Developing Direct Seed Organic Farming Systems for the Pacific Northwest (PNW)

Project Description

(a) Introduction

The main focus of our proposal is to combine direct seeding and organic farming into one system by developing natural herbicides and introducing crops with herbicidal activity into existing rotations. Direct seeding is defined as a farming system where seeding is done without prior soil disturbance. Organic farming is farming with minimal or no synthetic inputs. Both systems were designed to curb deleterious effects of current conventional farming practices to the ecology, environment and human health. Conventional tillage farming involves soil tillage, depends on large inputs of fertilizers and herbicides and is not sustainable (Duff et al, 1995). Soil tillage depletes organic matter leading to poor soil structure and low water holding capacity (Rasmussen and Parton, 1994). Productivity of soils is decreasing and more artificial fertilizers are needed to maintain high crop yields. High fertilizer rates leads to ground water and air pollution. Tillage buries crop residues and leaves the soil vulnerable to wind and water erosion.

Direct seeding was developed to halt or reverse soil organic carbon depletion caused by conventional farming. Under this system residues are left on the surface where they slowly add organic matter to the soil, reduce evaporation, increase water infiltration and reduce wind and water erosion. The major disadvantage of direct seeding is increased weed pressure. Under conventional farming, weeds are reduced or sometimes eliminated by tillage and harrowing and less herbicides are used. In contrast, the direct seeding systems depend almost exclusively on synthetic herbicides to control weeds. Although there is less environmental pollution by chemicals carried in water flowing over land, leaching of chemicals into underground water still remains a problem. Soil life that is greatly enhanced by direct seeding and increased residue cover is threatened by synthetic chemicals. Herbicide resistance is also on the increase. The continued use of herbicides and fertilizers causes serious ecological and environmental problems and threatens sustainable agriculture.

Concerns of ecological, environmental, and health problems led to the growth of organic farming. Under this system no synthetic herbicides and fertilizers are tolerated. In a recent survey conducted by the Organic Farming Research Foundation (OFRF), most respondents indicated that weed management and control was the number one problem that they would like research to address (Walz, 1999). Weeds remain the greatest barrier to transitioning to organic. The most frequently or regularly used method of weed control is mechanical tillage, a practice that depletes organic matter. About 46% of the respondents indicated that building and maintaining organic matter levels was one of their greatest concerns. Although land farmed organically has more diversified microbes, improved soil structure, and more water holding capacity than conventionally tilled land, tillage to control weeds exposes the soil and makes it susceptible to wind and water erosion.

Both direct seeding and organic farming address fundamental ecological and environmental problems caused by conventional tillage but are antagonistic in approach. Work to improve these systems is going on with little or no interactions between the respective scientists with each group believing that their approach is the best. It should be mentioned, however, that very few organic research work is being conducted. Only 34 projects out of 30,000 agricultural research projects on USDA's CRIS system are considered organic and other farmers were found to be the most useful information sources while cooperative extension advisors, state agricultural departments and USDA national and regional offices as least useful contacts (Walz, 1999). Nevertheless, the progress towards achieving sustainable agriculture can be accelerated if direct seeding and organic farming efforts can be pooled and organized to work for a common goal. We think good practices from both systems can be organized into one cropping system that will increase the sustainability of agriculture without deleterious effects on the ecology and environment. In direct seeding organic farming, the cropping system we are proposing, no artificial fertilizers and herbicides are applied and no tillage prior to planting is practiced. Our proposal aims at developing direct seed organic farming systems for the Pacific Northwest. Direct seed organic farming will increase soil residue cover, soil organic matter, soil microorganisms, water infiltration, soil water holding capacity, reduce soil and water erosion, increase productivity, and sustain agricultural production with reduced adverse effects on the ecology and environment. Combining direct seeding and organic farming, however, requires the development of natural herbicides and the introduction of crops with herbicidal activity in existing rotations. Research on direct seed organic farming is new and we are not aware of any work addressing this issue.

The development of natural herbicides is key in developing direct seed organic farming systems. In the period before the 1900s, natural remedies were widely used in the field of pharmacy. The thought of using natural products, however, was a foreign concept until the 1980s when chemicals like methyl bromide were found in well water and DDT (1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane) caused problems in the food chain (Cutler and Culter, 1999). Since then, ways to use natural products in agriculture has gained momentum. Most plants have natural defense mechanisms and produce allelochemicals that inhibit or promote germination and growth of other plants and microorganisms, a process called allelopathy (Rice, 1984; 1995). Research work to use allelopathy in integrated weed control management should be encouraged. Allelochemicals are potential sources of natural herbicides that will make it possible to develop direct seed organic farming systems. Rice (1984) summarized allelopathic effects of crop plants on weeds. In that review, the growth of corn cockle (*Agrostemma githago*) was inhibited by a substance produced from beet seed. Root excretions from lupin (*Lupinus albus*) and corn (*Zea mays*) inhibited growth of netseed lambsquaters (*Chenopodium album*) and palmer amaranth (*Amaranthus retroflexus*). It was also reported that wheat, oats, peas, and buckwheat also inhibit the growth of lambsquaters. Hiary vetch inhibited seed germination and growth of 13 species of weeds. Germinating barley seeds inhibited germination of crunchweed seeds, whereas germinating seeds of millet, wheat, oats, vetch, maize, and buckwheat stimulated its germination. Wheat, rye, and barley strongly inhibited wild mustard (*Brassica kaber*) whereas millet stimulated the weed. Some species of cucumber (*Cucumis sativus*) inhibited growth of a forb (*Brassica hirta*) and a grass, wild-proso millet (*Panicum miliaceum* L.). Rice (1995) made another review of allelopathy in crop plants. Extracts from alfalfa were observed to be inhibitory to alfalfa, wheat, cucumber, *Amaranthus*, cheat (*Bromus secalinus*). Buckwheat inhibited growth of several crops plants and weeds. Extracts of white clover inhibited germination of perennial ryegrass (*Lolium perene*). Increasing aqueous extracts of crimpson clover and hairy vetch (8.3 to 33.3 g debris/L) decreased germination and seedling growth of corn, Italian ryegrass (*Lolium multiflotum*), cotton, pitted morning glory (*Ipomoea lacunose*), and wild mustard. At full strength extracts of both legumes, mustard and ryegrass germination and growth were almost completely inhibited. Rye (*Secale cereale)* is allelopathic to many weed species including wild oats (*Avena fatua*). Germination of wild mustard seeds was inhibited by undiluted aqueous leaf extracts of sunflower (*Helanthus annus*). Seedling growth of velvetleaf, jimsonweed, morning glory, and mustard was inhibited by leachates of Hyrid 201 sunflower leaf and stem tissue. The genus, *Brassica*, has crop plants that are well known for allelopathy and have been shown to inhibit growth of many annual grasses (Vaughin, 1999). The *Brassicas* produce chemicals called glucosinolates that are toxic to a wide range of microbes. A breeder at the University of Idaho (Jack Brown) is now evaluating the use of mustard meal, high in glucosinolates, in soil fumigation (replacing methyl bromide) in orchards and weed control. Velvetbean (*Macuna pruriens*) produces a chemical called L-3,4-dihydroxyphenylalanine (L-DOPA) that is known to inhibit growth of nutsedge (*Cyperus* spp.), sticky chickweed (*Cerastium glomeratum*), corn spurry (*Spergula arvensis*), and moderately inhibits members of the Compositae family (Fujii, 1999). Rice (1974, 1984, 1995), Cutler and Culter (1999) and Wallace (2001) discuss many more crop plants that exhibit allelopathy towards other plants, weed species that are allelopathic to crop plants, and shrubs and trees that are allelopathic to both crops and weeds. Of particular interest is the tree-of-heaven (*Ailanthus altissima*) that has broad spectrum effects on plants like glyphosate, an artificial herbicide. Alcohol extracts of rachis, leaflets, and stem of the tree-of-heaven inhibited the growth of 35 gymnosperms and 11 species of angiosperms (Rice, 1984, 1995). Pine trees (*Pinus spp*) that are prevalent in the PNW have been also seen to inhibit growth of other plants and the list goes on and on (Rice, 1984, 1995). We should take advantage of the natural occurrence of allelochemicals and find ways to adapt them for weed control.

The chemical nature of allelopathic agents has been summarized by Rice (1984). They include (1) Simple water-soluble organic acids, straight-chain alcohols, aliphatic aldehydes, and ketones, (2) simple unsaturated lactones, (3) long-chain fatty acids and polyacetylenes, (4) naththoquinones, and complex quinines, (5) simple phenols, benzoic acid, and derivatives, (6)cinnamic acid and derivatives, (7) coumarins, (8)flavonoids, (9) tannins, (10) terpenoids and steroids, (11) amino acids and polypeptides, (12) alkaloids and cynohydrins, (13) sulfides and mustard oil glycosides, (14) purines and nucleosides, (15) miscellanous-other inhibitors that are related to one or more categories, and (16) unidentidied inhibitors. Almost all these agents are potential natural herbicides that need further evaluations.

Allelopathy may be used in several ways in weed control. Crop plants can be bred to be allelopathic to weeds common to specific regions in similar ways as in breeding crop plants for disease resistance (Rice, 1984, 1995). Work quoted by Rice (1984), indicate that it is possible to transfer toxins from wheat grass (*Agropyron glaucum*) to hybrids of this grass and wheat. Little, however, is known about the genetics of allelopathic agents and more work needs to be done. This field is however beyond the scope of our proposal.

The most practical and immediate way to use allelopathy in weed control is to apply residues of allelopathic weeds or crops as mulches or include crops with allelopathy in rotations where the crop residue remain in the field. To this end work should be initiated to evaluate local rotational crops, other adaptable alternate crops, weeds of the PNW, and by-products of forestry industry for allelopathy. In work quoted by Rice (1984), sorghum residues reduced populations of common purslane (*Portulaca oleracea*) and smooth crabgrass (*Digitaria ischaemum*) by 70 and

98%, respectively. Other indicator species were also affected by residues of barley, oats, wheat, rye, and sorghum. This information together with work quoted by Cutler and Cutler (1999) and Wallace (2001) indicate that there is use of cover crops and mulches of allelopathic plants in weed control.

An equally promising way to use allelopathy in weed control is using extracts of allelopathic plants as herbicides. Natural herbicides are much safer than synthetic herbicides and are easily degraded by soil microorganisms (Rice, 1984, 1995). The effects of aqueous extracts or leachates of crop plants on seed germination and growth of other plants and weeds has been discussed above. The use of natural herbicides in the control of weeds common to the Pacific Northwest should be evaluated.

We hypothesize that the development of natural herbicides and the use of cover crops or mulches of allelopathic crops in rotation to control weeds will pave the way for the development of direct seed organic farming.

(b) Objectives: The main objective of this project is to develop sustainable direct seed organic farming systems for the PNW that have less or no adverse effects on the ecology, the environment, and human health. Specific objectives are to:

1. Screen PNW crops, alternate crops, weeds, shrubs, trees, and forestry bi-products for allelopathic effects on weeds common to the PNW
2. Identify allelochemicals of potential plants, shrubs, and forestry bi-products and develop natural herbicides for controlling weeds common to the PNW in direct seed organic farming systems
3. Develop crop rotations that are effective in controlling weeds of the PNW in direct seed organic farming systems using allelopathic effects
4. Engage in outreach activities such as field days, workshops, and producing newsletters to disseminate information generated from this study to assist growers in the transition to direct seed organic farming.