Crowding out weeds in India

Increasing herbicide resistance in weeds called for a new approach. **Warren Page** reports on efforts to align several management options

Weed competition for crops has been the bane of farmers for time immemorial, and while modern herbicides have provided some relief in recent decades, their effectiveness is declining as weeds develop resistance. The experience in India mirrors this global trend. The Punjab and Haryana states in north-west India produce a third of the country's wheat, and from the late 1960s, when higher-yielding dwarf wheat varieties were introduced, to the late 1980s, production remained stable. But by the early 1990s, yields began to decline dramatically and one of the main causes was the weed, *Phalaris minor*. This had been kept under control with herbicides, but by the 1990s was developing herbicide resistance.

In India wheat is grown in rotation with rice. During the rice rotation, weeds are not a problem; the *Phalaris* only emerging during wheat germination. With both the wheat and weed competing for water and nutrients, overcrowding kills or reduces the growth of smaller crop plants. Wheat does not mature at the same speed as *Phalaris* so it struggles to compete, resulting in reduced yields.

In India's case, the development of *Phalaris* resistance was the result of overuse of one herbicide, isoproturon, over a 15-year period. The problem became noticeable when isoproturon-resistant *Phalaris* emerged rapidly in the early 1990s. In 1990, spraying killed about 78 per cent of weeds. By 1993, this had fallen to just 22 per cent.

Wheat yields began to plummet at a similar rate. In the worst-affected regions, yields were reduced by 50 per cent, falling to 1.5 tonnes per hectare, or even further.

Some farmers began to switch from wheat to sunflowers to make up lost income.

In the 1992-93 season, the introduction of a new wheat variety, changes to herbicide recommendations and alternatives to isoproturon all helped to arrest the slide, but this respite would be at best temporary.

The higher cost of the new herbicides, and the likelihood of future resistance emerging, meant that any option that put all hope of control on a herbicide alone would never be sustainable.

So ACIAR, together with the International Maize and Wheat Improvement Center (CIMMYT) and Haryana and Punjab Universities, sought to develop an alternative approach – integrated weed management, to build on earlier work by the Rice-Wheat Consortium.

This aligns several management options to extend the effectiveness of chemical spraying, rather than hoping for an alignment of optimal conditions to counter the yield decline from herbicide

resistance. It was anticipated these options would fit into a new approach to preparing soils – zero tillage.

Four management options were identified and trialled: changes to crop rotations, earlier sowing times, higher crop densities and the judicious use of alternative herbicides.

Also, wheat varieties that are more competitive were identified, and have started to be introduced into crop rotations.

It has been found that earlier planting of these varieties can reduce the direct competition between wheat and *Phalaris*. Planting wheat a month earlier than usual gives it an opportunity to grow without direct competition. This ensures wheat germinates and establishes itself before conditions become favourable for *Phalaris*.

Increasing crop densities further crowds the emerging weeds, changing the dynamics so that the weeds are the smaller plants, rather than the wheat. The reduced number of weeds in turn allows for more judicious spraying of herbicides. Less spraying reduces the likelihood of resistance and extends the timeframe in which the herbicide is effective.

These options were then integrated into a change to tillage practices. Zero tillage does not disturb the soil, with seed planted in the residue of rice crops. This lack of soil disturbance makes it hard for *Phalaris* seed to establish itself.

Zero tillage agriculture was introduced by international research organisations as an option for increasing yields rather than for weed control, but incorporating the management options for *Phalaris* with zero tillage is regarded as an effective integrated weed management package.

The main barrier to this has been farmers' need to be convinced that a change to zero tillage will deliver the wheat yields and the *Phalaris* control that they used to enjoy in the 1980s.

In the past, farmers have not adopted zero tillage. In the 1970s, Punjab Agricultural University experimented with zero tillage but failed to spark the imagination of farmers. One of the main problems was the lack of suitable equipment.

In zero till, seed is introduced to the soil via a drill. This helps water run through soil quicker, and allows rice straw residue to cover soils, keeping them closer to optimal temperatures in both colder and hotter weather. Disturbance to soil is minimised. This improves the soil's chemical, physical and biological properties and increases carbon storage, which helps reduce greenhouse emissions and boosts yields.

The drawback for farmers is that drilling into soil that has not been ploughed requires specialist equipment.

During the project, many of the trials were undertaken in farmers' fields, giving them a close look at the machinery and possibilities. The control of *Phalaris* was in itself enough to convince many farmers, and when coupled with increased yields, led to a demand for drill equipment.

Project personnel from both India and Australia supported the development of suitable drill equipment by several manufacturing companies. For example, spacing of 15 centimetres was used, rather than the 22cm that is used elsewhere, to deliver cropping densities that match the needs of integrated weed management packages.

This has helped accelerate the adoption of zero tillage farming throughout Punjab and Haryana states. Twelve recognised drill manufacturers are now operating, supplying equipment to farmers in both states. More than 3000 drills are in use.

An independent impact assessment of the ACIAR-supported research, which led to the acceleration in adoption by three years, has demonstrated benefits to India of A$238 million, arising from an investment of A$1.3 million.

This return is part of the A$1.8 billion in benefits that zero tillage has begun to bring to India, identified in the assessment.

A seeder to allow planting of wheat into rice-straw stubble, similar to that now being trialled for raised beds.

S S KUKAL

Measuring experiments with waterlogging-tolerant wheat.

Wheat yields are up to around 4t/ha in many areas of Punjab and Haryana. Given that the project identified that isoproturon-resistant *Phalaris* had spread throughout the rice-wheat growing areas of both states and that other herbicides would have suffered the same fate, the introduction of zero tillage and integrated weed management has made a dramatic difference to farmers. ◂