Canola in Western Oregon – Information from the Literature and OSU Research Activities and Some Speculations - January 16, 2010 – Prepared by Russ Karow, OSU Crop and Soil Science

Funding for a research project to address issues surrounding the production of canola seed for oil in Western Oregon was initially provided to the Oregon Department of Agriculture (ODA) by an Oregon Legislature Emergency Board grant in 2006. Follow-on funding for a three-year project was provided to ODA by the 2007-09 Oregon Legislature. ODA contracted with Oregon State University (OSU) to do research work with Russ Karow managing the project. Research was carried out by OSU scientists with expertise in the various areas of interest in the project. The research was conducted so that ODA could obtain information needed to make informed decisions about canola production zones in the state. The research was presented to the ODA Canola Advisory Committee that met during 2009 to develop recommendations to ODA regarding canola production in the Willamette Valley.

In summary, OSU's research work and associated literature reviews found the following:

- Literature reviews of pollen and bee travel indicate the potential for pollen movement up to 5 miles.
- Canola and certain specialty seed crops can successfully cross-pollinate and produce viable seed under Willamette Valley environmental conditions.
- Insect pest levels in canola research fields were low. This is not surprising as all but one field were first-time canola crops in these fields and they were surrounded by grass seed and grain crops. One field had been planted to turnips four years prior and also had low insect levels. Experience with *Brassica* specialty seed and vegetable crops suggests that if canola acreage increases and crops are nearer to each other in time and/or space, cabbage maggot could become a problem. Pollen beetles were found at low levels in canola fields.
- White mold was found in all monitored grower canola fields at low to high levels. We do not know how 5-10,000 acres of canola would affect white mold levels, as well as levels of other diseases that also affect vegetable and specialty seed crops.
- Significant amounts of canola seed are lost to seed pod shatter during harvest. Much of the seed is consumed by predators or destroyed with routine management practices used to prepare a field for a follow-on crop, but significant amounts of seed remain in the soil.
- Volunteer plants from seedbank seed can be controlled in follow-on grass or grain crops using typical weed management practices, but growers will need to monitor fields for volunteer plants for at least 2-3 years

The decision made by ODA, in consultation with Russ Karow, to not allow canola production in a major part of the Valley is a precautionary decision. The research work that was done resulted in as many questions as answers. We know that canola will persist in the seedbank in Valley soils for at least two years, so each acre of canola that is grown is a potential problem for several years. For example, if 1000 acres of canola were planted in each of three years, in the third year of planting, 6000 acres would need to be monitored for pests or volunteer plants. If canola crops are planted in different fields but the same vicinity on a given farm, will sclerotinia spread from field-to-field? Will cabbage maggot persist from year-to-year? While volunteer canola may be controlled in follow-on grain and grass crops, will field borders and roadsides and waterways be carefully monitored? Would a few hundred or thousand or tens of thousands of volunteer canola plants with a different flowering cycle than weedy *Brassica* species significantly add to the feral *Brassica* problem we already have in the Valley? We do not know

the answers to these and other questions and given the potential risk, precaution suggests not allowing canola production at this time.
Additional research and experience may offer future options for production. The following research would be particularly helpful.

- Monitor *Brassica* seed crop fields of different species planted using different methods for flowering date with the intent to determine if flowering date can be predicted.
- Conduct "spoke-wheel" or other types of pollen travel studies to determine the potential for canola cross-pollination with *Brassica* specialty seed crops under typical field conditions.
- Develop a detailed cabbage maggot monitoring program in all susceptible crops to determine if there is potential for predicting maggot outbreaks under Valley conditions. The electronic pinning system developed as part of the ODA project may be helpful in this regard.
- Develop a detailed white mold monitoring program in all susceptible crops to determine if there is potential for predicting white mold outbreaks under Valley conditions. The electronic pinning system developed as part of the ODA project may be helpful in this regard.
- Continue to track the fate of seeds lost to shatter in the canola fields that were planted by growers as part of the ODA study. The electronic pinning system developed as part of the ODA project could also be used to identify past-year *Brassica* specialty seed fields that could be monitored for seedbank *Brassica* seed and volunteer plants.
- Intensify work to identify alternate oilseed (camelina, soybean, flax, safflower, others?) or other broadleaf crops that can be profitably grown in rotation with grasses and grains in Western Oregon and would have less impact on *Brassica* specialty seed and vegetable crop production.

The following pages provide additional background information about the research project and more detailed results from the research and literature reviews.

What is the issue?

Western Oregon and western Washington have the ideal climate for the production of seed crops – mild winters, warm-dry summers. There are only four other areas of the world with a similar climate – the coastal areas of southwest British Columbia, parts of Chile, areas in the Mediterranean and parts of Australia. Seed crops of various types are grown in these other areas. In the Willamette Valley of Oregon where over 500,000 acres of grasses have been grown for seed in recent years, the specialty seed crop industry produces vegetable and flower seeds including *Brassicas*. *Brassicas* are a genus of plants that includes many popular vegetable crops such as broccoli, radish, rutabaga, as well as other plants such as canola and mustards,

While the *Brassica* specialty seed crop acreage is small, it is very profitable with annual farm gate value estimated to be over $25M and growers often netting $500-1500 or more per acre. These small acreages also represent a majority of the worlds *Brassica* seed production. It is estimated that this area produces nearly all (>90%) of the European cabbage, Brussels sprouts, rutabaga and turnip seed, and a substantial portion (20 to 30%) of radish, Chinese cabbage and other oriental *Brassica* vegetable seed.

Because canola is the most promising crop for the production of biodiesel in the Valley (reliable, high yielding, profitable at current prices) and farmers need an alternative crop in their grass cropping systems, there is a desire to grow canola. However, the specialty seed crop growers of Western Oregon and Washington have voiced concern about growing canola in the region. These growers feel that high value *Brassica* vegetable seed crop production will be jeopardized if contamination occurs from canola. A seed lot will be rejected if more than three out-crossed seed per 1,000 seed are found. Because of the potential for contamination, some specialty seed customers have threatened to pull all seed contracts, not just *Brassica*, from Western Oregon if canola production is allowed.

The taxonomy and genetics of the *Brassica* species are complex. The *Brassica* genus includes crops and weed species. One of the unique aspects of the crop species is that several crops with very different physical appearance were derived from the same species and are therefore highly interfertile (Hancock 2004). Cabbage, kohlrabi, cauliflower, broccoli, Brussels sprouts, and kale all originated from *Brassica oleracea*. In North America, most of the canola grown is *B. napus*; however, canola can be either *B. napus* or *B rapa*. Chinese cabbage (pak choi and pe tsai) and turnip are both *B. rapa* formerly (*B. campestris)* and rutabaga is *B. napus*.

Cross-pollination among *Brassica* species is not the only concern. Disease and insect pests can cross over between canola and the *Brassica* seed crops and between these two groups and the *Brassicas* that are grown for root vegetables in western Oregon. Cabbage maggot (*Delia radicum* – a crown and root infesting fly larva) and white mold (*Sclerotinia sclerotiorum* – a stem rotting fungus) are the pests of greatest concern.

What do we know about pollen and cross pollination?

- "The Biology and Ecology of Canola" Office of the Gene Technology Regulator, July 2002, Australian Govt., provides a comprehensive review of this topic.
- Canola flowers can be both self-pollinated and cross-pollinated. Because of the large amount of pollen typically produced, most flowers are self-pollinated.
- Literature reports for canola document that wind-blown pollen dispersal of a few meters to a mile or more is possible. Ten meters is most commonly cited as the distance to which pollen can be dispersed by wind. The amount of pollen decreases with distance from the source.
- Canola does not require bee pollination, but bees actively work most *Brassica* crops, canola included.
- Bees are reported to readily move up to 2.5 miles (studies in Oregon from 1960-70s and others around the world). As pollen transfer can occur within a hive, pollen movement of up to 5 miles is possible.
- The Willamette Valley Specialty Seed Association (WVSSA) strives for a 3-mile isolation distance among cross-compatible *Brassicas*. This seems a reasonable distance based on wind dispersal of pollen and bee travel.
- A survey of seed certification standards (nine states, Canada, Australia, AOSCA – the only information available) showed
    - Isolation distance requirements for out-crossing, foundation seed quality *Brassicas* ranged from 328 ft to 2 miles. The most common distance was 1/4th mile (1320 ft).
    - Most national and international seed certification agencies have no allowance for other plant types in fields at the foundation level, hence volunteer canola in another *Brassica* seed crop would be prohibited.
    - To be eligible for certification, fields must not have been seeded to a crop in the *Brassica* family for at least three years (Canada) with most agencies requiring 4-5 years.
    - Seed contamination tolerances are typically 1:10,000 in foundation seed.

    - The isolation distances and years out of crop stated in these seed certification standards are less than the self-imposed production requirements of the WVSSA. The off-type plant prohibition is identical and seed contamination level more restrictive.
- In order to cross-pollinate, two crops would need to be in bloom at the same time. There is no way to predict flowering time of the various *Brassica* crops grown in the Willamette Valley as some are direct seeded (the only way canola is planted at this time) while many vegetable *Brassicas* are transplanted at varying times. There are also differences in flowering time within a species dependent on the cultivar being grown. Direct-seeded crops will typically be in bloom before transplanted crops. In addition, canola and many *Brassica* specialty seed crops flower over an extended period of time (indeterminate flowering) increasing the timeframe within which cross-pollination can occur.

Recommendation for further research: Monitor *Brassica* seed crop fields of different species planted using different methods for flowering date with the intent to determine if flowering date can be predicted. This information will be useful for decision making related to cross-pollination and intercrop insect movement.

What did we learn about cross-pollination under field conditions?

Many studies have evaluated the potential for cross-pollination via pollen movement from transgenic or conventional canola to weedy or wild relatives (for example Jorgensen and Anderson 1994; Lefol et al. 1995; Lefol et al. 1996; Bing et al. 1996; Jorgensen et al. 1996). These studies did not include cross-pollination to the *Brassica* vegetable crops. Our OSU research addressed cross-pollination between canola and related *Brassica* vegetable crops. In particular, we examined the potential for cross-pollination of *B. oleracea* and *B. rapa* (*campestris*) vegetable crops by canola. It is known that such crosses are possible and have been accomplished under greenhouse conditions and in the field in other environments. We wanted to know if field crossing was possible under Oregon environmental conditions.

We did not have the monetary resources to conduct the type of spoke-wheel x distance study that is typically done to address issues of pollen movement and out-crossing. We instead did a worse-case scenario study in which male sterile vegetable *Brassica* plants were embedded in the midst of a pollinating canola field.

Field studies were conducted in 2007 and 2008 near Corvallis, OR. In each year, one 25 acre field was planted with conventional canola (*B. napus* cultivar Athena) at a commercial sowing rate (~ 8 lbs/A). In 2007 self-incompatible *B. rapa* var. chinensis (Pak-choi) and cytoplasmic male sterile (CMS) *B. oleracea* var. *italica* (broccoli) plants were grown in the greenhouse and moved into the field when the *B. napus* began flowering, then returned to greenhouse after pollination. In 2008, *B. oleracea* var. *capitata* and a second *B. rapa* var. *pekinensis* were also used as receptor species in the field experiments. Each field experiment was conducted independently to prevent cross pollination of the receptor species. Initiation and duration of flowering were recorded for each species. Receptor plants were arranged in a 7 x 7 m grid inside the perimeter of a 15 x 15 m study area with one plant located at the intersection of the grid axes. Seed of each receptor plant were harvested individually. The seed were placed into 10.2 x 10.2-cm germination boxes containing moistened blotter paper and put into a germination chamber. The number of emerged plants was recorded and germination percentages calculated for each cross.

The seed produced on individual plants varied both by species and by year. Germination also was variable among *B. rapa* var. *chinensis* plants and averaged 29 and 58% in 2007 and 2008, respectfully. Viable seed also was produced on the *B. rapa* var. *pekinensis* plants, and averaged 62% germination per plant. Although seed were produced on the *B. oleracea* var. *italica* plants in both years, they were shrunken and failed to germinate. Seed from the 2007 *B. oleracea* var. *italica* x *B. napus* cross were tested for viability with a tetrazolium assay according to methods described by the Association of Official Seed analysts (AOSA 2002). Results of that assay determined that none of the seed contained embryos. However, seed produced from the *B. oleracea* var. *capitata* x *B.napus* cross did produce viable seed with an average germination of 3.3% per plant.

Conclusion: Cross-pollination is possible under Western Oregon field conditions between some of the *Brassica* vegetable seed crops and canola. Cross-pollination levels will be species and cultivar specific.

Recommendations for further research: Conduct "spoke-wheel" or other types of pollen travel studies to determine the potential for canola cross-pollination with *Brassica* specialty seed crops under typical field conditions.

What do we know about insects?

The concern with insects is that large fields of canola grown for oilseed would serve as reservoirs of insects that would infest nearby *Brassica* specialty seed and root vegetable crops. This concern is greatest for cabbage maggot but aphids and other insects capable of movement among fields are of concern. Insects are already a problem in specialty seed crops and intensive monitoring and spraying are done to control insect pests. Monitoring and pesticide control are possible in specialty seeds as the potential value of the crop is high enough to allow these management practices. Specialty seed growers suggest that because of the lower value of canola ($0.173 per pound as of Jan 12, FOB Velva ND, not including $0.05 Oregon grower incentive; gross crop value of $606 at 3500 lb/a yield level; $780 with incentive) growers may not monitor their crops as closely or be able to afford to make the repeated pesticide treatments that may become necessary to achieve high levels of insect control. Potential canola growers counter that a single prophylactic insecticide treatment may be adequate to control insect problems given the low level of insects observed in experimental fields.

In our OSU studies, insects were monitored in both small, experimental field trials (several acres of test plots on Hyslop Farm north of Corvallis) and in large, grower field trials (@25 acres each) scattered throughout the Valley.

In 2007

- insects found included cabbage maggot, cabbage seed pod weevil, an assortment of aphids, flea beetles, sap beetles, black pollen beetles and lygus bugs
- none were close to economic threshold levels early in the season
- about 3% of pods in grower fields were infested with seed pod weevils at the end of the season
- cabbage maggot was reported to be a major problem in some *Brassica* vegetable crops in 2007 but none were found at economic threshold levels in the monitored canola fields; however, it should be noted that grower fields were "virgin" fields. *Brassica* crops had not been grown previously in these fields nor were other *Brassica* crops growing nearby.

In 2008

- Pests at the seedling stage included slugs and cucumber beetles. Both were found at very low levels and were not causing economic injury to the plants. Cucumber beetle numbers were highest in areas where volunteer rye grass was not controlled and in areas close to bordering shrubs and trees.
- Overwintering cabbage maggot puparium emergence was observed but there was no evidence of excessive damage (< 5%).
- Seed pod weevil monitoring began at the flowering stage. The threshold documented in Canada is two weevils per one 180° sweep. We observed less than 1 per sweep throughout the season.
- Other pests observed included pollen beetles (highest numbers), flea beetles, thrips, and lygus bugs.
- Pollen beetle adults are commonly seen on canola flowers. They are unlikely to cause great damage to winter oilseed canola, but they are a greater threat to later maturing winter and spring planted *Brassicas*. In the spring, adult pollen beetles fly to winter canola crops. They initially colonize the field margins before venturing further into the crop. The beetles feed on pollen. Crops at risk are those still at green-yellow bud where the beetles have to chew their way through the bud to get at the pollen – this kills the bud leading to blind stalks as no flowers will form. They are not a threat to crops in flower as pollen is readily available for feeding. Spring canola tends to be at a greater risk of damage from pollen beetles, which is why thresholds are different for winter and spring sown crops. Healthy, well established winter oilseed canola would need 15 beetles per plant to warrant treatment. Stressed winter oilseed rape crops cannot cope with the added stress of pollen beetles, so these crops only need 5 beetles per plant at green-yellow bud to justify treatment. The treatment threshold for spring canola is one beetle per plant.
- The pollen beetle observed in Western Oregon is not the same species as found in Europe, the latter causing extensive damage.
- Unlike 2007, no aphids were observed during early sampling and only limited numbers at crop maturity.

In 2009

- We regularly monitored the five grower winter canola fields for key pests - seed pod weevils, aphids, cabbage maggots, pollen beetles. Populations were counted by sweep net sampling and numbers were well below the established economic threshold for treatment over the season. Less than four terminals out of thousands had aphids throughout the season.
- Fifty main stems containing canola pods were collected on June 8th and an additional 250 per field in late June. They were analyzed for seed pod weevil exit holes. As of late-June, shortly prior to harvest, emergence of SPW from pods had occurred at only a very low level.

Conclusion: Insect levels in the monitored fields were low and below thresholds established in other production areas of the world. This is not surprising as most fields were first canola crop fields surrounded by predominantly grass and grain fields. One of the 2009 fields had been in turnip four years prior and while volunteer turnips were observed, no increase in insect pressure was noted. If acreage increases and crops are nearer to each other in time and space, experience with Brassica specialty and vegetable crops suggests that cabbage maggot could become a problem. Pollen beetle has the potential to be a problem if later-flowering *Brassicas* are grown in the same area as fall planted canola crops.

Recommendation for further research: Develop a detailed cabbage maggot monitoring program in all susceptible crops to determine if there is potential for predicting maggot outbreaks under Valley conditions. The electronic pinning system developed as part of the ODA project may be helpful in this regard.

What do we know about diseases?

In 2007 and 2008 crops, agronomist Daryl Ehrensing and entomologist Amy Dreves assessed grower fields for disease. While small amounts of sclerotinia were noted, levels were not of economic importance. In early June 2009, Dr. Cindy Ocamb, OSU Plant Pathologist, joined this team to assess levels of disease. Sclerotinia white rot was evident to some extent in all fields but observed at low levels. However, when the team returned two weeks later to the Freeborn field which was planted immediately adjacent to their 2008 field, the crop had exploded with white mold. Nearly 20% of plants were infected by June 22. White mold development is dependent on weather conditions during flowering. Conditions were nearly ideal for disease development in 2009. Short crop rotations can lead to a buildup of sclerotia. Sclerotia are overwintering fungal bodies which develop fruiting structures and produce aerial spores in following years. Spores are wind-borne and can spread as spore clouds several kilometers from a source. Most sclerotia will die if there is a 3-4 year period between susceptible host plantings but persistence at low levels for 6-8 years is quite possible. We speculate that the adjacent, prior year canola field was the primary source of white mold inoculums for the 2009 field. Kathy Hadley-Freeborn reported that the infested field had the lowest yield of the three experimental fields they had in 2009. There was significantly more shatter in the area of the field where the disease was the highest. Nonetheless, she stated that the disease, even at an elevated level, was not detrimental to the profitability of the field. Ms. Hadley does partial budgets on all crops on Freeborn Farms each year and the infested canola crop netted significantly more than their wheat and some grass seed fields.

What would be the effect on sclerotinia levels from growing 5-10,000 acres of canola in the Valley? We do not know. We do know that green beans, peas and clovers are also susceptible to sclerotinia and that these crops are routinely grown in the Valley, collectively on tens of thousands of acres annually. The addition of canola to such a mix, given the 6-8 year life span of sclerotia, would complicate rotation planning for susceptible crops. Cindy Ocamb in her March 20, 2009 presentation to the ODA Canola Advisory Committee repeatedly stated that if canola were grown in the Valley, growers would need to adopt the field and crop management techniques used by those growing other susceptible crops. She said that it would be best to plan on use of a fungicide each year in order to attempt to hold sclerotinia in check. Club root, alternaria, and blackleg are diseases that have been problematic on canola in other production areas and that will be of concern in Western Oregon. We have no data from the OSU research plots on these diseases.

Recommendation for further research: Develop a detailed white mold monitoring program in all susceptible crops to determine if there is potential for predicting white mold outbreaks under Valley conditions. The electronic pinning system developed as part of the ODA project may be helpful in this regard.

What did we learn about shattered seed, seedling recruitment, volunteer plants and seed bank?

Seed shatter was monitored through a standardized sampling process in each of two grower fields in harvest years 2007 and 2008. On a single date in late fall, the number of seedlings in each field was also assessed. Shatter levels and seedling recruitment are shown in the table below.

Means comparisons of shattered seed and the resulting seedlings for each of the field sites in both windrow and outside of the windrow sample locations.

	Mean Number of Shattered Seed/A[2]		Mean Number of Seedlings/A[2]	
Field Site	Windrow	Outside Windrow	Windrow	Outside Windrow
A2R-07[1]	82,988,000 a	57,372,000 a	6,730,000 b	5,677,000 a
VanLeeuwen-07	22,622,000 b	20,808,000 bc	1,610,000 c	1,197,000 b
Van Leeuwen-08	77,057,000 a	23,996,000 b	1,398,000 c	152,000 b
Freeborn-08	25,930,000 b	12,099,000 c	10,613,000 a	4,230,000 a

[1]Year notation indicates harvest year
[2]Means within columns followed by the same letter are not significantly different.

The number of seed lost to shatter in 2007 represent a return to the seedbank of 21 to 83 times the initial seeding rate assuming 125,000 seed per pound and an initial seeding rate of 8 lb/a (166 to 664 lb/a). Loss rates in 2008 ranged from 12 to 77 times planting rate (97 to 616 lb/a). Seedling numbers were @2.4 to 158 fold less than shattered seed. Shattered seed and seedlings were eaten by birds, insects, slugs and other fauna. Growers also sprayed out one or more volunteer seedling flushes after fall seedling counts were taken.

Fields were planted to grass or grain crops in the year following the single canola crop. Growers used typical weed management practices in these fields. No volunteer plants were observed in any of the monitored fields during the 2008 growing season. However, in the late fall of 2009 a significant number of volunteers were observed in the 2007 Van Leeuwen and 2008 Freeborn fields. The Van Leeuwen field had been planted to perennial ryegrass and it is believed that fall herbicide treatments had already been applied. It is anticipated that some of these volunteer plants will survive the winter. The Freeborn field had not been planted or worked as of the observation date and it is anticipated that the volunteer in this field will be controlled by subsequent field preparation tillage or herbicides. These four sites will continue to be monitored through the 2010 growing season for volunteer plants.

The seedbank was measured in five fields after a single *B. napus* planting. Twenty soil cores 8.3-cm in diameter and 10-cm deep were taken randomly across each field. In the first year for each field site, soil samples were taken prior to the flowering of the planted *B. napus* crop. The values shown as a year of planting sample in the table below represent a base-line figure for each site. Seed present could be planting stock seed that did not germinate or could be *Brassica* weed seed. All seeds found in samples were examined under a microscope and identified as being of a *Brassica*-type, but specific species identification was not possible.

The cores were stored at 5° C until *B. napus* seed were extracted using elutriation methods. The number of *Brassica*-type seeds found in each sample was used to estimate the number of seed present in an acre furrow slice. The table below shows the calculated number of *Brassica* seed present in the soil seedbank based on the number of seed found in the soil samples. Seed extracted from the soil samples were placed in the growth chamber to assess germination level. The remainder of the sample was grown out in the greenhouse. In 2007 and 2008 there was no germination of seed removed from the soil samples. This suggests that there was dormancy in the seed. However, in 2009 one seed from each of the Van Leeuwen field sites (2007 and 2008 planting dates) did germinate in the growth chamber. The 2008 Freeborn and Van Leeuwen field sites will be sampled in spring 2010 and screened for *B. napus* seed.

Calculated number of *B. napus* seed present in the soil seedbank from the number of seeds recovered from the soil samples from the field sites by year.

	Calculated # of Seed/A in Soil		
Field Site	2007	2008	2009
Venelle-07[1]	7,552,000	2,517,000	5,034,000
A2R-07	835,000	835,000	0
Van Leeuwen-07	1,750,000	0	1,166,000
Freeborn-08	----	0	1,807,000
Van Leeuwen-08	----	0	636,000

[1]Year notation indicates harvest year.

A field planted at 8 lb/a with canola seed having a count of 125,000 seeds per pound would have a planted population of 1,000,000 seeds/a. The fact that calculated seedbank numbers in the year of planting show higher than planted seed rate levels suggests that other *Brassica* seed were present in these fields and/or that sampling variation is inherently high in the technique used in these studies. The year-to-year variation in the Van Leeuwen 2007 field would suggest that sampling error is a factor as it is biologically difficult to explain the observed variation. The sampling technique used is one commonly used by scientists.

What do these data tell us?

- We know that a significant amount of seed will be present in fields after harvest due to shatter prior to harvest or loss during harvest. Predation by fauna and standard management practices will significantly reduce the amount of this shattered seed that becomes seedling plants, but data show that in a typical fall seedling plant count, seedling populations will often exceed those of a planted field.
- Observation indicates that in the first year after harvest, volunteers plants can be controlled in fields planted to grass or grains in which typical weed management practices are used.
- Observation indicates that shattered seed will remain in the seedbank after two years time and that some of these seeds will germinate to create a volunteer plant population after two years. In carefully controlled studies by Canadian weed scientists (Legere et al. 2001), seed was shown to persistent at low levels up to four years.

Recommendations for further research: Continue to track the fate of seeds lost to shatter in the canola fields that were planted by growers as part of the ODA study. The electronic pinning system developed as part of the ODA project could also be used to identify past-year *Brassica* specialty seed fields that could be monitored for seedbank *Brassica* seed and volunteer plants.

A prototype electronic pinning map system was developed as part of the ODA/OSU oilseeds project. Could this system be an effective tool for the management of a limited number of canola acres in the Valley?

The Willamette Valley Specialty Seed Association has committed to work with OSU to further develop and deploy an electronic pinning map system. Such a system would be useful in tracking not only canola fields but also *Brassica* specialty seed fields and if to be truly useful, vegetable *Brassicas* and green beans. As indicated earlier, cross-pollination is but one concern with canola in the Valley. Use of an electronic pinning map would allow easier current year pinning but perhaps more importantly could be used to effectively track fields for 3-4 years or more after the year of harvest. This would help in thinking about disease management. In terms of cabbage maggot and pollen beetle, knowing the location of all *Brassica* fields – specialty seed, canola and root vegetable - would be useful in current year management decision making. Would the use of an electronic pinning system solve the problems of canola production? The short answer is no, but it would certainly help in thinking about the problems.

What truly is needed to address the prospect of growing a crop like canola in the Valley, or even expanding specialty seed crop acreage, is information about the epidemiology of diseases and insects of the *Brassicas* and other crops with which pests are shared. Designing experiments to address epidemiological issues is difficult and expensive. A surrogate is to collect data over time from experts. If all specialty crop *Brassica*, vegetable *Brassica*, green bean and other crops as determined by a study group were pinned in an electronic system and crop management, crop development and pest observation data were entered into that same system, then simple epidemiological assessments could be made. For example, is there a difference in current year sclerotinia level in a field if that field is 1/4th mile or 1/2 mile or a mile from fields that had grown sclerotinia susceptible crops the year before? Two year before? Three years? What are pollen beetle levels in late flowering *Brassicas* versus those that flowered two weeks earlier? The power of an electronic mapping system is that a broad array of geo-referenced data can be easily collected and then spatially and temporally analyzed. If the Willamette Valley intends to become the top specialty seed growing area in the world, then it would seem logical that creating this type of knowledge base would be a goal. Once this type of knowledge were in hand, it would then also be possible to better assess the impact of introducing other crops such as canola to the system.

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