Mechanical Weed Management

Objectives: Students should understand

- The differences between tillage and cultivation
- Ways in which tillage and cultivation affect weeds
- Importance of life history, timing, and the need for multiple operations
- Pros and cons of tillage and cultivation
- Effects of tillage on weed seedling density.

Definitions

Tillage:

The use of farm implements to prepare a seed bed for crop production that promotes uniform, vigorous crop emergence.

- Used for residue management
- Removes existing vegetation and changes physical properties of soil to enhance crop germination and establishment.
- Prepares ground for later successful mechanical control operations
- Typically refers to operations done prior to planting

Cultivation:

- Typically refers to activities after seed bed preparation that utilize implements to suppress or control germinating and established weeds.

- Activities are usually shallow rather than high to reduce the likelihood of stimulating weed seed germination and to reduce incidence of root-pruning of the crop.

Primary tillage: The first operation to work the soil. It is used to prepare the soil for planting by reducing soil strength, covering plant residues, and rearranging soil aggregates. It is very aggressive, deep, and produces an uneven soil surface. (eg Ploughs)

Secondary tillage: Not as aggressive or as deep. Larger soil clumps are broken up, materials such as lime, fertilizer, manure and pesticides are incorporated, used for leveling and firming soil, close air pockets and control weeds. (eg Harrows and rototillers)

Tillage and cultivation affect weeds in three ways:

1. Uproot, dismember and bury weeds and dormant perennating organs.
2. Change the soil environment that generally promotes germination and establishment of weeds.
3. Move weeds seeds vertically and horizontally and this affects the likelihood that seedlings emerge, survive, and compete with crops.

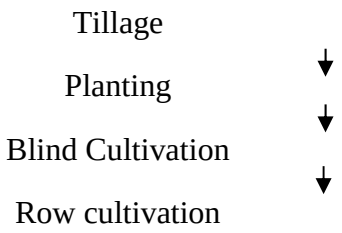
General Principles

1. Impact of tillage or cultivation on a species depends on the interaction between the nature of the soil disturbance and the life history characteristics of the weed.
2. The timing of tillage or cultivation determines how effective the operation is for weed management.
3. Mechanical weed management is most effective when multiple operations are done in a planned sequence.

Nature of soil disturbances and life history characteristics of weeds

1. Ability to survive a particular disturbance depends on factors such as:
    a. (For perennials) Size, position, and physiology of shoots and perennating organs.
    b. (For annuals) Size, longevity, and germination characteristics of seeds affect response to redistribution in soil by implements.
2. Timing affects efficiency. Timing is critical because:
    a. A desired effect on soil and weeds is dependent on seasons and weather.
    b. Species are more susceptible to a particular type of disturbance at some stages than others.

    c. Stage of crop development affects the degree and type of disturbance the crop can tolerate.
3. Multiple operations in planned sequence.
    a. Tillage prior to planting buries existing vegetation, disrupts roots and rhizomes.
    b. Shallow cultivation, prior to emergence (blind cultivation) and near to rows after emergence, can kill small weeds before establishment.
    c. Deeper cultivation between rows can dig up weeds and throw soil into the crop row to bury young weeds. By the time crops can establish this, weeds are too big for burying, unless early germinating weeds were suppressed by over the row cultivation (blind cultivation).



- Tillage between crops can be used to suppress perennials and deplete the weed seed bank.

Pros and Cons of Tillage

Pros

- Weed control, residue management, seedbed preparation.

- Reinitiates ecological succession so the annual crop predominates instead of perennial species that tends to dominate undisturbed vegetation.

Cons

1. Can cause soil erosion
2. Destroys soil tilth (soil aggregation characteristics)

These adverse effects can occur if soil conservation measures are not employed and when used with inappropriate soil and weather conditionsr.

Properly used tillage can improve crop productivity by:

- Increased water infiltration
- Facilitating management of soil fertility
- Helping to warm cold soils
- Improving crop establishment
- Improving root growth through better aeration
- Decreased bulk density of the soil
- Decreased soil resistance to penetration.

Effective ways of conserving soil if tillage is used:

- Cover crops
- Soil building crop rotations
- Contour plowing and planting
- Sod berms and water ways

Effects of tillage on weed seedling density

Timing:
Timing of tillage can greatly affect weed density of the crop. Most weed species germinate during specific periods of the year.

1. Shifting planting dates works best for seasonal weed species with a peak emergence occurring after the earliest practical planting date of the crop.

- Plant the crop as early as possible
- By the time weeds germinate, the crop has a competitive advantage
- Appropriate for temperate zone cereals.

2. Delay seedbed preparation or tillage and planting until after many weeds have germinated and are susceptible to destruction by disturbance.

- Applicable to row crops like maize and soybean, but yield loss may occur due to decrease in the length of the growing season
- Can result in lower yields due to shorter growing season.
- Can be used for some spring-seeded vegetables but not for summer-seeded vegetables.

Summer-seeded vegetables are infested with weeds that germinate in response to disturbance over a wide range of soil climatic conditions cannot be controlled by shifting the planting date. Use stale and false seed bed in these cases.

How is the optimum seedbed preparation/planting date determined?

1. Use of models that predict relative weed pressure at successive potential planting dates as a proportion of density that would occur without tillage.
   Planting date selected is when weed density predicted is less than a threshold level that the grower can control with the tools available or when expected yield loss due further delay in planting exceeds expected yield loss due to weeds.

2. Empirical studies (data derived from conducted experiments) are also used.

Delayed planting works best when deep tillage is avoided or occurs well in advance of seed bed preparation.

Type of tillage affects weeds seedling density

If most seeds are near to the surface and plowing buries deeply – tillage can reduce weed seedling density.
If most seeds are buried deeply, tillage can bring them to the surface and increase seedling density.

Effect of tillage on density depends on:

- How tillage redistributes seeds in the soil profile
- The capacity of species to emerge from various soil depths
- How soil depths affects weed seed survival

Redistribution

Fig. 4.3
In the absence of tillage seed infiltration into soil is due to cracks, activities of soil fauna, frost action – all slow processes.

Tillage implements move seeds vertically to different extents:

- Moldboard plow inverts soil and results in a skewed bell-shaped distribution of seed density.
- Other implements – monotonic decline with most seeds near the soil surface.
- In agricultural fields weed seed distribution is rarely stable because of a few years with high seed input interspersed sporadically with several years of successful control and low seeds input. With good weed control distribution becomes more uniform

Tillage and emergence of weed seedlings

So tillage affects seedling emergence indirectly through redistribution seeds.

- Seedling emergence - more likely to occur near the soil surface due to seeds exposed to light, fluctuating temperature and other germination cues.
- Less likelihood of exhaustion of nutrient reserves.
- Less exposure of growing shoot to hazards in the soil.
- Most individuals of most species emerge from the top 2-4 cm of soil.

(Fig 4.5)
Tillage affects soil properties - weed emergence is greater in loose soil than compact soil.

Tillage and Seed Survival

Fig 4.6 (No seed production was allowed to occur in experimental plots)
Tillage decreases the weed seed bank.
More frequent tillage depletes the seed-bank faster than less frequent tillage.

Fig. 4.7
Three effects of tillage on seed survival

- Stimulates germination – by exposing to light or scarifying (damaging seed coat in a way that permits germination of hard seeded species)
    - Causes death due to emergence from inappropriate depth or in weather conditions that do not favor establishment.
- Changes in soil conditions due to tillage - germination in conditions unsuitable for establishment.
- Action of seed predators, pathogens, and factors such as desiccation generally decrease with increasing soil depth.

Figures from Liebman et al. (2001)

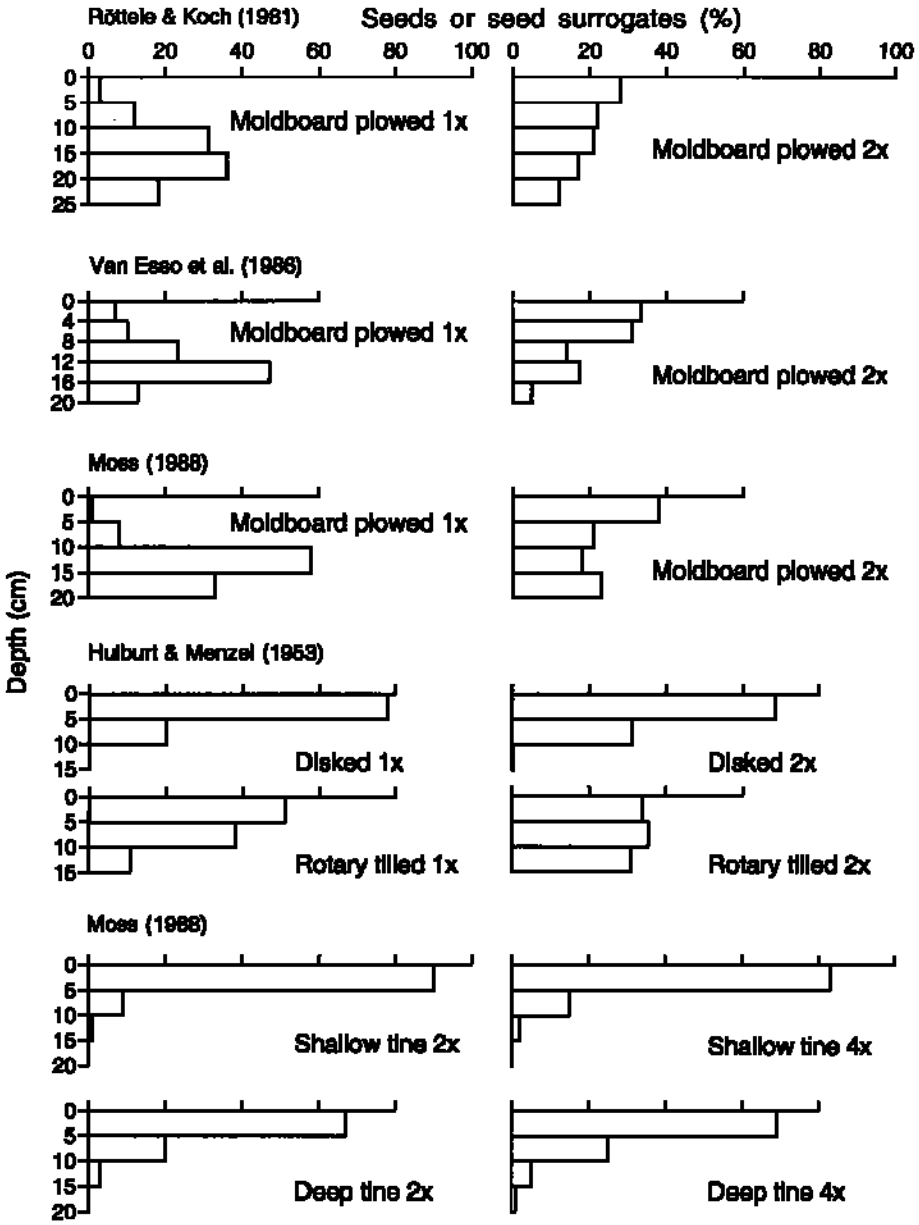


Figure 4.3 Vertical distribution of seeds and soil markers following one or two operations with various tillage implements.

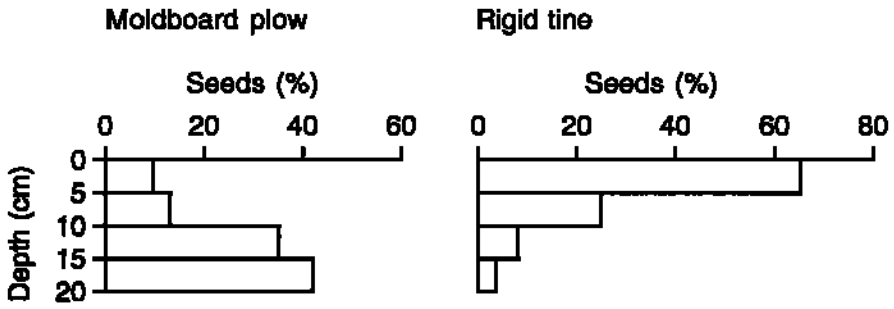


Figure 4.4 Projected stable vertical seed distributions for a weed reproducing according to the population model of Doyle, Cousens & Moss (1986) and subjected to yearly moldboard plow or rigid tine tillage. (Redrawn from Cousens & Moss, 1990.)

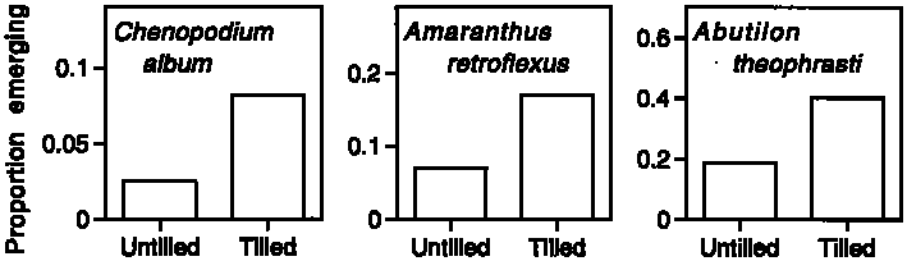


Figure 4.5 Proportion of *Chenopodium album*, *Amaranthus retroflexus*, and *Abutilon theophrasti* emerging after planting into either tilled or untilled soil with an apparatus that produced minimal soil disturbance. See Mohler & Galford (1997).

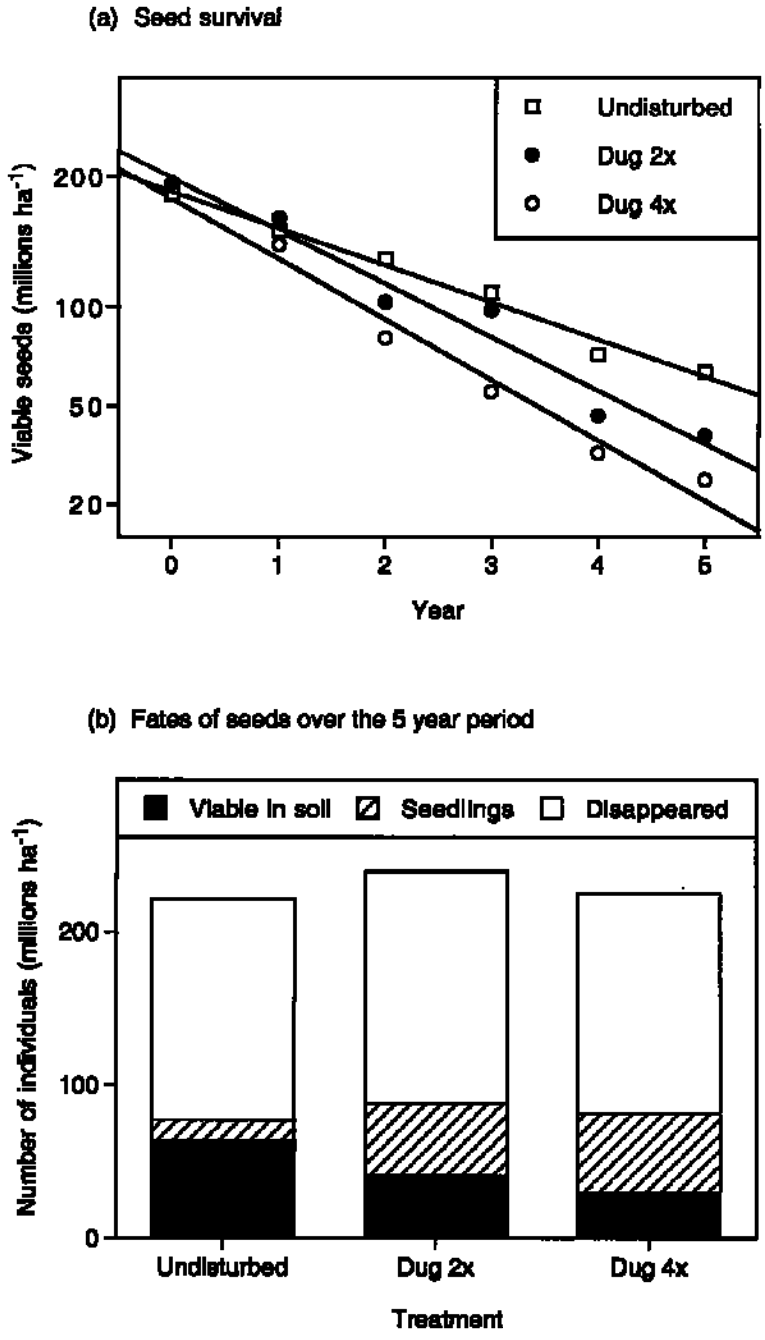


Figure 4.6 (a) Seed survival of mixed species of weed seeds in soil that was either undisturbed, or stirred by digging two times or four times per year. (b) Fates of seeds in the same experiment. (Drawn from data in Roberts & Dawkins, 1967.)

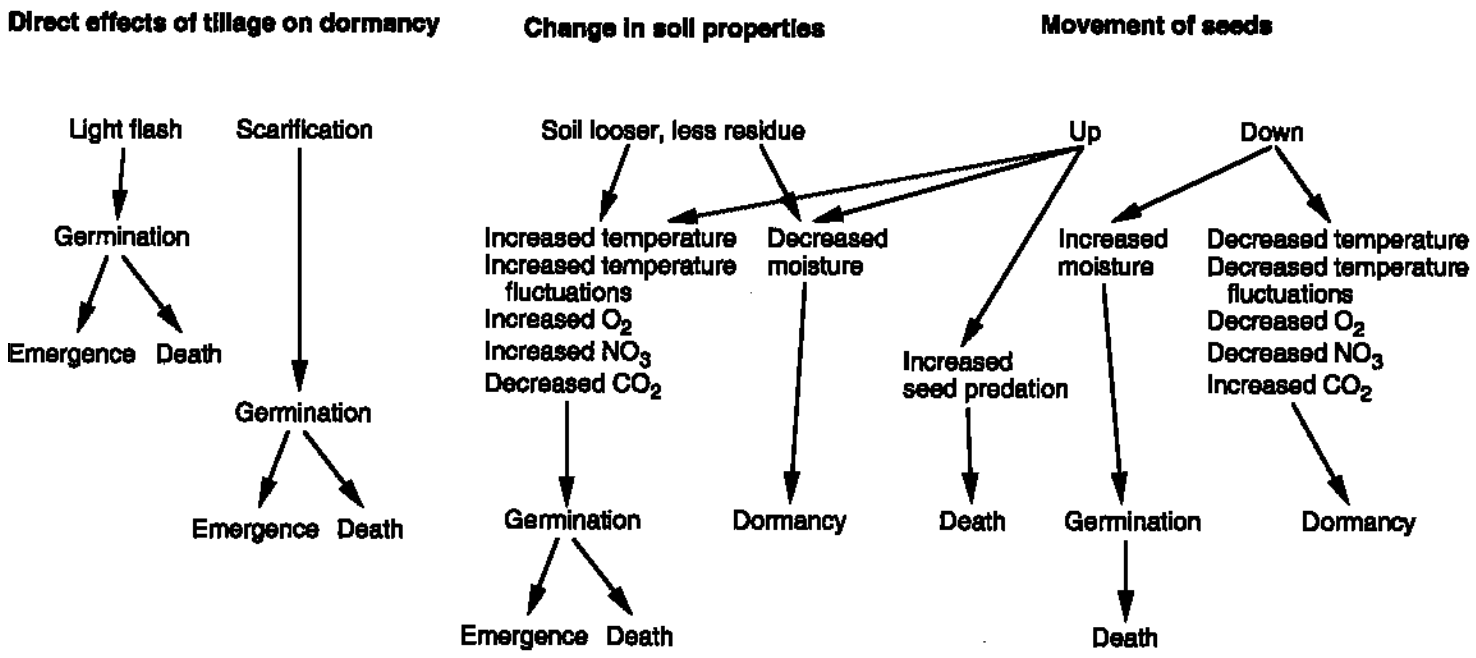


Figure 4.7 Effects of tillage on germination, dormancy, and death of weeds.