

## **Brainard and Bellinder**

### **Project Summary**

Both hairy galinsoga (*Galinsoga ciliata*) and corn chamomile (*Anthemis arvensis*) have been identified as particularly problematic species for vegetable growers, reducing yield and quality in a variety of crops. Crop rotation strategies involving use of short-duration cover crops may be helpful in managing these pests while reducing dependence on herbicides and building soil health. Successful management of these species would also benefit from improved understanding of their biology and ecology. The objectives of this research are to (i) evaluate the potential for summer smother crops following early harvested vegetables to prevent galinsoga seed production, (ii) evaluate the potential for residues from these crops to reduce the emergence and growth of corn chamomile and increase the rate of seed decay of both species, and (iii) obtain basic information on the population dynamics of these species in order to better target weed management practices. In the summer of 2006 and 2007, buckwheat, sorghum-sudangrass, oats, peas, and forage soybean, will be established following early harvested vegetable crops in fields with known infestations of galinsoga and corn chamomile. The effects of each cover crop and its residue on weed mortality, growth, seed production, and seed fate will be assessed. For corn chamomile, information on the timing of flower head and seed production for individuals emerging at different times (e.g. fall vs spring), will be obtained through a detailed observational study. Results from these experiments, in conjunction with on-going work using other weed management strategies, should be helpful for reducing yield losses and weed management expenses associated with these species, while reducing agrichemical runoff and maintaining and improving soil health.

## 4. Project Description

### 4.a Problem, Background and Justification

This project directly addresses several high priority issues identified by the Vegetable IPM Working Group. In particular, “Galinsoga” (total score 9) and “Better understanding of crop rotations” (total score 11) are central issues addressed in the proposed work. In addition, the proposal targets corn chamomile (“daisy”), a problematic winter annual weed, which has been identified by pea growers as an important and growing problem.

Galinsoga was listed as a major pest priority by the vegetable IPM Working Group for Northeastern vegetable growers. It is a rapid-growing, rapid-reproducing summer annual species that can reduce yields from 10-50% in a wide range of vegetable crops including beans, carrots and cabbage (Warwick and Sweet 1983). Galinsoga can also severely interfere with hand or machine harvesting of vegetables. Chemical options for control of galinsoga are limited for many vegetable crops, as many of the herbicides available for vegetable growers have only limited effectiveness against this species. Galinsoga is also a major problem for organic vegetable growers, as it is not easily controlled by cultivation, and it reproduces so quickly, that expensive hand-weeding is required to prevent it from going to seed. Galinsoga is a prolific seed producer, capable of producing over 1 million seeds per m<sup>2</sup> in unmanaged fields (Brainard, unpublished). Prevention of seed production in fallow fields is therefore an important step in reducing problems associated with this weed.

Corn chamomile (*Anthemis arvensis*), often referred to as “daisy” by growers, is also a major pest in vegetable production. It has been consistently listed as a highest research priority for pea producers, and is especially problematic in rotations involving winter wheat. Corn chamomile is a winter annual species which produces a flower head that has the same size and shape as pea. Peas contaminated with corn chamomile flower heads are routinely rejected by processors. Economic losses from this weed in NY State alone are estimated at approximately \$500,000 annually. Corn chamomile is also very tolerant of common herbicides used in peas, as well as those typically used in wheat. Even Roundup, sprayed at high rates, has limited effectiveness at controlling this species.

Crop rotation with species varying in their life history can be an extremely valuable tool for suppressing weeds (Liebman and Dyck 1993). Such rotations can disrupt weed life-cycles and prevent the buildup of individual species adapted to a specific crop. However, changes in the sequence of cash crops are driven largely by economic forces, and are unlikely to be easily changed to combat a weed. For example, the buildup of corn chamomile problem in peas may be due in large part to its rotation with wheat—whose winter annual life cycle matches that of corn chamomile—but elimination of wheat from the rotation sequence would be costly.

A more realistic approach which holds potential for reducing weed problems involves inserting short-duration cover crops into the rotation to fill fields that might otherwise lie bare. By planting aggressive cover crop species following harvest of early vegetable crops, weeds can be effectively suppressed while reducing erosion (Flach 1990), fixing N for subsequent crops (Peoples et al. 1995), and providing a carbon source to improve biological and physical soil quality parameters

(Karlen et al. 1990; MacRae and McDole 1985). Summer annual cover crops may also reduce insect and disease pressures by disrupting pest life cycles, attracting beneficial predators, and reducing dispersal of disease propagules (Liebman and Dyck 1993; Andow et al. 1986).

Cover crops may suppress weeds in several ways (Teasdale 1998; Liebman and Dyck 1993). First, they can smother weeds that might otherwise fill the void left after crop harvest. For galinsoga in particular, prevention of seed production during fallow fields is especially important. Second, their residues may suppress weeds through the effects of allelopathy, N-tie up or mulch effects (Teasdale 1998). This may be especially important for corn chamomile, which often emerges in the fall. Third, they may provide habitat for seed predators or a substrate for fungal pathogens of weed seeds which can indirectly increase the rate of seed loss from the weed seed bank (Reader 1991; Carmona and Landis 1999).

Because growers have limited time and resources to devote to managing non-cash crop fields, cover crop research must target cover crop species which (i) are low cost, (ii) require little or no management following establishment, (iii) are sufficiently aggressive to prevent weed seed production, and (iv) have benefits beyond weed suppression (e.g N fixation, disease suppression). Within the Northeast, cover crops which may meet these criteria include non-legumes like oats, buckwheat, and sorghum-sudangrass, and legumes like field pea, red clover, or forage soybean (Schonbeck 1988). Buckwheat and sorghum-sudangrass are especially inexpensive, fast growing species that are well adapted to warm summer temperatures (Creamer and Baldwin 2000). Legumes are often more expensive and less effective at suppressing weeds, but can fix substantial amounts of N, and hence reduce fertilizer costs, especially for organic growers. When grown in combination with non-legume species, the benefit of N-fixation and lower C:N ratios may be maintained without sacrificing weed suppression benefits.

Residues from late-season cover crops may be beneficial for suppressing corn chamomile emergence and growth in the fall. In preliminary experiments, buckwheat residue reduced corn chamomile emergence by 60% and biomass by almost 75% compared to bare soil (Brainard, unpublished). These stunted plants may have greater winter mortality, and may be more susceptible to herbicides, or competition from winter annual crops like wheat. Reduced emergence and growth of corn chamomile in wheat or bare soil would result in less seed production the following spring, and reduced probability of corn chamomile problems in future pea crops. Residues of other cover crops, including those examined in our proposed work, are effective at suppressing many weed species (e.g Haramoto and Gallandt 2005), but to our knowledge, no studies have examined their effects on corn chamomile. As with herbicides, the effects of these residues is often selective, so testing these effects on specific crops and weeds is critical to their success.

Successful management of galinsoga and corn chamomile would also benefit from improved understanding of their biology and ecology. Many basic biological questions remain unanswered. For example, if seed production is avoided, how long will it take to deplete the seed bank through loss of seed viability? To what extent might cover crop residues enhance the rate of decay of seeds? Will corn chamomile seedlings emerging several weeks following pea planting have sufficient time to produce flower heads that might contaminate the pea crop, or can these late emerging individuals be safely ignored? Answers to such questions would be valuable for

assessing the potential success of crop rotation strategies, determining the necessity for, and optimal timing of post-emergence herbicide applications, or assessing the full costs and benefits associated with cover crops.

Previous researchers have observed that seeds of galinsoga appear to be short-lived, and therefore practices which prevent seed production for as little as one year can significantly reduce or eliminate galinsoga populations (Warwick and Sweet 1983). However, resurgence of galinsoga following incorporation of perennial crops (Brainard, personal obs.), suggest that either their seeds are easily dispersed, or that they can live longer than previously thought. Mounting evidence suggests that seed mortality can also be strongly influenced by tillage and cover cropping practices through their influence on insect predators and fungal pathogens of weed seeds (Reader 1991; Carmona and Landis 1999), but studies of these kind are few and far between, and none have focused on galinsoga or corn chamomile.

For corn-chamomile, even less basic biological information is available to help guide management and formulate a research agenda. For example, we don't know whether corn chamomile individuals which produce flower heads in peas originate from seedlings emerging in the fall and surviving spring field preparation, or from seedlings emerging after pea planting. If escapes are most important, than more aggressive field preparation or changes in fall plowing methods might be targeted to improve management. On the other hand, if spring emergence is substantial, greater emphasis on management options within peas might be more appropriate. We also don't know how late a seedling can emerge in the spring and still produce flower heads or seeds. Such information would be invaluable for guiding decisions on the optimal timing of post-emergence herbicide applications or cultivation practices.

#### **4.b Objectives and Anticipated Impacts**

**Objectives.** The proposed study has three major objectives:

- 1) Identify cos-effective summer smother crops that can (a) prevent galinsoga (*Galinsoga ciliata*) weed seed production and (b) reduce the emergence and growth of corn chamomile (*Anthemis arvensis*).
- 2) Obtain basic information on the population dynamics of corn chamomile in order to better target weed management practices. In particular, evaluate the effect of time of emergence (fall versus spring) and cover crop residues on the survival, growth, timing of flower formation, and seed production of corn chamomile.
- 3) Estimate the rate of decay of seeds of galinsoga and corn chamomile in the soil, and the potential for cover crop residues to increase the rate of seed mortality.

#### ***Anticipated impacts***

***Safeguarding human health and the environment.*** We anticipate that our research will provide management tools to help growers reduce the incidence of two extremely problematic weeds,

while reducing reliance on pesticides and building soil health. The identification of optimal cover cropping strategies to suppress weeds should reduce dependence on herbicides and lower health and environmental risks associated with their use. In particular, we expect that the integration of cover cropping strategies will reduce the need for herbicides required to control corn chamomile in wheat and peas and galinsoga in multiple vegetable crops. Integration of low-cost cover crops following early harvested vegetables should also reduce leaching and runoff of N and pesticides, preserve and enhance soil health and reduce the incidence of insect and disease pests and the pesticides required to manage them. Improved information on the biology of corn chamomile should also be helpful in improving the efficiency of herbicide and cultivation practices, by identifying and targeting weaknesses in the life history of this weed.

***Economic benefits.*** By identifying practices which reduce the incidence of corn chamomile and hairy galinsoga, we anticipate that costs associated with yield losses and management of these species will be significantly reduced. It is estimated that corn chamomile alone costs the NY pea industry roughly \$500,000 per year and growing (see attached letter). Costs associated with galinsoga are felt across the Northeast in a wide range of vegetable crops. Other economic benefits potentially associated with cover crops include reduced N fertilizer input costs (due both to reduced leaching and N fixation by legumes), and higher crop yields due to improvements in soil health.

***Implementation.*** Ultimately, we expect that our proposed research will complement and improve the efficiency of on-going efforts to manage these species using other approaches. For example, we expect that on-going research focused on the efficacy of herbicides and cultivation practices aimed at managing these species, will be enhanced by better understanding of their biology. For example, research on the phenology of flower head formation of corn chamomile should inform decisions about the necessity of late herbicide applications. Information on the longevity of galinsoga seeds should provide guidance on the required duration of rotations in non-susceptible crops. We expect that information from these studies will also facilitate prioritization of future research activities by identifying potential weaknesses in the life cycle of both species, as well as cohorts that are most likely to cause problems.

#### **4.c Approach and Procedures**

**Cover crop effects on weed suppression.** Field experiments will be established in the summer of 2006 and 2007 at two sites: a field at the Homer Thompson Research Farm in Freeville, NY, known to have a very large hairy galinsoga weed seed bank; and a field at the Caldwell Research Farm, known to have a very large corn chamomile weed seed bank. At each site, the following cover crop treatments will be established: (1) Buckwheat 1: sown in mid July and mowed and disked approximately 10 days after anthesis (about 40 DAS) to avoid buckwheat seed production, (2) Buckwheat 2: sown in early August following a bare fallow period, and mowed and disked approximately 10 days after anthesis, (3) Sorghum-sudangrass, (4) oats, (5) Sorghum-sudangrass-soybean mixture, (6) Oats-peas mixture, (7) bare soil control maintained through periodic harrowing, and (8) weedy control. All non-buckwheat treatments will be sown in mid July and mowed and disked in early September, about 2 wks prior to the typical wheat planting date. All treatments will be establishing using a grain drill (7" between row) in plots measuring 10' x 40'. The experiment will be arranged as a randomized complete block design, with four replications.

Following cover crop incorporation, winter wheat will be established in 10' x 20' subplots within each main cover crop treatment by running a grain drill perpendicular to the cover crop strips.

At the Freeville site, galinsoga and cover crop counts will be conducted in four 0.25 m<sup>2</sup> quadrats within each plot at 20 DAS, 38 DAS (just before buckwheat mowing) and 65 DAS. Weed and cover crop biomass samples will be taken from two of these quadrats from all plots just before buckwheat mowing (38 DAS) and at 65 DAS. Roots of leguminous cover crops will be inspected and given a visual rating for nodule formation. Galinsoga samples will be assessed for seed production at both sampling dates. Galinsoga seed production estimates will be obtained by (i) counting mature flower heads on a subset of plants, (ii) multiplying by an estimate of seed number per flower head, (iii) estimating the relationship between plant weight and seed number using regression analysis, and (iv) calculating seed number based on plant weight using this regression equation (Brainard 2002). At the Caldwell site, weed and cover crop data will be collected as described for the Freeville site. In addition, following incorporation of cover crops, emergence of corn chamomile and wheat will be monitored 20 days after incorporation in two 0.25m<sup>2</sup> permanent quadrats in each subplot.

The effects of cover crop treatments on galinsoga seed production, and the effects of cover crop residues on corn chamomile and wheat emergence will be assessed using on-way ANOVA procedures of SAS. In addition, the costs of establishment and maintenance of each cover crop treatment will be estimated based on seed and labor costs.

**2. Emergence, survival, and reproductive phenology of corn chamomile.** At the Caldwell site, the fate of corn chamomile seedlings will be monitored in bare soil and cover crop treatments. Following emergence counts in the fall (see above), at least five individual plants per permanent quadrat will be tagged in order to track overwinter seedling survival and subsequent growth. The following spring, emergence counts and survival will be evaluated in the same quadrats, once every month for three months, beginning in early spring following snow melt. Following each emergence count, at least 5 individual plants emerging since the last census will be tagged and all other individuals removed by hand. A different colored tag will be used for each sampling period to distinguish groups of plants emerging at different times (cohorts). Survival, height, and timing of flowering will be recorded for each cohort.

Plants from each plot will be harvested on around July 15 (approximate time of pea or wheat harvest), bulked by cohort, dried, and weighed. In addition, seeds will be collected from a subset of plants from each cohort, separated from reproductive tissue, and divided into two seed size classes (large and small) using sieves. Previous research has demonstrated that the germination characteristics of corn chamomile vary by seed size, with large seeds exhibiting greater dormancy than small ones (Ellis and Ilnicki 1968). By comparing the proportion of seeds in a given class size, we can test whether seeds produced on plants emerging in the spring are likely to germinate at different times than those produced on plants emerging in the fall.

Weed counts at each sampling date will be used to assess the effects of cover crops on total emergence, the timing of emergence, and seedling mortality of corn chamomile. The effect of time of emergence on the timing of flower head formation, seed production, and seed size distribution will be assessed using ANOVA procedures in SAS.

In addition to the replicated trial at Caldwell field, several sites of known corn-chamomile infestation (e.g. Votypka Farms – see attached letter) will be surveyed in early spring prior to pea planting, approximately 20 days after planting, just prior to pea harvest, and again in the fall. At each site, corn chamomile density and growth stage will be assessed in five randomly placed quadrats.

**3. Seed mortality of hairy galinsoga and corn chamomile seeds in the soil.** At each site, soil samples will be taken from each cover crop treatment (i) before cover crop planting, (ii) following cover crop incorporation in the fall, and (iii) again in the spring. Weed seed bank estimates for galinsoga (Freeville) and corn chamomile (Caldwell) will be made by monitoring emergence from these samples in the greenhouse. Because galinsoga has little or no seed dormancy, emergence in the greenhouse should be well correlated with the seed bank. For corn chamomile, which does exhibit seed dormancy, soil samples will be split in two and tested for emergence immediately after sampling, and again following 3 months storage at 5 C.

In addition, 100 freshly collected seeds of each species will be buried in each plot in nylon mesh bags filled with soil from that plot. To avoid complication of different background levels of these species in the soil bags, each species will only be buried at the site where that species is absent (corn chamomile at Freeville and galinsoga at Caldwell). Seed bags will be exhumed in the spring and seeds separated from soil using a high volume column elutriator. Seeds will subsequently be counted and assessed for viability by germination and tetrazoleum testing.

Seed mortality will be calculated for both species by comparing initial and final weed seed bank estimates based on emergence, and by comparing viability of buried seeds in the fall and the following spring. The effects of cover crops on seed mortality will be assessed using one way ANOVA.

#### **4.d Evaluation Plans**

Following our field studies, data will be analyzed and the following questions addressed: Which cover crops studied were most effective at (i) preventing galinsoga seed production, (ii) suppressing emergence and growth of corn chamomile, and (iii) increasing the rate of seed mortality of both species? What was the cost of seed, field preparation, and maintenance for each cover crop? What other benefits might be attributable to the use of these cover crops within specific vegetable rotations? A summary of findings and the probable costs and benefits associated with each practice will be distributed to growers, provided at weed science field days, and presented at vegetable growers' conferences and weed science conferences, with opportunities for discussion and feedback.

The usefulness of basic information on the biology of corn chamomile will be evaluated for its helpfulness in informing weed management decisions and prioritizing future research. For example, using data from the Caldwell field site, we will assess whether meaningful differences exist in the severity of problems caused by different cohorts of corn chamomile. Do cohorts emerging in the spring produce flower heads by the time of pea harvest? Does significant seed production occur from these cohorts, or is it limited to those cohorts emerging in the fall?

## References for Project Description

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