Mechanical Weeding of Cereals

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The following is a historical record of our experiments with mechanical weeding. It consists of four reports covering the years 1999-2002. I wrote them for Prof. Ralph Martin at the NSAC from whom we initially borrowed a tined weeder. Each year we employed more organic techniques. We learned from experience, so my observations and recommendations are not always consistent from year to year. If you read any of this report, then I suggest you read it all. That way, you can pick and choose what advice you take.

REPORT #1, 1999

In April of 1999 we borrowed a 10' Lely finger weeder from the Plant Science Dept. of the Nova Scotia Agricultural College. We tried it on an 11.5 acre field of Chapais barley.

The field was a very well drained sandy/silty loam over gravel, with many small stones. It had previously been in a long-term alfalfa/timothy mixture. The bad winter of 1996-97 had killed much of the alfalfa. A fair amount of couch and dandelion had invaded the field.

The field was fall ploughed, then harrowed twice with an S-tine harrow several days before planting. The pH was OK. The field received 300 lb. per acre of 12-24-24. We broadcast the barley on 2 May, and used the finger weeder to cover the seed. Our goal was 88 lb./acre (one bag of seed), but the actual rate was about 75 lb./acre. The other fields of barley on the farm were broadcast seeded and harrowed in with the S-tines.

We blind harrowed the field with the finger weeder on 6 May just before emergence.

We harrowed the crop again on 28 May with the finger weeder. We set the weeder with as little tension as possible in the springs, and set it about 1" into the soil. The weather was totally dry between planting and this weeding. At this time, the crop ranged from 2 leaf to 5 leaf plus tillers. We weeded only once post-emergence.

Immediately after weeding, we used a Brillion seeder to plant triple mix into the barley crop.

We combined the barley on the 20 August. This was a bit late because of weather. The barley was well kinked, and there was a small amount of head loss (<1%).

Observations:

The ploughed and harrowed field had a considerable amount of trash on the surface, particularly couch grass roots. The finger weeder would clog up with trash and every few passes the operator would have to take the weeder to the edge of the field and remove the trash. We could not have weeded a large acreage this way.

Broadcasting the seed in this dry spring, we had very uneven emergence. We had to wait until all the crop was at least two-leaf to do the final weeding. By this point, much of the crop was five-leaf plus tillering, and the weeds were quite large: mustard with several true leaves and the size of a tea-saucer, lamb's quarters three inches high. The weeder did little to disturb the mustard, and only disturbed some of the lamb's quarters.

The weeder did, however, disturb the barley, leaving much of it flat. Nevertheless, it did not pull out an unacceptable number of barley seedlings. The barley recovered in a few days, though I could barely stand to look at it in the interval. Several observers thought that I had ruined the crop.

Jim Neary from NSDAM looked at the crop at mid-season. At that time he observed that about 10% of the field had yellow mustard plants showing. There was no mustard in the adjacent fields that we had sprayed with MCPA.

At harvest the mustard had gone to seed, but there were a considerable number of lamb's quarters showing above the barley. It was a very dry summer and Chapais barley is short-stemmed in a good year. The crop did not stand much over two feet high.

The custom combine operators complained about the weeds, saying that even a few percent lamb's quarters slowed the combining. They said lamb's quarters were worse than mustard in this respect.

In the adjacent sprayed fields, the moisture content of the barley generally was about 15.5%. The moisture content in the mechanically weeded field was 18.5% owing to the unripe weed seeds and bits of weed plant matter in the harvested barley.

Despite all this, the yield of the weeded field was slightly higher than that of adjacent sprayed fields, and of the farm generally. All round, because of the drought, yields were very disappointing, though no worse than the yields on nearby farms. Either we had had poor emergence, or poor tillering in the dry spring. For reference, last year's barley yield was about 87 bushels per acre. Our only measure of yield is combine tanks @125 or 100 bushels depending on which combine was used. Hence the results are rather rough. The following table shows the barley yields for the farm:

	Bushels	Acres	Yield (bu/acre)
Mechanically weeded (Erb front)	675	11.5	58.7
Adjacent (Crossman)	1862.5	43	43.3
½ miles away (Sargent)	225	6	37.5
2 miles away (New Prospect)	2787.5	53	52.6
Total/Averages	5550	113	49.1

The custom combine operators were of the opinion that the weeded field had the best crop. The heads were long (48 to 72 kernels per head) and the kernels were plump (grading 1CE). Perhaps harrowing in the seed in the test field with the weeder rather than the S-tines had given better emergence? Perhaps the test field was seeded a little more heavily? Perhaps the weeding encouraged tillering?

Because of its high moisture content, and because we have no drying facilities, we shipped the 14 MT of weeded barley, together with 4 MT or so of sprayed barley, to Bayhead. The load graded 1CE, moisture of 18%, dockage of 3.7%.

Lessons learned:

1. Kill the couch. I think the weeder would handle some short, straight trash like chopped straw. However, it cannot handle very much long, curled trash like couch roots. The work rate would be too slow. This may entail using Roundup before converting to the weeder harrow.

2. Plough cleanly. The ploughing needs to bury as much trash as possible. Dead furrows are a source of weed seeds and trash. The plough should have trash-boards or skimmers. The ideal would be spring ploughing (for erosion control) with a reversible plough equipped with skimmers and set shallow and wide. This would eliminate dead furrows and bury as much weed seed and trash as possible.

3. Use a disk harrow. S-tines bring trash to the surface. Disks cut trash and even bury some of it.

4. Seed at a uniform depth. Broadcasting gives a very uneven emergence especially in a dry spring. For example, I borrowed a seeder to plant winter wheat this September, and the whole field reached the 3 leaf stage in 2 weeks and 2 days. By contrast, broadcasting the barley last spring, it took 4 weeks less 2 days before most of the field had reached 3 leaf, and by then some was 5 leaf plus tillers. This makes a big difference in the size of the weeds. As I understand it, the weeder works mostly by burying the weed seedlings,

and for it to work, the seedling must be as small as possible. The ideal would be a good seeder with packing wheels to control the depth of seeding of each individual row.

5. Use a tall variety. Something taller than Chapais would help the grain out compete the weeds.

6. Seed heavily. Planting a pure stand of grain at about 120 lb. per acre without underseeding would aid the grain in out competing the weeds.

7. Weed without looking back. The crop looks awful, but it will recover as long as the weeder is not pulling too many grain plant right out of the ground.

8. Use a grain cleaner. Contemporary combines are made for sprayed grain and do not have integral grain cleaners like older models. All the weed seed goes into the bin. This summer the unsprayed grain looked almost black when it came out of the combine. The unripe weed seeds raise the moisture content of the grain. Example from this summer: 96% barley at 15.5% moisture plus 4% dockage at 80% moisture equals about 18.1 % total moisture, which is not storable. This summer was particularly bad for weeds since the grain was thin and moisture stressed. Still, counting on the grain being dry enough to store without cleaning it would not be safe. I have read that the moisture in the dockage will be transmitted to the grain within about 24 hours. (Another option would be to swath the grain to dry the weeds, but that entails buying a swather and another sort of header for the combine.)

9. Expect good yields. Our experience suggests that weeded grain will yield at least as well as sprayed grain, everything else being equal.

REPORT #2, 2000

Working with Ralph Martin, we again borrowed the 10' Lely tined weeder harrow from the NSAC.

We used the weeder on a 13 acre field of Chapais barley. The previous crop was winter wheat. The winter wheat stubble had been sprayed with Roundup in the fall of 1999 to kill the couch in the wheat stubble.

We ploughed the winter wheat stubble on 13 April.

We cultivated the ploughed stubble on 19 April with the S-tine harrows. In retrospect this was a mistake as the S-tines brought a considerable amount of trash, both straw and couch, to the surface which later interfered with the weeder.

The mechanically weeded field received no fertilizer or manure.

We disced and planted the field on 5 May. We broadcast approximately 110 lb. per acre of Chapais barley. Running out of seed we finished the field with 1 bag of feed oats. We harrowed in the seed with the S-tines.

We blind harrowed the field on May 15 and 16 with the Lely weeder. At this time a few spikes of barley had started to emerge. We used the Lely weeder only on the field which had no fertilizer.

Emergence was very irregular. The quickest and best emergence was in the tracks of either the tractor wheels or the cultivator guide wheels. My best guess is that this effect was due to the fluffing action of the discs on our light soil and the resulting poor seed to soil contact. We are unfamiliar with disc harrows. The discs were new to us this spring and we have never used discs before in my time on the farm. To solve this problem we need a seeder with press wheels.

The crop was 3-leaf and ready to weed by 29 May, but weather delayed us until 31May and 1 June.

Just as in the year before, couch trash gave us trouble in the weeding. We eventually found that if we allowed only a small amount of couch to tangle in the tines of the weeder, then we could get rid of it. We did this by backing up with the tines in the ground while slowly raising the harrow. The tines of the weeder are only an inch into the soil, so reversing with the tines in the ground does not hurt them. Nonetheless, couch still slows the weeding a great deal.

As last year, the weeding appeared to devastate the crop. But it recovered.

We underseeded the barley on 5 June with about 12 lbs./acre of single cut red clover for plough-down the following year.

Weed control seemed very good. The weeds were not as vigorous as in other years. The yellow mustard plants, for example, grew only to half their usual height, became covered in small insect holes like turnips do in the vegetable garden, and appeared to be eaten nearly as fast as they could grow. My guess is that the weeds suffered from the lack of chemical fertilizer.

Wherever the Roundup had been sprayed outside the ploughing a large flush of weeds appeared. We hand mowed these.

We combined the grain on the 31 August by which time the barley was well kinked. We used combine bins as the unit of measurement (125 bu./bin). The following table shows the result for the whole farm:

	Fertilizer	Acres	Yield (bu/acre)
Mechanically weeded (Erb back)	0	13	72
Plough Shed Centre	400 lb. 5-30-10	37	94.6
Lunn	200 lb. 5-30-10	78	86.5

There was a drop in yield in the mechanically weeded field of about 1/3 of a metric tonne/acre (700-800 lb.) Because we used no fertilizer. This represented a loss in potential revenue of about $40 - $50 per acre. Yet this loss in revenue is very little more than the expense of fertilizing. With fertilizer at $300 per tonne, 220 lb. of fertilizer would cost $30 per acre plus $5 - $10 per acre to spread it.

The barley came off very cleanly. We sent two samples for grading, with the following results:

	Chemical	Mechanical
Grade	1CE	1CE
Moisture	13.7%	13.8%
Dockage	0.6%	0.9%

The custom combine driver, Dean Acton from near Sackville NB, commented that the field was "the best field of organic [sic] grain that I've ever combined." Dean was of the opinion that the good catch of underseeded clover might have helped keep the weeds down.

Lessons learned:

1. Couch is a problem. Unlike straight pieces of straw, couch roots curl and tangle in the weeder tines.

2. Roundup is not the solution. Couch roots do not rot and disappear. Roundup creates its own problems with annual weeds at the margins of the fields. S-tine harrows aggravate the problem; perhaps discing w/o using S-tines would help keep couch buried. The time for S-tines would be in the stubble after harvest to bring couch roots to the surface to die and be buried by the plough.

3. Don't use fertilizer. Fertilizer encourages weeds. The weed problem in this unfertilized field seemed to be reduced considerably over last year's fertilized field next door.

4. Underseed. Underseeding discourages weeds. The red clover underseeding seemed to keep down the growth of lamb's quarters in particular.

5. Use a grain drill. A drill with press wheels is especially necessary after discing in our light soil.
Plus it makes for more uniform emergence.

6. Blind harrow as late as you dare. We had better results this year blind harrowing 10 days after planting than last year when we harrowed after 5 days.

7. Weed as early as you dare. This year, the mustard and lamb's quarters were smaller than they had been the year before at weeding. This may have been an effect of the later blind harrowing.

REPORT #3, 2001

Working with Ralph Martin, we borrowed a 10' Lely tined weeder harrow from the NSAC for a third time.

We used it on a 6.2 acre field of barley. The field had previously been in grass for at least 5 years. Most of the tame grass had run out and been replaced by wild grasses. Previously the field had produced grass silage. The field was too far from the farm to receive liquid manure, but had received about 220 lb./acre of 17-17-17 each year. The nutrient status of the field was not good. It contained no couch grass.

We had ploughed the field the previous fall with a set of reversible ploughs. The field showed little trash or sod, and had no dead furrows. The only sod was where the finishes had not blended well with the ploughing of the ends.

To try the effect of reduced cultivations, we disced the field only once on the day before seeding.

We seeded the field with a grain drill with press wheels at 120 lb./acre on 2 May. With staggered double disc openers, the drill worked well in the reduced cultivation.

We applied 440 lb./acre of 5-20-20 to the seeded ground a few days later. We used this rate on the sprayed fields too.

A small portion of the field (less than ½ acre) was too wet to cultivate and seed. We were not able to seed this bit until 28 May. It was never sprayed, so it provided somewhat of a control for the mechanical weeding.

We used the weeder to blind harrow the field on 9 May. Because there was no couch, the weeding went very quickly. Because the ground was not very level from the reduced tillage, and because the weeder had no gauge wheels, the weeder's penetration of the ground was not uniform.

The grain emerged by the 14 May. The emergence seemed equal in both the weeded and non-weeded fields.

The grain started to show 3 leaves on 23 May. We weeded it post-emergence on 25 May in the 2 to 3 leaf stage. We drove very slowly. Because of the reduced tillage the field had little dips and raises. We observed some damage to the seeding on the high points. The weeder totally buried the seedlings at some points.

The neighbouring fields, planted at the same time and rate, were sprayed with MCPA on 8 June.

We observed the weeded field and a neighbouring sprayed field a few weeks later. The control of pigweed in the weeded field appeared to be as good, or better than, in the sprayed fields.

During July, the 6.2 acre weeded field had only six to ten mustard plants that were able to show flowers above the barley.

In August, the late-planted, unweeded, unsprayed ½ acre piece of the field looked awful. It contained a great deal of vetch, lamb's quarters, and wild grass.

We combined the crop on 26 August, late and with some head drop. We measured yield by counting combine bins of 125 bu. We could only estimate to an accuracy of 1/4 bin, so the yield differences in the following table are not really significant.

	Acres	**Fertilizer**	**Yield (bu)**	**Yield/acre (bu./acre)**
Mechanically Weeded	6.2	400 lb. 5-20-20	406	65.5
Neighbouring Sprayed	14	400 lb. 5-20-20	937	67
All Barley Incl Above	67	400 lb. 5-20-20	4219	63

The combine chopped the barley straw. We incorporated the stubble and chopped straw in early Sept with one discing and one harrowing. We seeded the weeded field with 14 lb./acre of oil radish, and the neighbouring field with 58lb./acre of buckwheat.

By October we had a cover crop. About half of it was 12" high barley volunteered from the head drop, the other half was oil radish. The neighbouring buckwheat was frost killed in mid October, but the oil radish flowered and was still alive in early November.

Lessons learned:

1. Use gauge wheels on weeder. Otherwise, the weeder depth varies with hills and dips under the front wheels of the tractor.

2. Level the field. Hills and dips make it difficult for the weeder to do a good job. Our single discing was not enough. A pass with a cultivator, or the addition of some leveling attachment to the discs, would be better. Track eradicators on the seeder would help too.

3. Don't worry greatly about buried plants on post-emergence weeding. Many of the plants appear to reemerge through the soil. The rest of the crop appears to fill in gaps. There was no yield loss that we can observe.

4. Be careful of oilradish covers. Not all the oil radish seeds germinate in the fall that they are planted. They then volunteer aggressively in the next year's crop. I hope that we have not introduced a new weed.

REPORT #4, 2002

This year we committed ourselves to mechanical weeding by purchased a 9 metre (30 foot) Einbock tined weeder from HWE-AgriTech Ltd in Embrun, Ontario. We used the weeder on about 230 acres of spring cereals.

The weeder has gauge wheels and floating sections that follow the contours of the land. We ordered ours with 8 mm. straight tines, instead of the standard 7 mm. hooked tines. This was our gamble. The hooked tines of the NSAC weeder , when working in couch grass residue, had made weeding so slow that it would have been impossible to cover the bigger acreage in a timely manner. Straight tines at low angles are used as levelers on high residue cultivators. We hoped that they would work in couch residue while still providing adequate weeding in our light soils.

This year we used no fertilizer or herbicide on any of our fields.

1. Erb Back (13 acres) This is the field mechanically weeded in 2000. We ploughed down a heavy crop of red clover, tops and all, in April, disced it once and planted 118 lb. of Chapais barley on 8 May. We weeded it pre-emergence at 8 days and post-emergence at 26 days. A small plot in this field was used by the OACC for barley trials. It has had no fertilizer of spray since 1999.

2. Erb/Crossman (57 acres) Grassland ploughed fall 2001, disced once, planted 8 May with 118 lb./acre Chapais barley, weeded at 8 days and 26days.

3. Skidmore (14.7 acres) Fall rye stubble worked down with S-tines and discs in fall of 2001 and spring of 2002. Planted on 5 May with mixture of 40 lb/acre hull-less oats and

40 lb/acre peas. Weeded at 7 days and 28 days. Underseeded with red clover timothy at 29 days

4. Down Shore (85 acres) Barley stubble cultivated fall 2001, disced once in spring 2002, seeded with 60 lb/acre Nova oats 5-7 May, weeded at 6-7 days and 27-28 days. Underseeded with red clover timothy at 30-35 days.

5. Plough Shed North (31 acres) Pasture ploughed fall 2001, disced once in spring 2002, seeded with 118 lb/acre Chapais on 10-13 May. Weed once pre-emergence at 9 days.

6. Simpson's Small (3 acres) Ploughed fall 2002, disced on 8 May, weeded pre-plant and seeded 13 days later on 21 May with 118 lb/acre Chapais, and weeded post-emergence at 22 days.

7. Crossman Back (30 acres) Wet, heavy land, ploughed fall 2001, disced and seeded on 28 May, weeded pre-emergence at 7 days only.

Yields: (measured by combine bins @ 125 bu)

Field Location	Yield	Crop
Erb Back	70 bu/acre	barley
Erb/Crossman	47 bu/acre	barley
Skidmore clipped because of poor weed control		
Down Shore	44 bu/acre	oats
Plough Shed N	79 bu/acre	barley
Simpson's Small	33 bu/acre	barley
Crossman Back	47 bu/acre	barley

Lessons learned:

1. Straight tines. Our gamble payed off. The straight tines worked without plugging in both couch grass residue and unploughed, chopped, barley-straw residues. At the middle setting out of five, the weeder left the residue where it was. At one setting steeper, it pulled the residue into piles. The weeder still provided adequate soil disturbance for weed control. A straight tined finger weeder seems to work under min-til conditions.

2. Field edges. Fields ploughed inwards often slope downward to the edges. The wings of a wide weeder tend not to follow this contour. Often the edge of a field has the most weeds. The problem can be solved by going around the outside of the field with the wings raised, weeding with only the 10' middle section of the weeder.

3. Grass. Even though the couch did not affect the weeder, it did affect the yields. The poor yields in 2&7 are due to lack of nitrogen and too much couch grass. The fields

labeled 4 were not ploughed and there was a considerable amount of wild grass in them. This also affected yields.

4. Clover plough down. The barley in field 1 was grown on a clover plough-down and had had no fertilizer or manure for nearly 3 years. The 70 bu/acre yield here gives the best indication of what an organic rotation could accomplish. This yield approximately equals this same field's yield of 72 bu/acre in 2000. Clover residue remained in the soil by the fall, so this field was seeded to AC Samson winter wheat for 2003.

5. Level fields. Fields 5 and 7 were so rough after just one pass with the discs that I decided not to risk a post-emergence weeding. Weed control was still good. I think it is worth getting the fields level for mechanical weeding. Now that I don't have to worry about couch residue, I plan to reattach the track removers (which drag up couch roots) to the seeder.

6. Weed control failure. The weeding failed to control the mustard in field 3, so I decided to clip it. So there was a 15 acre failure out of 230. The field had grown a crop of fall rye the previous year without herbicides. I don't know the reason for the failure. The oats were sown very lightly (40 lb/acre) and the peas had a very slow emergence. Perhaps there was not enough crop to suppress the mustard. Perhaps some fields have too large a reservoir of weed seeds to grow spring cereals with mechanical weeding. If we had started our mechanical weeding experiments in this field we might well have given up after the first year.

7. Stale seed-bed, pre-plant weeding. Field 6 was seeded this way; prepared on May 8, weeded and seeded 13 days later on May 21. Weed control was adequate, despite lack of pre-emergence weeding. Yields, however, appear to have suffered considerably, though our way of measuring yield is very rough. The OACC did careful yield experiments on delayed seeding.

8. Late planting = quick emergence. Under our conditions, seeding in early May results in emergence in about 10 or 11 days, and pre-emergence weeding can take place from day 7 - 10. However, seeding in mid-May results in emergence in about 7 days and requires earlier pre-emergence weeding. I was fooled by this and so missed the pre-emergence weeding on Field 6, and on the OACC test plot. I notice that though field 6 was planted 13 days later than fields 1 and 2, the barley in 6 headed out only 4 days later than in 1 and 2, and was combined at the same time.

9. Heavy crops. The best defense against weeds is a heavy crop. It is important not to have any misses with the seeder. It is likely easier to attempt mechanical weeding in a full 120 lb/acre seeding of cereals than in 40-60 lb/acre seeding with a clover and grass underseeding. Tall oats are likely better at suppressing weeds that short barley.

10. Underseeding. Underseeding with grass and clover presents several problems for mechanical weeding. First, it requires low rates of seeding for the cereal crop and so allows more room for weeds. Second, mechanical weeding requires that underseeding be

delayed until after the post-emergence weeding, often more than a month after the cereal planting. A brillion seeder is relatively slow to cover ground which adds to the delay. If the soil is dry in June, germination will be affected. This compares to chemical weed control, where the underseeding can be done by the grain drill in early May. Red clover appears to underseed more successfully than white. Next year, I plan to try broadcasting the clover and grass seed a few days before the post-emergence weeding, harrowing the seed in with the weeder, and perhaps rolling a few days after weeding. Failure of an underseeding can result in a proliferation of couch and other weed-grasses in succeeding years.