and pest pressure. The 2000 season was very wet and cold resulting in poor crop emergence and slow growth, and there was significant pest pressure from CEW and ECB. The 2001 season was drier and hot with almost no CEW pressure, except on coastal farms. See Table 1 for farm locations, planting dates, and trap captures.

Oil treatments gave statistically significant improvements in the percent of marketable ears and tip damage ratings on all farms for almost every planting. An analysis of all of the blocks on all of the farms shows a statistically significant increase in the percentage of clean, marketable corn in the treated (oiled) verses the untreated samples for each year of the experiment: the overall mean improvement in the percentage of clean ears between the untreated and the oiled ears for all plantings on all of the farms was 21.6% and ranged from 0-56% (Figure 1), with the highest levels of improvement generally occurring on farms with the greatest pest pressure. Significant reductions were also achieved in the number of caterpillars found and in the percent of ears with side damage. The number of plantings with differences in the amount of side damage between the treated and untreated ears decreased in the last year of the project,

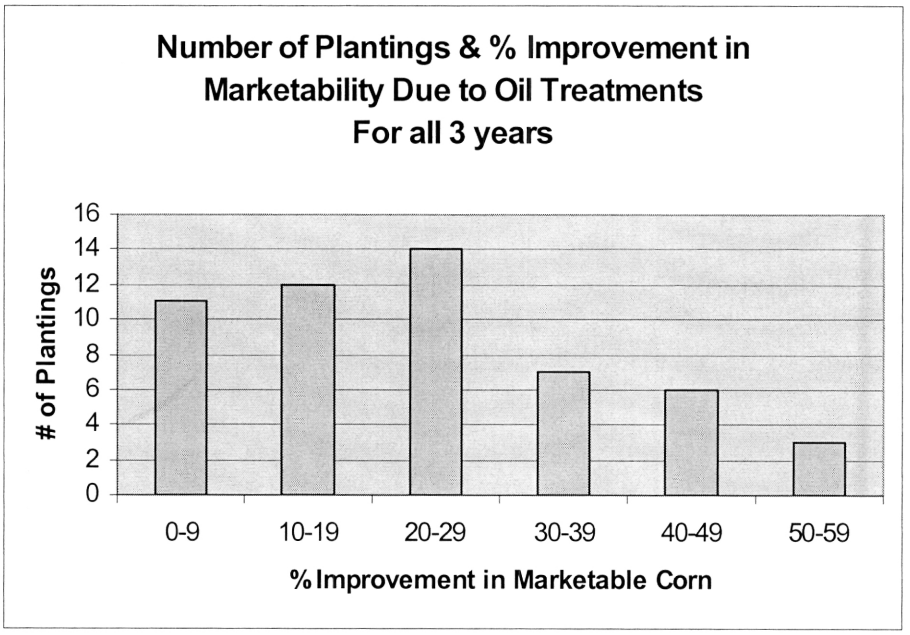

Figure 1. Number of plantings with percent improvements in the oil treated over the untreated corn.

which we attribute to the more consistent application of the Bt foliar sprays to reduce European corn borer tunneling through the side.

The number of clean ears was defined to be the number of corn ears that had no damage to the kernels. If there was damage to the kernels from caterpillars entering either through the tip or the side of the ear it was considered unmarketable for the purposes of this

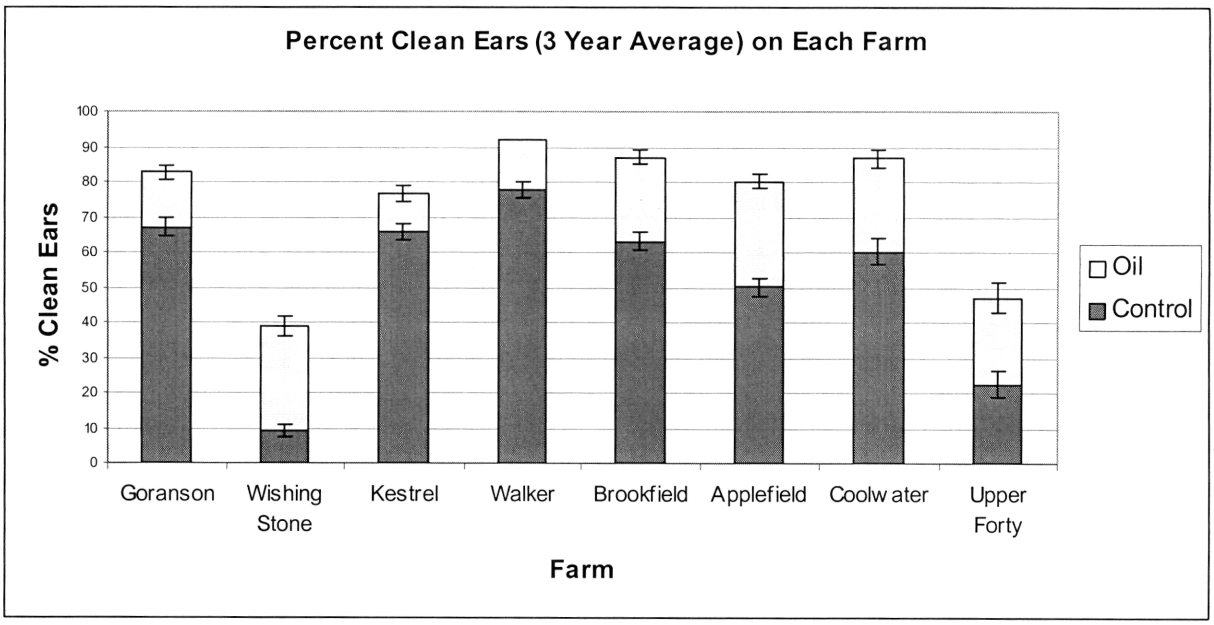

Figure 2. Average percent clean ears for all three years on each farm.

study. Figure 2 shows the average percent of clean ears on each farm for the 3 growing seasons from 1999-2001. Of the eight farms that participated, five were able to achieve a 3-year average of over 80% clean ears with the oiling. Out of all of the plantings (57), 30% more of the blocks achieved >80% clean ears in the oil-treated versus the untreated blocks of corn. The number of blocks of corn that had >90% clean ears increased by 18% between the untreated and oil-treated blocks.

Figure 3 shows the percent of clean ears for each farm and year (average of 1-3 blocks per year per farm). Most farms demonstrated a trend toward better control over the course of the three years. Both 1999 and 2000 had substantial corn earworm pressure on all farms, while in 2001 low corn earworm pressure resulted in an increase in the number of clean ears in the untreated and treated blocks in most plantings. Greater numbers of clean

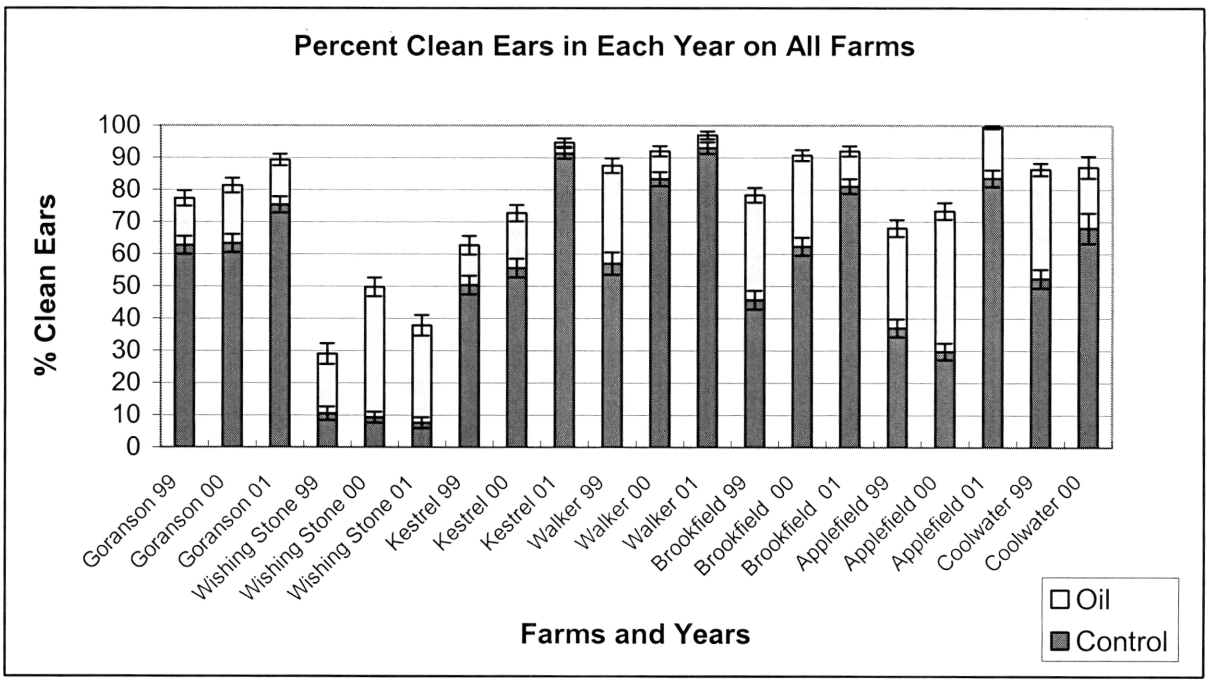

Figure 3. Average percent clean ears for each year and farm (average of all plantings).

ears in all years were also due to improved timing, materials and equipment, better use of Bt sprays for ECB control, and growers' increasing familiarity with the method.

One of the farms that had very good control using the bio-intensive system is Brookfield Farm. The caterpillar populations on this farm include both CEW and ECB, the relative numbers of which vary throughout the season. Together they cause significant damage to late corn. Non-oiled corn ranged from 7% clean to 78% clean during 1999 and 2000, when no foliar Bt sprays for ECB were applied. In these two years, oiled corn

averaged 78% clean in 1999 and 91% clean in 2000 (Figure 4), with an average improvement of 30% due to oiling.

In the final year of the project, when all blocks were sprayed with Bt for ECB control, and CEW pressure was relatively low, Brookfield farm had >91% clean ears in the oiled corn. This was partly due to the Bt sprays to reduce side damage, as seen in the yearly average of 82% clean ears in the control, non-oiled corn that had Bt foliar sprays, compared to 46% clean in 1999 and 64% clean in 2000, years in which no foliar sprays were applied. Increases through foliar sprays in the number of clean ears helps to increase the success rate in oiled corn. Also, increases in the number of clean ears

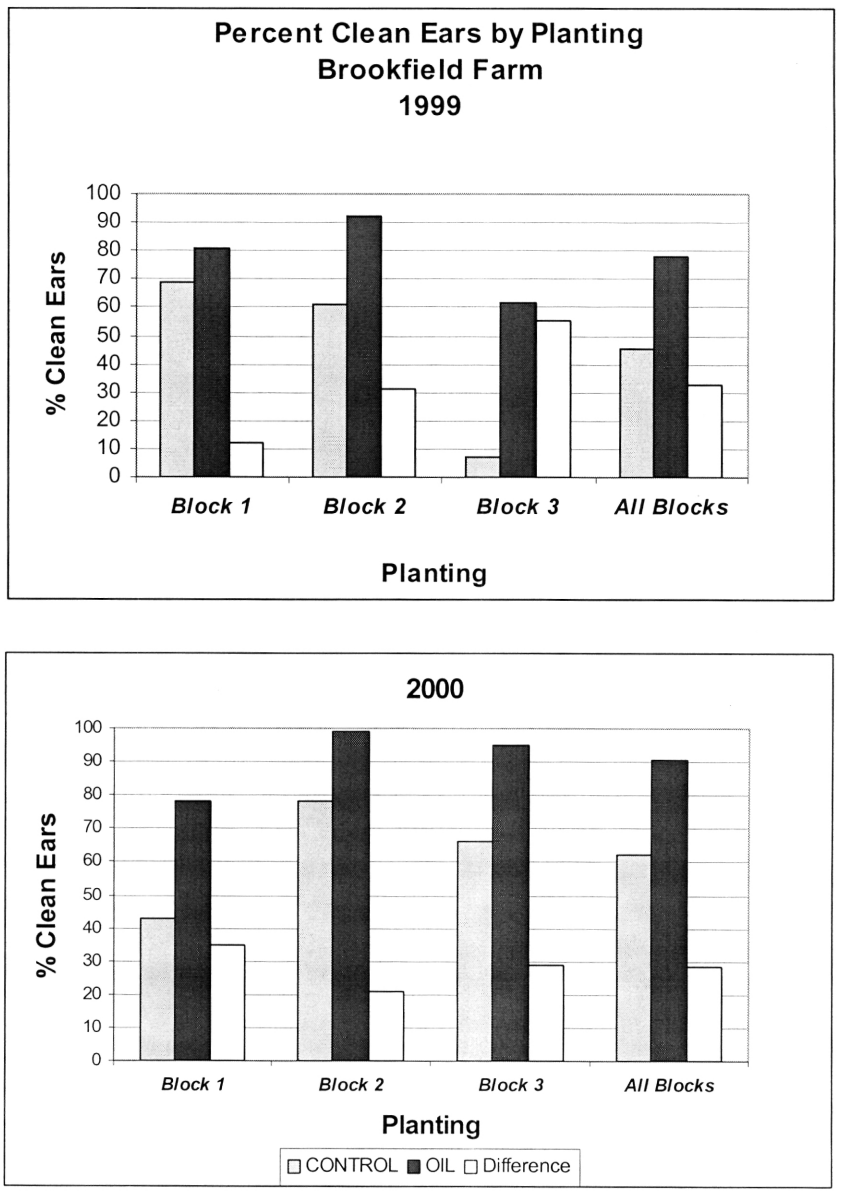

Figure 4. Percent of clean ears in control (non-oiled) and oiled treatments in the three plantings (blocks) of corn in 1999 and 2000 on Brookfield Farm.

through the project can be attributed to improvements in the oil + Bt mix and the improved Zea-later application device.

Kestrel Farm highlights how the effectiveness of the bio-intensive control system depends upon the control of ECB as well as CEW. The oil treatment is aimed at preventing damage to the tip by blocking the silk channel with oil and coating the tip of the ear with oil and Bt; while it was designed to control the CEW it is also effective against ECB or fall armyworm (FAW) attempting to enter the ear through the tip. To achieve acceptable levels of control of caterpillars that tunnel through the husk into the side of the ears (ECB &FAW) the foliar sprays should be used as well.

Most of the caterpillar damage on Kestrel farm is due to the European corn borer: corn earworm pressure is relatively low. ECB moths (>45/night) consistently far outnumbered corn earworm moths (2 or less per night), and the actual caterpillars found in the corn were mostly ECB. For example, in 2000, the ratios of ECB to CEW found in 100 ears of non-oiled corn in the three blocks were 75 ECB: 5 CEW in planting one, 110:10 in planting 2, and 180:5 in planting 3 (Figure 5). In these blocks, oiling produced 88%, 60%, and 70% clean corn, respectively, for a

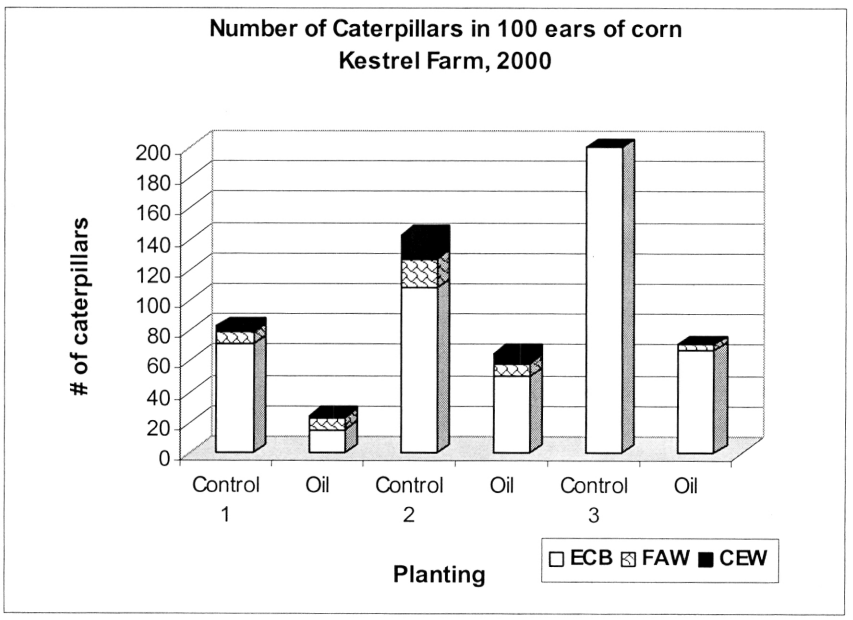

Figure 5. Number of corn earworm, fall armyworm and European corn borer caterpillars in 100 ears of corn on Kestrel Farm, 2000.

seasonal average of 72% clean (an improvement of 17% compared to non-oiled corn). Given the numbers of ECB caterpillars in the corn, one would expect that most of the damage would be from ECB entering through the side of the ears. Yet, as can be seen in Figure 6, while there is a substantial amount of side damage in the oiled corn, there is also a significant amount of tip damage despite the low numbers of CEW. This indicates that the ECB enter from the tip of the ear as well as eat through the side.

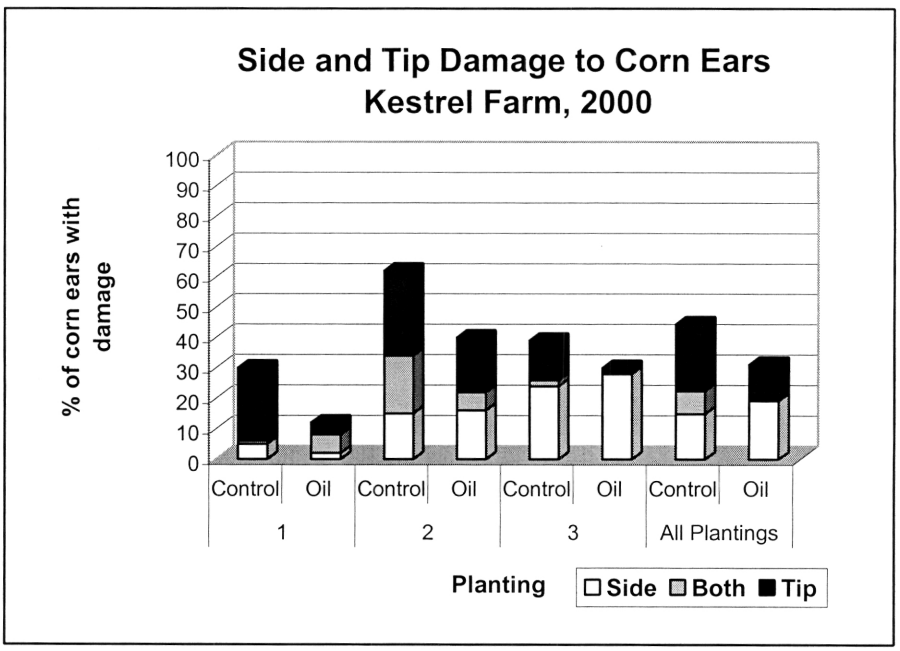

Figure 6. Type of feeding damage to corn ears on Kestrel Farm, 2000.

When the grower saw these results at the winter meeting, he realized the value of focusing more on using Bt sprays to prevent ECB damage. A second foliar Bt spray was added to the trials in the 2001 growing season. The first one was applied in the tassel stage while the second was applied during early silk. Sprays were applied to the whole field and are therefore reflected in the data for the untreated control, as well as the oil treated corn. At Kestrel Farm, ECB moth captures in 2001 were comparable to those in 2000, but the number of ECB caterpillars found in the non-oiled corn ears was much less in 2001 (2, 82, and 57 ECB per 100 ears in each of the three blocks) (Figure 7). The number of corn ears with caterpillar damage was correspondingly lower, with all blocks (both oiled and non-oiled)

having <15% damage, and the oiled blocks averaging 95% clean and marketable ears compared to 91% in the non-oiled. This shows that in situations where ECB is a problem, using control measures such as foliar Bt sprays are critical to obtaining clean and marketable corn. Further, while the oil treatment is targeted to the damage caused by CEW in the tip, the results from Kestrel Farm show that the oil treatments reduce the damage and number of ECB caterpillars, as well (Figures 5-7).

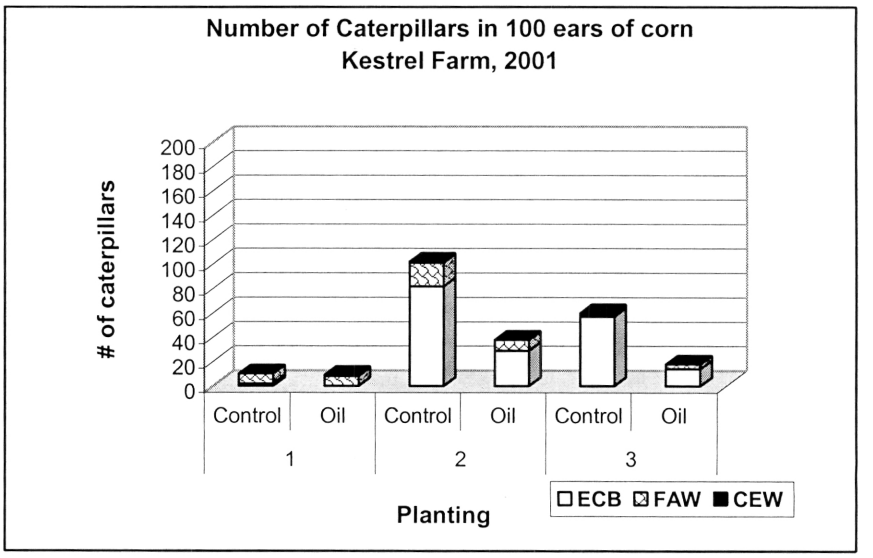

FIGURE 7. Number of corn earworm, fall armyworm and European corn borer caterpillars in 100 ears of corn on Kestrel Farm, 2001.

Wishing Stone Farm demonstrates a different extreme in pest pressure. This Rhode Island farm is on the southern coast of New England in the migratory flight path of CEW moths and is subject to flights that arrive early, continue all season, and cause extremely high levels of corn earworm infestations each year. In this region conventional growers apply insecticide at three, or sometimes two-day intervals throughout silking. At the outset we knew that this farm would present the greatest challenge to the bio-intensive system.

While the intense corn earworm pressure on Wishing Stone Farm does vary, the CEW moth captures were nearly always greater than the threshold of two moths per week throughout the experiment. In August and early September captures exceeded 5 moths per night during all three years (Appendix A, Table 1). In the first planting of 2000 the CEW

trap captures on Wishing Stone Farm reached a high of 44 per night (that's over 300 per week!), which resulted in heavily infested corn that had an average of two CEW caterpillars per ear of corn (see Figure 8, Block 1, Control) and nearly 100% damage to the corn (Figure 9, Block 1, Control).

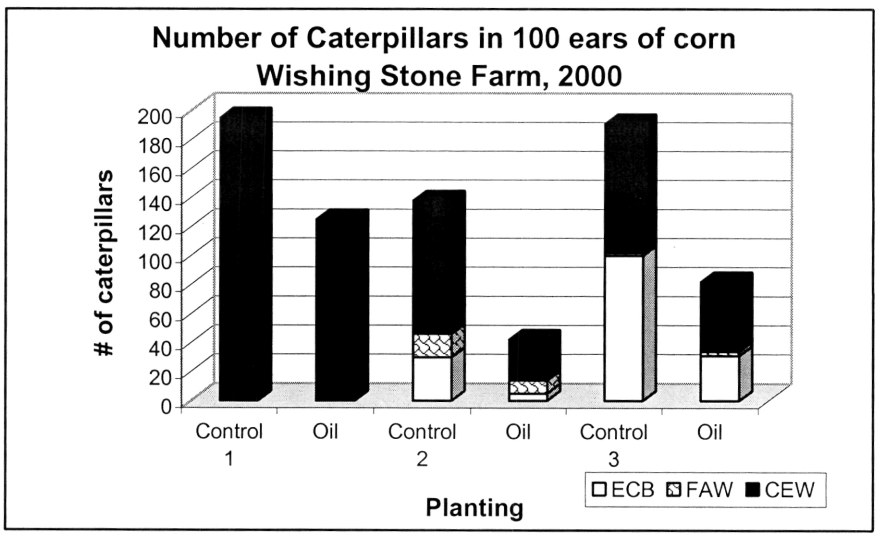

Figure 8. Number of corn earworm, fall armyworm and European corn borer caterpillars in 100 ears of corn on Wishing Stone Farm, 2000.

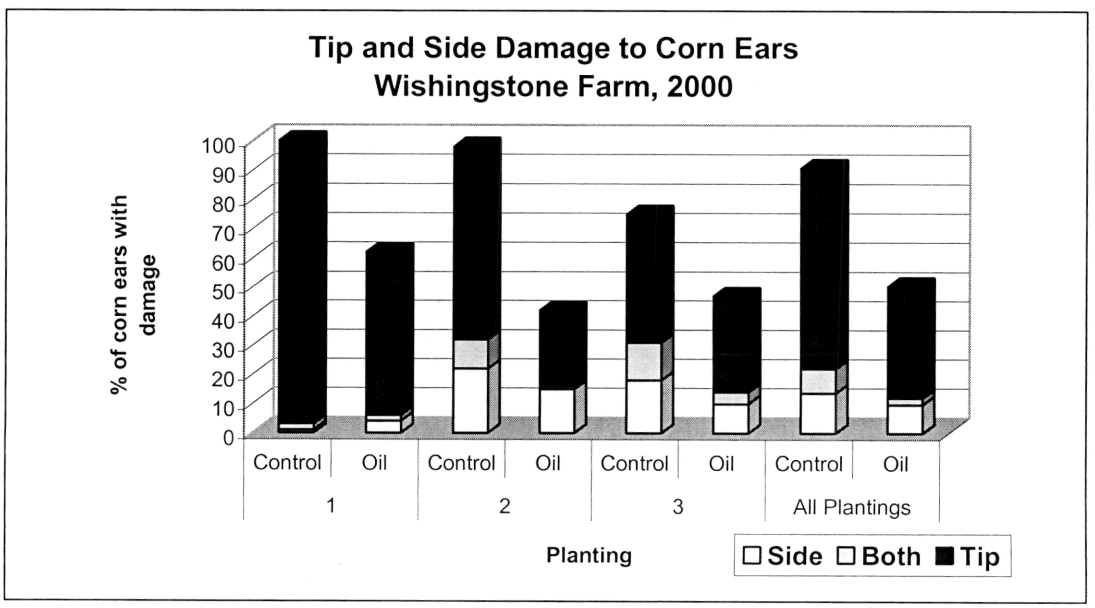

Figure 9. Type of feeding damage to corn ears on Wishing Stone Farm,

During the course of the project on Wishing Stone Farm, non-oiled corn had, at the best, 25% clean ears, and at the worst, 0 % clean ears. Even in 2001, when most growers had

little to no CEW pressure, the non-oiled corn at Wishing Stone Farm had corn earworm in just about every ear (Figure 10). In contrast to the 401 caterpillars found in the non-oiled corn on Wishing Stone Farm, there were only 206 caterpillars in all of the non-oiled corn on all of the other farms combined (94 of which were from one farm). This resulted in 10 out of 12 plantings on all of the other farms in 2001 having greater than 82% clean ears in the non-oiled plots, while Wishing Stone Farm had less than 10% clean ears combined that year.

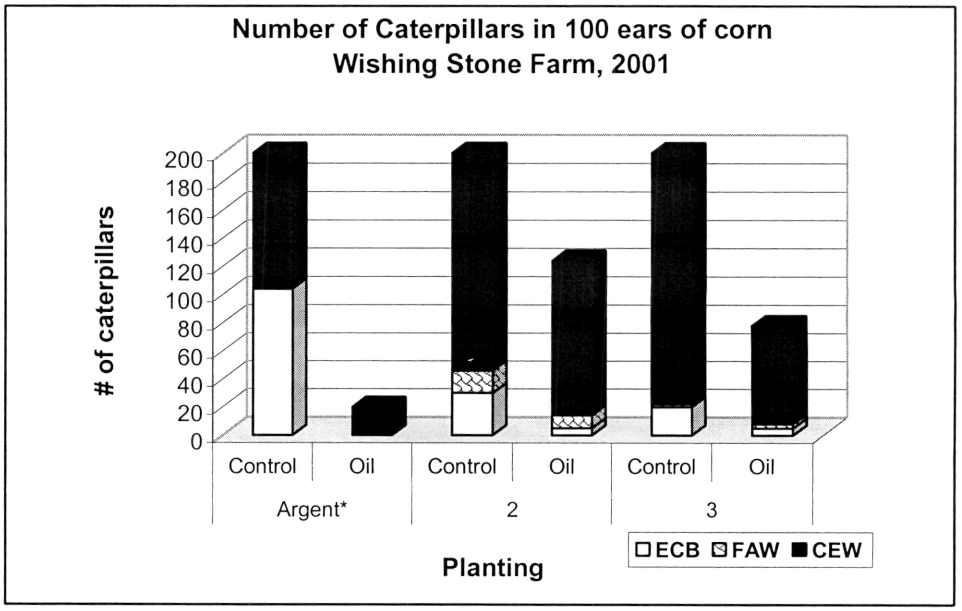

FIGURE 10. Number of corn earworm, fall armyworm and European corn borer caterpillars in 100 ears of corn on Wishing Stone Farm, 2001.

Although the grower was unable to achieve 80% clean ears in the three years of the experiment, the greatest improvements in the numbers of clean ears were obtained on this farm. The farmer had significant reductions in the number of caterpillars and percent of clean ears (high of 59%, low of 21%) in his oil-treated corn. The greatest increase in clean ears between the untreated and oiled samples on all farms was achieved on this farm in 2000 (59%).

The data from Wishing Stone Farm in 2001 (Figure 11) suggests that a tighter-husked variety can reduce the amount of corn earworm that can get into the ears. The sub-sample of the cultivar Argent, which had a tighter husk than the Delectable variety used in the trials,

was planted at the same time as the second planting of Delectable in 2001. The Argent had more clean ears in the control (8/25=32%) verses the Delectable (2/100=2%), and a greater improvement in clean ears in the oil treated corn (44% improvement; 19/25=76% clean) than in the Delectable (24% improvement; 26/100=26% clean). This is a strong indication that other factors, such as variety of corn planted, may make a large difference in the effectiveness of the oil treatments. Use of a tight-husked variety, along with *Bt* foliar sprays and oil could together provide adequate control under these high-pressure circumstances.

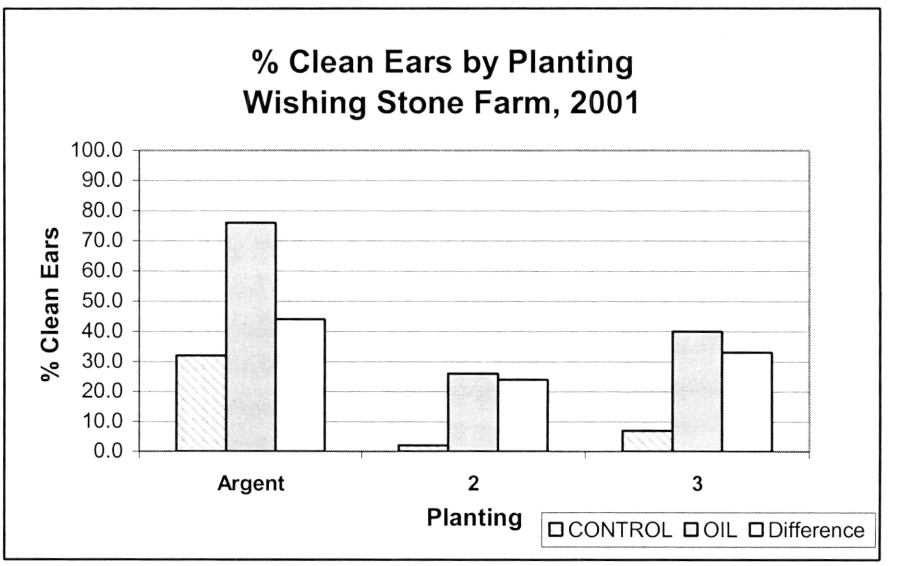

Figure 11. Percent clean ears on Wishing Stone Farm in 2001. Argent was planted at the same time as planting 2. Plantings 2 and 3 are the variety Delectable.

It is also likely that other factors played a role in the relatively low numbers of clean ears obtained in oiled corn on this farm. One of the largest factors may have been weed control. The fields in which corn was planted were far from the rest of the farm, thus good timing of weed control operations was difficult. Further, fields were filled with large stands of jimsonweed, which not only gets very tall, but contains narcotic-poisonous oils as well. Thus there was a large physical barrier within the corn planting that prevented workers from walking through the field and reaching every ear. For the purposes of our experiment, however, enough oiled ears were obtained for data collecting purposes.