Session 2B

Crop Protection Practice

Formulas for Success

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Success through knowledge in crop protection

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The policy environment: global influences

This paper provides some ideas on the context for the successful adoption of crop protection practices through knowledge transfer. The key players in the crop protection 'chain' include Government and policy makers, crop protection businesses, land-based industries, farmers and especially the public. Indeed, the concerns of the public in Europe provides a clear illustration of the profound impact that can be served upon other components of the 'chain'. While GM technology could provide technical and economic benefits to farmers, in Europe, societal opposition stimulated regulatory and policy reforms.

Crop protection businesses were faced almost overnight with spiraling research and regulatory costs, trade limitations, ethical and moral debates. Secondary issues followed that tested public confidence including food safety, environmental concerns and public information/engagement. The discriminatory effects of contrasting policy environments can be seen with European production of GM crops at only 0.03% of world production. In other parts of the world GM soybeans, cotton, maize and rapeseed have seen annual plantings of around 90 M ha, an equivalent of 20 times the total cropping area of the UK.

The policy environment: managing change

While GM technologies secured change in some crop protection markets, the promise of genetic modification of crops for human health benefits is heralded as the next prize. The impact of European policies has undoubtedly moved significant elements of commercial crop protection research out of Europe. For an industry to remain commercially competitive and to support the land-based industries and farmers, research is essential. This will remain a challenge for the European crop protection industry. EU legislative developments have the objective of the protection of health and environment rather than the competitiveness of European agriculture at the top of the agenda. Changes in EU legislation will see a further reduction in the number of crop protection products available. With increased regulatory burdens and declining sales, the prospects for European industry crop protection research looks limited.

The industry is responding positively to the new environment of regulation. No longer can industry researchers work in isolation. Instead, scientific endeavors are linked to regulatory and policy needs, assessment of risks and communications in the public domain. Such a European perspective is not the only element of the International scene.

Beyond the classical chemical approaches to crop protection and the biotechnological, targeted developments, the research community has risen to the challenge of non-chemical inputs, environmentally benign practices and sustainable systems. This is true not only in parts of the world associated with intensive and extensive systems of production, but also in developing countries. Over the last decade we have seen more practical uses of techniques to encourage natural enemies to have a major role in integrated pest management. Pest management strategies have exploited the use of repellant and trap plants grown to push and pull the pest away from the main crop. Broad-spectrum insecticide use has declined in favour of pest-specific insecticides that rely on foliar feeding. Improvements in pesticide formulation, packaging and delivery systems have increased operator safety without sacrificing pesticide efficacy.

In addition, improved disease resistance in crops, new diagnostic tools, epidemiological and disease surveillance methodologies, induced disease resistance and organic farming systems have all contributed to delivering technological solutions in crop protection. The key to success in knowledge or technology transfer is not in the technology itself but that potential providers and users must be brought together. A case study will illustrate the principles.

Scotland's land-based industries : a case study in knowledge transfer

In Scotland, the land-based industries operate within a plethora of EU, UK and Scottish policies and legislative instruments. For the land-based industries the most influential policies include CAP reform, implementation of the Scottish Rural Development Plan, the Water Framework Directive and associated legislation. Essentially, farmers and land-owners now operate without subsidy in a free market business environment. Business sustainability depends upon a range of innovative and novel approaches combining technical and management skills.

To assist the land-based sector to change and evolve in this new policy environment, publicly-funded research and knowledge transfer measures are combined. The Scottish Executive Environmental and Rural Affairs (SEERAD) research programme is founded on crop, livestock, environment and human health/welfare research. A pre-requisite of research funded through this programme is that it must be policy relevant and deliver benefits to end-users. Knowledge transfer and exchange activities are provided to a range of audiences (scientific, public, commercial, farmers/land-based industries and government/policy makers) by the collaborating main research providers (including SAC). This programme places significant emphasis on integration and collaborator, with cross cutting themes that include responding to climate change, protecting biodiversity and environmental, social and economic sustainability of rural Scotland.

In particular, the programme relies heavily upon knowledge exchange, engaging with the customers and stakeholders. Examples in the crop/environment disciplines include environmental focus farms, potatoes in practice/partnership, cereal open days, conferences and workshops working with the five key audiences. The outputs are designed to help the land-based industries secure a sustainable future in economic terms with due regard to environmental stewardship. Developing greater linkages and involvement with the public to explain the societal value of research and technological developments is an essential part of knowledge exchange.

Conclusions

For success in knowledge transfer we need the crop protection industry customers and stakeholders to articulate the problems that they face. Only then can market demand be accommodated by the key service providers. Delivering solutions requires joined-up working across the sector to include researchers, consultants, crop protection businesses and land-based industries taking account of geography and the policy environment.

Managing more sustainable agroecosystems using mustards and mustard byproducts

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Developing sustainable dry land winter wheat cropping systems in the Pacific Northwest region of the USA

Including mustards into a rotation with winter wheat and spring cereals produces a more sustainable rotation than the commonly used dry land winter wheat/spring cereal/pea rotation. However, any approach that integrates a new crop into a cropping system must include consideration farm-level production processes, ecological effects, and ultimate uses of the crops and their byproducts when developing cropping strategies that are truly more sustainable, ecologically sound, and economically viable.

Thus, it is important to quantify the overall agricultural, environmental, and economic benefits of incorporating mustards into dry land winter wheat rotations and answer fundamental questions related to the mechanisms responsible for any observed benefits. In addition to rotational and environmental benefits of growing mustards, there are several potential advantages related to the utilization of mustard oils as biodiesel and biolubricants, and mustard seed byproducts as biopesticides and nitrogen rich soil amendments that make it an excellent choice for increasing sustainability in managed ecosystems.

Participation of identified beneficiaries in sustainable winter wheat cropping systems

Identifiable end uses of an integrated and sustainable winter wheat/spring cereal/mustard cropping system include farmers that grow these crops, organic fruit and vegetable producers that use the seed meal byproducts of mustard and the public that use biodiesel, biolubricants and edible cooking oils. Public funding often is used to support sustainable cropping system research and development, therefore requiring effective technology transfer to insure that end users can access, understand, and implement the new knowledge. Transfer of knowledge is achieve through summer field tours, on-farm demonstrations, extension and public outreach meetings and workshops, news releases, and published literature.

Solutions delivered

It may be possible to grow mustards in a rotation with a significantly reduced need for synthetic pesticides. They are highly competitive crops that suppress weeds and resist insect damage. Pest problems are typically reduced in crops that follow mustards in a rotation. Allelochemicals produced by the tissues appear to provide pest control benefits that exceed those of a pea crop. Mustard crops may increase plant available nitrogen for the next crop in the rotation. Increased plant available nitrogen has been measured in soils following mustard crops equal to that of a legume. Mustard crops are highly drought tolerant and require less water than small grains. In addition, they utilize water from deeper in the soil profile than other crops, possibly reducing nitrate movement and the associated potential for groundwater contamination. Mustard seed can be pressed to produce oil for multiple products ranging from biodiesel to edible cooking oils. This allows the grower flexibility and the opportunity for product diversification. Meal remaining after the oil is removed can be used as a soil amendment in high value crops such as fruits, vegetables, and horticultural crops to control pests and increase soil nitrogen. This will reduce the need for synthetic pesticides and inorganic fertilizers, and promote low-input and organic agriculture. The combined effects of using biobased materials as substitutes for petroleum-based fuels, lubricants, and synthetic pesticides will decrease the atmospheric CO_2 burden.

Barriers to success

The adoption of mustard into a dry land winter wheat cropping system requires a reliable and profitable market for growers to sell mustard seed. Construction of crushing and biodiesel production facilities is required to process harvested mustard seed. Biodiesel must be competitively priced compared to diesel, or public legislation mandating used of biodiesel must be in place. Seed meal left after extracting oil must have value such as animal feed, a soil amendment, or a biopesticide. One of the largest obstacles prohibiting utilization of the seed meal to control plant pests is USA EPA registration. However, products derived from mustard meal or the contained biopesticides have been registered for a variety of purposes. EPA has granted an exemption from the requirement of tolerance to isothiocyanate as a component of food grade mustard oil, and EPA-approved pesticides containing propenyl isothiocyanate as an active ingredient are marketed in the USA.

How to measure success

The number of hectares grown will measure successful adoption of mustard into dry land winter wheat production systems in the Pacific Northwest region of the USA. Decreased use of synthetic pesticides and fertilizers in these crop rotations will be another measure of success. Sustained production and use of biodiesel and biolubricants, along with EPA registration of mustard seed meal or its products as biopesticides are other measures of success, both of which will reduce dependence on petrochemicals. Organic farming and sustainable agriculture will be promoted by the use of seed meal products that decrease pest problems and improve soil fertility. Weeds, the most significant problem in organic farming systems, can be effectively controlled with mustard seed meal. This will decrease the need for aggressive tillage, thereby reducing the potential for soil erosion. Meal amendment will also result in increased soil nitrogen, thus improving soil fertility.

Conversion of traditional high-input agricultural lands to organic production will decrease the potential for environmental contamination caused by synthetic pesticides and inorganic fertilizers. New industries will result from the development of crushing facilities, biodiesel/biolubricant products, and seed meal by-products. This will help to revitalize the agricultural economy and rural communities.

Empowering small farmers in Kenya to improve maize productivity through the promotion of farm inputs and efficient management

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In many regions of Kenya, characterized by large populations of small farmers, crop productivity is below potential. Maize grain yields are in the range of 0-2 t/ha whereas yields of 5-8 t/ha are quite possible. The major constraints to improved crop productivity are poor soil fertility, disease (e.g. maize streak virus), and weeds. Farmers lack access to the appropriate fertilizers, disease-tolerant maize varieties, and herbicides, and information on how to use them most effectively to increase productivity.

Over the past five years, Farm Input Promotions Africa, has developed methodology, in partnership with private sector seed, fertilizer, and crop protection chemicals to quickly, and cost-effectively, stimulate the demand for the appropriate farm inputs and improved soil and crop management practices amongst small farmers. Methodology is designed according to the specific constraints, soil and crop management practices, and socio-economic conditions of farmers in different regions.

Two case studies are described from different production systems where farmers are succeeding in adopting improved technology to improve their livelihoods.

Case study 1: Mass adoption of improved fertilizers, disease-tolerant maize, and early-maturing bean varieties in Central Province.
In this region, farmers have very small plots of land (0.1-1 ha), and prepare their land by hand. Most farmers live near the poverty line with an income of US$ 1/day. The major constraints to improved productivity are poor soil fertility, and the Maize Streak Virus (MSV). Farmers are empowered to identify these constraints and technology needs through leaf colour charts which depict N, P, and K deficiency, and symptoms of the maize streak virus.

Solutions offered are improved fertilizers, packaged in affordable 1 kg bags (US$0.5) and small packs of seed (100g) of MSV-tolerant varieties, provided by co-operating companies.

Farmer participation is secured by the small pack method which empowers thousands of farmers to experiment with the inputs simultaneously on their own plots of land. Farmers who purchase a 1 kg pack of planting fertilizer receive a free 100g sample of maize seed and a 30 seed pack of an improved bean variety, free-of-charge.

Farmers are offered the promotion package at farmer field days around demonstrations, and through farm input stockists to which farmers are drawn through market promotions on busy market days. At these events, farmers are instructed how to space the seed, and place the fertilizer to give an optimum plant population.

Major barriers to success are addressed by effective private sector participation which ensures supply of seed and fertilizer for demonstrations and promotions, the supply of inputs in affordable bag sizes to empower farmers to experiment with their use with little risk, and the supply of inputs to farm input stockists for purchase by farmers in subsequent seasons.

Adoption is measured by assessment of sales of the inputs through the local farm input stockists. The effect of the adoption of the inputs at farmer level was assessed through a survey of 100 farmers in Kirinyaga district. Farmers on average increased their yields from 344 kg/0.33 ha (equivalent to 1.04 t/ha) to 850kg/0.28 ha (equivalent to 3.04 t/ha).

Case study 2: Adoption of reduced tillage, improved fertilizer/seed management, and herbicides in the Rift Valley Province.

In this area, farm size is larger (1-8 ha), and farmers hire contractors to prepare their land with a tractor-drawn disc plough. Farmers plant using hybrid maize varieties and fertilizers either by hand or by machine. Farmers tend to hire labour to control weeds manually two or three times/growing season. Yields through conventional soil and crop management are low (ca. 2.2 – 3.3 t/ha).

In this region, the major constraints to improved productivity are poor soil fertility, poor fertilizer application methods, and late weeding. In some areas, continuous use of the disc plough has resulted in the formation of hard pans at plough depth which inhibit root penetration and infiltration of rainwater into deeper soil layers.

Solutions offered are use of the chisel plough to break the plough pan, post- and pre-emergence herbicides to control weeds, and training in improved seed spacing and fertilizer placement within the furrows created.

Farmer participation is secured by training community members to offer herbicide spraying services, and by involving farmers in demonstrations of reduced tillage technology.

Major barriers to success are addressed by development of a cheap, easily transportable, and low cost chisel plough which can be pulled by the locally-available tractors, and through the rapid creation of demand for its use so that contractors can be persuaded to purchase the chisel plough.

Adoption is measured by the number of contractors offering chisel ploughing services, the number of farmers adopting the use of the chisel plough, and the number of farmers using post-emergence and pre-emergence herbicides. The effect of the adoption of the inputs at farmer level is assessed through surveys of farmers. Results show that the adoption of reduced tillage increases yields to 7.5 t/ha, and halves cost of production compared to conventional practice.

A Canadian perspective on herbicide-resistant crops

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Current status of herbicide-resistant crops in Canada

One decade has passed since the first commercial introduction of herbicide-resistant (HR) crops in Canada. The earliest introductions included oilseed rape, soybean, and maize. Crop rotations in eastern and western Canada are distinctly different with maize/soybean rotations dominating eastern Canada, while shorter season cereal/oilseed/pulse crop annual rotations dominate in western Canada. Oilseed rape in western Canada and soybean in eastern Canada have been the biggest commercial successes with greater than 80% of the annual acreage sown to HR genotypes. In 2004, about 20% of the maize acreage was resistant to herbicides (approximately 12% glyphosate-resistant and 8% glufosinate-resistant). With the recent emergence of the ethanol market for maize and concomitant increase in price, the HR maize acreage already has increased to greater than 30% in 2007. In western Canada, imidazolinone–resistant lentils and spring wheat were introduced recently into the marketplace. The market for these herbicide-resistant crops is still developing.

Needs and beneficiaries of the technology

The need for HR crops in Canada has been a recurring topic of discussion since their introduction. However, HR crops have provided a series of benefits to producers that include more flexible use of herbicides, high efficacy and more consistent weed control, improved crop tolerance, fewer residual problems, reduced herbicide cost, reduced environmental impact and the introduction of new modes of action in some cropping systems. Many of these benefits have been well received by producers who manage more land as farm size continues to increase in Canada. A strong argument can be made that the introduction of HR oilseed rape in western Canada substantially slowed the development of HR weed biotypes as HR oilseed rape reduced the application frequency of ACCase inhibiting herbicides in these cropping systems. Glyphosate-resistant cropping systems typically provide more of these benefits than some other commercially available herbicide-resistant varieties of the same species. This has contributed to the high commercial success of glyphosate-resistant crops such as soybean. Although most benefits of herbicide-resistant crops in Canada have been directed towards producers, the resulting application of lower absolute amounts of active ingredients in some cases and a shift to more environmentally friendly herbicides is clearly a benefit that extends beyond the producer.

Solutions delivered and barriers to success

Over the past decade, many different herbicide-resistant crops have been registered and commercialized. In Canada, the most successful modes of action of herbicide-resistant crops have been glyphosate-resistance (soybean, maize, and oilseed rape), glufosinate-resistance (maize and oilseed rape), and imidazolinone-resistance (oilseed rape). However, not all commercially introduced HR crops have been successful in the marketplace. Commercial releases that have been removed from the Canadian market include sethoxydim and imidazolinone-resistant maize, sulfonylurea-resistant soybean, and bromoxynil-resistant oilseed rape. In many cases, reasons for market failure were primarily due to the availability of varieties resistant to herbicides that provided more broad-spectrum control at a lower cost. In contrast, successes such as glufosinate-resistant oilseed rape are based, in part, on superior-performing genotypes and not solely on herbicide performance.

In addition to agronomic performance, there have also been other barriers to success of these crops, including public opinion, food safety, and producer concerns regarding access to global markets. For example, Percy Schmeiser vs. Monsanto catapulted HR crops into media spotlight and to the highest court in Canada. Concerns around access to global markets ultimately prevented the commercial release of genetically-modified glyphosate-resistant wheat after passing all other regulatory steps in Canada. To address these concerns, HR crops have been subjected to unprecedented scrutiny by scientists. While most of the agronomic research has been funded by industry and commodity groups, funding for research topics outside of agronomy has been provided primarily by the public sector and to a lesser extent by producer groups. In Canada, research on HR cropping systems also has included several studies on field scale outcrossing, volunteerism, fitness of multiple-resistant volunteers, and the impact of this technology on non-target organisms.

How do we measure success?

In Canada, science-based regulation has been very successful at bringing these technologies to the marketplace. Nevertheless, the question of how do we measure their success remains. It is clear that HR crops can provide a number of agronomic and other advantages to conventional production systems. High acceptance of these crops by producers in Canada is testament to some of these advantages. However, there also may be other means for measuring success of these cropping systems including ecosystem health or environmental benefits, energy budgets and efficiencies, or carbon emissions related to these cropping systems. These are more difficult to assess and therefore, little effort has been spent on measuring the success of HR crops based on factors other than agronomic advantages to date. This type of research may also be a key component in addressing some of the public concerns over these technologies. In conclusion, ten years of commercial production have shown that herbicide-resistant crops can be an important component of sustainable cropping systems in Canada. However, to maintain the success of this technology, judicious and balanced use of HR crops is essential to ensure that overuse of this technology does not compromise its longevity.