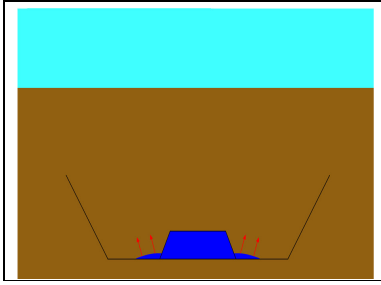
# Wicking worm bed

## *Basic principles*

Water shortages are creating increasing pressure on food production. The wicking worm bed is a highly productive growing system which not only produces more food from limited water, but also recycles waste organic material to provide plant nutrient and capture carbon.

The essence is to form an underground reservoir of water or pond contained by a waterproof container or liner below the surface.

Problems would arise if the underground pond was routinely filled by applying water from the surface. The water percolating down through the soil would absorb nutrients which would accumulate in stagnant nutrient rich water in the pond. This would soon become anaerobic, starved of oxygen forming a toxic putrid mess which would inhibit plant growth.



This is resolved in the wicking bed system water by applying water to the bottom of the pond where it is pulled upwards to the roots of the plant by surface tension or wicking action. The water is now not stagnant but continuously moving from the base of the pond upwards to the roots. First in first out.

The system gives the plant access to a continuous supply of water. There is minimal loss of water from either soaking into ground or from surface evaporation. This makes the system highly water efficient however plants need more than water, they need a balance of water air and nutrients. Too much water is just as bad as not enough water. Root systems need oxygen. They also can emit gasses such as carbon dioxide and ethylene which act as growth inhibitors.

The wicking worm bed system correctly managed achieves this balance of water, air and nutrients.

## *Improving performance*

### Increasing the wicking action

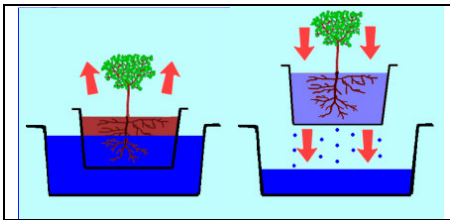
The upward movement of the water by the wicking action can be significantly increased by incorporating additional organic material into the soil above the

underground pond. Virtually any organic material will increase this wicking action but a highly fibrous product like bagasse, a waste product of the sugar industry is particularly effective.

## Allowing the roots to breathe

In conventional above ground irrigation the wet soil on the surface act as a partial seal preventing air infiltrating into the soil below. With the wicking beds water is applied from below so the surface is dry allowing better air infiltration.

However the bed can be operated on a cycle, with the underground pond being filled with water, which expels stale air, and as the water is used fresh air is drawn into the soil creating a breathing action.



The principle is similar to the established flood and drain system in which air is expelled in the flood cycle and sucked back in again on the drain cycle.

## Maintaining the soil

The condition of the soil is an important factor in the correct operation of the wicking bed. A heavy compacted clay soil is unlikely to be really effective. Incorporating organic material such as bagasse into the soil will help initially but this will gradually decompose with time.

Worms will naturally help condition the soil; however worms need to be fed continuously to survive on an ongoing basis. Worms do not eat organic material directly; there is a process in which the organic material is first broken down by a combination of micro biological actions, the result of bacteria, fungi, nematodes etc. The worms feed on the output from this microbiological activity and then add further microbiological activity form their guts which make a highly productive growing medium.

## Introducing the worms

These are best added using an inoculator kit. This is a mix of worms, worm castings, microbiology, food and minerals. This can be spread on the surface before planting. Seeds are then placed on the surface and covered with worm castings.

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|  | Alternatively the inoculator box can be simply turned upside down in the corner of the box and the worms allowed to migrate. |

## Feeding the worms

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|  | Worms need a continuous supply of food. This can be added by covering the surface with an organic mulch such as bagasse but this creates a nitrogen drain. A better way is to use an upturned container with organics material such as household waste.<br><br>Worms do not create plant food from nothing. They are the end of a biological food chain which makes nutrients accessible to the plants. |

## Storing and harvesting water

One aim of the wicking bed is to store as much water as possible; this extends the period between irrigations and increases the likelihood of rain between irrigations. Water can be stored directly in the wicking bed using an internal storage in a container outside the wicking bed using external storage.

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|  | Wicking beds can also incorporate water harvesting systems where water is captured outside the growing area and funnelled into the wicking bed pond. This is particularly important in area with no irrigation infra structure where rain is the only source of water. |

# *Versions of the wicking worm bed*

## Wide range of usage

These basic principles are used in all versions of the wicking worm bed, which can be used from large scale agriculture involving say an established vineyard covering hundred of hectares to a family growing fresh organic vegetables for their own use on their patio. Naturally the mechanics of applying these principles vary widely.

Wicking worm bed can be formed in the ground or be self standing either on the ground or in a plastic box.

They can be a narrow strip feeding plants outside the wicking bed area by surface tension or they can be wide, with plants growing directly above the wicking bed.

## Simple box

The simplest wicking bed can be made by placing a plastic pipe in plastic box and filling with soil. Water is simply poured into the pipe. A small pipe will work but a bigger pipe allows the water level to be inspected to check when to water and how much water to add to reach the right depth, typically 100 mm below the surface.

A larger pipe makes it easier to see the water level in the box. It also holds more water, so extends the time between irrigations.

Many soils are not very permeable so the water will only spread slowly. Mixing organic matter, such as bagasse into the soil will help. Even better is to use a slotted drainage pipe to distribute the water. This also increases the water holding capacity.

If the box is outside there is a danger that the box will fill with water in heavy rain. This can be simply syphoned off but a small drain hole in the side of the box is more secure.

A simple box like this will hold enough water to last for about a week.

## Drainage pipes and holes

A drainage pipe around the base will help disperse the water through the soil.

Drainage holes are needed so the water does not rise about a set level

## External water storage

As the soil is saturated wicking beds hold significant more water than soil at field capacity. The pipes also hold some additional water. However the amount of water stored can be increased by using external water containers piped to the base of each box or section. This also allows any excess water from a heavy rain to drain back into the storage container

External water storages are very easy to manage, fill them up and leave. They may hold enough water for several weeks without needing any water to be added.

Alternatively they can be fitted with a float valve and if needed could be left unattended for a long time with the water automatically controlled to the level set by the float valve.

Having a constant level may not be ideal as this misses out on the beneficial effect of the pulsing action from filling the container and allowing it to almost empty.

When seeds are planted it is better to raise the water level to help germination. This can be done manually be pushing the ball valve down until the water reached the required level, (which must be below the seed level). As the plant grow they will use the water so the level will drop - the valve will now open to control the water level. Simple but effective automation.

Root crops like carrots will grow down to the water level and will not grow any further. When they have germinated it is important to allow the water level to drop so the tubers can form properly.

## On ground wicking worm beds (Raised beds)

Wicking beds can be built directly onto the ground. A wall is built around the bed, this can be earth bank, sleepers, or a simple stake and wire fence lined with straw. The bed is lined with a sheet of polyethylene to form the pond. The height of the liner sets the depth (typically about 300 mm) and allows for excess water to drain away.

The base must be flat and a slotted drainage pipe laid to spread the water.

On ground beds are well suited to shade houses which provide protection from insects.

Each bed can have its own internal water supply or they can be coupled together to an external water supply, possibly using a float valve.

These beds are built on a slight slope; the bed is split into a number of smaller beds to form a terrace so each bed is flat.

Water use is dramatically reduced and the whole system is very simple and reliable, making it suitable for school projects.

## In ground wicking worm beds

In ground beds are formed by digging a hole and lining. Ideally the beds should follow the contour lines but if that is not possible terraces may be used on the slope so each small bay is flat.

Typically the liner would finish about 100 mm below the surface and may be protected, for example by an old carpet.

Good soil is important, sieved compost makes an excellent base but heavier soil need to be mixed with an organics material such as bagasse.

With subsurface irrigation the actual surface is dry however a top layer of mulch creates a humid zone around the upper roots which helps germination.

Productivity is significantly higher than with conventional growing systems, even though less water is used.

## Strip irrigation beds

Strip irrigation beds are suitable for deep rooted plants eg trees and are the only viable option with established orchards.

Instead of the plant being directly above a wide bed, the bed is narrow and alongside the plant row.  Water wicks up and sideways to irrigate the plant.

This method is suitable for converting existing irrigation systems with established trees or with any deep rooted perennial plants cultivated in orchards.

While small plants such as vegetables can be grown directly in the bed larger plants can be grown beside a much narrower bed relying on surface tension to move the water sideways.

This as effective way of irrigating existing orchards.

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|  | In some cases with existing orchards the rows will not be on a contour but sloping. A long bed can then be broken up into a series of smaller, near horizontal beds so water cascades from one bed to the next. |

There is no real limit on how long the beds can be but they must be horizontal eg built on the contour if the land is sloping. With long beds it is preferable to have an external container with a float valve as it can take some time for the water to flow to the end of the bed.

The tap is turned on and left on until the entire bed is filled.

## Tiered beds and pots

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|  | With large trees a single pot or bag can be used, this is filled with organic material and buried; water will wick out of the bed and into the surrounding soil. |

## Grey water

Cascading beds are particularly useful for reusing grey water. The first beds may be used for say fruit or ornamental trees but as the water is purified at each section the later sections can be used for vegetables.

# *Root damage from immersion*

Many plants have a twin root system.

The fine upper roots with many hairs are effective at extracting nutrients, but are also very delicate. They are easily damaged by either too little water, when they will collapse by the suction forces or by excess water when the will rot.

The deeper roots are much coarser and tougher. They are not as effective as the fine roots at extracting nutrients and water but can survive periods of too much or too little water. They will keep the plant alive in tough conditions but growth will be reduced. Even when water is available good growth will not occur until the fine feeder roots have regrown.

In a wicking bed the fine roots system will grew in the upper layers of the soil and so it is important not to flood this upper region for any length of time. The tougher deep roots can be found quite happily surviving in the pond itself without damage.

While plant in the wicking bed may survive even if the pond is allowed to dry out there will be a loss of production. Worms and the microbiological action may be killed by either allowing the bed to either dry out or flood.

In the wicking worm bed systems plants obtain their nutrients from the natural process of biological action. The aim it to look after this microbiological process, if this is working properly the plants will automatically be healthy and grow.