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Examining How Growing Conditions Management Affects Oyster Mushroom Performance among Smallholder Farmers: A Case Study in Mumias Division, Mumias Sub-County, Kenya.

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ABSTRACT

The economic significance of mushroom cultivation cannot be overstated, contributing to revenue generation and possessing notable nutritional and medicinal attributes. However, global production has been suboptimal, registering only 3,414,392 tons in 2007 with an annual growth rate of 5.6%. Particularly, mushroom production in Africa remains minimal, with Kenya demonstrating a lackluster performance, producing a mere 500 tons annually and relying on imports (150 tons) to meet domestic demand. This low output in a country rich in agricultural waste resources raises concerns. The study addresses the inadequately researched aspects of mushroom cultivation, focusing on critical factors such as growing houses, substrates, pests, temperatures, and relative humidity. The central research question probes the impact of growing condition management on the performance of smallholder mushroom farmers. The study draws on the Resource-Based Theory and employs a conceptual framework to guide the research. Employing a descriptive research design, the study encompasses a population of 300, with a sample size of 30 respondents selected through simple random sampling. Questionnaires were administered for data collection, and the analysis was conducted using the Statistics Package for Social Science (SPSS version 12). Key findings include the revelation that 90% of mushroom growers possess adequately ventilated growing houses, but none have a thermometer or radiometer. Additionally, 43.3% of growers utilize a mix of substrates, while 93.3% are aware of the prevalence of pests and diseases. The study concludes that effective management of mushroom growing conditions significantly impacts the performance of oyster mushrooms. In light of these findings, the study recommends further research on mushrooms, an increase in agricultural extension services, and the establishment of a Mushroom Training Institute. The insights derived from this research are anticipated to benefit policymakers, academicians, scholars, and mushroom growers alike.

Keywords: Mushrooms, production, substrates, mushroom growing house, pests and diseases

INTRODUCTION

Mushroom enterprise can play a big role in economic development of a country in revenue generation and contribution towards wellness of the citizens. The fungiculture which involves mushrooms cultivation is a global practice. For many years mushrooms were considered as vegetables, but now have been classified under fungi kingdom [1]. There are a lot of species of fungi in the world, estimated at 1.5 million, however, researchers have managed to describe about 64,000 species and 10,000 are capable of producing mushroom [2]. Among the 10,000 species known, 300 are edible and 30 have been domesticated [3]. The worldwide mushroom production has not been impressive. In 1997, global production was 2,186,222 metric tons and increased to 3,414,392 metric tons in 2007 [4]. Therefore 1,228,170 metric tons, is seen as an increase in production for over ten years, implying that production per year has been on average 5.6%. Further scenario in production, in 1961, mushroom production was 0.30 million metric tons and in 2010 was 3.41 million metric tons [5].The efforts to increase mushroom production without solving its growing conditions would be counter-productive. Stan Hughe seems to be

mystified by mushroom growers in that they put a lot of effort into production and little is available for sale. The mushroom production in Africa is dismally low compared to other countries engaged in mushroom industry globally [6]. The continent is heavily endowed with abundance of agricultural wastes, a source of substrates (Table 1).

Table1.Estimated production Oyster Mushroom (Fresh)

Country	Production(1000 Ibs)	%
China	1675496	86.8
Japan	29321	1.5
Rest of Asia	194887	10.1
North America	3307	0.2
Latin America	441	-
EU	13668	0.7
Rest of Europe	12787	0.7
Africa	441	-
Total	1,930,348	100.0

Source. [6]

Kenya has a challenge of achieving income growth particularly in rural economy where more people are domiciled and also the whole economy [7]. The country has high potential of mushroom production. The two commercialized types of mushrooms, Button (*Agaricus bisporus)* and Oyster (*Pleurotus ostreatus*) have not posted any significant impact in terms of yield performance, therefore portrays similar situation like global scenario where production is low. The production on average is 500 metric tons per year and imports is on average 150 metric tons annually [8]. The report of [9] portrays a gloom situation in that production status in 2017 was 484.5 metric tons against consumption demand of 1200 metric tons giving a wide shortage variance of about 715.5 metric tons .Button production accounts for 95%(476 tons) of the total production and Oyster contributes 5%(24 tons).The implication on mushroom is that consumption demand outstrips production or supply of mushroom.

[10], in their research reported that 80% of mushroom producers grow Oyster mushroom *(Pleurotus ostreatus*) while 20% grows Button (*Agaricus bisporus*). This implies that all farmers (80%) combined produce only 5% (24 metric tons) of Oyster while 20% for Button produce 476 metric tons. Inspite of the potential mushroom has to accelerate the economy of Kenya, minimal or little reasearch has been conducted on mushroom to provide adequate information about production [10]. The decreasing arable land in Kenya require entrepreneurial approach to economy development which may require less land, therefore mushroom enterprise then becomes an opportunity of choice.

Problem statement

The management of mushroom growing conditions is paramount given that to large extent can determine the yield performance which is the component needed most in food security of a country. Apart from contribution towards healthful food, it has therapeutic benefits. The global sustainable development goals toward 2030, particularly goal number two: Zero hunger to large extent depends on innovative initiatives such as mushroom enterprise [11]. The aim of this goal is to have production of food matched with consumption demand so that there is no deficit. The production of mushroom worldwide has been low compared with consumption demand [4]. In Kenya, the situation is similar to global scenario in that production on average is 500 metric tons annually and importation stands at 150 metric tons [8]. The gap seems to have widened in 2017 when production was 484.5 metric tons and consumption demand increased to 1200 metric tons [9]. The concern issues are mushroom growing house environment, substrates, insect pests and diseases which have been inadequately researched. If the situation is left uncontrolled in the long run mushroom industry will collapse, consequently both nutritional and medicinal values shall be lost. Therefore, it is against this background this paper sought to evaluate the impact of management of growing conditions on performance of oyster mushroom for smalholder farmers.

Significance of the study

i)Kenya Government

The study will be beneficial to Kakamega County Government and the rest of fourth-six counties (46) and National Government in the development of policy framework to guide the mushroom industry in the country.

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ii) Fungiculture Community

The mushroom growers will benefit from the research results in order to expand and increase production which will assist in reducing the existing wide gap between production and consumption demand. Local cultivation and expansion of mushroom industry will help reduce food insecurity which is in line with the 2015 global Sustainable Development Goals (SDGs)

iii) Academicians, researchers and scholars

The findings would be helpful to academicians, researchers and scholars who are constantly searching for knowledge. The knowledge created adds to existing literature on management of Oyster growing environment.

Theoretical framework

The foundation of this study is the Resource Based Theory (RBT). The theory was developed by [12]. The theory gives knowledge on how organizations can achieve sustainable competitive advantages (SCA). The resource are means to achieve superior performance and creates competitive advantage. If the organization wants to achieve competitive advantage over the competitors, then resources should be heterogeneity in nature: valuable, rare, imitable and organizational focus [13].

Relevance of the theory.

The smallholder mushroom growers require resources for two major reasons: to grow mushroom in sustainable manner and also be able to develop competitive advantage. The competition could be in the form of the right employees, financial resource, material and equipment resources. The cultivated mushrooms particularly Oyster can grow on wide agricultural wastes as substrates which must undergo pasteurization. Additionally, a mushroom growing house should be constructed from which growing conditions are monitored and evaluated. Therefore, RBT underpins this study and provides guidance on resource selection and utilization.

Conceptual framework

The conceptual framework showing various variables in the study are indicated in figure 1

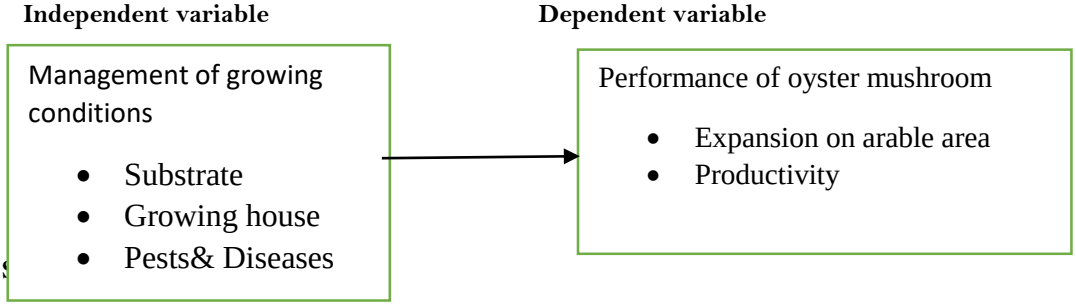

Figure1.Relationship between independent and dependent variables

Literature review

Mushrooms are a good source of nutrients required by human beings for their wellness. Also, they have been identified as therapeutic foods that are helpful in preventing diseases like hypertension, diabetes and cancer [14]. The growing conditions of mushrooms if well managed can spur production which could satisfy local demand and excess left for export market. China seems to be the world leader in mushroom production with 1,568,523 metric tons in 2007 which is threefold from 562,194 metric tons in 1997 [4]. The United States of America (USA) coming on distant 2nd and least is Japan with 67,000 metric tons and there is no mention of Africa (Table 2). The local consumption in China is more than 10kg per person per year which is also impressive [4]. Mushrooms are classified under fungi kingdom [1] and key components to world mushroom industry is edible, medicinal and wild mushrooms [15].

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Table 2. World Production of Mushrooms in metric tons

Countries	1997	2007
China	562,194	1,568,523
USA	366,610	359,630
Netherlands	240,000	240,000
Poland	100,000	160,000
Spain	81,304	140,000
France	173,000	125,000
Italy	57,646	85,900
Ireland	57,800	75,000
Canada	68,020	73,257
UK	107,359	72,000
Japan	74,782	67,000

Source: [4]

The growing mushroom condition in the context of this paper involves growing house environment, suitable substrates, spawn, pests and diseases. [16], refer substrate as an organic material where mycelium of mushrooms can grow. [17] studied various agricultural wastes for Oyster mushroom (*Pleurotus ostreatus*) cultivation in Egypt. The result revealed that mixture of rice straw and wheat straw yielded 7600gm while single rice had 6650gm.Therefore the researchers concluded that the two substrates are the best for oyster mushroom because they produced the highest yields. [18], conducted research on four substrates to evaluate growth and yield performance of oyster mushroom. The result indicated that the highest yield performance was obtained from cotton seed, followed by paper waste and least from sawdust. Four substrates used were cotton seed, paper waste, wheat straw and sawdust. Therefore, recommended cotton seed and paper waste. [19] indicated that beginners in mushroom cultivation prefer Oyster Mushroom (*Pleurotus ostreatus*) because it is easier and inexpensive to grow, can utilize wider agricultural wastes as substrate but [20] singled out sawdust as the best substrate for better yield.

The house should have adequate ventilation [21]. This allows exchange of gases particularly carbon dioxide and oxygen for better growth of mycelium. The ambient temperature should be $18^{O}C$ -$25^{O}C$ while ambient relative humidity should be 55%-85% [22]. Generally desired environmental growing conditions on average, temperature should be $29^{O}C$ and relative humidity at 78.7% [23]. According to [24], the temperature which is considered the best for mushroom growing is $24^{O}C$-$29^{O}C$, while relative humidity should be within the ranges of 90% to 95%. If there are extremes on these two factors in growing house the yield performance will be reduced. [25], mushrooms are often affected by diseases and pests. The diseases consist of fungal, bacterial and viral. They include dry bubble, mildew, green mold, inky cap. Insect pests are mainly nematodes. Study conducted by [14], also identified some diseases and pests such as Dry Bubble, Wet Bubble, Green Mould, False Truffle, Bacterial Blotch, mummy, viral and nematodes. The study recommended a general management approach of sanitation and hygiene.

Research Methodology

This study employed descriptive research design. This type of design helps to describe the state of affairs as they exist [26]. The study population was 300 mushroom farmers and a sample size of 30 (10%) respondents. The simple random sampling technique was used to select the participants [26]. The primary data was collected by use of questionnaire and secondary through documentary analysis and e-internet materials. Reliability test for research instrument was undertaken through test-retest technique using information of 10 respondents during the pilot study. The face validity and content validity were improved by use of research experts. The descriptive statistics with help of Statistics Package for Social Sciences (SPSS) were used to analyze the data and results presented using tables.

RESULTS AND DISCUSSION

Mushroom growing house

The findings showed that all the mushroom growers (30/100%) had constructed mushroom growing house which is the basic requirement for cultivated oyster mushroom. The houses were fairly well ventilated to allow exchange of gases between Carbon dioxide (CO_2) and Oxygen (O_2) for better mushroom growth. The result indicates that 11(36.7%) had good ventilated houses, 16(53.3%) growers their houses had fair ventilation while 3(10%) were poorly ventilated which implies that mushrooms from them were of poor quality. Therefore majority , 27(90%) of

the mushroom growers had houses with sufficient ventilation as required to facilitate better performance of mushrooms (Table 3). This result supports [21], who reported that well-ventilated mushroom houses are suitable for Oyster mushroom.

Table 3. Ventilation status of mushroom house

Ventilation status	Frequency	Percent (%)	Cumulative (%)
Poor	3	10.0	10.0
Fair	16	53.3	63.3
Good	11	36.7	100.0
Total	30	100.0	

Source: Field data,2021

Substrate of mushroom

A substrate is the growing medium of mushroom just like soil is to the plant. The result revealed that 11(36.7%) mushroom growers were using maize stovers as substrate, 6(20%) sugarcane bagasse, 13 (43.3%) mixture of substrates (Table 4). The result contradicts findings of [20], whose finding showed that sawdust was the best substrates which can produce higher yields of oyster mushroom. However, the finding is in agreement with [27], who reported that oyster mushroom can be cultivated on wide range of substrates at times difficult to think about. On pasteurization of the substrates, results showed all the mushroom growers undertake this crucial activity to kill undesirable pathogens and avoid contamination.

Table 4. Types of Substrates

Substrate type	Frequency	Percent (%)	Cumulative (%)
Maize stovers	11	36.7	36.7
Sugarcane bagasse	6	20.0	56.7
Mixture	13	43.3	100.0
Total	30	100.0	

Source: Field data, 2021

Insect pest and diseases

The findings showed that insect pests and diseases were common occurrence, 28(93.3%) although a minority farmer, 2(6.7%) indicated that there was no pest and diseases. This implies that farmers incur a lot of pre-harvest and post-harvest losses due to pests and diseases (Table 5). The study found that the major control measures of insect pests and diseases is the use of cultural practices such as the removal of infected mushrooms. The findings are in conformity with the report of [28], who reported that most of the mushroom growers suffer heavy losses due to insect pests and diseases.

Table 5. Pests and diseases infestation

Pest	Frequency	Percent (%)	Cumulative (%)
Presence of pest& Diseases	28	93.3	93.3
No pest	2	6.7	100.0
Total	30	100.0	

Source: Field data, 2021

Determination of temperature and relative humidity in growing house

The two conditions to large extent determine the performance of oyster mushroom. The findings showed that none of the mushroom growers had scientific instrument to measure temperature and relative humidity. They relied on body feelings when they are in the growing house. The conventional methods in temperature measurement are to use thermometer while relative humidity is by use of radiometer. These results are in disagreement with [29] who reported that temperature should be measured using thermometers if not yields will be affected.

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CONCLUSION

The findings of the study indicate that a significant proportion of mushroom growers possess well-ventilated growing houses. Additionally, a substantial number of farmers opt for a combination of substrates derived from agricultural waste. The prevalence of insect pests and diseases was observed as a common occurrence among the participants. Notably, the study also highlighted a noteworthy gap— the absence of scientific instruments for monitoring temperatures and relative humidity in growing houses. This deficiency could potentially result in increased losses in mushroom yields.

Recommendations

The recommendations from the study included the following:

i) Research on mushroom substrates

Research to be conducted to determine a universal substrate which will act a standard for others to be measured against. Available empirical studies show that many organic materials can be used but fail to give universal substrate. Therefore research institutions should intensive research on this area. This is a suggested further study case.

ii) Agricultural extension service

The services used to assist farmers get farm-based skills, during study period, the services were insufficient due to reduced number of Agricultural Extension Officers. The government should hire more Agricultural Extension Officers who will advise farmers appropriately particularly identification of mushroom pests and diseases and management techniques. General sanitation and hygiene practiced is insufficient. The disease ranges from fungal, bacterial and viral which might require specific techniques of management.

iii) Introduction of scientific instruments in growing house

The cultural methods, body feelings in measuring temperatures and relative humidity may not work in 21st century where each entrepreneur is focusing all activities from economic perspectives and return on investment. Therefore, all the farmers must have both thermometer for measuring temperature and radiometer for measuring relative humidity.

iv) Establishments of mushroom Training Institute

Fungiculture is unique from agriculture, therefore agricultural specialists may not be able to adequately handle or manage it well. Therefore, establishing Mushroom Training Institute (MTI) exclusively for mushrooms will be a great booster to yield performance of Oyster mushroom.

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