

# An Illustrated History of Plant Protection – Part 1

1. This tutorial series provides an historical overview of plant protection, from subsistence agriculture through to modern plant protection practices.
2. We examine three case studies **in Part 1**, illustrating changes that took place in subsistence agriculture (rice and maize-cowpea intercropping) and subsequently in a commercial cropping system (sugar beet), in response to decisions aimed at reducing intensive labour practices.
3. These case studies illustrate that pest\*problems, and how we deal with them, involve interactions between “Natural systems” and “Human use systems”. In this context, a major role played by chemical pesticides is to uncouple decisions made on crop production from plant protection decisions. *\*The term “pest” is used here to cover insect pests, fungal diseases, weeds, nematodes, and other organisms causing crop damage and yield and/or quality loss.*
4. We examine current, more complex plant protection systems **in Part 2**, involving dynamic interactions between pest populations, beneficial organisms, technological developments, and decisions made by farmers, chemical manufacturers, pesticide distributors, food retailers, consumers, and policy and regulatory authorities.
5. While pesticides can play an important role in plant protection, they can also cause negative impacts. We consider how Integrated Pest Management (IPM) strategies, government regulation, training, quarantine measures and the development of alternative control methods can reduce the negative impacts of pesticides. Finally, we discuss how the role of stakeholder workshops can facilitate a better understanding of the relevant “natural-human use” systems that need to be considered when designing smarter and more collaborative and resilient approaches to plant protection in the future.

## Case study #1 - Plant protection in subsistence agriculture: rice

- Rice has been the staple subsistence crop for many civilizations over thousands of years.
- Through trial and error, subsistence farmers developed various cultural practices to deal with “pest problems”.
- In the case of rice, farmers developed the practice of flooding fields to control weeds and transplanting young (nursery) rice plants in standing water. This practice is still used in some parts of the world where alternative means of controlling weeds in rice is not possible.



- Transplanting rice was not the only practice requiring a lot of labour on traditional rice cropping systems. Harvesting the rice crop also required a great deal of labour.
- It involves cutting the plants by hand, stacking them to dry, and finally manually thrashing the plants (as shown in the photo) to harvest the rice grains.



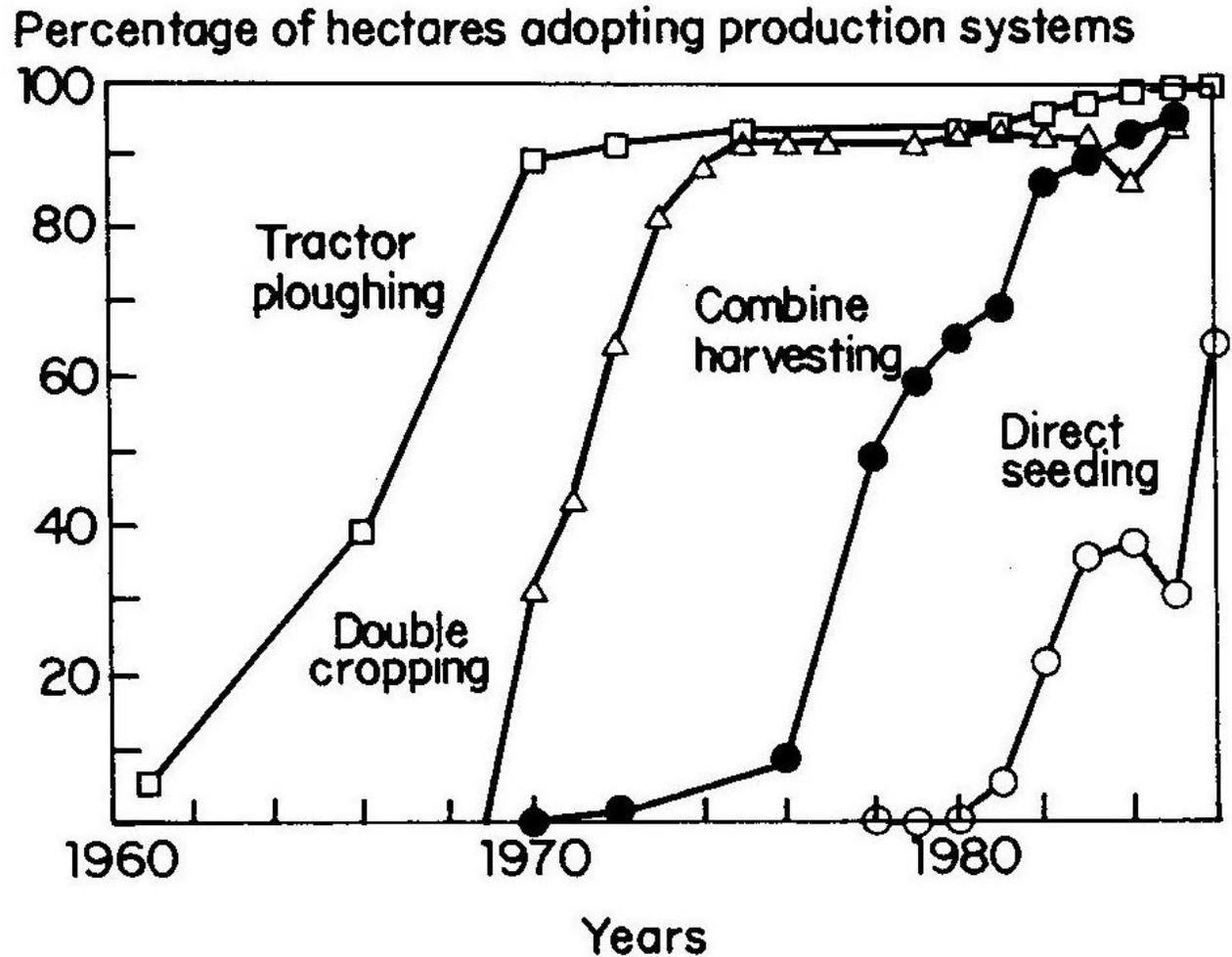
- With economic development, farmers were always looking for ways to reduce their own labour inputs or to reduce the cost of employing farm workers.
- Over 40 years ago in Malaysia, an alternative means of harvesting rice and reducing labour costs became a possibility with the mechanisation of rice harvesting (i.e. using combine harvesters).
- Since most rice farmers had limited hectares of rice, the economic solution involved agricultural contractors. They invested in combine harvesters and were contracted by small farmers to harvest their rice, which was then bagged in the field (as shown in the photo).
- After this development, the only remaining labour intensive practice was transplanting rice by hand.



- Depending on location, farm size and soil type, rice farmers explored various ways of establishing a rice crop that did not have as high a labour requirement as transplanting.
- In Japan, for example, farmers adopted the use of transplanting machines.
- In this region of Malaysia, transplanting by machine was not feasible, due to the soil type. Instead “drilling” machines (as shown) were used to plant rice seeds in rows.



- This graph shows the sequence of changes in farming practices adopted in the region of Malaysia we've been considering, resulting in a reduction in the labour involved in growing and harvesting rice.
- Initially, the traditional use of water buffalo to plough the land was replaced by hand tractors and subsequently by 4 wheel tractors.
- Growing two crops a year led to increased rice production, while the cheaper use of combine harvesters replaced hand harvesting.
- Finally, labour intensive transplanting was replaced by direct seeding.



- Direct seeding, using tractors to eliminate labour intensive transplanting, is only possible in dry soil. Consequently, the control of weeds achieved by transplanting rice into standing water no longer occurred.
- As a result, rice farmers who direct seeded were often faced with an increase in weeds, particularly grass weeds, such as ***Echinochloa crus-galli*** (as shown).
- Since the seeds of this weed contaminate the rice and reduce its price, farmers looked for alternative means of controlling rice weeds.
- Some went back to transplanting once every few years to control weeds, depending on the build up of the weed problem.



## The role of pesticides

- During the 1940's & 1950's a dramatic increase in the development, production and use of synthetic pesticides occurred.
- Dealing with crop "pests" became a matter of determining which insecticide would best kill insect pests, and which fungicides and herbicides would best control crop diseases and weed problems.
- A review of scientific research papers published in relevant journals during this period were predominantly focussed on laboratory and field experiments concerned with answering this question.



**The major consequence of this increased focus on pesticides was the uncoupling of decisions made about plant protection from decisions made concerning other agronomic practices.**

- This resulted with a change in the decisions made by plant breeders, agronomists and farmers, with a move away from traditional varieties and practices that were generally more resistant or capable of compensating to “pest attack”.
- The emphasis now was on the development and adoption of varieties and practices designed to increase yields, particularly as part of the “Green Revolution”, resulting in greater reliance on pesticides to “control” pests.



Varietal trial at the International Rice Research Institute

## Case study #2 - Plant protection in subsistence agriculture: maize-cowpea intercropping in Africa

- A traditional rotational practice in some areas of Africa involved clearing bush, growing crops for a number of years, then allowing the bush to grow back again, to replenish the soil.
- This photo shows a maize-cowpea subsistence intercrop. The cowpeas fix nitrogen in the soil and suppress weeds, while the maize forms a barrier between the rows of cowpeas, helping to reduce the spread of any disease or insect pest that attacks the cowpea crop.
- This intercrop practice provides plant protection functions while also spreading the labour requirement more evenly over the year and reducing risk: if one crop is damaged by pests, the farm family is still likely to have the other crop for subsistence.



- As the population of Africa increased, the rotation system of bush → cropping → bush has virtually disappeared.
- Local urban markets developed and farmers increasingly focused on growing maize and cowpeas for sale rather than subsistence. This led to an uncoupling of plant protection decisions from decisions focused on increasing crop yield.
- The result was the adoption of new, high yielding varieties and a switch to monocultures, as shown in this photo of a cowpea crop.
- Since there is a higher risk of revenue loss due to pest attack on a higher yielding, monoculture cowpea crop, farmers often resorted to protecting their investment by applying pesticide as an insurance measure.



### Case study #3 - Commercial cropping system: changes in sugar beet plant protection in the United Kingdom

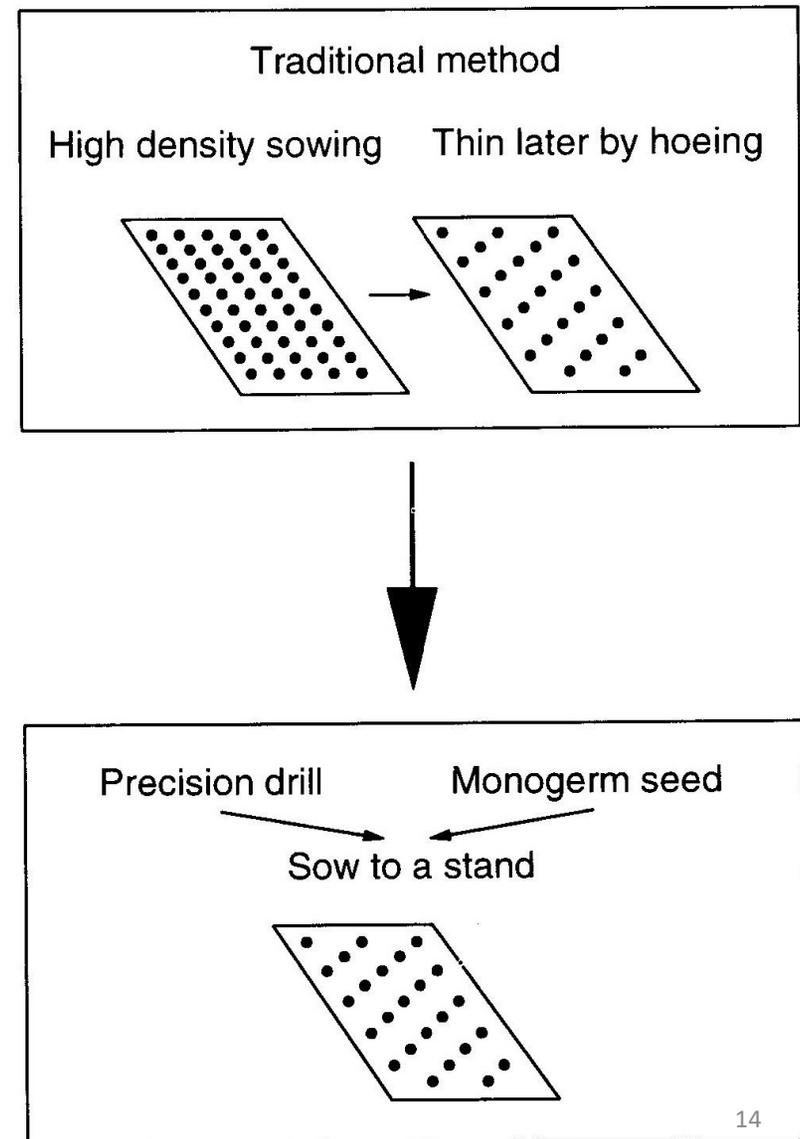
- The temperate crop of sugar beet provides a third example of how plant protection practices have changed over time.
- Sugar beet growers in the UK grow their sugar beet crop on contract to a sugar company. When the harvested crop is transported to the sugar mill, the grower is paid according (a) the weight of the beets delivered and (b) the average quality (% sugar) of the beets.
- To maximise their income, growers aim for large, well-spaced plants with no gaps.



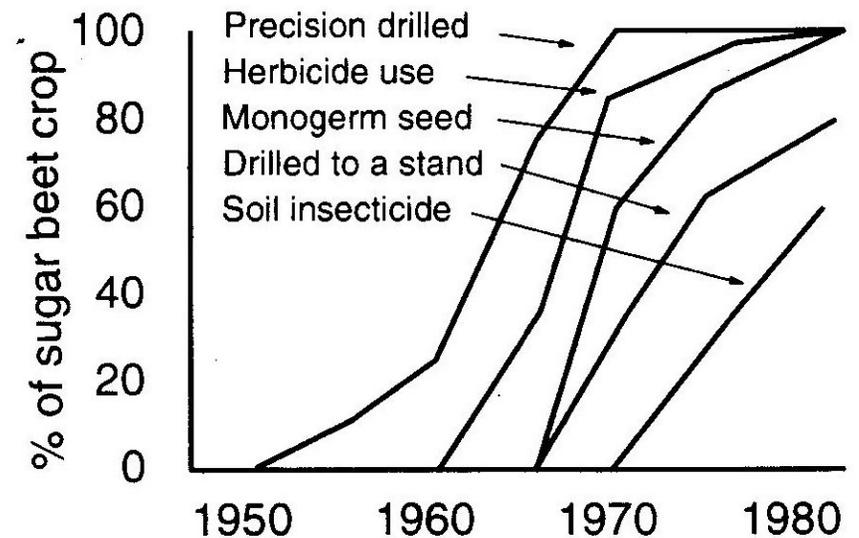
- The top part of the image shows the traditional way of establishing a sugar beet crop. Oxen were used for ploughing, then the seed was sown by hand.
- Once the crop plants reached seedling stage, farm labourers worked through the crop, using a hand hoe to:
  1. Remove any weed seedlings that would compete with the crop and reduce yield.
  2. Thin the crop to a density that would result in large beets and an optimal yield per hectare.



- In more recent times, tractors are used to plough, and a seed drill used to sow sugar beet seeds in rows. However, the traditional hoeing practice to remove weeds and reduce a thickly sown crop to an “ideal” density was still necessary (see top diagram).
- As the labour cost of this practice was expensive, growers (and probably farm labourers) were keen to find another solution to achieving an “ideal” crop density. The development of the precision drill, which sows seeds to a specific density, was a step in this direction. Together with the use of herbicides to reduce weeds, both developments contributed to a reduction in the need for hoeing.
- However, older beet varieties had multigerms, which meant, on germination, each seed produced two or more plants. Therefore, hand hoeing to thin the crop was inevitable; it was not until breeders developed monogerm seed (one plant per seed) that beet crops could be sown to the desired stand, thus eliminating the need for hoeing (bottom diagram).



- The adoption curves in this graph summarise the sequence of events resulting in growers sowing their beet crop to a stand, finally eliminating hand hoeing.
- Precision drilling was adopted first, closely followed by an increase in the use of herbicide to reduce the hoeing required to remove weeds. The adoption of monogerm beet seed quickly enabled the practice of drilling to a stand to be adopted, removing the need for hoeing.
- The final adoption line shows a steady increase in the use of soil insecticide, due to the fact that the crop became much more susceptible to insect pest attack.
- This was because in crops previously sown to a high density, any beet plant destroyed by pests could often be compensated for by adjacent plants growing larger. In contrast, in a crop drilled to a stand, the greater distance between neighbouring plants means that compensation cannot occur: a destroyed plant results in the complete loss of a mature tuber.



## Plant protection - a process resulting from interactions between “natural” and “human use” systems

- The previous case studies have shown that changes in natural systems and in human use systems can both affect pest problems, food production, and cause further natural system (*ns*) – human use system (*hus*) interactions.
- **Example 1:** *High levels of pesticide use (hus) can cause the development of resistance to insecticides in insect populations (ns) resulting in greater crop loss (hus).*
- **Example 2:** *Changes in cropping practices (hus), or burning fossil fuels (hus) - that emit green-house gasses that cause global warming (ns), can both have an impact on pest development (ns) and cause crop losses (hus).*
- Plant protection scientists, agronomists, policy makers and farmers need to be aware of these interactions.

