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# Mulch, the magic

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**Publisher:** Digitalverlag GmbH, Germany  
www.ChemLin.com

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Edition ChemLin

www.ChemLin.com

## Mulch, the magic

Mulching is putting all kinds of organic waste materials like leaves, weeds, wood chips, bark etc., in the field with purpose of providing a cover over soil so that weeds do not grow. Some time black plastics, small stone or brick pieces and charcoal are also used as mulch. Much is said about "Mulch and its advantages", but our experience showed that mulch was beyond ordinary description. It could truly be described as magic. Although the advantages of mulch are well-known, yet it is too costly to carry-out on commercial scale even where cheap labour is plentiful. Its cost can only be off-set by high density planting and advanced technologies. Ten years ago we decided to use weeds growing between the tree rows in the fruit orchard as mulch to suppress weeds under the trees. We were aware of the disadvantages of flood irrigation, which creates temporarily anaerobic conditions after every application, which is frequent in our hot and dry weather, resulting in to reduction in yield. We therefore planned to irrigate indirectly by planting and trees on ridges about 2 meters (6 feet 8 inches) wide and 25-30 cms (10-12 inches) high and apply water in the furrows. Furrow width varied between 2.5 - 4.0 meters (8 feet 4 inches to 13 feet) depending upon the type of fruit tree. High density planting on the ridges was done. In our sub-tropical desert area on 25°-37'N and 68°-36'E, climate is like that at Carnorvon Western Australia. The pan-evaporation is approximately 30 cm (one foot) per month from 15<sup>th</sup> April to end August. Winters are mild, but yet evaporation of 4-6 cms (1.5 - 2.4 inches) is common in January the coldest month. Average annual rainfall is 15 cms (6 inches), which occurs in July-August and is spread over 7 days. Rainfall of 12.5 cm (5 inches) can occur in 24 hours one in every 10 years. Annual evaporation is about 2.3 meters (90 inches). Under such climate all kinds of perennial and non-perennial weeds grow profusely and year around. Since the labour in Pakistan is cheap and in high density and close spacing trees, machines can not do the mowing, we decided to mow the weeds manually and spread them on the ridges under the trees. Initially the volume of weeds was not too high, but after a few mowing weeds started multiplying fast and we could harvest them 4-5 times a year and dump them on the ridges. Much got digested fast and in about 2 ½ months its bulks reduced to about 20%, when fresh mulch was added raising the pile height to about 30 cm (12 inches). We did not know the exact process by which mulch was digested. The pesticide companies representatives who visited us periodically, were frightened by presence of large number of insects in the mulch and advised to remove and burn it up. We observed that these insects do not climb the trees and therefore could be harmless. We also found that perennial weeds do come up on the ridges, but they become weak, sickly and dwarf and can easily be pulled out with their roots by hand. The perennial weeds were gradually reduced to nil or negligible. One thing happened that annual weeds started flourishing in the furrows, their bio-mass increased and they virtually have become permanent ground cover. We found one advantage that the soil under mulch was moist all the time and had become very porous so much so that instead of driving a fork into soil, we could push our five fingers in the soil and take a good hand full out without much effort, as if it was sand. Since soils under mulch were moist longer than without ridges and mulch, we readjusted irrigation cycle from one week to ten days in summer and from 10-15 days in winter. We still did not know that what was going on but found the trees very healthy, growing very fast and producing first crop within 20-32 months after planting i.e., in the year two of three. The yield started rising and in three to four years doubled. In new plantations under mulch yield was three times in five years. Initially we were putting fertilisers along the bottom 4 inches wall of the ridge and applying 4 inches dose of water so that most of the fertiliser seeps in to ridge as soon as water is applied, though we knew that some of it would seep down in the nearby furrow and promote weeds. For small plants we also had reduced the ridge width to 0.6 meters by simply cutting a trench 30 cms wide, and 60 cms long and deep to furrow level so that water reaches it quickly. This gave us a small channel, for irrigation water to reach the plant roots. These small channels are filled with mulch from ground level to top level of ridge, so that weeds do not grow. In the year 3 we found that the dry weight of the mulch material applied annually was about 25 tons per hectare. In the year 5 yield of small trees was at par with national average of mature trees, usually 15 year old. It was out-come of increased root growth, canopy diameter and density, improved leaf colour as compared to clean cultivation and herbicide use.

- Our observations showed that mulching increases root growth within 3-6 months, but response to yield and canopy health takes 2 years. It was also observed that there is close relation between tree health and yield.
- We did not resort to forage and legume crops as it would mean periodic ploughing. Sub-tropical and irrigated weed growth produces equal biomass and therefore more diverse micro-organisms and invertebrate animal populations and their break-down products.
- From the above observations, we concluded that “mulch was magic”, but we had to find the scientific reasons for this, specially when we found that while trees in other orchards in high heat (+40°C) become nearly dormant and did not show any new growth, our trees were putting on new growth even in the three warmest months of 15th April to 15th July. We also found that trees in other orchards get dormant from October onwards but with us they kept growing even throughout the winter except in January, having average minimum temperature of 10 °C. It was then, that we started investigations and came across very interesting results enumerated below:
  - There is triangular relationship between organic matter, living forms within and above soil and soil properties, as against less complex communities in arid regime and mono-culture system of agriculture which is vulnerable to deterioration.
  - There was a concentration of roots in the ridges and the feeder roots were just at the surface. Up to 35% roots were in the top 30 cm (12 inches) of the soil or ridge and about 30% in the next 30 cm.
  - The mulch lying close to the surface of soil easily absorbs moisture from soil and was attacked by bacteria, fungus, and other micro-organisms. Insects were eating mulch infected with these micro-organisms and they were also eating rest of the dry mulch. Further to it, there were insects which were predators and were preying on some insects eating mulch, and finally there were earthworms swallowing dead insects, their eggs and also mulch pieces. It was these earthworms which had made soil very porous by burrowing inside the ridge to a depth of 30 cms or more, i.e., whole ridge was porous. Over a period of time equilibrium can develop between plant species, enhancing and driving benefit from each other to fulfill its particular requirements. Then a steady state develops between organic and inorganic soil components to enhance plant growth. All these fauna need aerated soil and food consisting of dead plant tissue and soil micro-flora for growth. They feed on excrete of each other or on population of one another. Finally the organic matter passes through guts of several groups of animals to become humus.
  - Some millipedes and wood lice can digest sugars, starches and proteins available in mulch materials.
  - Some nematodes live on cellulose and decompose lignin. Some bacteria and fungi also decompose them. These two fauna are food for mites and springtails.
  - Earthworms, snails and termites can also digest cellulose.
  - All this lead to increase in organic matter and organic carbon in the ridges.
  - Weeds dried in 2-3 days and no harm occurs if they touch the tree trunk. However we pulled mulch away from trunk in rainy season by about 10 cm (4 inches), but rainy season in Sindh lasts only 4-5 weeks and in that time total rains come in 7 days a year.
  - We measure temperatures under the mulch, as well as under the trees of which, mulch was removed for couple of days to bring the temperature of the ambient. The temperatures under mulched and un-mulched trees at various depths when ambient air temperature in early May was 45°C are given in table below:

Depth	Temperature in Degrees °C	
	Under mulch	Mulch removed 48 hours earlier
0cms (Ground level).	42	45
5°cm.	37	42
10°cm.	32	38
20°cm.	29.4	35

The table above shows that while temperatures at the ground level were 45°C under unmulched trees, the mulched trees had 42°C temperature below 37°C. The plants grow the best between 25-36°C and therefore the mulch created a conditions where by high summer temperatures were lowered and winter temperatures were increased and root growth continued and there was profuse vegetative growth.

- The earthworm population increased from negligible and has kept increasing year after year and to-day ten years after mulching was started, worm population in the month of January in each square meter is over 1000 and in the furrows which are flooded with water periodically about quarter as much. In summer months their population is reduced.
- Earthworms in this part of the world are almost white colour. With non-transparent bodies. They burrow in ridges as well as furrows. The population decreases in summer and only juvenile are found in the field. Probably they go and inhabit deeper, to off-set affects of the high heat or die. They increase in number from August to February and start decreasing in March and early April, when they disappear.
- The furrows also had the earthworm populations and they probably live on decaying roots of annual weeds, which are cut down every 2-2 ½ months.
- With earthworm population reaching a maximum 5 millions per hectare and each weighing about 1 gram we have approximately 5 tons of animals power burrowing soil day in and day out and this would be equivalent to 12.5 horse power stirring each hectare of land. However average population of earthworm for the whole year may be 25-35% of this. Due to earthworm tunnels, the soil holds more moisture, has more organic matter leading to larger root biomass of plants, which in turn produce larger biomass in the canopy.
- Because of mulch and thereby worm activity, we have not used any tillage and inter-cultivating equipment which normally cuts the feeder and other roots of the plants.
- We could visualise that the weeds contain all major nutrients as well as trace elements like copper, zinc, boron, iron, manganese molybdenum, taken up from the soil. These are in chelated form and become readily available by increased ion exchangeability. This was secret of fast growth of trees on account of improved physical and chemical processes and better soil fertility.
- Twenty five tons of mulch per hectare annually does not provide total NPK requirements, as the weed are poor in macro-nutrients. However since vermicasts excreted by earthworms have pH around 7.0 there should be no micro-nutrient deficiency. At this pH soil phosphorus, nitrogen and potash are better taken by plants and utilised. Fungal groups also help in uptake of phosphorus. Since our soils are very deficient in copper and zinc, we spray both of them in sulphate forms, as a part of fungicide control and also to meet their deficiencies. The plants have remained in an excellent health. NPK are also sprayed, in small quantities whenever deficiency has been observed or leaf analysis has shown. Plants like

mango and apple can uptake 4-6% urea but NPK are applied at about ½ 1% whenever micro-nutrients, growth regulators or disease or insect control chemicals are required. Low doses of nutrients are able to meet this requirement. Only rarely are macro-nutrient applied along ridge wall. Molasses a cheap wetting agent is available from nearly sugar mills in large quantities.

- It appears that effects of mulching are increased by micro-nutrients as well as NPK.
- Urea, ammonium nitrate, ammonium sulphate, phosphates, potassium chloride and potassium sulphate kill earthworms. Spraying them on canopy saves earthworms populations.
- Herbicides, pesticides and insecticides kill earthworms. We do not use herbicides. Pesticides, an insecticides and fungicides are used in very small quantities when ever needed. Low pressure, sprays, cover the canopy and dribbling of them on the ground is discouraged. Copper sulphate can also kill earthworms but whatever quantity falls down on the ground in furrows is immediately fixed to the soil having pH of about 8.2. Thus it will not do great damage except if it falls on ridges, which are covered with mulch.
- Recently we resorted to use of neem nut husk as mulch. It does not affect the earthworms. Its long term effects need further observations.
- Deep ploughing can reduce earthworm population. Before our resorting to mulch whenever land was ploughed, hundreds of birds would follow the plough furrow and quickly pick earthworms in thousands. Even shallow ploughing like harrowing did similar damage, but to a less degree. We have eliminated ploughing, and harrowing from our farm.
- The other predators of earthworms include: rats and todes. These are difficult to eliminate but these also eat many other harmful insects of the crops and therefore are tolerated. Rats can burrow and can do great damage but foxes and snakes kill and eat them. Foxes are encouraged on the farm.
- The pesticides and fungicides which kill earthworm are: Aldicarb, Benomyl, Carbaryl, Carbofuran, Carbendazin, Chlordane, Copper oxychloride, Dasinit, Heptachlore, Oxamyl, Parathion, Phorate and Thiabendazole. These are not used.
- Earthworms eliminate harmful soil fauna namely; nematodes, aphids, fungi, and viruses. Earthworms eat nematodes.
- Analysis of vermicast excreted by earthworms contains natibiotic namely; streptomycin, earthromyicin, teramyicin. These control viral diseases of plants.
- The secret of early first crop, early maturity, and early commercial production, healthy plants and free from viral diseases probably is on account of the macro and micro nutrients and antibiotics produced by the earthworms and all these nutrients in chelated forms. That earthworms eat nematode is another reason for high yields under mulch without use of nematocides.
- Since mulch leads to healthy trees, we did not have to report to frequent use of pesticides. It is weak and unhealthy trees which are attacked by insects, fungus and bacterial and viral diseases. We surprisingly had few problems.
- Vermicast contain macro and micro-nutrients in a well balanced form, as chemical analysis of it shows.
- The soil under the mulch has very high percentage of porosity caused by earthworm tunnels. We found that soil could easily hold 5 cms of rainfall within 24 hours without runoff in its soil tunnels.
- Thus soil tunnels formed by earthworms remain moist all the times and help plant roots to uptake nutrients.

- The herbicides damage soil fauna namely; earthworm, actinomyceles, protozoa, fungi, bacteria, springtils, feather winged beetles, mould mites, beetle mite, pscuidosorpinos, centipeds, ground beetles and predator mites. Herbicides lead to high pH, reduction in soil organic matter, exhaustion of soil, soil hardness and low draiability.
- As against herbicides, clean cultivation is being recommended in Pakistan. Both ultimately create poor soils and declined production. The disadvantages of clean cultivation are that tree roots are damaged up to the ploughing deep, soil fauna like actinomycels and earthworms are exposed to sun and killed, organic matter is exposed to sun and quickly destroyed by high temperature resulting into, losses of soil porosity, reduction in soil water retention capacity, and hardening of soil. Soil compaction is a problem with tractors and implements. Clean cultivation also raises soil temperatures in summer during day time and reduces winter temperature at night. In both cases plant growth is affected due to damaging tiny feeder roots. In winters exposed soil can easily freeze when ambient temperatures come down below 4°C. It also degrades soil structure.
- Mulch reduce all these damages to soils and crops.
- Mulching 30 year old mango trees helped in overcoming tree decline. It appeared that there is co-relation between degraded soil and fruit production, tree decline, loss in fruit canopy density and twig die back. Mulching for 3-4 years will reverse the position and rejuvenate the declining trees.

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**Publisher:** ChemLin  
<http://www.ChemLin.com>  
**May 11, 2005**

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