Lesson 9

Benefits and economic returns

Learning outcomes

- The trainee explains the improvement in the physicochemical properties of the soil caused by the production of vermicompost.
- The trainee explains the positive effects of vermicompost on soil fertility and plant development.
- The trainee explains the improvement in the biological properties of the soil caused by the production of vermicompost.
- The trainee knows the economic benefits of vermicompost production.
- The trainee evaluates the economic benefits of waste recycling.

Instructions for the trainer

- The trainer shares theoretical knowledge through presentation

Basic requirements: Computer, projector

9. Benefits and economic returns

9.1. Benefits

Vermicomposting has advantages at different levels. On the one hand, the benefit of applying worm castings, or vermicompost, to arable land to increase its fertility is well known, since at least ancient Egypt. Multiple studies show that worm castings have many beneficial properties:

- Improves the composition of the soil, making it more spongy, aggregated and aerated, in addition to making it permeable to water, while helping to retain it. Also, chemically, vermicompost helps regulate, to a certain extent, an optimal pH for the plants. Biologically, the bacterial abundance and diversity of soil enriched with humus are easily verifiable. The increase in fertility of a soil supplemented with vermicompost is evident, with virtually zero side effects.
- It is also shown that the components of the mature vermicompost help the growth of the plants and their production. The acids, enzymes and hormones present in worm castings are of great help for the development of crops, from germination to their adult stage. Worm castings feed and make plants grow more vigorous, productive and resistant to pests and inclement weather.
- As if that were not enough, there is no chemical fertilizer comparable in results to vermicompost, a completely natural product, which reduces the possibility of harmful effects on health. Vermicomposting even helps in the elimination or degradation of chemicals, toxins or contamination existing in the waste that is fed to the worms.

On the other hand, vermicomposting is an activity that implies other indirect or less obvious benefits:

- Its educational potential for children, young people and adults has been known and has been applied for decades in educational systems. Conveniently introduced, vermicomposting is a living experiment that promotes countless values such as caring of fragile but fundamental living beings, the biological scientific aspects that it carries with it, the maintenance of the ecosystem, the analysis of its results...

- Waste management has a considerable social impact. Composting and vermicomposting are very welcome solutions for some of the problems of modern societies such as the management of certain organic waste. Often the excess of organic "garbage" from the individual or family level, to the communal level, in companies, schools, hospitals and many other environments, can be remedied with composting systems. The investments and maintenance required are minimal, especially when verifying its low cost and maintenance and the high return in nutritional terms, health improvement and environmental balance.

- It is worth mentioning the level of consciousness that composting in all its forms introduces into our societies that are increasingly voraciously consumerist and disconnected from the environment. It is especially curious that the most profound and simple beings, from bacteria to worms, give us recycling lessons and help us reconnect with the nature that sustains us. Worms have taught us to convert waste into a resource and are the very link with our origin and sustenance, we cannot forget them.

9.1.1. The role of vermicompost on soil fertility

The main role of earthworm compost is the change of physical, chemical and biological properties of the soil by earthworm activities and therefore they are called soil managers. It significantly improves the structure, texture, aeration of the soil and prevents soil erosion. By increasing the macropore area between 50 and 500 μm, it causes the air-water relationship in the soil to improve and thus positively affects plant growth. It also positively affects soil pH, microbial population and soil enzyme activities. In addition, vermicompost is a rich source of nutrients such as nitrates, phosphates and exchangeable calcium and soluble potassium. Besides adding mineralogical nutrients, vermicompost is also rich in beneficial micro-flora such as N-fixers, P-solubilisers, cellulose-decomposing micro-flora, etc. It also reduces the proportion of water-soluble chemicals that cause possible environmental contamination. The mucus secreted by the digestive tract of the earthworm produces certain antibiotics and hormone-like biochemicals, thereby accelerating plant growth and increasing the decomposition of organic matter in the soil. Vermicompost has been reported to have a favourable effect on growth and yield parameters of various crops like paddy, sugarcane, brinjal, tomato and okra. Thus, vermicompost acts as a soil conditioner and a slow-release fertiliser, ultimately improving soil structure, soil fertility, plant growth and suppressing diseases caused by soil-borne plant pathogens, increasing crop yields [20, 61, 62, 63].

9.1.2. The role of vermicompost on the soil physicochemical properties

Vermicompost improves the physicochemical characteristics of soil, such as soil structure, soil water holding capacity, penetration resistance, bulk density, soil organic carbon, aggregation, nutrient content, etc. According to the findings of various long term research, addition of vermicompost reduces the bulk density of the soil and increases the water holding capacity of soil [64]. It is found that when vermicompost was added in the soil, the mean bulk density, and mean total porosity were the least. Air permeability rose and penetration resistance reduced dramatically as wet aggregate stability improved and bulk density reduced. Increased microbial population and activity led to the development of aggregates and increased soil porosity, resulting in decreased particle and bulk densities. Physicochemical characteristics such as pH, electrical conductivity (EC), porosity, moisture content, water holding capacity, and chemical properties like nitrogen, phosphorous, potassium, calcium, and magnesium were all found to be significantly improved in vermicompost treated soil, while the corresponding physicochemical values in control soil were minimal in rice crop [65]. Vermicompost has indeed been found to have significant concentration of total and bioavailable nitrogen, phosphorus, potassium (NPK), and micronutrients, as well as microbial and enzyme activity and growth regulators. Polysaccharides appeared to be abundant in vermicompost. Polysaccharide worked as a cementing ingredient in the soil, causing aggregate stability, which helped to establish and maintain the soil structure for improved aeration, water retention, drainage, and aerobic conditions. The preservation of soil structure is essential for root elongation and nutrient uptake. The inclusion of mucus secretion and microorganisms from the earthworm's gut improves the soil's aggregate stability. The absorbent organic matter in vermicomposts increases the soil's water retention capacity by holding only the quantity of water required by the plant roots [66, 67]. Vermicomposts have been found to have a higher base exchange capacity and a higher oxidation potential rise [68]. The C/N ratio of vermicompost is usually lower, indicating that it is more suited for use as a soil amendment. By altering the physicochemical parameters of the soil, vermicompost was able to limit the loss of nutrients through leaching [69]. Humic acid and biologically active compounds like plant growth regulators are abundant in vermicompost. Humic acid has been proven to improve nutrient accretion in situations where nutrients are scarce or when additional nutrients are provided. Humic acids may have a hormone-like effect on plant growth and productivity as a result of their involvement in cell respiration, photosynthesis, oxidative phosphorylation, biogenesis, and a variety of other enzymatic functions [24, 70].

Table 6. **Effect of vermicompost on physicochemical properties of soil on different crops [24]**

Crop	Treatments	pH	EC (dSm^{-1})	BD ($g.cm^{-3}$)	Porosity (%)
Rice	Control	7.4 ± 2 01	2.0 ± 1.0	—	39 ± 2.0
	Vermicompost	7.1 ± 0.01	1.01 ± 1.0	—	41 ± 1.0
	Vermi-wash	7.2 ± 1.02	2.0 ± 1.1	—	40 ± 1.1
	Vermicompost + Vermi-wash	7.0 + 0.03	0.02 ± 0.01	—	44 ± 1.0
Wheat	Soil sample	8.56	25.82	1.52	25.38
	Vermicompost / 5 $g.kg^{-1}$ soil	7-6	4.65	1.42	26.85

Table 7. **Comparison between the effect of vermicompost and conventional compost on different nutrient content of the Amaranthus viridis production [71]**

Parameters	Compost ($g.m^{-2}$)			
	Vermicompost		Conventional compost	
	100	150	100	150
Nitrogen (%)	0.61	0.72	0.54	0.62
Phosphorus (%)	0.0057	0.0077	0.0039	0.0047
Potassium (%)	11.11	11.17	10.41	10.48
Calcium (%)	1.443	1.683	0.561	0.641

9.1.3. Effect of vermicompost on the soil biological properties

Biological properties of soil can be enhanced through application of vermicompost. Recent studies found that soil biological characteristics viz. soil organic carbon as well as soil microbial biomass, enzymatic activity, population of different beneficial microorganism, hormones, etc. significantly improved with application of vermicompost. The activity of the dehydrogenase enzyme, which is commonly employed to quantify the respiratory activity of microbial communities, was shown to be higher in vermicompost than in commercial medium. Application of vermicompost improved the nitrogen status of soil by introducing the beneficial microorganism in the rhizosphere of the plant which ultimately enhances the nitrogenase activity in soil, which is the enzyme responsible for nitrogen fixation [24, 72, 73].

9.1.4. Effect of vermicompost on plant growth and development

Vermicompost promotes the growth and development of a variety of plant species, especially various horticulture crops, that is, sweet corn, tomato, strawberry [74], cereals crop rice [65], wheat, sorghum [69], fruit crops papaya [75], and pineapple [76]. Several growth and yield metrics viz. stem diameter, plant height, marketable yield per plant, mean leaf number, and total plant biomass of tomato plant were recorded significantly higher with the application of vermicompost. The increase in growth and development of plants is due to the improving action of vermicompost application on soil physical, chemical, and biological properties which ultimately improves the overall soil fertility, which enhances the plant growth and development. Vermicompost has been demonstrated to improve plant dry weight and uptake of plant N serving as a naturally available, slow released source of plant nutrients [24].

9.2. Economic Returns

Vermicomposting offers several economic benefits. Firstly, it is an efficient and cost-effective method of converting organic waste into valuable compost, which can be used as a nutrient-rich manure for crop cultivation [77]. This reduces the reliance on chemical fertilizers, which can be expensive. Additionally, the demand for vermicompost has been increasing rapidly, creating a potential market for its commercialization [78]. This presents an opportunity for farmers and small-scale entrepreneurs to generate revenue by producing and selling vermicompost. Furthermore, vermicomposting has the potential to reduce the cost associated with food waste disposal, as demonstrated by a financial analysis. By utilizing vermicomposting, the cost of waste treatment can be significantly reduced, making it an economically viable option. Overall, vermicomposting offers economic benefits through the production and sale of vermicompost, as well as cost savings in waste management [79].

The economic benefits of vermicomposting include a potential reduction in the cost associated with food waste disposal from $57 to $18 per ton. In today's world, where the total amount of global waste is 20 billion metric tons and municipal solid waste is 2.7 billion metric tons, the transformation of waste into economic value is also important in terms of the circular economy [80]. Considering that 70% of the municipal solid wastes generated are of organic origin [81], the contribution of reprocessing these wastes with environmentally friendly approaches such as vermicomposting to the world economy is approximately 73.7 billion dollars. The amount of solid waste from small-scale farms can often vary depending on the size of the farm, type of production, and processing methods. Regardless of size and scale, recycling organic wastes through vermicomposting will reduce the solid waste management costs of small agricultural enterprises by at least 70%.

The positive effect of vermicompost on plant growth and development and its protective effect against plant diseases and pests make it a powerful fertilizer and a successful plant protection component. Considering that the average annual fertilizer and plant protection product costs of small-scale agricultural enterprises/farmers are 22.175 and 15.915 dollars [82], respectively, it is obvious that, in addition to the 70% cost reduction provided by vermicompost in the field of waste management, a cost reduction of approximately 38.000 dollars will be a significant gain for small farm enterprises/farmers.