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Vermicomposting Transformed Farm Women Livelihood: A Case Study from the Cold Desert (Ladakh)

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A B S T R A C T

Vermicompost has adequate amount of micro-nutrient and macro-nutrients depending on sources of earthworm's feed-stock. Earthworm promotes soil fragmentation and increase aeration of soil by volume 8-30 per cent. Vermicompost has at least four times more plant nutrients than conventional cattle dung compost. Vermicomposting is a source of creating self employment and revenue generation. This is an easy and faster process of converting organic matter into compost than other conventional methods. This study carried on Latsal Lukhar Tsogspa SHG in Sumoor Nubra seeing the facts and properties of vermicompost, 14th ladies SHG group started Vermicompost producer start up and set an example for the village. First time they harvest around 3600 kgs and sold at the rate of Rs 35 /kg and earned 126000 rupees in 4 month, in a year Rs 252000 earned. Ladies are very happy with this technology and decided to sail worms @ 300 per Kg. The B.C ratio of this technology is (1:2.60) which played significant role in uplifting of socioeconomic status of farm women to uplift the socio- economic status of all farm women/farmers of Ladakh and boost organic farming which is the main mandate of nation.

Introduction

Vermicompost is an organic fertilizer obtained from the earthworms by passing out the organic wastes through the digestive systems. The process of preparation of this organic fertilizer may be called as vermicomposting. Earthworm improves and restores soil fertility and boost up crop productivity by the use of their excretory products known as vermicast. Vermicast is popularly known as Black gold because of rich in nutrients, growth promoting substances, beneficial soil micro flora, having properties of inhibiting pathogenic microbes and synergistic relationship in plant rhizospheres. Being stable, multifunctional organic manure which enriches the soil quality by improving physio-chemical and biological properties it must be promoted (Datta *et al.,* 2016). Vermicompost is becoming popular day by day as it provides quality products through major component of organic farming system (Yadav *et al.,* 2013). Mixture of leguminous and non-leguminous crop residues enriches the quality of Vermicompost. Its moisture content remains in between 45- 65% which is ideal for land applied compost and pH values near neutral due to the production of CO2 and organic acids. Other by products

of microbial activities is also known which promote plant growth, disease antagonists and growth influencing substance like hormones. Vermicompost is a safe, non-polluting and one of the most economical and convenient way of solving the waste disposal problems and recycling of organic waste. It is an excellent form of natural manure which is cost effective, easy to make, handling and contain high nutrients with growth hormones and are 4-5 times powerful growth promoter than all other organic fertilizers and over 30- 40% higher than the chemical fertilizer (Narkhede *et al.,* 2011; Attarde *et al.,* 2012). Various workers reported that Vermicompost contain 17-36 % Humic acid and 13-30% Fulvic acid of total concentration of organic matter.

Besides, Vermicompost has an adequate amount of micronutrient and macronutrients depend on sources of feedstock. Earthworms and vermi-compost can promote growth 50-100 per cent than compost and 30-40 per cent over chemical fertilizers (Sinha *et al.,* 2010). Keeping in view the above facts and properties of Vermicompost, Latsal Lukhar SHG of 14 farm women from Summor Nubra, Leh started their start up unit in Nubra after getting Ten days skill development training on Vermicompost producers under NABARD project. SHG transformed their life and livelihood, beside that they generated employment for numerous agro farmers of nearby area. Now, they became a role model / master trainer of Nubra village among farmers community.

Materials and Methods

Latsal Lukhar Tsogspa SHG in Sumoor Nubra, 14th ladies group started Vermicompost producer start up and set an example for the village summor Nubra under Sumor Tehsil block Panamik Nubra of Leh district in Jammu & Kashmir, India. They opted the Agriculture occupation for livelihood since 40year. SHG came in contact with High Mountain Arid Agriculture Research Institute (HMAARI), SKUAST-K Leh in the year 2020 during Skill development programme of Vermicompost under NABARD project. Before this training all of them doing cultivating traditional crops of wheat, barley and some vegetable on a usual pattern and applied chemical fertilizer. After coming in contact with HMAARI scientists SHG took initiative in Ten days skill development training programme in Vermicompost producers under NABARD project and now started their own vermicompost unit at large scale on scientific basis. In the meantime under NABARD project on Dissemination of Vermicompost technology in Ladakh region they got 2 bags of plastic vermibed and worms to this farmer to encourage their work and for start up their business. Today with the help of that training SHG'S got the good linkages with other department. Agriculture department gave three unit of large size cemented structure of 30 x 8ft sizes for Vermicompost production.

With this setup of technology they are receiving more demand of vermicompost not only from line departments but also from farmers and hotel owners. Within three cemented structure and two bag they earned Rs 94500/ and Rs 31500 from Vermicompost bag= in four months they harvest twice in year. After getting training and vermibags from HMAARI SKUAST-K Leh they earned around Rs 252000/=per year. Now they spread their business to large scale and Dr Jigmet provide a market linkage to them.

SHG's having own agriculture land and a dairy unit with each group member. SHG'S also interested in raising crops in an organic way after successful capacity building through this training programme. Sumoor village is tourist spot and plenty of hotels and guest houses. Farm women get good return from this technology and very satisfied with this technology because SHG is not only securing their livelihood but also sets an example for coming generation as well as for farmers community of Summor and Nubra region.

Through this training SHG's got various training on different cash crop cultivation through Vermicompost manure. SHG's developed their farm by knowing organic farming through vermicompost in watermelon production, cucumber, mulching technology branjal, cucumber etc for army supply. Today Latsal Lukhar Tsogspa SHG has become a role model cum master trainers for farm women's of Sumoor as well as entire Nubra region in the field of Agriculture

Method Transferred to SHG for Vermicompost Preparation

Factor affecting lengths period of Vermicomposting process in Ladakh

The length of time necessary for the vermicompost process depends on six conditions

- ✓ Carbon-to-nitrogen ratio
- ✓ Surface area of particles
- ✓ Aeration

- ✓ Moisture
- ✓ Temperature
- ✓ pH

Carbon-to-nitrogen ratios

All organic material contains carbon and nitrogen. Carbon is a major component of the cellulose and lignin that give cell walls their strength. Nitrogen is found in proteins and many other compounds inside plant cells.

The carbon-to-nitrogen ratio (C: N) of a material is an estimate of the relative amounts of these two elements it contains. It is usually based on the percent dry weight of carbon and nitrogen in the material. A ratio of about 30:1 is ideal for the activity of the microbes in the vermicompost. This balance can be achieved by controlling the materials included in the vermicompost or by adding nitrogen either from fertilizer or from organic materials high in nitrogen, such as manure or grass clippings. Table 1 shows the approximate ratios for some materials commonly added to vermicompost piles.

The items at the beginning of the list are highest in nitrogen; those at the bottom are highest in carbon. These ratios represent comparative weights. The 30:1 ratio in vermicompost is the most desirable to supply the microorganisms with the proper amount of carbon they need for energy and the proper amount of nitrogen they need for protein synthesis so they can function efficiently and quickly.

To estimate the C: N of a mixture, average the ratios of the individual materials. For example, a mixture of equal parts grass clippings and leaves might have a C: N of (20 + 50) ÷ 2 = 35.

Temperature

Microorganisms generate heat as they decompose organic material. The appropriate temperature for vermicompost pile is between 25 and 32^0C is for effective vermicomposting. Due this temperature the rate of decomposition rate was very high by rapid growth in worm's production. The high temperature in pile significantly helps in pathogen reduction. Vermicompost piles reduce decomposition rate in cold weather. Worms facing problem in cold temperatures when temperature goes to -22^0C they are doing struggling for survival and the decomposition process rate slowed down during winter season in place like Ladakh.

Moisture

Microorganisms can only use organic molecules if they are dissolved in water, so the compost pile should have a moisture content of 60-80% of water holding capacity. If the moisture content falls below 40% of water holding capacity the microbial activity will slow down or become dormant.

If the moisture content exceeds 80% of water holding capacity, aeration is hindered, nutrients are leached out, decomposition slows, and the odor from anaerobic decomposition is emitted. The "squeeze test" is a good way to determine the moisture content of the composting materials.

Aeration

The decomposition occurring in the compost pile takes up all the available oxygen. Aeration is the replacement of oxygen to the center of the compost pile where it is lacking. Efficient decomposition can only occur if sufficient oxygen is present. This is called aerobic decomposition. Timely turning of manure at least twice a month is very necessary to proper aeration and proper decomposition.

Surface Area

Surface Area of vermicompost pile is neither to large or nor to small. It should be medium so that proper temperature and moisture can manage under Ladakh condition. Location of vermicompost unit should be selected were maximum solar radiation they can get especially in places like Ladakh. But in other plan areas the vermicompost unit should be in shaded area.

pH

The level of pH in the waste depends upon the decomposition rate and characteristics of feed material. The release of organic acids may decrease the pH and production of ammonia from nitrogenous compounds may raise the pH. At higher pH levels, more ammonia gas is generated and may be lost to the atmosphere. A pH value between 6.5 and 8.5 is optimal for compost microorganisms. As bacteria and fungi digest organic matter, they release organic acids. Normally, the pH of the organic manure will be very acidic at first, at a level from 4.0 to 4.5. By the time the process is complete, the pH should rise to approximately 7.0 to 7.2.

Classification of Earth worms

Earthworm, also called angleworm, any one of more than 1,800 species of terrestrial worms of the class Oligochaeta (phylum Annelida)—in particular, members of the genus Lumbricus. Seventeen native species and 13 introduced species (from Europe) occur in the eastern United States, L terrestris being the most common. Earthworms occur in virtually all soils of the world in which the moisture and organic content are sufficient to sustain them. One of the most detailed studies of earthworm activities was conducted by English naturalist Charles Darwin. Some studies said that there are about 240 species of generally worms worldwide, among them about 50 species are available in India. On the basis of habitat, worms can be categorized into three groups:

Epizoic

It is known as manure worms or compost worms which have short life span and rapid breeding ability. Epizoic worms obtain their food from upper surface of half decomposed organic matter and move downward. *Eisenia foetida* (Red earthworm), Eudrilus eugeniae (night crawler), Perionyx excavatus etc. are under this group. *Eisenia foetida* is selected because of its high multiplication rate and converts abundant amount of organic wastes into vermicompost. Red earthworm have body length 3-10cm, body weight 0.4-0.6g, maturity 50-55days, conversion rate 2.0 q/1500worms/2 months, cocoon production 1 in every 3 days and incubation period is 20- 23days.

Endozoic

Endozoic worms, known as field worm, consume food from lower portion and prefer soil than organic matter. Endozoic worm help in churning of soil, air circulation in soil and mixing of organic matter.

Anesic

Anesic form hole and stay in it. Lives of anesic are very complex and prefer leaves Vermicomposting unit size (1.50cm X 1.30 cm X 70cm) was established in a warm place under Ladakh condition where temperature goes to -300C to +350C. Number of units increased according to availability of raw materials and requirements. Cow dung and chopped dried leafy materials were mixed in the proportion of 3: 1 and kept for 20-30 days for partial decomposition. During this period, heap was kept moist by sprinkling of water so that temperature can be favourable to worms. A layer of 15-20cm of chopped dried leaves/grasses was kept as bedding material at the bottom of the bed. Each bed contained 4- 5q of raw material. Now 1500-2000 Red earthworms were released on the upper layer of the bed and covered with gunny bags/paddy straw so that worms can be saved from predators. Water was sprinkled immediately after releasing worms and it was kept moist by frequent sprinkling as per need. Bed was turned once after 15-20 days for maintaining aeration and proper decomposition. A reddish colour liquid, with an alkaline reaction having dissolved nutrients, called vermiwash was collected in the small chamber connected through drainage pipes fitted at the bottom of the tank. By this way vermicompost was ready in 4months and amounting by 350-450 kg were harvested from one bag. Moreover, vermiwash was additional product which was abundant in nutrition having plant growth hormones, micronutrients and organic acids. For value addition of vermicompost, rock phosphate, azolla etc. was added accordingly.

For this study we used Epizoic worms such as *Eisenia foetida* (Red earthworm) which is selected because of its high multiplication rate and converts abundant amount of organic wastes into Vermicompost and less mortality rate in place like LADAKH at high altitude zone.

Preventive measures

During production Selection of site was most important according to purpose of production either commercial or personal. Producer was trained by scientists of High Mountain Arid Agriculture Research Institute SKUAST-K Leh before start the production. At least 30 day's old cow dung used to avoid excess heat. Avoid fresh dung and waste because worms would die in fresh cow dung. The organic wastes were free from, chemicals, pesticides and metals etc. Aeration was maintained for proper growth and multiplication of earthworms.

Optimum moisture level (50-60 %) and temperature 25-32^{0}C (Sharma, 2009) was maintained for proper functioning of worms. Ants are dangerous enemy of worms, so charcoal powder was mixed to the raw materials to escape from them. Activities of worms were monitored frequently for producing quality produce. All works from production to packaging was done in shade and the products were stored in shade and one kg poly bags or 50 kg poly bags were used for marketing.

Precaution Measures

No sugar, salt, sour, bitter contents material used in Vermicompost bedding to protect worms from aunts, lizard, rats, rabbit, etc. Prevent from birds so cover the bed nicely to retain heat as well as protection from above mention enemies of worms.

Results and Discussion

Under Ladakh condition when temperature variation is too high from -30^{0}C to + 32^{0}C then epizoic species such as *Eisenia foetida* (Red earthworm) perform best for this region. As the mortality rate is too low during harsh winter. Rate of multiplication is 4-5 worms from each cocoon. During summer season the rate of multiplication is too fast than winter season. It's taken normally three and half month in summer season and during winter around eight nine months for proper decomposition. Once it decomposed it perform best at field crop because Ladakh is already having low organic carbon and its boost the quality and fertility of the soil. Data collected from farmer's field and its statistics is depicted in (Table 2) which clearly indicated that benefit and cost ratio is 1:2.36 which is profitable enough for farmers.

The success of any production system basically depend on need, availability of inputs and marketing channels by which one can get the remunerative price by using locally available resources. The key to the success of organic farming system is the production of all inputs like, manures, plant protection etc., and on-farm utilizing the local resources wherein animal husbandry plays a catalytic role. The study on economics of vermicompost production indicated that it is 50-57% economical enterprise as compared to costly chemical fertilizers.

Direct marketing of vermicompost from producer to consumer was found to be strongest marketing channel, however marketing through cooperatives and trader was also found in few instances. Economics of vermicompost production was carried out in Coorg district of southern Karnataka, India to compare benefit cost ratio and observed 1.78 and 1.52 for wet method and heap method, respectively (Reddy *et al.,* 2009). Specialized market for vermicompost was not observed in the study area but obvious that about 85 % Vermicompost was marketed directly from producers to local consumers. It is essential to clearly define a national policy on organic farming by supporting private sector groups, NGOs or associations, and encouraging farmers to produce their own fertilizer in respective country (Ranaivoarisoa *et al.,* 2016).

By this case study it can be concluded that Latsal Lukhar Tsogspa SHG in Summoor Nubra, 14th ladies group started Vermicompost and set an example for the village, beside that started using Vermicompost in their farm mean time they started sailing in Hotels and Guest houses of Nubra itself. First time they harvest around 3600 kgs in 4 month and solded at the rate of Rs 35 /kg and earn 126000 rupees, in entire year SHG earned Rs 252000.

Table.1 Carbon to nitrogen ratios in various materials

Various material	C:N Ratio
Cow manure	20:1
Vegetable waste	20:1
Grass clippings	12 to 25:1
Tree leave	30 to 80:1
Straw	40 to 100:1
Wood	700:1
Poultry	13 to 18:1
Saw dust	200 to 500:1

Source: Dr. Chris Starbuck "Processes in Compost Making"

Table.2 Cost: Benefit ratio of Vermicompost

Cost of Vermicompost production per bag in 4 month (Rs.	Gross Income(Rs) per year	Net Income(Rs) Per bag	B.C. Ratio	Total 3 unit cement structure 30x 8ft produces 900kg/unit, 2 unit of vermin bag(4'x4'x2') produces 450kg/unit ,total compost produced-7200kg, sale per year of vermicompost@35/Kg
106500	252000	145500	1:2.36	

Figure.1

Ladies are very happy with this technology and decided to sail worms @ 300 per Kg. Beside that they encouraging interested farmers/ farm woman to prepare this multifunctional quality product on their own farms so that farming community can be benefitted.

Data collected from SHG's field indicated that benefit and cost ratio (1:2.36) is significantly higher and can boost-up women economy which is today's essential need. Meantime it also help women towards self empowerment in this remote areas with the help of NABARD and SKUAST-K Leh which played significant role to uplift the socio economic status of all farmers of Ladakh and boost organic farming which is the main mandate of nation.

Author Contributions

Jigmet Yangchani: Investigation, formal analysis, writing—original draft.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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