USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Advanced Assessment for Spot Spraying Plants to Reduce Chemical Input and Improve Water Quality

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Federal Funds Requestedfrom USGS: $64,436

non-Federal Funds: $131,199

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Congressional District:Nebraska - First District

Critical Water problems

The U.S. Department of Interior through the Water Resources Division of the U.S. Geological Survey has identified the research priority area of technology for non-point source pollution reduction - better management practices. This proposal describes a project needed to evaluate improved assessment technology for controlled spot spraying of chemicals during intensive agricultural food or fiber production and road-side or highway control of weeds. Spot spraying technology could prevent pollution by potentially reducing the amount of pesticides. growth regulators, or fungicides, but also applying them more efficiently. This would result in a decrease in adverse environmental and health consequences and the benefit of improved water quality. This research supports a strong educational component by investing Federal funds in graduate student training. It supports the development of new design concepts leading to improved plant sensing and system evaluation capabilities and commercialization of intelligent spot spraying control.

Chemical inputs in large amounts as described below are routinely used to control weed. insect. fungus. and nematode infestations in plant production systems. Adverse effects from these chemical inputs include surface and groundwater contamination (Ross. 1994; Wentz et al., 1993; Shock. Ray and Mehnert. 1993: Holden et al., 1992). health risks to humans (Doe and Paddle. 1994; Davis, Caswell and Harper. 1992). effects on soil macro and microorganisms (Tu, 1994). and increased costs of high input production practices (Hoag and Hornsby, 1992). Consumers are concerned over food safety and the environmental consequences of high pesticide use (Dittus and Hillers. 1993).

Chemical use exemplifies both the success of the American agricultural system. but also a potential tragedy to the environment. Wiles, et al (1994) report 8.2 metric tons (18,000 lbs) per day of herbicide flow down the Mississippi River during peak spring runoff. 68,182 metric tons (150 million pounds) of the herbicides - atrazine, cyanazine. simazinc, alachor. and metolachor are applied every spring across the corn belt. A 1993 survey in Illinois found that 22.727 metric tons (50 million pounds) of herbicides were applied at an average rate of 2.8 kg/ha *(2.5* pounds/acre) to corn and soybeans (Shock. Ray and Mehnert. 1993). In Nebraska. approximately 7200-15,000) metric tons (20-33 million pounds) of pesticides are applied annually (Wiles, et al 1994, Baker. Peterson and Kamble. 1990). with a large percentage applied during the Spring. An average acre of corn receives 1.1 kg *(2.4* pounds). while an average acre of soybeans receives 0.5 kg (1.1 pounds) of herbicide. Most herbicides are applied preemergence to the crop.

While herbicides have been effective weed control tools. water quality problems have also resulted. Present corn production methods are responsible for the presence of atrazine. cyanizine and. to a lesser degree. metolachlor and alachlor in the groundwater (Klaseus et at., 1988 Koterba Banks and Shedlock, 1993). Shock. Ray and Mehnert (1993) estimated 12% of the rural wells in Illinois are contaminated with pesticides. A recent survey estimated 12% of the six million domestic water wells have detectable levels of atrazine (Holden et al., 1992). Groundwater serves as the drinking water source for over 90% of the rural population (14.1 million people) within the North Central states. Recent studies indicate that surface water quality has also been adversely affected by herbicide use (Wentz et al, 1994). During a three month period (April through June). a number of herbicide active ingredients were found in the Plate. Missouri and Mississippi rivers at alarmingly high concentrations. In the Midwest corn belt. pesticides frequently occur in surface water at concentrations that exceed maximum contaminant levels (Wiles. et at. 1994. Spalding et al.. 1994). Approximately 456,000 Nebraskans or 36 percent of the states population. receive their drinking water from systems utilizing surface water. Water quality of both surface and groundwater is a health as well as environmental issue in other agricultural areas of the country. Runoff losses of herbicides in conventional and no-till watersheds were examined in the southern United States (Schreiber. Smith and Cullum. 1993). They found up to *20%* loss of herbicides to surface waters.

Statement of Benefits

We believe that spatially variable or spot pest management promises to reduce significantly the amount of chemicals applied. while maintaining the benefits of pesticide use. Widespread adoption of this technology could dramatically reduce pesticide loading in the environment. For herbicide use. automated spot-spraying would reduce the cost of postemergence herbicide use which would help producers or managers shift from high to low active ingredient use rate herbicides. Results of weed sampling surveys suggest that weed plants occur in clumped distributions (Wiles et at.. 1992). Since herbicides would be applied only to these weed patches. non-weed areas of the field would be left free of herbicide. Potential applications of spot sprayer technology also exist for horticultural and vegetable production. Individual crop plants (such as vegetable crops). would be targeted and spot sprayed using pesticides such as insecticides and fungicides particularly when small. leaving the nearby bare ground untreated. Electrostatic spray enhancement may be more feasible with spot spraying. Spot application technology would be also important in non-chemical or biological control agent methods (bioaerosols) of controlling pests (PUnentel. 1991). A significant reduction (15-65%) in the amount of pesticides applied could be potentially achieved by using intermittent or spot spray technology.

Sensor controlled spot application of pesticides appears to be economically feasible in the foreseeable future. but remains to be proven in several categories. The objective of this technology is to apply chemicals to individual or specific clusters of plants using a correct dosage rate. significantly reducing chemicals in the soil and environment. Contrast this to broadcast spraying where chemicals are continuously applied to both. To accomplish efficient spot spraying. a sensing system must be developed that can accurately locate and enumerate plants in complex biological and environmental settings. Location and numbers of plants are critical in spray control timing and volume. Simple silicon-based optical sensors with appropriate red and near infrared filters can generally locate plants (weeds or crop) against soil and some residue systems. but not as to their number or type. These plant sensors are affected by lighting conditions, moving plants in windy conditions. and dust and humidity. Spot spraying accuracy is only 60-70 percent (Ramaekers. 1996). A practical system is needed to accurately classify plants and chemical impact on plant physiological properties for field use. Image analysis can enumerate optically contrasted individual plants and under certain conditions classify them as either broadleaf for grass (Woebbecke. et at, 1995 a.b, Mehta. et al. 1996). Other properties include coverage of chemical materials (wetting) on both background and plant leaves and subsequent physiological impact. These are problems that can be solved by advanced image analysis software. With this project. independent machine vision methods of spot spray assessment will be developed and evaluated [or accuracy and efficiency. Using these methods. the simple plant detector controlled spot sprayer will be evaluated. The spatial distribution of treated and untreated field plants will be mapped using this machine vision system. The impact of spot spraying to improve water quality will be evaluated using modeling and simulation. simulated performance data will be used to assess changes in water quality.