm, they pull the plants on top of a plastic bag, wind them into a bundle, and then spray the bundle with Roundup. It goes into the root system and kills the plants off quite effectively. In areas where the soil is more loose, they hand-pull the plants. These plants tend to come back, but it is difficult to determine if it's the same piece of plant growing back, or a different piece that was missed. With continual treatment, Spencer has noticed a reduction in field bindweed over the years and says that it is not as much of a problem as ivy.

Spencer explains that field bindweed has been at Government House for decades. In some areas that have been used for composting or where materials were dumped it is worse. She has never observed this species in a "wild" setting, but only in sites that have had previous disturbance, such as composting or an old nursery.

Turner, Nancy. 2005. *Personal communication*. Ethnobotanist, University of Victoria, Victoria, BC. February 18, 2005.

Turner has observed field bindweed occasionally, but it doesn't seem to be as pervasive as some other invasive species.

Turner, Susan. 2005. *Personal communication*. Biological Control Specialist, Ministry of Forests, Kamloops, BC. March 22, 2005.

Turner explains that *Aceria malherbae* has been released in BC but *Tyta luctuosa* has not. *Aceria malherbae* was released in two locations, the first in 1992 and the second in 1998. Presence of this agent was noted as positive in one site in the year following the release but since then no evidence of this agent has been found at either site. At this time, therefore, she concludes that neither agent is an option for biocontrol on the coast.