Developing the Capacity and Improving Access of Small-scale Farmers to Low Cost Artificial Substrate Mushroom Cultivation in South-Eastern Nigeria

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Abstract

Low cost artificial substrate mushroom production and marketing hold some potential to create wealth and reduce poverty among small-scale farmers as well as improve nutritional status of households' members. It offers a way to mitigate the effects of climate change on availability of endangered forest species like mushroom. The study is a capacity building mentorship to acquire and disseminate low cost artificial substrate mushroom cultivation in South Eastern Nigeria. The innovation acquired included major steps of low cost mushroom production such as: mushroom house construction, art of making a composted substrate, pasteurization, spawn maintenance, spawn production procedure, spawning, substrate supplementation, casing to trigger reproductive stage, watering or irrigation, monitoring the pinning processes to harvesting, harvesting and sorting and marketing. The up-scaling process involved selection and training of personnel who will continue to transfer the innovations to their clientele and students as well as training of selected students. Instruction manual was developed to ease the imparting of the technology to trainees. Workshops have been conducted to create more awareness and facilitate adoption and consumption of cultivated mushroom. Post-training evaluation included not only questions and answers but working on a small project to raise mushroom under supervision of the instructor who provided the material for the exercise. Results showed that the capacity building project was successful because the trainees subdivided into groups were able to raise mushroom. The experience showed that farmers are happy with the innovation. The paper opined among others that government and non-governmental agencies should invest in capacity building in mushroom cultivation and production to create jobs and improve households' nutrition.

1. Introduction

Mushroom production has now become popular all over the world. It has been described as the most versatile and prolific agricultural venture all over the world (Ikeji, 2010). The total world production of mushroom rose from 4.9 metric tons in 1994 to 7 million metric tons valued at $30 billion in 1997, a phenomenal rise from the 350 metric tons produced in 1965 (Chang, 1999; Ikeji, 2010). In Nigerian, mushrooms are widely consumed. Akpaja et al. (2005) documented that, over ninety percent of the populace consume mushrooms as food, while 22% use some mushrooms for medicinal purposes in southern Nigeria.

Mushrooms contain many essential amino acids and are thus good sources of protein. Mushrooms also contain some unsaturated fatty acids, provide several of the B vitamins, and vitamin D as well as the minerals potassium, phosphorus, calcium, and magnesium (FAO, 2000; FIIRO, 2009). Increased recognition of the nutritional value of many species, coupled with the income generating potential of mushrooms has generated desirable interest in the artificial cultivation of mushrooms. Commercial production of edible mushrooms is also growing because of its potential contribution to economic growth and as a source of cheap protein (Onuoha, 2007). There are hundreds of identified species of fungi which have made a significant global contribution to human food and medicine (FAO, 2000).

1.1 Problem statement

Rising temperature and deforestation is reducing forest cover which threatens the natural habitat of mushroom with consequential impact on mushroom production which is contributing immensely to the welfare of Nigerians (Idowu, 2004; Kimiywe, 2009; Nnamani, et al., 2009). Increasing temperature has not favored mushroom production because they grow in temperatures less than 29oC (Mushworld, 2004).

Efforts to scale up the cultivation of mushroom in Nigeria have been limited capacity of farmers to adopt innovation. Another impediment to mushroom production is the lack of a reliable source of spawn, which is very sensitive to temperature changes, prolonged exposure to sunlight and contamination. Much is unknown about the growth requirements of indigenous mushrooms to facilitate their cultivation on a commercial scale (Gbolagade, et al, 2006).

1.2 Justification

Low cost artificial substrate mushroom cultivation is emerging as profitable venture with the prospects of contributing to poverty alleviation in Nigeria (Idowu, 2004; Kimiywe, 2009; Nnamani et al, 2009). It has been noted that a standard small scale mushroom enterprise would cost about N400, 000 to establish. It will provide an annual income of about N250, 000 per annum. The rate of return is between 60% and 100% (Allafrica, 2008). Low cost artificial substrate mushroom cultivation offers the opportunity to grow mushrooms at homestead with low cost inputs, instead of searching and collecting mushrooms from forest. With some training and technical assistance, mushroom can be produced in commercial quantities in Nigeria.

1.3 Objectives

This project aims at developing capacity and improving access of small-scale farmers to low cost artificial substrate mushroom cultivation and marketing techniques in Nigeria through effective innovation transfer. Above all, the project will give small-scale farmers a leeway to cope with effects of deforestation and climate change with respect to sustainable mushroom supply.

The specific objectives;

i. Outline the process of low cost artificial substrate mushroom cultivation for incubation.
ii. Assess the social-economic status of selected trainees for artificial substrate mushroom cultivation technology training
iii. Identify constraints or challenges envisaged in the cultivation of mushrooms
iv. Develop and deploy an effective strategy for up scaling the technology.

2. Literature Review

2.1: Edible mushrooms and their uses

Mushrooms belong to the genus fungi. Mushroom has been widely cultivated since the 1700's and presently more than 30 known species are cultivated as foods. In Nigeria, mushrooms are usually collected in the wild during the early periods of the rainy season. It is a practice mainly engaging women and children. Such mushrooms are used as meat substitute, sold fresh in local markets, or dried for use during the dry seasons when meat becomes very scarce.

Twelve mushroom species are commonly grown for food and/or medicinal purposes, across tropical and temperate zones, including the Common mushroom (Agaricus), Shiitake (Lentinus), Oyster (Pleurotus), Straw (Volvariella), Lion's Head (Hericium), Ear (Auricularis), Ganoderma (Reishi), Maitake (Grifola frondosa), Winter (Flammulina), White jelly (Tremella), Nameko (Pholiota), and Shaggy Mane mushrooms (Coprinus). International mushroom markets are dominated by Agaricus bisporus, Lentinula edodes and Pleurotus spp, which represent three quarters of mushrooms cultivated globally (FAO, 2000).

Pleurotus tuberregium (Fr.) Sing is a common mushroom in the southern part of Nigeria and forms large spherical to ovoid, subterranean sclerotia which sometimes measure up to 30 cm in diameter (Oso, 1975). Found in tropical and subtropical regions of the world, P. tuberregium is the only species of Pleurotus that produces true sclerotium (Oso, 1975; Isikhuemhen et al., 2000; Isikhuemhen and LeBauer, 2004; Olufokunbi and Chiejina, 2010). The fungus infects dry wood, where it produces the sclerotium, usually buried within the wood tissues but also found between the wood and the bark. Both the sclerotium and the mushrooms are eaten in Nigeria. One of the most common dietary applications of P. tuberregium in Nigeria is as a soup thickener. The white tissue is blended into fine powder and when added to soup, it swells and adds bulk to the soup (Iwuagwu and Onyekweli, 2002).

Sclerotia are used in various soup and medicinal preparations both for human consumption and in traditional medical practice in Nigeria (Zoberi, 1973; Oso, 1975; Stamets, 2001; Chen and Huang, 2004; Okungbowa, 2005). African herbalists have used P. tuberregium sclerotia to solve a variety of health problems, ranging from skin diseases, inflammation, childhood malnutrition, headache, stomach problem, cold, asthma, fever, high blood pressure, diabetes to small pox and even in embalmment of bodies (Oso, 1977; Okhuoya et. al., 1998; Chen & Huang, 2004). Badalyan et al., (2008) reported that the antifungal activity of P. tuberregium against filamentous fungi is utilized in treating mycoses in mammals. The sclerotia can also be cut into pieces and buried in the soil, and then watered regularly to produce the sporophore (mushroom) which is consumed. Sclerotia give rise to fruiting bodies in most environments at high temperatures.

2.2 Mushroom Cultivation

Several discussions and publications have been made on process of mushroom cultivation. Mkpado and Onuoha (2008) opined that the process includes:

a) Selection of a suitable substrate such as wood logs or fiber from processed palm fruits, maize cobs, maize husks or saw dust,

b) Allow the substrate to ferment; subsequently pasteurize it
c) Sterilize the substrate; sterilization can be done by suspending the substrates in jute bags above drums of water such that only steam from the boiling water can sterilize the substrate
d) Steaming can last for 3-6 hours, and then allow to cool with enough ventilation and little light. However, some mushrooms prefer the dark with no ventilation for colonization of the mycelia.
e) The cooled substrate is introduced into the room and the desired mushroom spores are introduced on the substrates.
f) Water regularly to sustain the growth of inoculated materials harvesting can last up to six weeks
g) Harvested mushroom is better packed in paper, which absorbs water and allows air to pass through. 1-1.5kg of mushroom can be packed in a box/basket which allows ventilation.

Chiejina and Olufokunbi, (2010) investigated the effects of seven substrates for the cultivation, yield and protein content of Pleurotus tuberregium (Fries) using a complete randomized design (CRD) of 7 treatments and 10 replicates. The highest fresh weight yield was obtained from mushrooms grown in river sand and sawdust mixture (T6) while the least was from those grown in top soil mixed with sawdust (T4). Oil palm fruit fibre substrate (T3) produced no fruit bodies at all. Protein analysis of the mushrooms revealed that those grown in river sand alone (T1) had the highest protein content while fruit bodies harvested from sawdust substrate alone (T2) had the least protein content. They, therefore recommended river sand plus sawdust substrate (T6) as the best substrate for the production of P. tuberregium in view of the fact that it produced the highest fruit body weight and its protein content was not significantly lower than that of river sand alone (T2).

Cultivation of the mushroom on different nitrogen sources namely, lima bean extract, soya bean (Glycine max) and vigna species (brown beans) showed that soya bean (Glycine max) gave the highest mycelia yield while lima bean gave the lowest yield. Optimum mycelia yield was also achieved at pH 6.5. This study shows that given the right substrate and optimal environmental conditions, oyster mushroom can be mass-produced to meet the nutritional requirement of the Nigerian populace.

Okhuoya and Okogbo (1990) attempted to cultivate mushroom (Pleurotus tuber-regium) on various farm wastes. They noted that mushroom cultivation was still in its infancy in Nigeria, and many species that might be cultivated for food are known only in the wild state. Sclerotia used for this study were obtained from logs in the savanna area of Ekpoma in the Okpebho Local Government Area of Bendel State of Nigeria. They were taken to the laboratory and stored for 4-5 days at room temperature before use. The following waste products were used: cassava (Manihot sp.) peelings collected fresh from a cassava mill, corn (Zea sp.) straw collected from the University of Benin farm, oil palm fruit fiber from the oil mill of the Nigerian Institute for Oil Palm Research (NIFOR) near Benin City, rice (Oryza sp.) straw from a private farm in Benin and wild grass (Pennisetum sp.) collected after land preparation from the University farm. The cassava and yam peelings were sun-dried for 10 days and crushed to coarse sizes (3cm) with a mortar and pestle. Corn, rice, and wild grass straws were separately cut into small pieces (3cm) and the large cylinders of straw were split into 3-4 slices.

Oil palm fruit fibers were also sun-dried for 10 days before use. The substrates were separately bulked and treated with 5% bleach (v/v) with a moisture content maintained at 70%. Two hundred grams of each of the substrates were loaded into plastic trays (30 trays), 60cm x 60cm x 15cm. Controls were trays filled with 200g of white river sand. Each tray was seeded with 50 g of fresh sclerotia, at three different equidistant points on the tray. Trays (uncovered) were then placed in a greenhouse (25 ± 3 °C) for observation of fungal growth.

Their spawn trial result showed that oil palm fruit fiber supported extensive growth and was tested as a spawning material. The spawn was prepared by stuffing three polyethylene bags (75cm x 60cm) with oil palm fruit fiber treated with 5% bleach (v/v) and inoculated with sclerotial pieces (25g each), 10 of such bag, was incubated at room temperature. After 20 days, extensive and compact mycelium (mushroom “seed”) had developed on the oil palm fruit fiber. The bags were opened, and the mushroom seed were divided into 15-g portions and used to inoculate the different substrates. Fifteen days after “seeding,” 10 trays cased with garden top soil. Fresh mushroom yield per tray was recorded 20 days after casing. Each tray was watered once per day with 40 ml of sterile distilled water.

Higher yields were produced on substrates inoculated with sclerotia than for those inoculated with spawn. Sclerotia grow directly into sporophores and mycelium. This is not the case with spawn, which has to develop extensive mycelium before fruiting, and the more the mycelium developed, the greater the yield. Hence, the better developed mycelium on oil palm fruit fiber supported the highest sporophore production. Although the substrates were not analyzed for nutrients, the extensive mycelial development on oil palm fiber indicates that it is a rich medium for the growth of the mushroom. Higher yields were recorded on substrates cased than those without casing. This was best illustrated with oil palm fiber spawn- treatments, which produced mainly vegetative mycelia with little or no yield from uncased substrates.

Onuoha’s (2007) work on cultivation of the mushroom involved the use of substrates such as: Sawdust = T0, Topsoil = T1, Poultry droppings and topsoil = T2, Sawdust and topsoil = T3, Poultry dropping = T4. The fruit bodies produced on topsoil were comparatively higher than the mean height of those produced on sawdust, (T0) and a mixture of sawdust and topsoil (T3). The study observed a significant difference between the height of the fruit bodies produced on a mixture of sawdust and topsoil (T3) and sawdust (T0) at 0.05%. The study concluded that the fruit bodies produced on topsoil (T1) and a mixture of topsoil and poultry droppings (T2) had higher dry weight than those produced on sawdust and a mixture of sawdust and topsoil. There was significant difference between the dry weights of the fruit bodies produced on all the substrates. Though there was a significant difference between the mean fresh weight of fruit bodies produced on all the substrates, those produced on the mixture of topsoil and poultry dropping weighed higher than the mean weight of those produced on the other substrates, while the use of poultry dropping alone gave the poorest result.

2.3 Enabling Conditions for Low Cost Mushroom Cultivation

According to Aroye et al, (2005), prevailing climatic condition in Nigeria (apparently before the advent of climate change and high deforestation,) favors the natural growth of mushrooms. In the southern part of Nigeria, the rainfall was high, and this region was predominantly covered by the rainforest ecosystem that made it favorable for mushrooms to thrive. Gbolagade et al., (2006) noted that environmental factors count in mushroom cultivation. In South-western Nigeria, mushroom grows naturally during the early and late raining season (April–June and September–November). The fruit bodies of P. florida develop in large number as a group or turfs on fallen tree logs and at the base of dead wood or poles. The pileus (cap) ranges from 1.5 to 8.5cm in diameter while the stipe (stem) is very short and ranges from 0.1-0.5cm in length. This mushroom, which possesses a weak odour of edible mushroom lack annulus and spore print, is creamy white.

Mushrooms are best cultivated indoors in a dark, cool and sterilized and enclosed building. This enables the growing conditions to be maintained most suitable for mushrooms, in terms of temperature, humidity, uniform ventilation and substrate moisture levels. Unwanted contaminants, moulds and sunlight can also be kept away from the crop. Any small room with ventilation and a cement floor can be used, and it should be possible to close off the room to the outside by shutting ventilation and doors. The interior should be arranged so that it is easy to clean at the end of each cropping cycle. The mushroom house should be well insulated (by using, for example, fiber glass wool or expanded polystyrene) to maintain a steady temperature, and concrete or clay tiles are preferable over corrugated metal for roofing.

Many of the facilities required for mushroom cultivation are not exclusive items, but rather assets which help meet livelihood needs in general, including transport and communication infrastructure, clean water, a source of energy, and buildings for shelter and storage. For instance, energy is required to refrigerate mushroom spores. The more developed the infrastructure, the easier it is to establish and undertake mushroom cultivation. Transportation is of importance when market mushroom products outside due to their perishable nature.

3. Methodology

3.1 Methods

The criterion for the selection was guided by the need to have many trainees and develop plans for its up-scaling and sustainability. The selection of trainees included the students and farmers as well as other instructors who will continue to impact the knowledge to others. The students were mainly selected from the Faculty of Agriculture. Selection was based on their motivation and contents of application they submitted in line with achieving the objectives of the project. Farmers and instructors were selected from the Agricultural Development Projects (ADP). The Centre for Entrepreneurship and Development Research (CEDR) nominated five instructors who will continue to impact the knowledge to its students. Five ADP staffs were selected for the training of trainers programme.

Table 1: Distribution of selected trainees from the various participating institutions

	Number of trainees
Faculty of Agriculture	24
ADP	21
CEDR	8
Total	53

Source: Survey, 2011

Information was sought from trainees on demographic and socioeconomic characteristics such as sex, age, marital status and occupation as well as knowledge of mushroom cultivation. Structured questionnaires were distributed among selected trainees. The questionnaires contained questions with available options and also open-ended questions requiring participants to supply the answers. Oral Interview was also used to elicit responses from the trainees. Data collected was analyzed using descriptive statistics.

Following the workshops, the trainees were regrouped into 3 categories namely (A) the subject matter specialists of ADP and their contact farmers, (B) the 4th year students and their supervisor and (C) the other lecturers/instructors in the faculty of agriculture and CEDR. The mentors provided materials for running pilot mushroom farms. Groups (A) and (B) prepared and monitored the experiments for mushroom cultivation under the supervision of the mentors; while group (C) had access to the experiments to further enrich their knowledge.

4. Results and Discussion

Through an internship program at the National Biotechnology Development Agency, the project outlines some processes involved in the cultivation on mushrooms. The small scale farmers and other trainees were taken through this process to equip themselves with the requisite skills for low cost artificial substrate mushroom cultivation in South-Eastern Nigeria.

The process of low cost artificial substrate mushroom cultivation includes:

- Low cost housing for artificial mushroom cultivation, ventilation requirements and improvising of dark room equipment: a small hut roofed with local mat or thatch/grasses, netted with wire gauze, wooden cardboard and black cellophane.
- Making a substrate: Many agricultural by-products/wastes such as rice bran, maize leaves, shredded cobs, saw dust, banana leaves wheat straw and palm kernel cake or palm fibers are used to make mushroom substrate. Water is used to moisten the mixture selected and stirred. Nitrogen supplements and gypsum can be added to enrich the substrate mixture and thoroughly mixed in a mixer or a clean big basin (use maize cob, saw dust, palm kernel cake and lime in the ratio of 5:3:2:1). Put small parts of the mixture in colorless cellophane, you may allow it to ferment for about 2 weeks.
- Sterilization: use big pot or drum, use big stones to prepare tripod stand, place drum or pot on it, put small tripod stand in the pot, add enough water, use hard material to suspend the material in cellophane on the small tripod stand, heat the pot such that only steam touch the material in cellophane for 6-8 hours, after 2 days put the substrate in plastic containers and compress, then spawn.
- Spawning: This is the process of introducing the spawn on prepared medium for growth. It can be by broadcasting over the surface of the substrate in containers which are firmed by compacting. This compacting helps to reduce the air in the substrate and enable incubation of the spawn.
- Spawn Maintenance: The desired mycelial culture should be pure and free from contaminants. Contaminants include dirty water, other fungi, bacteria, or insects growing on or infesting the culture media along with the desired mycelial culture. Spawn must be procured from reliable sources such as research institutes avoid open market trading on spawn. Storage is usually by refrigeration.
- Spawn production procedure: Small pieces of pure-culture mycelium are placed in small batches on the choice grain- wheat, ‘Cajanus cajan’, millet or sorghum. The choice grain is prepared by soaking for 2 days, air drying for about 24-29 hours and autoclave for 24 hours along with the small container with cover for storing the spawn. Put the spawn into the container and cover it. Once the small batch is fully colonized, it is used to inoculate several larger batches/portions of grain. This multiplying of the inoculated grain continues until the commercial-size containers—usually plastic bags with breathable filter patches—are inoculated. During the colonization of each batch, the containers are shaken every few days to distribute actively growing mycelia around the bag or bottle. During the process, temperatures are maintained at 74 ºF –76ºF (23 ºC –24ºC).
- Casing to trigger reproductive stage: Casing is the method of forcing mushroom mycelia to change from the vegetative phase to a reproductive state. This can be achieved by applying a cover of a suitable material on the mycelia growth.
- In watering or irrigation care must be exercised to avoid water logging the substrate.
- Monitoring the pinning processes to harvesting: Mushroom rhizomorph grows and expand into structures called primordial or pins. The pins grow larger through a pre-

button stage and enlarge to mature mushrooms. Harvesting begins 17–24 days after casing, which is normally 15–20 days after flushing and 8–9 weeks after broadcasting.

- Harvesting and sorting: Mushrooms are harvested over a 2–3 or 4 day. Mushroom is harvested when its fruits have developed into a well blown cone. Harvesting of mushroom is by hand picking, care must be exercised to harvest the mushroom cap with its stem and some root. The harvested mushrooms are cleaned and kept in cartons or baskets. They are sorted according to sizes and weighed for sale.

4.1 Demographic and socio-economic characteristics of trainees

Overall, 53 people ranging from students to small scale farmers were trained on the process of establishing low cost artificial substrate mushroom farms. The composition of the group entailed 67.9% of males while females accounted for 32.1% which was fairly a good gender representation (Table 2). Generally, the majority of the trainees were in their productive period within the age range of 21-50 years, with less than 6 percent in their 60's.

Table 2: Gender and age group of selected trainees

Sex	Frequency	Percent
Male	36	67.9
Female	17	32.1
Total	53	100.0
Age		
21-30	24	45.3
31-40	4	7.5
41-50	13	24.5
51-60	9	17.0
Greater than 60	9	5.7
Total	53	100.0

Source: Survey, 2011

Among this group, only about 2 percent of the trainees did not possess first school leaving certificate (FSLC). Majority of the trainees possessed West African senior school certificate provide a decent level of ability to understand and apply the techniques to be acquired from the training. Some trainees had very high educational qualification which provides the ability to act as instructors and subject master specialist to further train other students and clientele in mushroom cultivation. This particular group forms the pillar for up-scaling and sustainability of the project (Tables 3).

Table 3: Educational qualifications of selected trainees

Educational level	Frequency	Percentage (%)
No primary school certificate (no FSLC)	1	1.9
First School leaving Certificate (FSLC)	5	9.4
West African Senior School Certificate Examination, (WASSCE) / General Certificate of Education (GCE)	22	41.5
Ordinary National Diploma (OND) /	3	
National Certificate of Education (NCE)		5.7
Higher National Diploma (HND)	1	1.9
Bachelor of Science (BSc) / Bachelor of Agriculture (B. Agric)	13	24.5
Master of Science (MSc)	5	9.4
Doctor of Philosophy (PhD)	3	5.7
Total	**53**	**100.0**

Source: Survey, 2011

With the exception of the students, most of the trainees were engaged in public services or farming. Other secondary activities include honey production, trading, poultry keeping and hair dressing. Mushroom cultivation was a new venture to all the trainees. Table 4 and 5 entail the various occupational activities of trainees.

Table 4: Primary occupation of trainees

Occupation	Frequency	Percentage (%)
Student	22	41.5
Civil /public servant	15	28.3
Farming only	14	26.4
Total	51	96.2

Source: Survey, 2011

Table 5: Secondary occupation of trainees

Secondary occupation	Frequency	Percentage (%)
None	11	20.8
Honey production	2	3.8
Trading	13	24.5
Poultry keeping	8	15.1

Hair dressing	1	1.9
Crop farming	18	34.0
Total	53	100.0

Source: survey 2011

Constraints/ Challenges in Mushroom Cultivation

The trainees through the experience with the process of mushroom cultivation enumerated some challenges envisaged in the cultivation and production of mushrooms. These included: cultural barriers, lack of skills/technical know-how, capital constraints and marketing problems (See Table 6).

Table 6: Trainees response on constraints envisaged in mushroom cultivation

Constraints	Frequency	Percentage
It is not cultural	14	26.4
No skill	27	50.9
low capital	5	9.4
Marketing risk/acceptance	7	13.2
Total	53	100.0

Source: survey 2011

Issues related to culture and practice

Culturally, there is an existing practice of mushroom collection from the forest. This collection is seasonal with collection of different mushrooms at particular season. About 26 percent of the trainees viewed the homestead mushroom cultivation as un-cultural. Many development processes are not cultural. However, the important thing is explaining why the change is necessary. The change is necessary because it will lead to saving of time, increased access to mushroom and creation of wealth. The practice of mushroom collection from the forest is time consuming as people wonder in the forest from morning to evening in search of mushroom. Dangers associated with such search include snake bit, sustaining wounds from the forest and lately little 'catch' as forest resources resources are getting depleted as s result alternation of environment due to climate change. The low cost mushroom production can be managed as enterprises which will generate income and ensure steady supply of mushroom.

Lack of skills-technical know-how

Over 50 percent of trainees reported that lack of Technical knowhow for cultivation of mushroom is a major challenge in mushroom cultivation

Capital constraints

Interestingly, only 9.4 percent were of the view that lack of capital constitutes their major challenge. Financial constraints can be compounded if there is no substitute for the materials to be purchased. But in low cost artificial mushroom cultivation, farmers can use local substitutes generated from their farm, thus reducing the effects of cost of production.

Market (demand) and social acceptance of cultivated mushroom

Marketing and acceptance of cultivated mushroom is a serious issue due to the fact that some mushrooms are poisonous and the cultivation process is exotic.

Plans for up-scaling the innovation

Figure 1 is an illustration of the model adopted for up-scaling of the innovation. Effectively, such model of innovation/technology transfer allows the coordinating institution to continuously seek collaborations for continuous up-scaling of the innovation. It allows for at least two way communications among the coordinating institution and other stake holders.

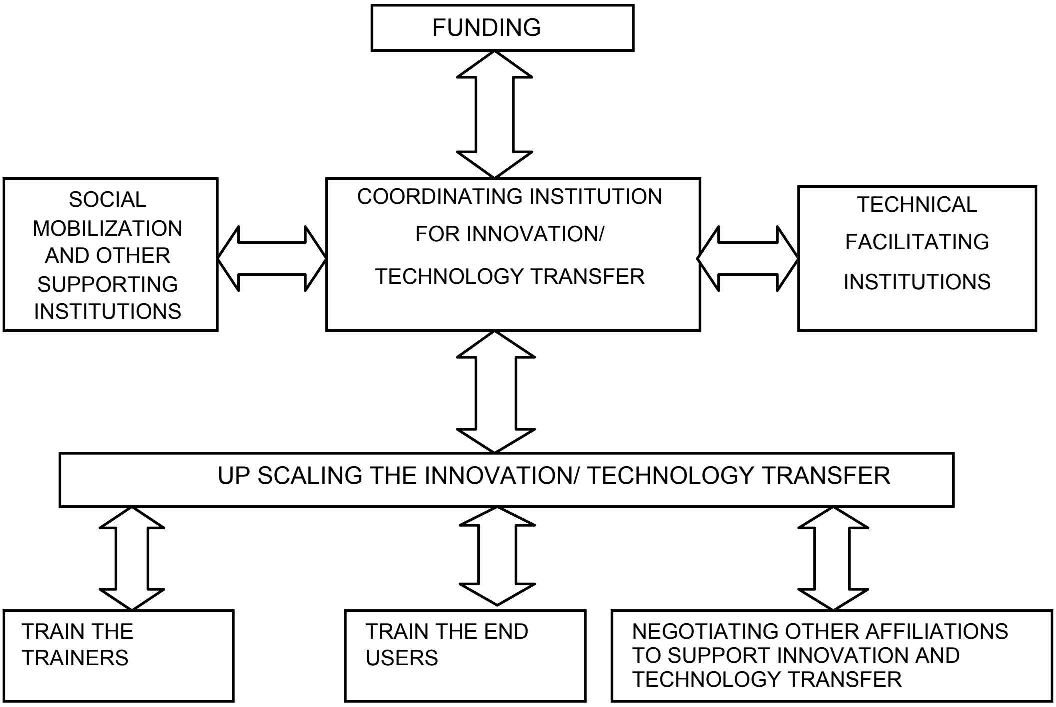

Figure 1: Model for Effective strategy for up scaling innovation/technology transfer (Source: Adapted from Eboh et al., 1995)

The training was successful owing to enthusiasm and commitment of the trainees. The 3 groups namely (A) the subject matter specialists of ADP and their contact farmers, (B) the 4th year students and their supervisor and (C) the other lecturers/instructors in the faculty of agriculture and CEDR recorded successes in their experiments. The groups were encouraged to engage in the cultivation of mushroom and to seek assistance of the mentors whose phone number and contact addresses were given to all. Some of the student trainees were examining the possibility of engaging in an aspect of mushroom cultivation as their final year project. It was expected that before the end of October, the 2nd phase of the capacity building would have been completed. This include empowering the students who want to cultivate mushroom in their final year project and supply of inoculum material to ADP, and the selected contact farmers to continue the adoption as well as engagement of other stake holders such as policy makers and journalist.

5. Conclusion and Recommendations

The capacity building programme help to improve awareness and cultivation of edible mushroom which currently is limited in Africa and in its early stage in Nigeria. It has been reported that edible mushrooms are highly nutritious than egg, milk and meat. Mushroom is imported into Nigeria but with some training and technical assistance of the locals, it can be produced in commercial quantity in Nigeria. Low cost artificial substrate mushroom cultivation can help reduce vulnerability to poverty and strengthen livelihoods through the generation of a fast yielding and nutritious source of food and a reliable source of income amidst environmental challenges posed by climate change. Since it does not require much access to land, mushroom cultivation is a viable and attractive activity for both rural farmers and peri-urban dwellers. Small-scale mushroom growing does not require any significant capital investment; mushroom substrate can be prepared from certain common and clean agricultural waste. Constraints to artificial substrate mushroom cultivation include low awareness, cultural beliefs, fear of food poisoning and financial constraints besides technical know-how and poor infrastructure. These constraints in the area of the study were handled by organizing a workshop to sensitize the people with facts about the technology and trend in global mushroom production, consumption and marketing/trade in which Nigeria is an importer.

It is recommended that the media should feature mushroom cultivation as a lucrative business to create more awareness on artificial substrate mushroom cultivation and government and non-government should invest in this capacity building exercise to create jobs and improve households' nutrition. Efforts should be intensified by governments and non-government organization to provide enabling environment for mushroom cultivation. Such enabling environment includes good road network, electricity and refrigerators as well as proper funding of research institutions. In-service training can be extended to a number of researchers to acquire the skills of cultivating mushroom.

Local mushroom producers should effectively collaborate with prospective buyers in their locality during their planting to make arrangement for marketing and sales. Such include hotels and fast food centers. They can also take advantage of markets beside major road networks where they can find many different individuals who can purchase the mushroom. Public centers such as the church, hospitals, and local government headquarters can serve as good markets for mushroom, because of the variety of people they can reach. The use of well known edible mushroom and use of substrates from edible materials will help to remove the fear of food poising through mushroom cultivation.

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