Final Scientific Report

Cover Page

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Project Title: Novel Herbicide Formulations for Conservation-Tillage

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Keywords *not* appearing in the title and in order of importance. Avoid abbreviations.

Metolachlor, controlled-release,

Abbreviations commonly used in the report, in alphabetical order: CRF – controlled release formulation; CsT – conservation tillage; CT – conventional tillage; MTC – metolachlor; ODTMA – octadecyltrimethylammonium; PTMA – phenyltrimethylammonium; SEM – scanning electron microscope; SFZ – sulfenthrazone; SOC – soil organic carbon; ST – strip tillage; WDC – wetting drying cycle.

Budget: IS: \$186,600

US: \$158,400

Total: \$345,000

Signature
Principal Investigator

Signature
Authorizing Official, Principal Institution

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Publication Summary (numbers)

	Joint IS/US authorship	US Authors only	Israeli Authors only	Total
Refereed (published, in press, accepted) BARD support acknowledged		1	1	2
Submitted, in review, in preparation	1	2	2	5
Invited review papers				
Book chapters				
Books				
Master theses			4	4
Ph.D. theses				
Abstracts		3	4	7
Not refereed (proceedings, reports, etc.)		2	1	3

Postdoctoral Training: List the names and social security/identity numbers of all postdocs who received more than 50% of their funding by the grant.

Cooperation Summary (numbers)

	From US to Israel	From Israel to US	Together, elsewhere	Total
Short Visits & Meetings	0	2	0	2
Longer Visits (Sabbaticals)	0	0	0	0

Description Cooperation:

Principal investigators corresponded regularly on technical matters. Both the Bet Dagan and Tifton groups conducted rainfall simulation studies of metolachlor. Dr. Yael Mishael (HUJI) visited the Tifton laboratory in October 2006 and provided guidance on the preparation of the organo-clay based metolachlor formulation. Dr. Zev Gerstl (ARO) visited in February 2007. Dr. Gerstl guided preparation of the granular alginate formulation.

Patent Summary (numbers)

	Israeli inventor only	US inventor only	Joint IS/US inventors	Total
Submitted	0	0	0	0
Issued (allowed)	0	0	0	0
Licensed	0	0	0	0

TABLE OF CONTENTS

Abstract	4
Achievements	5
Details of Cooperation	7
List of Publications	8
Appendix I - Contribution from the HUJI	9
Copy of Article from the HUJI	12
Appendix II – Contribution from the ARO	19
Appendix III	47
Copy of Article from the ARS	73

ABSTRACT

The overall objective of this study was to develop, optimize and evaluate novel formulations, which reduce herbicide leaching and enhance agronomic efficacy.

Numerous studies have demonstrated that CsT promotes environmental quality and enhances sustainable crop production, yet continued use of CsT-practices appears threatened unless cost effective alternative weed control practices can be found. The problem is pressing in the southern portion of the Atlantic Coastal Plain region of the eastern USA where cotton and peanut are produced extensively. This research addressed needs of the region's farmers for more effective weed control practices for CsT systems.

HUJI: CRFs for sulfentrazone and metolachlor were developed and tested based on their solubilization in cationic micelles and adsorption of the mixed micelles on montmorillonite. A better understanding of solubilizing anionic and nonionic organic molecules in cationic micelles was reached. Both CRFs demonstrated controlled release compared to the commercial formulations. A bioassay in soil columns determined that the new sulfentrazone and metolachlor CRFs significantly improve weed control and reduced leaching (for the latter) in comparison with the commercial formulations.

ARO: Two types of CRFs were developed: polymer-clay beads and powdered formulations. Sand filter experiments were conducted to determine the release of the herbicide from the CRFs. The concentration of metolachlor in the initial fractions of the effluent from the commercial formulation reached rather high values, whereas from the alginate-clay formulations and some of the powdered formulations, metolachlor concentrations were low and fairly constant.

The movement of metolachlor through a sandy soil from commercial and alginate-clay formulations showed that the CRFs developed significantly reduced the leaching of metolachlor in comparison to the commercial formulation. Mini-flume and simulated rainfall studies indicated that all the CRFs tested increased runoff losses and decreased the amount of metolachlor found in the leachate.

ARS: Field and laboratory investigations were conducted on the environmental fate and weed control efficacy of a commercially available, and two CRFs (organo-clay and alginate-encapsulated) of the soil-residual herbicide metolachlor. The environmental fate characteristics and weed control efficacy of these products were compared in rainfall simulations, soil dissipations, greenhouse efficacy trials, and a leaching study. Comparisons were made on the basis of tillage, CsT, and conventional, i.e no surface crop residue at planting (CT). Strip-tillage (ST), a commonly used form of CsT, was practiced.

The organo-clay and commercial metolachlor formulations behaved similarly in terms of washoff, runoff, soil dissipation and weed control efficacy. No advantage of the organo-clay over the commercial metolachlor was observed.

Alginate encapsulated metolachlor was more promising. The dissipation rate for metolachlor when applied in the alginate formulation was 10 times slower than when the commercial product was used inferring that its use may enhance weed management in cotton and peanut fields in the region. In addition, comparison of alginate and commercial formulations showed that ST can effectively reduce the runoff threat that is commonly associated with granular herbicide application. Studies also showed that use of the alginate CRF has the potential to reduce metolachlor leaching.

Overall study findings have indicated that use of granular herbicide formulations may have substantial benefit for ST-system weed management for cotton and peanut production under Atlantic Coastal Plain conditions in the southeastern USA. Commercial development and evaluation at the farm scale appears warranted. Products will likely enhance and maintain CsT use in this and other regions by improving weed control options.

ACHIEVEMENTS

Numerous studies have demonstrated that conservation-tillage (CsT) promotes environmental quality and enhances sustainable crop production. Adoption of CsT is increasing worldwide. Continued increases and/or current use of CsT-practices appears threatened unless cost effective alternative weed control practices can be found. This is because of the heavy reliance by CsT practioners on the broad-spectrum herbicide, glyphosate, and recent discoveries of troublesome weeds that are highly resistant to products containing this active ingredient. The problem is pressing in the southern portion of the Atlantic Coastal Plain region of the eastern USA where cotton (*Gossypium hirsutum*) and peanut (*Arachus hypogaia*) are produced extensively. This research addressed needs of the region's farmers for more effective weed control practices for CsT systems.

Our main objectives were to: 1) Prepare optimized CRFs that provide effective weed control for cotton and peanut production in the southern Atlantic Coastal Plain region; 2) Compare CRF active ingredient fate in field and laboratory studies, to evaluate leaching, runoff, and dissipation rates under ST and CT management.

Over three years, field and laboratory investigations were conducted that focused on evaluating the environmental fate and weed control efficacy of a commercially available, and two controlled-release formulations of the soil-residual herbicide metolachlor.

Our major achievements were as follows:

- 1) We have designed and tested micelle-clay CRFs of sulfentrazone and metolachlor. Both CRFs demonstrated controlled release properties. A bioassay in soil columns determined that the new sulfentrazone and metolachlor CRFs significantly improved weed control and reduced leaching (for the latter) in comparison with the commercial formulations.
- 2) We studied the effect of wetting and drying cycles (WDCs) on metolachlor fate in the soil. CRFs reduced the effect WDCs have on the behavior of the herbicide and show promise of improved weed control and reduced leaching under WDCs.
- 3) Two types of CRFs were developed: polymer-clay beads and powdered formulations. Sand filter experiments were conducted to determine the release of the herbicide from the CRFs. The concentration of metolachlor in the initial fractions of the effluent from the commercial formulation reached rather high values, whereas from the alginate-clay formulations and some of the powdered formulations, metolachlor concentrations were low and fairly constant.

4) The movement of metolachlor through a sandy soil from commercial and alginate-clay formulations was studied in a series of column experiments. The results showed that the CRFs developed significantly reduce the leaching of metolachlor in comparison to the commercial formulation.

5) Mini-flume and simulated rainfall studies indicated that all the CRFs tested increased runoff losses and decreased the amount of metolachlor found in the leachate.

6) The environmental fate and weed control efficacy of the CRFs developed by the ARO and HUJI teams were compared to a commercial “generic” metolachlor formulation through conduct of rainfall simulations, soil dissipations, greenhouse efficacy trials on selected weed species, and a leaching study. Comparisons were made on the basis of tillage, CsT, and conventional, i.e. no surface crop residue at planting (CT). Strip-tillage (ST), a commonly used form of CsT, was practiced.

7) The organo-clay and commercial metolachlor formulations behaved similarly in terms of cover crop mulch washoff and in runoff response with and without irrigation incorporation. Metolachlor soil dissipation rates and weed control efficacy associated with application of these formulations were also nearly identical. Results did not indicate an advantage of the organo-clay over the commercial metolachlor products.

8) The studies comparing a commercial generic product and alginate encapsulated metolachlor were more promising. Again, similar weed control efficacy was indicated in greenhouse evaluations. The dissipation rate for metolachlor when applied in the commercial formulation was 10 times faster than when the alginate CRF was used.

9) Comparison of alginate and commercial formulations showed that ST can effectively reduce the runoff threat that is commonly associated with granular herbicide application. This was indicated in rainfall simulation studies which found that when the alginate formulation was applied metolachlor runoff from ST-plots was nearly 2 times less than from plots in CT management. Studies also showed that use of the alginate has the potential to reduce metolachlor leaching. Less metolachlor leached when the alginate formulation was applied to lysimeters containing ST soil then when comparable amounts of the generic formulation were applied.

Overall study findings have indicated that use of granular herbicide formulations may have substantial benefit for ST-system weed management for cotton and peanut production under Atlantic Coastal Plain conditions in the southeastern USA. Commercial development and evaluation at the farm scale appears warranted. Products will likely enhance and maintain CsT use in this and other regions by improving weed control options.

At this stage it is hard to evaluate the economic impact of our findings. The data suggests that cotton farmers in Georgia may have to spend an additional \$27 an acre to control glyphosate resistant weeds. There are about 2 million acres in production in Georgia. If all acreage incurred the same cost we are looking at a \$50 million dollar impact. Our work has shown that granular formulations have the potential to offset this cost by making conventional products like metolachlor more effective in reduced tillage systems. This should encourage growers to stay in conservation tillage. One of the concerns is that growers will return to the plow and conventional tillage if they can't find a low cost solution to their weed problems. A return to conventional tillage will have negative environmental impact (sediment in streams) and in turn economic costs (loss or recreational and other uses of public waterways). It is hard to put a price tag to it.

Details of Cooperation:

Principal investigators corresponded regularly on technical matters. Both the Bet Dagan and Tifton groups conducted rainfall simulation studies of metolachlor. Dr. Yael Mishael (HUJI) visited the Tifton laboratory in October 2006 and provided guidance on the preparation of the organo-clay based metolachlor formulation. Dr. Zev Gerstl (ARO) visited in February 2007. Dr. Gerstl guided preparation of the granular alginate formulation. The success of the present research project was a direct result of the synergistic interaction of the different research groups. The initial development and testing of the CRFs was carried out by the 2 Israeli groups who have much experience in this field. The final testing of the products under actual field conditions in an area where the CRFs present a possible solution for weed control under CsT was carried out by the team from the USA after technology transfer on the production of the various CRFs.