A Historical View of Weed Control Technology that Informs Current Practice and Future Development.

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The domestication of wild plants to become desirable crops was the beginnings of agriculture. Weeds were the concomitant domestication of unwanted plant species along with the crop species in the same site. So the history of weed control technology is co-existent with the history of agricultural technology. Weed control technology started out in 8000 BCE as the plow and hand-weeding (which includes hand-pulling, cutting with a knife, hoes and mattocks), and it stayed that way for the next 10,000 years until the 18th Century CE; there was not much change. An important factor, one that is sadly overlooked, for this 10 millennia lack of improvement is that there was an abundance of labor, mostly women and children, to hand-weed.[1] It is not surprising, therefore, that the beginning of the industrial age in Europe was accompanied by improvements in weed control technology; not just because it was an age of invention but also because women and children were being pulled off farms to work in industry.

The name that stands out in the industrial age with regard to weeds is Jethro Tull (1674-1741), a gentleman farmer in England. He invented the grain drill and cultivation tools. Actually, Romans and farmers in India were using similar tools 2,000 years ago, but they were never in widespread use (likely because of the abundance of labor); so maybe we should say that Tull re-invented these tools. Regardless, Tull's grain drill and cultivation ideas were widely adopted and replicated in the 18th Century, aided by the ease of creating and distributing printed materials like newspapers, books and pamphlets. Tull's creations fostered the rapid development of these types of tools in Europe and North America, and formed the basis of what was called the British Agricultural Revolution. The grain drill did a simple thing; it planted the grain crops in rows. Before the drill, crops were hand-scattered over plowed fields. The weeders, the women and children, had to take time to make sure they were weeding just the weeds and not the crop; so knowing that anything outside the crop row was a weed made the job much simpler. It also allowed Tull's cultivation tool, a horse-drawn harrow to be used between the crop rows to loosen the soil between the drill rows and to kill weeds.

Cultivation tools have been the mainstay of weed control for nearly three centuries. These tools, using animal traction and later tractors, became quite varied and specialized. One of the most useful and inventive tools in California was the sled planter system. This tractor-drawn implement was a platform with runners that ran in the furrows. The sled hugged the beds and kept the platform closely in line with the bed-top. During a cropping season, the sled was first

[1] See http://croplifefoundation.files.wordpress.com/2012/05/solving-africas-weed-problem-report1.pdf for an excellent discussion of this issue as it exists today in Africa. This Crop Life Report states that smallholder farms spend 50-70% of their labor handweeding; that women contribute 90% of the handweeding labor; and 69% of farm children aged 5-14 miss school during peak weeding periods.

outfitted with planters, which sowed seed in very straight lines. After the crop germinated, cultivation tools were fitted on the sled just off the seed lines. This tool allowed cultivation very close to the emerging crop, usually within two inches on both sides of the seedline. Some of the other ingenious cultivation tools, many developed on farms in California for specific purposes, include flexible tine and rod weeders; rotary hoes; and finger weeders. In orchard crops cultivation implements like the French Plow cultivate weeds, but then through a mechanism, are automatically pulled back away from the vine or tree trunk. These tools are discussed thoroughly in the fourth edition of Principles of Weed Control. The success of cultivation for weed control has been remarkable, but close guidance to crops, especially between crops in the seedline has always been the major challenge. The realization of robotic weeders and thinners in recent years has been very exciting. Robotic systems and digital guidance only happened, in my opinion, because there was a highly developed practice of mechanical cultivation to build upon.

In Asia, rice was domesticated about the same time as cereal grains in the Mideast. But because it is grown in water, crop production practices were different but weeds were still a problem. By at least 3,000 BCE grass carp were a part of rice production in flooded paddies. This might have been serendipity, some fish got into the paddy because of a monsoon rain or a break in the dikes and the farmers noticed that they ate weeds and some insect pests. So putting fish, mostly grass carp but also tilapia and other species, into rice paddies is a common practice from Japan to India. The fish is also an agricultural commodity, so it's a win-win situation. Another rice growing practice is using transplanted seedlings instead of direct seeding - the common practice in the US. Transplants minimize weed and some other pest problems because the rice plants have a head start over the weeds. So Asia initiated agricultural practices that conform to the Integrated Pest Management (IPM) philosophy long before it came to be a part of our language in the west.

In the New World there were no draft animals, so plowing never developed. Instead a common farming method was 'slash and burn' (also known as 'fire and stick'), where an area of forest or brush is burned, then roughly cleared for planting. Crops are sown by making a small opening into the soil with a stick and dropping in seed. In what is called the Milpa system in Mexico and the three sisters in the US, three crops were sown together. These were corn (maize), squash and bean. The squash germinated and grew quickly, creating a cover crop for the corn and bean. The corn grew tall, providing a pole for the beans. This integrated system delivered carbohydrates from the corn, protein from the bean and anthocyanins plus fiber from the squash; simple and nutritious. When the notion of cover crops was being introduced in the US in the 1980's, the Milpa was often referenced as the model.

For most agronomists and weed scientists in the 20th century, the history of technology in weed control is the history of herbicides. For some it didn't begin until the introduction of synthetic herbicides in about 1950. In reality, herbicides, in the sense of chemicals used intentionally on a crop for weed control started in the mid 19th Century. The first herbicides were inorganic salts such as sodium chloride, sodium chlorate, arsenic salts and carbon bisulfide as a fumigant. In addition various oils, inorganic acids like sulfuric acid, and solvents were used as burn-down herbicides. All of these chemicals were used at what today would be unbelievable rates, 600-1000 pounds per acre for sodium chlorate for example. They were toxic and some were extreme

fire hazards. The discovery of 2,4-D and the chemical synthesis process that allowed for this discovery opened the floodgates for herbicides. The ninth edition of the Herbicide Handbook published by the Weed Science Society of America in 2007 includes more than 200 herbicides presently in use or in development in the US.

It has been known for a long time that the use of weed control technologies is inversely correlated with poverty and the abundance of women and children for weeding. So technology is not something that is uniformly available. It may be hard to imagine that the latest technology, the robotic weed control machines, will ever be developed for small scale use on a family farm in Pakistan, but it is perhaps better to ask, “Why not?”