

Development of Imidazolinone Tolerant Lentil Varieties

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Imidazolinone tolerance in lentil was developed over the past 9 years at the Crop Development Centre, University of Saskatchewan in a partnership effort with BASF and Saskatchewan Pulse Growers. Weed control has always been a primary productivity constraint for the lentil crop and this new approach will be beneficial for the lentil industry. The breeding program at the CDC has been modified to accommodate rapid development of imidazolinone tolerant varieties.

Over the years, we carried out numerous genetic and agronomic investigations of imidazolinone tolerance in lentil. Studies were conducted on genetic inheritance and various aspects of tolerance to Odyssey herbicide for RH44 lentil, the original breeding line in which imidazolinone tolerance was first discovered. Agronomic studies included rate of imidazolinone application, timing of application, and cross-tolerance to other herbicides.

The imidazolinone tolerant lentil genotype designated RH44 was discovered in 1997. A genetic study was initiated to determine the mode of inheritance of imidazolinone tolerance. Crosses were made between RH44 and several current lentil cultivars. Parents, F₁ plants, F₂ plants and F₃ progeny rows were treated with post-emergent Odyssey herbicide (imazethapyr + imazamox) to determine genetic segregation ratios for herbicide tolerance. Agronomic experiments were conducted in the field and in the greenhouse using RH44 to determine (1) the effect of timing of imazamox application and (2) the effect of rate of imazamox application. Additional experiments were conducted to determine (a) the effect of 1x and 2x rates of imazamox ($x = 20 \text{ g a.i. ha}^{-1}$) and metribuzin ($x = 120 \text{ g a.i. ha}^{-1}$) on RH44 and 7 lentil cultivars, (b) the extent of cross tolerance of RH44 to other Group 2 herbicides, and (c) the level of injury and effectiveness of weed control with Odyssey application to RH44 lentil.

Genetic analysis of a large number of F₂ and F₃ populations of single crosses with RH44 showed that tolerance to imidazolinone herbicides was due to the expression of a single dominant gene. When Odyssey herbicide was applied (at 2x the recommended rate for pea production) to segregating lentil populations, three phenotypes were observed two weeks after application. Homozygous recessive plants stopped growth and showed the classic stunting and yellowing of imidazolinone herbicide damage. Heterozygous plants showed similar symptoms but were able to slowly recover. Homozygous dominant plants were unaffected by Odyssey application. Because we were clearly able to distinguish heterozygous from homozygous plants we were able to initiate an accelerated backcrossing program to convert current and near-future lentil cultivars to imidazolinone tolerance.

We developed a suite of backcross donor lines in each market class of lentil. Our current strategy is to backcross all promising breeding lines for at least 3-4 generations beginning with the tolerant backcross donor line for each market class. We developed a method that allows us to complete four crossing cycles per year. After the final backcross the resulting F₁ plants are used

to produce an F2 generation from which homozygous plants are selected. These are then multiplied in progeny rows to allow subsequent yield testing as soon as possible in comparison to appropriate check varieties and the original parent line. After selection on the basis of yield and disease resistance, the imidazolinone tolerant backcross lines are entered into a breeder seed production scheme for subsequent release through the Saskatchewan Pulse Growers Variety Release Program.

Field and greenhouse studies showed that imazamox had virtually no effect on growth and phenology of RH44 when applied up to the 11-node stage (flowering). Field studies showed that RH44 was not injured by application rates up to the 8x rate. Under greenhouse conditions no injury occurred up to the 4x rate. In experiments involving RH44 and non-tolerant lentil cultivars CDC Glamis, Richlea, CDC Vantage, CDC Milestone and CDC Robin at 1x or 2x imazamox caused injury, stunting, delayed flowering, and yield and biomass reduction in all non-tolerant genotypes under most environmental conditions. Experiments involving metribuzin application at 1x and 2x showed that RH44 and the other 5 cultivars were tolerant but that late stage application (after 7 nodes) resulted in height reduction in some cases. Group 2 cross tolerance experiments showed that RH44 lentil was susceptible to injury, flowering delay and biomass and yield reduction from thifensulfuron methyl, tribenuron methyl and flucoarbazone-sodium.

Herbicide trials using RH44 in 2001 and 2004 showed that Odyssey application at 30 g a.i. ha⁻¹ resulted in very low levels of crop injury. Yield of RH44 lentil was increased by 60-80% when compared to unweeded controls. Odyssey treatment at 30 g a.i. ha⁻¹ resulted in similar yield when compared to treatment with Odyssey (30 g a.i. ha⁻¹) + Poast Ultra (200 g a.i. ha⁻¹) and Poast Ultra (200 g a.i. ha⁻¹) + Sencor (210 g a.i. ha⁻¹).

We expect that imidazolinone tolerance in lentil will be beneficial for Canadian lentil production. The very low level of crop injury across a wide range of application rates and growth stages, combined with the wide spectrum of weed control offers growers substantially improved weed control. New lentil varieties with imidazolinone tolerance will become widely available in the next few years. Future agronomic research stemming from these developments will likely include (1) crop rotation studies, (2) the interaction between imidazolinone application and development of foliar disease and (3) the relationships among imidazolinone application and crop maturity, crop quality and seeding rate. The lentil research community has a golden opportunity to develop the concept of variety specific agronomy as a means of further reducing risk and maximizing productivity in lentil production.

The first supplies of seed of imidazolinone tolerant lentil varieties will be released to Select seed growers in the spring of 2006. About 75,000 kg of seed is available (total of 2 varieties). CDC Impact most closely resembles the variety CDC Blaze. CDC Imperial is most similar to CDC Robin. Both should have widespread commercial availability by the spring of 2008 and will likely play a role in helping Saskatchewan become the world's leading supplier of red lentils in whole and split form. Green lentil varieties with imidazolinone tolerance should become widely available within 3-4 years. One of the most noticeable impacts at the farm level will be the improvement in reliability of earlier harvests for the lentil crop. To visualize this, imagine the economic cost of the late maturing portion of the green lentil crop that was severely affected by an early frost in August 2004. This weed control technology may also help expand our red lentil

market. Our red lentil marketing held back by having high moisture content relative to other global suppliers because we are the only major lentil-producing area that harvests the crop at a time when temperature is declining. Earlier harvest will help us become the preferred supplier because we should be able to more reliably supply a superior product.

A truly unique combination of research partners spearheaded a research and development effort that enabled us to rapidly develop this technology. We now have a new registered broadleaf weed control option in a minor crop at a time when it is almost impossible to economically develop new herbicides. Canada is the first place in the world to have access to imidazolinone tolerant lentil varieties.

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References

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