

# EARTHWORMS, VERMICASTS AND VERMI-CULTURE EXPERIENCE IN SINDH

By

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About 2,350 years ago Aristotle had said. "Earthworms are intestines of the earth". Only in the twentieth century has the truth in this statement been verified and found correct. He was ahead of our times by two and half of millennia. Darwin was another one to state: "No other creature has contributed to building of earth as earthworm." The National Agriculture Research Council of Pakistan has recently announced a programme of introducing earthworm technology. Mostly fashionable house wives of urban areas do it on a small scale, many to make a show off. It is not done on the farms, where it is badly needed can be remunerable.

## **Massacre of earthworms**

For the past 42 years we have massacred earthworms mercilessly. This coincided with beginning of Green Revolution in the world and USAID in Pakistan, under which synthetic fertilisers replaced cumbersome green manure and bulky farm yard manure. Plant insects, pests and diseases were overcome with the use of synthetic chemicals. Most of fertilisers, plant protection chemicals and herbicides killed earthworm abiding in the soil. The Green Revolution had failed around 1980 and the Western World was the first to realise. We in the Third World are still unaware of it.

On our 108 acre fruit farm, we had found yields getting either stagnant or actually coming down, inspite of use of more and more fertilisers and more frequent applications of plant protection chemicals. The Agriculture Department had been recommending clean cultivation under fruit trees and this meant frequent ploughing to get rid of weeds. Every time we ploughed we found large flocks of birds following the plough furrow to pick up some insects. Our Kamdar (farm foreman) said: "Those are harmful insects, which are being exposed to air and sun and these friendly birds are getting rid of them." On close examination we found that it was large population of earthworms which were being exposed to surface and they were being killed by solar heat and light and also were swallowed by birds. We concluded that no tillage of soil was the solution.

## **Yield reducers**

Under Green Revolution, we had our own problems with fruit crop yields, which averaged to 20-30 percent of those in the developed countries. Conventional fruit yields in Pakistan are about 20 percent those in developed countries. This means increase in yields by five times is possible. The various factors for reduction in yield are given in table below:

<b>S.No.</b>	<b>Factor</b>	<b>Reduction</b>
1.	Weeds.	30%
2.	Lack of micro-nutrients.	13-16%
3.	Root-rot due to flood irrigation.	10%
4.	Lack of organic matter and presence of harmful soil pathogens	10%
5.	Root damage at low and high soil temperatures.	5%
6.	Lack of plant hormones to high pH soils.	2%
7.	Lack of vitamins.	2%
8.	Fixation of phosphates.	2-3%
9.	Lack of growth regulators.	2%
10.	Lack of antibiotics.	2%
11.	Leaching of nutrients.	4%
	<b>TOTAL</b>	<b>80%</b>

We thought that we could increase the yield 2.5 times from the present 20 to 30 percent easily, if we control weeds, eradicate root-rot caused by anaerobic conditions due to flood irrigation and apply micro-nutrients. We prepared a simple plan. We had been introducing new fruit crops since 1980 and in 1990, we dramatically changed the field layout by making ridges six feet wide and one foot high and planted trees on them at densities three to four times the conventional ones and applied water in the furrows, from which it reached the plant roots by horizontal permeability. Furrow width varied between nine to fourteen feet for various fruit trees. We allowed the weeds to grow profusely in the furrows and these were cut-down every two months with scythes, and dumped on the ridges. We found that the continuous clean cultivation had eliminated annual or non-perennial weeds and perennial weeds specially dicotyledons had almost covered the whole area. The new method introduced left many seeds of annual weeds in the furrows and in a couple of years these reduced and weakened the perennial grasses in competition. The weeds became so profuse that cutting them every eight to ten weeks produced some 30 to 50 tons of grass per acre per year. This was dumped on the ridges and gradually the height of weed pile or mulch became about 20 to 26 inches thick. The weeds on the ridges weakened due to lack of light and even worst perennial grasses could easily be pulled out. We found that this enhanced tree growth which became two to three times that of the un-mulched ones, trees were healthy, had less insects, pests and fungal attacks, were nearly disease free and had first flowering within twenty to thirty months. In spite of sufficient know how we have never considered our knowledge perfect and therefore requested my senior officers of the department of agriculture and also many farm chemical companies to send their representatives to visit and advise us. They expressed their horror and considered that dumping of grass under the trees was a most foolish act any sensible person can even dream of. After pulling up mulch materials, they showed us hundreds of insects running about on the ridge on

every square foot. They stated: “These insects are going to destroy your trees. Remove the dirty stuff and burn it up.”

We verified and found-out that the insects that they talked about were different from those attacking the trees and none of them was every present on the trees or climbing them. We also found that soil surface was invariably moist under the mulch so irrigation frequency was reduced in summer from once a week to every ten to twelve days. Soil temperatures were also lowered in summer days and were higher in cold winter nights. In addition we found earthworms burrowing the soil which had become very porous to the depth of about one foot. We were convinced that this was the worm-technology which was being discussed in various books but, was not introduced on large scale anywhere. We studied the environments under the pile of dead grass (mulch) on the ridges and also in the furrows where no mulch was applied and found similar insects and worms in the furrows too. It was clear that all these fauna were living on dead and decaying material dumped as mulch on ridges and in the furrows, produced from decaying roots and stems of non-perennial grasses, which we had cut down. Our observation showed interesting results. There are insect fauna, which eat live on any organic matter which once was alive but is dead now. This organic matter in presence of moisture on the top of the ridge is attacked by actinomycetes and fungi, hereafter called first level consumers of mulch. The fungi are attacked by spring-tails, mould mites and feathered winged beetles, the second level consumers of mulch materials. These, in turn have their own predators namely: ground beetles, centipedes, pseudoscorpions, the third-level consumers of mulch materials. All these insects excrete, leave their own dead bodies, eggs, larvae etc., which are swallowed by earthworms. In their digestive tract earthworms have actinomycetes, a kind of highly useful bacteria which not only help in digestion but also produces a large range of useful chemicals discussed below.

Mature earthworms weight about one gram each and consume mulch material mixed with earth. Every day, they excrete small porous balls, called vermicast, weighing about one gram. Vermicast is most wonderful thing one can imagine of and is beyond today’s technology to reproduce it synthetically.

### **Chemical analysis of dry vermicast.**

Table below gives a chemical analysis of vermicast excreted by earthworms.

Chemical analysis of dry vermicasts.

<b>Nutrient.</b>	<b>Range</b>
Nitrogen.	1-4 percent.
Phosphorous.	0.3-3.5 percent.
Potassium.	0.2-2.1 percent.
Sulphur.	0.24-0.63 percent.
Calcium.	1-2.2 percent.
Magnesium.	0.3-0.6 percent.

Iron.	0.4-1.6 percent.
Others.	Parts per million parts or ppm:
Manganese.	270-950
Zinc.	185-1005
Copper.	22-380
Molybdenum.	18-77
pH.	5.8-6.1

On our farm we have observed population of more than 100 earthworms per square foot on the ridges and about 45 in the furrows. Considering a very low average of 45-50 earthworms per square foot, their population will be over two millions per acre. At an average one gram each, weight of earthworms per acre two tons. Charles Darwin in 1881 had stated “Weight for weight they are the strongest animal on the earth.” Their body consists a number of tubular segments which are filled with water and which in turn is incompressible. This is the secret of their being the strongest animal on the earth. With their total body weight of two tons per acre, they keep burrowing the soil day and night. This weight is also equivalent to the weight of five strong horses or 5 horse power. In other words we have at our disposal five horse power per acre. With this power they have been working day in and day out and stirring the soil, which not only becomes porous but very rich in nutrients and oxygen and also in its drainability. The whole soil up to depth of one foot is nothing but vermicasts. The table above shows how rich the environment left by vermicast is.

If adequate mulch is available, the plants will need no outside application of fertilisers and micro-nutrients. It has now been confirmed that environments created by earthworms contains antibiotics like streptomycin, erythromycin and terramycin produced by actinomycetes living in those environments of body of earthworms. These antibiotics are responsible for suppressing all kind of viral and fungal diseases attacking the plants. Oxygen-rich environments created by earthworms suppresses all plant pathogens. The vermicasts also contain growth regulators and vitamins essential for plant growth. The pH of vermicasts is about 6.0 (5.8-6.2) at which there is easy and free intake of phosphate and micro-nutrients by plants from the soil. The mulch materials and vermicasts in soil also contain micro-nutrients which are readily available to the plants due to their low pH.

### **Reduction in use of synthetically produced fertilisers, micro-nutrients growth regulators, antibiotics and vitamins.**

The earthworms and actinomycetes produce antibiotics, vitamins, growth-regulators, slow release fertilisers and macro and micro-nutrients, etc., which make plants healthy. Our experience shows that if we can provide 40 tons of dry organic matter as mulch per acre, we will need no applications of all above chemicals. Dry organic mulch materials available to use contain less nitrogen and this is the only nutrient that we apply by spraying in small quantities every month, during the growing season, not on the ridges or furrows but only along side wall

of ridge in a band, to be dissolved in irrigation water and moved in soil by horizontal permeability.

### **Nematode control**

Worms eat soil nematodes and reduce their population to almost one third. Thus no chemical nematocides are needed when adequate mulching is done.

### **Control of harmful soil fauna.**

Harmful soil fauna namely; aphids, some fungi and soil viruses are all reduced in population by earthworms, which eat them.

### **Earthworms and water infiltration**

Our experience is that under mulch earthworms make soil so porous that it is nothing but vermicasts scattered and piled to depth of twelve inches, and one can easily push both hands down and remove soil up to a depth of one foot. The soil has become so porous that there is no runoff from the ridges even if there has been a heavy rain of more than one inch per hour. We have measured an infiltration of about two inches of water per minute. The surface of a burrow is about five to six times in area than surface soil. Air in the burrows is more moist than in the rest of the profile, creating moist tropical conditions in dry sub-tropics. Soil aeration increases even by more than hundred percent due to its porosity. Worms excrete nutrients at different depths and thus they are redistributed in the whole root-zone.

### **Earthworms and natural grasses**

We have been cutting grass every second month from the furrow and dumping it on the ridges on which no weeds grow due to continuous cover of mulch. With each cutting, the remaining stems and roots in the furrow decay and form food for earthworms. This soil has not only turned porous and suitable habitat for earthworms but yield of grass has increased five folds in the past fifteen years (1991 to 2006) and we are able to get five tons of grass per cutting per acre or about twenty five tons of grass per year. The grass growth is low from mid November to mid February due to cold winter and is maximum in warm months.

### **Creating an environment for promotion of earthworms.**

Earthworms do not survive at temperatures above 36°C and they are also not able to function properly at low temperatures. Ten inch thick layer of mulch reduces the soil temperatures on our farm (near Tando Jam) even on the hottest days of May from 45°C to less than 36°C at a depth of two inches below the surface of ground and at depth of 8-10 inches they fall to about 32°C. When winter temperatures fall to below 4°C, ground temperatures at two inches depth are over 10°C and at 8-12 inches depth about 16-18°C. These environments are most suitable for promotion of earthworms and their renovating the soil.

### **Chemical killers of earthworms**

Earthworms enemies are fertilisers like single super phosphate, triple superphosphate, diammonium phosphate, potassium sulphate, potassium chlorides, ammonium sulphate,

ammonium nitrate and concentrated forms of nitrogen like urea. Many pesticides kill earthworms and some such common pesticides used in Pakistan are: aldicarb, benomyl, carbaryl, carbofuran, carbendazim, chlordane, copper oxychloride, heptachlor, oxamyl, parathion, phorate and thiabendazole. Of these heptachlor (dieldrin and aldrin) has been banned recently, but the rest are still being used and contributing their share to earthworms kill. All herbicides, and nematocides also kill earthworms.

### **Animal killers of earthworms**

Snails, rats, birds, foxes, jackals, ants, canetodes, earwigs, and flatworms prey upon earthworms. These creatures become a serious problem, when due to ploughing earthworms are exposed to atmosphere. Rats and snakes burrow in the soil during drought and dill earthworms out, but under irrigated condition it is not a serious problem. Bagris, an aboriginal tribe of Sindh catch foxes, jackals, porcupines, pigs and large rodents for food and thus their population is under control and they are not a problem for earthworms. Under mulch earthworm population is so large that their enemies do not reduce their population even fractionally.

### **Mass killing of earthworms.**

The Green Revolution which came to Pakistan some forty five years back in the form of fertilisers, plant protection chemicals, herbicides and extra water, led to killing of earthworms. Promotion of clean cultivation in orchards by the Agriculture department, leads to reduction of organic matter and exposure of earthworms to light which kills them, besides being preyed upon by birds. This has led to disproportionate reduction of earthworms population. Mechanisation of agriculture and establishment of huge milk plants, lead to abandonment of draft animals (bullocks) and milch animals (cows and buffaloes). The concentration of milch animals in milk colonies of large cities has made farmyard manure too costly to transport to long distances and apply to the farm. The availability of fertilisers for enhancing the yield made green manuring unnecessary. All these lead to reduction in soil organic matter, the feed of earthworms and therefore reduction in their population and consequently non-availability of natural nutrients, growth regulators, vitamins, hormones and antibiotics, which in turn has reduced yield and increase plant diseases.

Green Revolution was no longer able to increase yield and it ended in fiasco in 1980. Since then yields have virtually become stagnant and even with applications of extra fertilisers and plant protection measures, extra yield from crops does not pay for the cost of extra inputs. The cause and effect has remained unrealised and the remedial measures are not taken up.

For the past forty years agriculture education, research and extension have been promoting technologies, which have failed to increase yields. These technologies have reduced soil's organic matter, the food for earthworms and thus the government at agricultural set-ups have promoted large scale massacre of earthworms. They are the most useful animals on the earth and had been free to do their role of renewing the soil for the past sixty million years. Only in the past forty five years, the Green Revolutionaries has started their mass massacre.

The National Agricultural Research Centre is planning to introduce earthworm technologies. There are highly fashionable methods of raising earthworms from kitchen scraps and lawn shavings, but besides being a hobby, it has produced no economic impact of any appreciable degree. Some fashionable urban households may want to start this hobby and create a market for others to buy earthworms from them, but this is not going to help the economy. The only way-out is what we have done in fifteen years on 108 acres, using organic waste material, irrigation water and air.

For mulching 108 acres year around, we have ten extra labourers working under a person holding an M.Sc year around. This means extra employment. Besides this, yield increase three to four times, and expenditure on fertilisers, plant protection chemicals and herbicides is reduced too.

The earthworms are called “the intestines of the earth”, we must save them. They have served our planet for sixty millions years and by saving them we will get in return chemical free, healthy food and extra money from the earth.