International Journal of Agriculture, Environment and Biotechnology
Citation: *IJAEB*: **17**(04): 663-672, December 2024
DOI: 10.30954/0974-1712.04.2024.3

ASSOCIATION FOR AGRICULTURE ENVIRONMENT AND BIOTECHNOLOGY

RESEARCH PAPER

Growth and Yield Characteristics of Three Species of Oyster Mushroom (*Pleurotus* spp.) Treated with Lime

Samuel C. Chukwu[1,2], Emmanuel O. Okporie[1], Ede Peace[1], Emmanuel A. Ude[1], Mohd Y. Rafii[3], Oladosu Yussuff[3] and Kazeem K. Olalekan[4]

[1]Department of Crop Production and Landscape Management, Faculty of Agriculture and Natural Resources Management, Ebonyi State University, PMB 053, Abakaliki, Nigeria

[2]Department of Crop Production and Agricultural Technologies, Faculty of Agriculture, Engineering and Natural Sciences, University of Namibia, PMB 5520 Oshakati, Namibia

[3]Institute of Tropical Agriculture and Food Security, Universiti Putra Malaysia, Serdang, Selangor, Malaysia

[4]Department of Agronomy, Faculty of Agriculture, Osun State University, Osogbo, Nigeria

*Corresponding author: schukwu@unam.na (**ORCID ID:** 0000-0002-8041-8479)

Paper No. 1183 **Received:** 10-09-2024 **Revised:** 03-11-2024 **Accepted:** 24-11-2024

ABSTRACT

The edible mushroom has both nutritional value and health benefits to man. The present study was carried out to evaluate the phenotypic characteristics of three species of mushroom which the substrates were amended with lime. The factorial experiment was conducted at the Crop Development Laboratory of Ebonyi State University Mushroom Farm, Abakaliki. The design was completely randomized (CRD) in three replications. Factor A comprised three species of mushroom (*Pleurotus ostreasus, Pleurotus sajor* and *Pleurotus florida*) while factor B comprised four levels of lime (0, 5, 10 and 15 gram/15kg mixture). Data were collected on some agro-morphological characteristics and analysed for their variances. The three species of mushroom showed significant differences ($p<0.05$) with regards to percentage spawn running, number of branches, stalk diameter, cap diameter and fresh weight of mushroom while lime doses had non-significant differences ($p>0.05$). In the same vein, the interaction effect of mushroom species and lime rates were significantly different ($p<0.05$) with regards to percentage spawn running, number of branches, stalk diameter and fresh weight of mushroom. *Pleurotus florida* expressed the highest mean value for fresh and dry weights, fruit number, branches and productive bags hence performed better than the other two species studied. The 5g and 10g lime rates expressed higher mushroom yield components. The mushroom species were recommended to farmers to be grown using 5 – 10 g of lime for commercial cultivation.

HIGHLIGHTS

- The three species of mushroom evaluated namely; *Pleurotus ostreasus, P. sajor* and *P. florida* had significant differences in phenotypic traits which could be utilized for further improvement.
- Lower rates of lime such as 5g/15kg substrate supported better growth and yield of the mushroom.

Keywords: *Pleurotus ostreasus, sajor, florida,* $CaCO_3$, primordial initiation

The nutritional, health and economic benefits of oyster mushroom makes it attractive to many developing countries including Nigeria. The presence of white shell on the fruiting body of the

How to cite this article: Chukwu, S.C., Okporie, E.O., Peace, E., Ude, E.A., Rafii, M.Y., Yussuff, O. and Olalekan, K.K. (2024). Growth and Yield Characteristics of Three Species of Oyster Mushroom (*Pleurotus* spp.) Treated with Lime. *Int. J. Ag. Env. Biotech.*, **17**(04): 663-672.

Source of Support: None; **Conflict of Interest:** None

mushroom gives it "oyster mushroom" as a common name. The mushroom is a saprophytic fungi in the Pleurotus genus (Kong, 2004). The genus *Pleurotus* belongs to family Tricholomataceae and has about 40 well-recognized species, out of which over 12 species are cultivated in different areas of the world. Mushroom production involves acquiring substrates at cheap prices or free sometimes and our environment is conserved by wastes recycling (Khan *et al*. 2012, Oladosu *et al.* 2022). Oyster mushroom (*Pleurotus* spp.) grows in various types of substrates compared to other types of mushroom (Ahmed et al. 2022; Cohen *et al.* 2002). The mushrooms are useful as food and in garnishing our various dishes (Shin *et al*. 2007). Pleurotus species are edible and grown commercially, ranking second in mushroom world production (Royse *et al*. 2017). The pleurotus are popular mushroom grown in Europe, Asia, America and other parts of the world due to their relatively affordable production cost and technology including high biological efficiency (Ahmed et al. 2022; Mane *et al*. 2007). Pleurotus species such as *P. ostreatus*, *P. florida*, etc., require temperature of 15 – 25 °C and grow well on substrates such as rice husk, saw dusts and other agricultural wastes (Hasan *et al*. 2010). According to Chukwu *et al.* (2022a), relative humidity of 80 – 90% support oyster mushroom growth, temperature range of 25 – 30 °C and 18 - 25 °C required at spawn running and fruiting stages, respectively. Different species of *Pleurotus* are ideally suited for cultivation throughout the year in various tropical regions of the country (Ahmed *et al*. 2009). The mushrooms can grow on plastic bags, jars, basins, etc., given artificially controlled conditions (Chukwu *et al.* 2022b).

Mushrooms have been reported to help in improving health and nutrition when used as food, being rich sources of protein and vitamins (Kinge *et al*. 2014) especially in developing countries where high incidence of malnutrition and protein deficiency are very common. Mushrooms are progressively becoming an important component of human's diet globally (Ajonina and Tatah, 2012) because of their high nutritional value and medicinal properties (Chang and Miles, 2004). The vegetarians eat the mushroom as their substituted meat (Ahmed *et al.* 2009) and it's a good diet for people suffering from diabetics (Halim *et al.* 2021; Devi *et al.* 2015). They contain 19-35% protein, 0.6-3.1% fat, 70-90% moisture content, 7.5-16.5% fibre content, 9.8 % ash content and 57.6 % carbohydrate content (Ananbeh, 2003; Alananbeh *et al*. 2014; Jamil *et al*. 2019), while some quantities of vitamins and minerals are as well contained in the mushrooms (Ananbeh and Almomany, 2005; Yusop *et al.* 2020). The proper amendment of substrate's pH affects large scale production of mushroom. Lime ($CaCO_3$) is used in amending the pH of the substrate to slightly alkaline or near neutral (Paul *et al.* 2022; Khan *et al*. 2013). Fungal mycelia derive nutrients from the substrates and a pH of 6.4 – 7.8 is required for rapid growth of mycelium (Sarker *et al*. 2007; Khan *et al*. 2013). According to Khan *et al*. (2013), the quantity of lime used can range between 2-6% or even more. This results to variations in yield and as well dependent on the pH level of the substrates used.

In Nigeria, ignorance, dependence on wild mushrooms and lack of growing technology have hindered the integration of mushroom cultivation into agricultural briefs across the country and its recognition as a potential national income earner and source of nutrition (Osemwegie & Dania, 2016; Okporie *et al.* 2014). Increasing productivity of oyster mushroom depends on use of best growing technology, appropriate liming and most adaptable variety. There are still paucity of information on these indispensible factors of mushroom production in the study area, hence the need to evaluate the phenotypic characteristics of the three species of oyster mushroom under various lime application rates. The study also seeks to unravel the interactions between mushroom species and lime rates for possible recommendation of the best combination to mushroom growers.

MATERIALS AND METHODS

Experimental site and its design: The experiment was carried out at the Crop Development Laboratory of Ebonyi State University Mushroom Farm, Abakaliki. The area is located between Latitude 06⁰04ᴵ N and Longitude 08⁰ 65ᴵ E. Daily temperature in the study area ranges from 22°C to 32°C. The area has a bimodal rainfall pattern which comprises April to July rain, usually at its peak; followed by August break, then September to November rain that comes as a conventional rainfall. The total rainfall ranges from 1700 mm – 2000 mm (Okporie *et al.* 2015; Chibuike *et al.* 2015). The factorial experiment had three replications in completely randomized design (CRD). Factor A comprised three species of mushroom (*Pleurotus ostreasus, P. sajor and P. florida*) while factor B consists of four levels of lime (0 gram/15kg mixture (control), 5 gram/15kg mixture, 10 gram/15kg mixture and 15 gram/15kg mixture).

Preparation of potato-dextrose-agar (PDA) plate: The petri dish was sterilized prior to media preparation and stored in a refrigerator at -4°C. A total of 39g PDA powder was weighed and mixed in 1000ml of distilled water and shaked thoroughly. The mixture was steamed to dissolve completely using microwave heater. The solution was sterilized by autoclaving at 15 lbs pressure (121°C) for 15 minutes and allowed to cool. Streptomycin was added and mixed very well. Thereafter, the sterilized petri dish was taken to the laminar flow hood and the prepared PDA was poured into the petri dish up to half level of the petri dish. The petri dish plates were covered and wrapped with paraffin wax under aseptic condition. The plates were stored in a slanting position inside -4°C refrigerator.

Isolation procedure: The desired Mushroom specie (fresh, large healthy mushroom with the volva still intact) was first cultured on a Potato Dextrose Algae (PDA) plate. The inoculated plates were incubated at 25 ± 1 °C for 6-12 days and the mycelia growth was observed. All Petri plates/glass tubes showing contamination were discarded. Sub-culturing was done following standard procedure (Chukwu *et al.* 2022a).

Preparation of mother spawn: The pure mushroom culture was used to make the mother spawn. The materials used included PDA culture, sorghum grains, pint whiskey bottles, cotton wool, aluminium foil and rubber bands, propagation hood, autoclave, inoculating loop, alcohol burner and knife. The grains were immersed in water for 12 hours. The grains were steamed until approximately 25 percent cooked or were just beginning to crack open. A sterilized pint whiskey bottles were filled to one half with the prepared grains and closed with a cotton plug, aluminium foil and rubber band. Sterilization of grains in the bottles was done using autoclave and allowed to cool.

Preparation of growth media (substrate composting): The substrates were mixed together by adding 30kg of rice husk, 120kg of saw dust and 143L of water. Lime was added to the mixture according to the experiment design and 1kg of the substrate was compressed in the white polythene bag. The polythene bags containing the substrates were loaded into the sterilization cylinder and

Sl. No.	Trait	Description
1	Spawn running	The spawn running also known as mycelia running was measured using 30cm meter rule and expressed in percentage.
2	Number of fruits	In each of the substrates, the number of effective fruiting bodies were counted and recorded.
3	Number of branches	The number of branches in each substrate was counted and recorded.
4	Number of productive bags	The number of bags in each of the units that initiated primordial was counted and recorded.
5	Number of unproductive bags	The growth media bags in each of the units that could not initiate primordial was counted and recorded.
6	Days to next flowering	This is the number of days from harvest to next fruiting.
7	Fresh weight	The harvested mushrooms was weighed per substrates units and recorded in grammes.
8	Dry weight in grammes	The dry weight of the mushroom was measured and recorded in grammes after freeze-drying.
9	Stalk height	The stalk is the stem or stalk like feature supporting the cap of a mushroom Prior to harvesting, the stalk height of the mushrooms were measured using meter rule and recorded in cm.
10	Stalk diameter	The stalk diameter of the harvested mushroom was determined using a vernier caliper and recorded in cm.
11	Cap Diameter	The cap/pileus diameter of the harvested mushroom was determined using a vernier caliper and recorded in cm.

boiled up to 121°C for 8 hours. The sterilized media were left to cool for 24 hours after which they were off-loaded and allowed to cool under room temperature for another 24 hours.

Inoculation and incubation: The inoculation room was properly fumigated using a mixture of insecticide and fungicide. The mother spawn were utilized for inoculation of the prepared growth media under aseptic condition at 5g inoculums per medium (a measure of a tea spoon per medium). The spawn were spread on top of the medium and the neck closed with cotton wool. The bags were placed vertically in the dark incubation room and maintained at room temperature without watering for the first one week. Spawn running was observed while watering daily and maintaining relative humidity of 80 – 85% for three to four weeks until maximum mycelia growth was achieved. Upon completing maximum spawn running, cultivating bags were irrigated twice daily (morning and evening).

Recording of data and statistics: We took record of data on some growth and yield traits following the procedures described in the table below. The data were analysed for variance (Hashim *et al.* 2021; Musa *et al.* 2021) using SAS software version 14 while differences between means were separated using Tukey's test also known as Honestly significant difference (HSD).

RESULTS AND DISCUSSION

Spawn/mycelium running

There was a significant (P<0.05) difference among the three species of mushroom as regards percentage spawn running (Table 1). The mushroom species varied among themselves with *Pleurotus ostreatus* recording the highest percentage spawn running (45.42%) followed by *Pleurotus florida* (27.83%) while *Pleurotus sajor* recorded the lowest percentage spawn running (18.17). However, *Pleurotus florida* differed significantly (P<0.05) from *Pleurotus ostreatus* while *Pleurotus ostreatus* also differed significantly from *Pleurotus sajor.* Non significant (P>0.05) difference was also observed between *Pleurotus florida* and *Pleurotus sajor* (Table 2). The main effect of lime rates on the spawn running was not significantly different (P>0.05). The media with 10 gram lime however recorded the highest percentage spawn running (33.20%) while 15g lime (27.30%) recorded the lowest percentage spawn running. 0g lime and 5g lime recorded 29.8 and 31.6 percentage spawn running respectively. Significant differences (p<0.05) were observed on the interaction effect of mushroom species and lime rate on the spawn running percentage among the treatment combinations. The interaction effect of *Pleurotus ostreatus* × 5g of lime and *Pleurotus ostreatus* × 10g of lime recorded the highest spawn running of 52.33%. The two combinations also differed significantly from *Pleurotus sajor* × 0g, *P. sajor* × 5g, *P. sajor* × 10g and *P. sajor* × 15g, each. (Table 2), while they had no significant difference with other combinations studied. The interaction of *Pleurotus sajor* × 15g of lime and *Pleurotus sajor* × 5g of lime recorded the lowest percentage spawn running (15.70) but were significantly similar to other interactions except *Pleurotus ostreatus* × 5g and P *ostreatus* × 10g. Variations in spawn run rate may be attributed to specie effect and not the size of the media grains as suggested by Pathmashini *et al*. (2008) and Mamiro and Royse (2008). Pathmashini *et al*. (2008) reported 17-20 days for spawn running and 23-27 days for formation of pinheads. Similar result was also obtained by Shah *et al*. (2004).

Number of productive bags

Non significant difference (P>0.05) existed among the three species of mushroom with regards to the number of productive bag of mushroom. The result showed that all the mushroom species were not significantly different among each other, with *Pleurotus florida* recording the highest number of productive bags (20.2) followed by *Pleurotus sajor* (17.2) while *Pleurotus ostreatus* recorded the lowest number of productive bags (17.00). The main effect of lime rates on number of productive bags was not significantly different (P>0.05). However, the media with 5 gram lime recorded the highest number of productive bags (20.0). This was followed by 10g lime rate (17.9) and 15g lime rate (17.4) while 0g lime produced the least (17.1). The result in Table 2 showed that the interaction effect of mushroom species and lime rate on the number of productive bags of mushroom was not significantly different (P>0.05) among treatment combinations. All the interactions of the two factors studied were statistically similar among each other;

Table 1: Mean squares (MS) of the agronomic characteristics obtained on the three species of mushroom treated with various rates of lime and their interactions

Agronomic trait	d.f	Spawn / Mycelia running	No. of Productive Bags	No. of unproductive bags	No. of fruits	No. of branches	Fresh weight	Stalk height	Stalk diameter	Cap/pileus diameter	Days to next flowering	Dry weight
Species	2	6450.33^{*}	38.11^{ns}	38.11^{ns}	0.08^{ns}	103.36^{*}	2100.58^{*}	5.20^{ns}	7.41^{*}	55.20^{*}	0.70^{ns}	1.26^{ns}
Lime rates	3	102.33^{ns}	15.19^{ns}	15.19^{ns}	0.10^{ns}	6.62^{ns}	59.88^{ns}	1.71^{ns}	0.05^{ns}	4.91^{ns}	1.29^{ns}	0.37^{ns}
Species x Lime rates	6	184.56^{*}	2.41^{ns}	2.40^{ns}	0.05^{ns}	3.40^{*}	124.32^{*}	12.65^{ns}	1.53^{ns}	2.27^{ns}	2.06^{ns}	0.18^{ns}
Error	24	273.33	37.72	37.72	0.08	3.06	161.08	15.31	0.75	6.05	1.22	0.76

**significant difference (p=0.05), ^{ns} not-significant.*

Table 2: Effects of mushroom species and lime rates on some agronomic characteristics of the oyster mushroom (*Pleurotus* spp) evaluated phenotypically

	Spawn running (days)				Number of branches				Stalk diameter (cm)				Cap diameter (cm)				Fresh weight (g)			
	Pf	*Po*	*Ps*	Mean	*Pf*	*Po*	*Ps*	Mean	*Pf*	*Po*	*Ps*	Mean	*Pf*	*Po*	*Ps*	Mean	*Pf*	*Po*	*Ps*	Mean
0 g	30.00	38.70	20.70	**29.80**	5.33	4.33	1.00	**3.56**	2.87	3.33	2.93	**3.04**	11.43	7.23	7.10	**8.59**	30.00	21.30	8.00	**19.80**
5 g	26.70	52.30	15.70	**31.60**	8.00	7.67	1.00	**5.56**	3.10	2.20	4.07	**3.12**	12.00	9.03	8.03	**10.22**	23.00	26.30	7.70	**19.00**
10 g	26.70	52.30	20.70	**33.20**	5.00	6.00	1.00	**4.00**	2.03	2.77	4.53	**3.11**	12.00	10.67	8.00	**10.08**	32.00	33.00	5.00	**23.30**
15 g	28.00	38.30	15.70	**27.30**	7.33	4.67	1.00	**4.33**	2.30	2.80	4.75	**3.22**	12.10	9.03	7.30	**9.69**	43.70	22.70	6.30	**24.20**
Mean	**27.80**	**45.40**	**18.20**		6.42	5.67	1.00		2.58	2.77	4.02		11.88	9.44	7.61		32.20	25.80	6.70	
	$TMSD_{(0.05)}$ Mushroom species = 10.29 Lime rates = ns Mushroom species × lime rates = 29.70				$TMSD_{(0.05)}$ Mushroom species = 1.78 Lime rates = ns Mushroom species × lime rates =5.146				Non-significant F-test in Mushroom species, lime rates and Mushroom species × Lime rates interactions				$TMSD_{(0.05)}$ Mushroom species = 2.506 Lime rates = ns Mushroom species × Lime rates = ns				$TMSD_{(0.05)}$ Mushroom species = 12.94 Lime rates = ns Mushroom species × lime rates = 37.36			

Notes: *Pf = Pleurotus florida, Po = Pleurotus ostreatus, Ps = Pleurotus sajor, TSMD = Tukey's Minimum Significant Difference, ns = not significant.*

while the interaction of *Pleurotus florida* × 5g of lime recorded the highest number of productive bags (22.0) though statistically the same with other treatment interactions. The interaction of *Pleurotus ostreatus* × 0g of lime recorded the lowest number of productive bags. This result suggests that 5g of lime rate encouraged better pin head formation through provision of adequate pH and environmental conditions of the substrate to that affected directly the growth of primordia more than other lime rates (Khan *et al*. 2013).

Number of unproductive bags

Main effect of the three mushroom species on number of unproductive bags had no significant difference (Table 2). Result showed that all the mushroom species were statistically similar with one another. *Pleurotus ostreatus* recorded the highest number of unproductive bag (13.00) followed by *Pleurotus sajor* (12.8) while *Pleurotus florida* recorded the lowest number of unproductive bags (9.8). Similarly, the main effect of lime rates with respect to number of unproductive bags was not significantly different (p>0.05). However, the media with 0gram lime recorded the highest number of unproductive bags (12.9). This was followed by 15g lime rate (12.6) and 10 g lime rate (12.1) while 5g lime (10) recorded the lowest number of unproductive bags. This result also revealed that the interaction effect of mushroom species and lime rate had no significant difference. All the interaction effects did not vary significantly among each other. However, the interaction effect of *Pleurotus florida* × 5g of lime recorded the lowest number of unproductive bags (8.0) though significantly similar with other treatment interactions while the interaction of *Pleurotus ostreatus* × 0g of lime levels recorded the highest number of unproductive bags (14.3). This result agrees with Khan *et al*. (2013) who observed best mushroom performance using lower rate of lime.

Number of fruits and number of branches (fruiting bodies)

The main effect of three mushroom species with respect to the number of fruits of mushroom was not significant. Result showed that all the mushroom species were statistically equal. *Pleurotus florida* (1.167) recorded the highest number of fruits followed by *Pleurotus ostreatus* (1.083) while *Pleurotus sajor* recorded the lowest number of fruits (1.00). The main effect of lime rates on number of fruits was not significantly different (P>0.05). However, the media with 5 gram lime level recorded the highest number of fruits (1.222). This was followed by 0g lime rate (1.111) while 10g lime rate (1.00) and 15g lime (15) recorded the lowest number of fruits. The result in Table 2 also revealed that the interaction effects of mushroom species and lime rate with regards to the number of fruits of mushroom was not significantly different (P>0.05). All combinations three mushroom species and levels of lime were statistically equal. However, the interaction effect of *Pleurotus florida* × 5g and *Pleurotus ostreatus* × 5g of lime recorded the highest number of fruit bags (1.33) though statistically similar to other treatment combinations. The result in Table 1 shows that the main effect of the three mushroom species with regards to number of branches of mushroom varied significantly (P<0.05). *Pleurotus florida* (6.42) differed significantly (P<0.05) from *P. sajor* but did not vary significantly (P>0.05) from *Pleurotus ostreatus* (5.67). *Pleurotus ostreatus* also varied significantly from *Pleurotus sajor* (1.00) while significantly different from *P. florida. P. sajor* produced the least number of branches with a significant difference from other species. The result also revealed that the main effect of lime rates on the number of branches was not significant. However, the media with 5 gram lime recorded highest branches (5.56) while others followed the decreasing order of 15g lime (4.33) > 10g lime (4.00) > 0g lime (3.56). The interaction effect of mushroom species and lime rate with respect to the number of branches was significantly different (P<0.05). The interaction effect of *Pleurotus florida* × 5g of lime recorded the highest number of branches (8.00). This, however, was statistically similar with other interaction of *Pleurotus florida* × 0g, 10g, and 15g of lime as well as the interaction of *P. ostreatus* with all levels of lime (0g, 5g 10g and 15g) while differing significantly (P<0.05) from all interaction effects of *Pleurotus sajor* x lime rates. The interactions of *P. florida* × 15g (7.33) lime differed significantly from all the interactions of *P. sajor* but were statistically similar to all other interaction of *P. ostreatus* and *P. florida.* The interaction of *P. ostreatus* × 5g lime (7.67) also varied significantly from all interactions of *P. sajor* but were significantly similar from all other treatment interactions. The interactions of *P. florida* × 0 g lime, *P. florida* × 10 g lime, *P. ostreatus* × 0g, 10g, 15g lime were all statistically similar to all other interaction effects. Some environmental factors such as high relative humidity and moderate/suitable temperature could lead to growth of healthy mushrooms. Khan *et al*. (2013) reported that 2% application of lime produced the highest fruiting bodies compared to 0%, 4% and 6% lime in growing media. Akter *et al*. (2019) reported that *Pleurotus ostreatus* (37.33) produced the best fruiting body compared to *Pleurotus florida* and *Pleurotus cystidiosus*. Mudakir and Hastuti (2015) also reported a fruiting body ranging from 22.31 - 46.56 for all media used in growing oyster mushroom.

Fresh weight

Significant difference (P<0.05) existed on the main effect of three mushroom species on fresh weight of mushroom. *Pleurotus florida* (32.17 g) which recorded the highest fresh weight was significantly similar to *Pleurotus ostreatus* (25.83) but varied significantly (P<0.05) from *P. sajor*. *P. ostrestus* also differed significantly (P<0.05) from *Pleurotus sajor* which recorded the lowest fresh fruit weight (6.75 g). The main effect of lime rates with respect to the fresh weight was not significantly different (P>0.05). However, the media with 15 gram lime recorded the highest fresh weight (24.2 g cm) while 5 gramme lime recorded the lowest fresh weight of mushroom (19.0 g). In the same vein, 0 gramme lime and 10 gramme lime recorded 19.8 g and 23.3 g fresh weight of mushroom respectively. The interaction effect of mushroom species and lime rate with regards to fresh mushroom weight was significantly different (P<0.05). The interaction effect of *Pleurotus florida* x 15g of lime recorded the highest fresh weight (43.67 g). This was however similar with other interaction effects except the interaction of *Pleurotus sajor* × 15 g lime and *Pleurotus sajor* × 10g lime. All other interaction effects are statistically equal among each other except *Pleurotus florida* × 15g of lime. The interaction effects of *Pleurotus sajor* × 10g lime recorded the lowest fresh weight (5.00 g). The result obtained in this study agrees with the work of Garib (2019) who noted that the bags containing 10 g lime gave the largest yield of mushroom. Hence confirming an analysis with (Alemu and Fisseha, 2015) as the high acidity leads to less the mycelium filaments and reduced the result due to increased acidity. According to Khan *et al*. (2013), "2% lime completed mycelial growth after 18 days of inoculation of spawn and highest yield of mushroom in 1st flush (41.02g), yield of mushroom in 2nd flush (15.3g) and total yield of mushroom put at 56.32g and 9.57g on fresh and dry weight basis, respectively". This present study hence recorded a yield lower than that obtained by Khan *et al*. (2013). Specie influence on the weight of mushroom was in line with the work of Akter *et al*. (2019) who reported that *Pleurotus florida* produced a higher dry weight and biological yield when compared to *Pleurotus ostreatus* and *Pleurotus cystidiosus.*

Stalk height and diameter

The main effect of three mushroom species with regards to the stalk length of mushroom was not significantly different (P>0.05). The result showed that all the mushroom species were statistically the same, with *Pleurotus sajor* (12.43 cm) recording the tallest mushroom followed by *Pleurotus florida* (12.34cm) while *Pleurotus ostreatus* recorded the shortest mushroom (11.25). The main effect of lime rates on mushroom stalk length was also not significantly different (P>0.05). However, the media with 5 gram lime level recorded the tallest mushroom (12.43 cm). This was followed by 15g lime rate (12.12) while 0 g lime rate and 10g lime recorded 12.08 cm and 11.40 cm respectively. Table 2 also revealed that the interaction effect of mushroom species and lime rate on the stalk length of mushroom was not significantly different (P>0.05). However, the interaction effect of *Pleurotus sajor* x 0g lime rate recorded the tallest mushrooms (15.00 cm) though statistically similar with other treatment combinations. The interaction effect of *Pleurotus sajor* x 0g lime rate recorded the lowest mushroom stalk length (9.33 cm). The result in Table 1 revealed that the effect of three mushroom varieties with regards to stalk diameter of mushroom was significantly different (P<0.05). The result showed that *P. sajor* (4.02 cm) differed significantly from both *P. florida* (2.58cm) and *P. ostreatus* (2.77cm). *P. ostreatus* was statistically similar with *P. florida* but differed from *P. sajor* (P<0.05). The main effect of lime levels on stalk diameter was not significant. The media with 15 gram lime however recorded the highest stalk diameter (3.22 cm). 0g lime recorded the lowest stalk diameter (3.04 cm) while 5 gramme lime and 10 gramme lime recorded 3.12 cm and 3.11 cm stalk diameter respectively. The interaction effect of mushroom species and lime rate with respect to the stalk diameter was not significant different (P>0.05). The interaction effect of *Pleurotus sajor* x 15g of lime recorded the highest stalk diameter (4.6 cm). The interaction effects of *Pleurotus florida* x 10g lime recorded the lowest stalk diameter (2.03 cm). Ajonina and Tatah (2012) also reported a lesser stalk length (2-3 cm) and pileus diameter. Habib (2005) mentioned that the stalk length of oyster mushroom on different substrate varied from 1.93cm to 2.97cm and the diameter ranged from 0.74 cm to 1.05 cm. The difference in the mean value of the pileus diameter and stalk diameter across the main treatment and their interaction could be as a result of varying genetic make-up of the different species used for the study.

Cap/pileus diameter

The main effect of three mushroom species on the cap diameter of mushroom was significantly different (P<0.05) among treatment means. *Pleurotus florida* (11.88 cm) varied significantly from *Pleurotus sajor* (7.61 cm) but statistically equal to *Pleurotus ostreatus* (9.44 cm). Similarly, *P. ostreatus* was statistically similar to both *P. sajor* and *P. ostreatus* in respect to cap diameter. Habib (2005) had previously reported similar result. The main effect of lime rates with regards to cap diameter of mushroom was not significantly different (P>0.05). However, the media amended with 10 gram lime recorded the cap diameter (10.22 cm). This was followed by 15g lime rate (10.08) while 0 g lime rate and 5g lime recorded 8.59 cm and 9.69 cm respectively. Interaction of species × lime had no significant difference on diameter of cap of the mushroom studied (P>0.05). However, the interaction effect of *Pleurotus florida* × 15g lime rate recorded the highest cap diameter (12.10 cm) though significantly similar with other treatment interactions. The interaction effect of *Pleurotus sajor* × 15g lime rate recorded the lowest cap diameter (7.30 cm). Our findings are in consonance with the work of Buah *et al*. (2010) who reported a fruiting cap diameter of 5-8cm across substrates used to grow oyster mushroom (*Pleurotus ostreatus*). Muswati *et al*. (2021) also recorded a diameter of 4-5cm for oyster mushroom grown on different substrate concentration. The result was also higher than the values recorded by Akter *et al.* (2019) who reported a pileus diameter of 2.18 cm- 6.00 cm for *Pleurotus ostreatus* and 3.83 -5.83 cm for *Pleurotus florida* as well as stalk length of 2.20-4.5 cm for *Pleurotus florida* and 2.23-4.80 cm for *Pleurotus ostreatus.*

Days to next flowering

The result in Table 1 indicates non-significant variation on effect mushroom species on days to next flowering. The treatment mean showed that all mushroom species recorded similar flowering days with *Pleurotus florida* (8.17) and *Pleurotus ostreatus* (8.17) recording the joint highest days to next flowering while *Pleurotus sajor* recorded the lowest days to next flowering (7.75). The result also showed that main effect of lime rates on days to next flowering of mushroom not significant. However, the media with 10 gram lime level recorded the highest days to next flowering of mushroom (8.56 days). This was followed by 15g lime rate (8.00 days) while 0 g lime rate and 10g lime recorded 7.67 days and 7.89 days, respectively. Result also revealed that the interaction species and lime rate on the days to next flowering of mushroom was not significantly different (P>0.05) among treatment combination means. However, the interaction effect of *Pleurotus ostreatus* × 10g lime rate recorded the highest days to next flowering of mushrooms (9.33 days) though significantly similar with other treatment combinations. The interaction effect of *Pleurotus sajor* × 0g lime rate and *Pleurotus sajor* × 15 g lime rate recorded the lowest days to next flowering of mushrooms (7.00).

Dry weight

The main effect of mushroom species on the dry weight of mushroom was not significantly different (P>0.05) among treatment means. The result showed that all the mushroom species were statistically to *Pleurotus florida* (1.44g) recording the highest dry weight of mushroom followed by *Pleurotus ostreatus* (1.24 g) while *Pleurotus sajor* recorded the lowest dry weight of mushroom (0.81g). The main effect of lime rates on dry weight of mushroom was not significant as well. However, the media with 10 gram lime level recorded the highest dry weight of mushroom (1.36 g). This was followed by 15g lime rate (1.32 g) while 0 g lime rate and 10g lime recorded 0.98 g and 1.00 g respectively. Results in Table 2 also revealed that the interaction of species and lime rate on the dry weight of mushroom was not significantly significant (P>0.05) among treatment combination means. However, the interaction effect of *Pleurotus florida* × 15g lime rate recorded the highest dry weight of mushrooms (1.83 g) though significantly similar with other treatment interactions. The interaction effect of *Pleurotus sajor* × 0g lime rate recorded the lowest dry weight of mushrooms (0.53 g).

CONCLUSION

From the result of this study, it was concluded that the three species of mushroom studied varied significantly in some phenotypic traits evaluated. This variation could be utilized by breeders in improving the mushroom species for commercial cultivation. It was also concluded that lower rates of lime treatment such as 5g/15kg substrate supported better growth and yield of the mushroom. Also, an interaction of *P. florida* × 5g of lime produced the best phonotypic characteristics. It was therefore recommended that future research should examine the various rates of lime to see if there could be significant differences and lime doses lower than 5g should also be critically studied for possible better growth and yield performance.

REFERENCES

Ab. Halim, A.A.B., Rafii, M.Y., Osman, M.B., Oladosu, Y. and Chukwu, S.C. 2021. Ageing effects, generation means, and path coefficient analyses on high kernel elongation in mahsuri mutan and basmati 370 rice populations. *BioMed Research International*, (1): 8350136.

Ahmed, M.A., Rafii, M.Y., Izzati, M.N.A., Khalilah, A.K., Awad, E.A., Kaka, U., ... and Sazili, A.Q. 2022. Biological additives improved qualities, in vitro gas production kinetics, digestibility, and rumen fermentation characteristics of different varieties of rice straw silage. *Animal Production Science*.

Ahmed, S.A., Kadam,J.A., Mane,V.P., Patil, S.S. and Baig,M.M.V.(2009). Biological efficiency and nutritional contents of *Pleurotus florida* (Mont.) singer cultivated on different agro-wastes. *Nat. Sci*., **7**(1): 44.

Ajonina, A.S. and Tatah, L.E. 2012. Growth Performance and Yield of Oyster Mushroom (*Pleurotus ostreatus*) on Different Substrates Composition in Buea South West Cameroon" *Science Journal of Biochemistry*, Volume 2012, Article ID sjbch-139, 6 Pages, 2012.doi: 10.7237/sjbch/139

Ajonina, A.S. and Tatah, L.E. 2012. Growth Performance and Yield of Oyster Mushroom (*Pleurotus ostreatus*) on Different Substrates Composition in Buea South West Cameroon" Science Journal of Biochemistry, Volume 2012, Article ID sjbch-139, 6 Pages, 2012.doi: 10.7237/sjbch/139

Akter, F., Ahmed, K.U. and Miah, N. 2019. Effect of different spawn seed on growth and varieties of the oyster mushrooms (*Pleurotus* spp.). *Research in Agriculture Livestock and Fisheries*, **6**(2): 181-192.

Alananbeh, K.M., Bouqellah,N.A. and Al Kaff. N.S. 2014. Cultivation of oyster mushroom *Pleurotus ostreatus* on date-palm leaves mixed with other agro-wastes in Saudi Arabia. *Saudi J. Biol. Sci*., **21**(6): 616–625.

Alemu, F. and Fisseha, M. 2015. Cultivation of *Pleurotus ostreatus* mushroom on *Ficus vasta* leaves (solid waste of plant) at Dilla University, Ethiopia. *International Journal of Applied Science-Research and Review*, **2**(1): 006-019.

Ananbeh, K.M. and Almomany, A.R. 2005. Production of oyster mushroom *Pleurotus ostreatus* on olive cake agro waste. *Dirasat*, *Agricultural Sciences*, **32**(1): 64-70.

Ananbeh, K.M. 2003. Production of oyster mushroom on different agricultural wastes available in Jordan. Thesis, University of Jordan, Jordan.

Buah, J.N., Van der Puije, G.C.. Bediako, E.A Abole, E.A. and Showemimo, F. 2010. The Growth and Yield Performance of Oyster Mushroom (*Pleurotus ostreatus*) on Different Substrates. *Biotechnology*, **9***:* 338-342.

Chibuike, C.S., Okporie, E.O., Ekwu, L.G., Onyishi, G.C. and Nwogbaga, A.C. 2015. Maize genotypes collection and characterization from local Government areas in Ebonyi state, Nigeria. *Journal of Plant Breeding and Genetics*, **3**(1): 17-23.

Chukwu, S.C., Ibeji, C.A., Ogbu, C., Oselebe, H.O., Okporie, E.O., Rafii, M.Y. and Oladosu, Y. 2022a. Primordial Initiation, Yield and Yield Component Traits of Two Genotypes of Oyster Mushroom (*Pleurotus* spp.) as Affected by Various Rates of Lime. *Scientific Reports* (in press)

Chukwu, S.C., Nwambam, C., Paul, K., Okporie, E.O., Igboji, P.O. and Nwite, P.O. 2022b. Effects of Watering Frequency and Watering Method on the Growth and Yield of Oyster Mushroom (*Pleurotus ostreatus*). *Nigeria Agricultural Journal*, **53**(1): 297-302.

Cohen, R., Persky, L. and Hadar, Y. 2002. Biotechnological applications and potential of wood degrading mushrooms of the genus Pleurotus. *Applied Microbiology and Biotechnology*, **58**: 582-594.

Devi, M.K., Haobam, B., Devil, T.I., Singh, W.N. and Singh, W.R. 2015. Study of spawning response of Pleurotus *sajor-caju* in two different substrates (wheat and rice). *J. Sci. Eng. Res.*, **6**: 1-3.

Garib, B. 2019. Impact different Level of Calcium Carbonate ($CaCO_3$) on Growth and yield of Oyster Mushroom (*Pleurotus* Spp.). *International Journal of Engineering and Technology*, **11**. 10.21817/ijet/2019/v11i4/191104050.

Habib, M.A. 2005. Comparative study on cultivation and yield Performance of Oyster Mushroom (*Pleurotus ostreatus*) on different substrates. M.S. Thesis, Department of Biotechnology, BAU, Mymensingh.

Hasan, M.N., Rahman, M.S., Nigar, S., Bhuiyan, M.Z. and Ara, N. 2010. Performance of oyster mushroom (*Pleurotus ostreatus*) on different pretreated substrates. *Int. J Sustain. Crop Prod.*, **5**(4): 16-24.

Hashim, N., Rafii, M.Y., Oladosu, Y., Ismail, M.R., Ramli, A., Arolu, F. and Chukwu, S. 2021. Integrating multivariate and univariate statistical models to investigate genotype–environment interaction of advanced fragrant rice genotypes under rainfed condition. *Sustainability*, **13**(8): 4555.

Jamil, F., Yaqoob, A., Mehmood, Z., Hamid, A., Shah, Z., Imtiaz, M., Jamil, N. and Ijaz, R. 2019. Comparative study for growth and yield performance of oyster mushroom (*Pleurotus* spp.) on different substrates under temperate condition. *Journal of Environmental & Agricultural Sciences*, **19**: 10-22.

Khan, M.W., Khan, N., Khan, M., Rehman, A. and Javed, N. 2013. Effect of different levels of lime and pH on mycelial growth and production efficiency of oyster mushroom (*Pleurotus* Spp.). *Pakistan Journal of Botany*, **45**: 297-302.

Khan, S.M., Nawaz, A., Ali, M.A., Ahmad, T., Khan, N.A. and Atiq-ur-Rehman. 2012. Response of Oyster mushroom on different agricultural wastes of southern Punjab. *Pak. J. Agri. Sci.*, **49**: 127-130.

Kinge, T.R., Nji, T.M., Ndam, L.M. and Mih, A.M. 2014. Mushroom research, production and marketing in Cameroon: A review. *Journal Issues ISSN*, *2350*, 1588.

Kong, W.S. 2004. Descriptions of commercially important Pleurotus species. Oyster mushroom cultivation. Part II. Oyster mushrooms. Seoul: Heineart Incorporation, pp. 54-61.

Mamiro, D.P. and Royse, D.J. 2008. The influence of spawn type and strain on yield, size and mushroom solids content of Agaricus bisporus produced on non-composted and spent mushroom compost, *Bioresource Technology*, **99**(8): 3205-3212.

Mane, V.P., Patil, S.S., Syed, A.A. and Baig, M.M. 2007. Bioconversion of lowqualitylignocellulosic agricultural waste into edible protein by *Pleurotussajor-caju*(Fr.) Singer. *J. Zhejiang Univ. Sci. B.*, **8**: 745-51.

Mudakir, I. and Hastuti, U.S. 2015. Study of wood sawdust with addition of plantation wastes as a growth medium on yields and quality of white oyster mushroom. *Agrivita*, **37:** No.ISSN : 0126-0537

Musa, I., Rafii, M.Y., Ahmad, K., Ramlee, S.I., Md Hatta, M.A., Magaji, U. ... and Mat Sulaiman, N.N. 2021. Influence of wild relative rootstocks on eggplant growth, yield and fruit physicochemical properties under open field conditions. *Agriculture*, **11**(10): 943.

Muswati, C. Simango, K., Tapfumaneyi, L., Mutetwa, M. and Ngezimana, W. 2021. "The Effects of Different Substrate Combinations on Growth and Yield of Oyster Mushroom (*Pleurotus ostreatus)*", *International Journal of Agronomy*, vol. 2021, Article ID 9962285, 10 pages.

Okporie, E.O., Chukwu, S.C. and Onyishi, G.C. 2013. Phenotypic recurrent selection for increase yield and chemical constituents of maize (*Zea mays* L.). *World Applied Sciences Journal*, **21**(7): 994-999.

Okporie, E.O., Chukwu, S.C., Onyishi, G.C., Ekwu, L.G. and Oko, G.O. (2014). Increase in protein, oil, amylose and amylopectin contents of two populations of maize (*Zea mays* L.) after two cycles of reciprocal recurrent selection. *IOSR J. Agric. Vet. Sci.*, **6**(6): 17-22.

Oladosu, Y., Rafii, M.Y., Arolu, F., Chukwu, S.C., Salisu, M.A., Fagbohun, I.K. ... and Haliru, B.S. 2022. Superabsorbent Polymer Hydrogels for Sustainable Agriculture: A Review. *Horticulturae*, **8**(7): 605.

Osemwegie, O. and Dania, T. 2016. Production of Mushrooms as Complimentary Agro-income in Nigeria. *Annals of Science and Technology*, **1**: 19-27.

Pathmashini, L., Arulnandhy, V. and Wijeratnam, R.S. 2008. Cultivation of oyster mushroom (*pleurotus ostreatus*) on sawdust. *Cey. J. Sci. (Bio. Sci.)*, **37**(2): 177-182.

Paul, K., Aniekwe, N.L. and Samuel, C.C. Effects of Rice Hull and Different Fertilizer Sources on the Growth and Yield of Carrot (*Daucus carota* L.) In Abakaliki.

Rafii, M.Y., Osman, M.B., Oladosu, Y. and Chukwu, S.C. 2021. Ageing Effects, Generation Means, and Path Coefficient Analyses on High Kernel Elongation in Mahsuri Mutan and Basmati 370 Rice Populations. *BioMed Research International*, *2021*.

Royse, D.J., Baars, J. and Tan, Q. 2017. Current overview of mushroom production in the world. *Edible and medicinal mushrooms: technology and applications*, **5**: 5-13.

Sarker, N.C., Hossain, M.M., Sultana, N., Mian, I.H., Karim, A.J.M.S. and Amin, S.M.R. 2007. Effect of different levels of pH on the growth and yield of *Pleurotus ostreatus* (Jacquin ex. Fr.) Kummer. *Bangladesh J. Mush.*, **1**(1): 57-62.

Shah, Z.A., Ashraf, M. and Ishtiaq, M. 2004. Comparative study on cultivation and yield performance of oyster mushroom (*Pleurotus ostreatus*) on different substrates (wheat straw, leaves, sawdust). *Pakistan Journal of Nutrition*, **3**(3): 158 – 160.

Shin, C.K., Yee, C.F., Shya, L.J. and Atong, M. 2007. Nutritional properties of some edible wild mushrooms in Sabah. *J. Appl. Sci.*, **7**: 2216-2221.

Yusop, M.R., Sukaimi, J., Amiruddin, M.D., Jalloh, M., Swaray, S., Yusuff, O. and Chukwu, S.C. 2020. Genetic improvement of oil palm through recurrent selection. *The oil Palm Genome*, pp. 35-46.