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Impact of changes in climatic variables on wild and cultivated mushroom in Rivers State, Nigeria

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ABSTRACT

Mushroom enjoyed as a local culinary delicacy in most parts of Nigeria is fast disappearing from our meals. The bulk of the edible mushrooms consumed in Nigeria are collected from the wild. Several wild mushroom species have disappeared from the Nigerian forests owing to deforestation and climate change. This study surveyed the impact of temperature and rainfall on the fruiting bodies of wild and cultivated species of *Pleurotus ostreatus*, *Pleurotus tuberregium* and *Lentinius subnudus*. It was observed that the wild mushroom had longer fruiting time and their fruiting bodies were smaller in weight compared to those cultivated. Given the numerous benefits of mushroom in health and nutrition, and the abundance of agro-waste from farming activities across Nigeria, a case is made for more cultivation of mushroom among rural dwellers towards reduction of the contribution to greenhouse gasses from burning agro-waste, and as a means of poverty reduction to forestall the use of firewood for cooking.

***Keywords*:** Edible mushrooms, *Pleurotus ostreatus*, *Pleurotus tuberregium*, *Lentinius subnudus*, agro-waste

1. INTRODUCTION

Most basidiomycete fungi produce annual short-lived sexual fruit bodies called mushroom. Mushrooms are non-wood forest products which can serve as an indicator of the state of the forest. Deforestation and rising temperature are linked to disappearance of Nigeria's tropical rainforest, which supports diverse species of mushrooms [1 and 2].

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One of the primary factors affecting mushroom growth is the temperature during the vegetative and reproductive phases. The vegetative phase is the stage at which the mycelium colonizes the substrate, while the reproductive phase is when the fruiting bodies develop. Studies have found that mushrooms thrive well within a narrow temperature range of 20 °C to 24 °C, with humidity levels ranging between 80 to 90% [3]. Numerous studies have shown that maintaining a constant temperature within a narrow range of 20-24 °C during vegetative phase is crucial for higher yields [3 and 4]. However, with the rising global temperature due to climate change, temperature extremes have become more recurrent, leading to adverse effects on mushroom production. Temperature affects the timing of fruiting in mushrooms [5 and 6] as well as the size and shape of the mushroom [4]. It has been reported that higher temperatures during the fruiting phase of *Pleurotus* spp. resulted in smaller mushrooms, whereas lower temperatures resulted in larger, flatter mushrooms [4].

Changes in rainfall amounts and timing affect soil moisture [7], which is critical for mushroom growth. Changes in rainfall patterns, such as prolonged dry periods, can lead to lower yields of mushrooms, particularly for those species that are less tolerant to drought conditions. Furthermore, the shift in weather patterns can leads to changes in pest and disease pressures that affect mushroom production [8]

Mushroom production in Nigeria has not hit the targeted capacity, with most farmers lacking adequate knowledge about modern mushroom cultivation techniques, and still rely on traditional methods of picking in the wild [9]. *Lentinus subnudus*, *Pleurotus tuberregium* and *Pleurotus ostreatus* are three species of edible mushrooms that have been the subject of considerable research due to their medicinal and nutritional value, and they are the commonly cultivated edible mushrooms in Nigeria [10-13]. There are several reports of the disappearance of common mushroom from Nigerian forest [14 and 15] and the reasons for their disappearance has been puzzling to keen observers.

With changing climatic conditions, wild mushroom species are becoming exceedingly difficult to find even in the Niger Delta rainforest where they normally grow luxuriantly. This study aimed to determine the impact of temperature and rainfall on the fruiting time and weight of wild and cultivated species of *L. subnudus*, *P. ostreatus* and *P. tuberregium*.

2. METHODOLOGY

2. 1. Study Area

Rivers State lies between 4° 45′N 6.50′E and 4.750° N 6.833° E. Rainfall which in the wet season, is usually between March and November, with peaks in July and September, though precipitation is expected all year round. The average temperature of the state lies between 25 °C – 28 °C. The vegetation is chiefly rainforest, with mangrove swamps around the coastal corridors. Agriculture is the main stay of the economy in rural areas, although the state is the epicentre of the oil and gas industry in Nigeria.

2. 2. Data Collection

Meteorological data for the study area were obtained from the Nigerian Meteorological Agency (NIMET) for the period 2009-2019. Within the study period, three wild mushroom species (*Lentinus subnudus*, *Pleurotus tuberregium* and *Pleurotus ostreatus*) were purchased from farmers in Rivers State. Mushroom production records for the three mushroom species were also collected from mushroom growers within Rivers State.

2. 3. Statistical analysis

Data were analysed using Microsoft Excel and SPSS VS 20. Trend graphs were produced to show variations in monitored parameters. Multiple regression analysis was used for inferential statistics between climatic variables and mushroom yield.

3. RESULTS AND DISCUSSION

3. 1. Rainfall pattern

Figure 1 shows the annual mean rainfall in Rivers State between 2009 and 2019. The trend analysis reveals a decline in rainfall pattern (coefficient of regression = 0.4476). In the present study, mean rainfall changed in the negative direction (decreased over the years) over the study period. It shows that the highest rainfall, 2842.2 mm, was observed in 2009 and the least, 1840.04 mm in 2015. The mean rainfall was 2256.9 mm. Chinago [16] in a study of rainfall pattern in Rivers State over 84 years, similarly, observed a gradual decrease in rainfall as well as the intensity. Rivers State has received a humungous share of atmospheric pollution consequential GHG emissions and aerosols accretion [17]. This is supported by fact that the state produces about a fifth of all annual CO_2, CH_4 and N_2O emissions in Nigeria (74,374.49 Gigagrams) majorly from oil and gas installations [18-26].

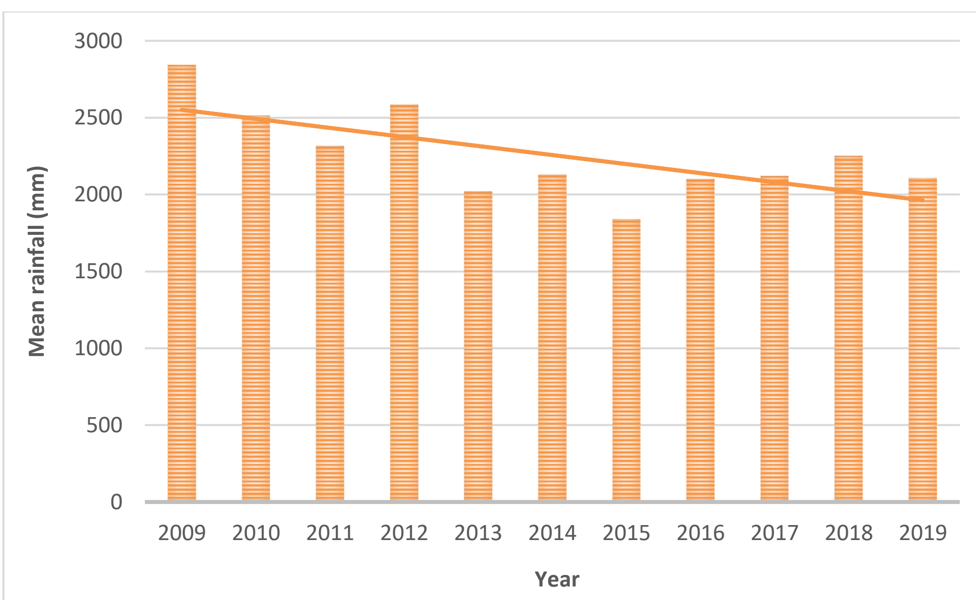

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Figure 1. Annual mean rainfall of Rivers State, 2009-2019

Chinago [16] averred that sundry factors are accountable for the variations in rainfall pattern over Port Harcourt, including anthropogenic and natural events that inject gaseous material into the atmosphere, inhabiting transpiration and evaporation from land and vegetation over several decades. Kpang and Weli [19], in their model of rainfall under emission scenarios in Port Harcourt predicted that future precipitation would grow more unpredictable and with some improbableness owing to climate change. Agbor *et al*. [17] also established that Port Harcourt has a high rainfall erraticism to the degree that the probable risks cannot be discounted as the rainfall anomalies are connected to local atmospheric variations propelled by anthropogenic activities such as emissions.

3. 2. Temperature pattern

Figure 2 shows the annual mean temperature in River State within the period of the study. The trend analysis reveals increase in mean temperature over the 10 years period (coefficient of regression = 0.3017). In the present study, mean temperature changed in the positive direction (increased over the years) over the study period. It shows that the highest temperature, 28.01 °C, was observed in 2019 and the least, 27.28 °C, in 2009. The mean temperature was 27.6 °C. One of the critical climatic factors that affect mushroom cultivation is temperature. Wali *et al*. [20], that temperature in Rivers State is steadily increasing and within the study period (1986 to 2016) temperature was inversely related to precipitation, just as observed in the present study. Temperature affects the timing of fruiting in mushrooms, with certain species requiring specific temperature thresholds, both maximum and minimum, to trigger the fruiting process [6]. Mushrooms respond differently to environmental conditions, especially temperature [3]. The shiitake mushroom (*Lentinula edodes*) requires a temperature range of around 5-20 °C to initiate fruiting, while the oyster mushroom (*P. ostreatus*) requires a temperature range of around 22-28 °C [6]. Temperature is associated with quality attributes of the mushroom. Several studies have found that temperature during the fruiting phase affects the size and shape of the mushroom. Higher temperatures during the fruiting phase of *Pleurotus* spp. resulted in smaller mushrooms, whereas lower temperatures resulted in larger, flatter mushrooms [4].

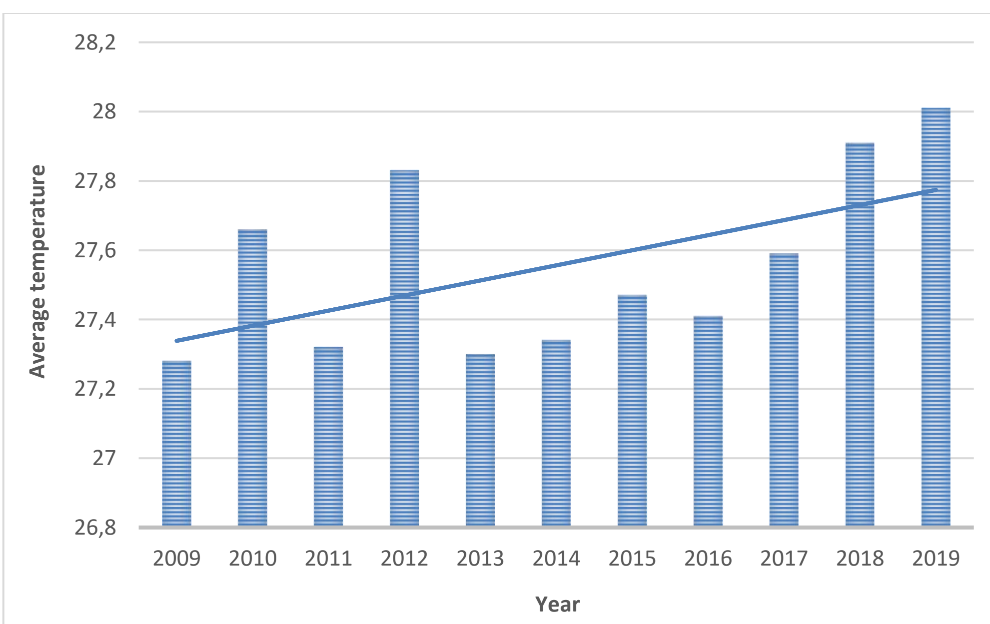

Figure 2. Annual mean temperature in River State, 2009-2019

3. 3. Fruiting duration

Figures 3-5 show variations in fruiting duration of wild and cultivated *L. subnudus*, *P. tuberregium* and *P. ostreatus* with mean duration of fruiting body of 171.4 & 103.5; 143.1 & 69.8, and 154.8 & 86.1 days, respectively. The mean fruiting duration for wild and cultivated species of *L. subnudus*, *P. tuberregium* and *P. ostreatus* were 171.4 &103.5; 143.1 & 69.8, and 154.8 & 86.1 days, respectively.

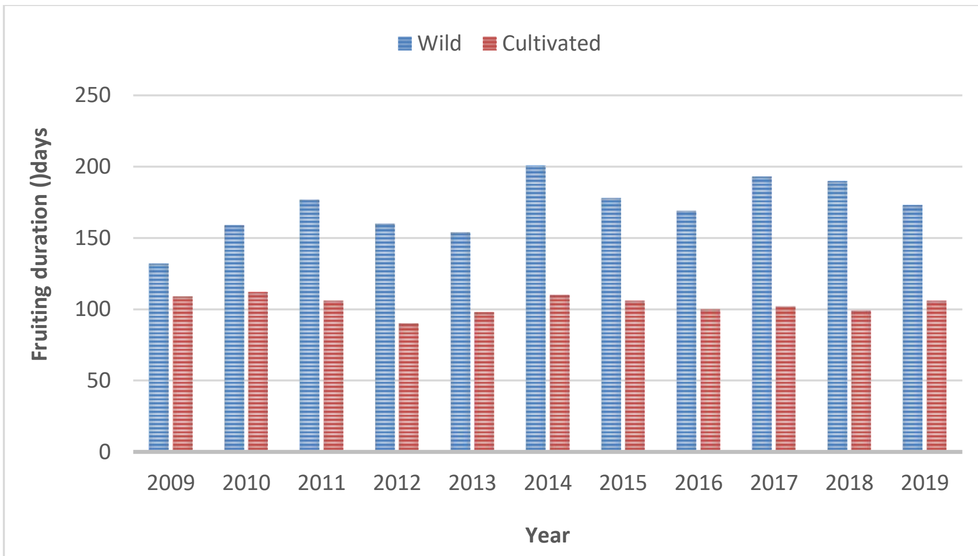

Figure 3. Variations in fruiting duration (*Lentinus subnudus*)

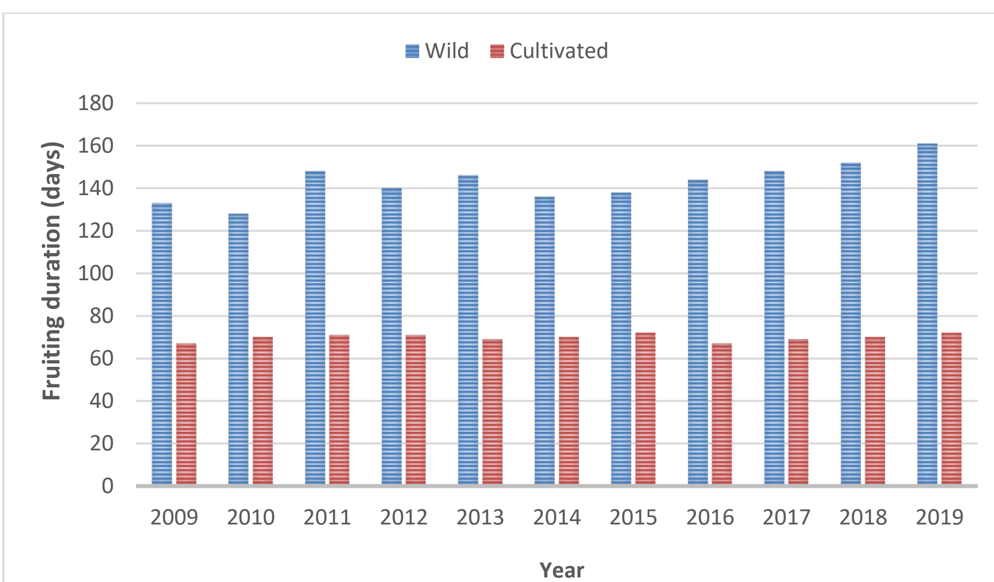

Figure 4. Variations in fruiting duration (*Pleurotus tuberregium*)

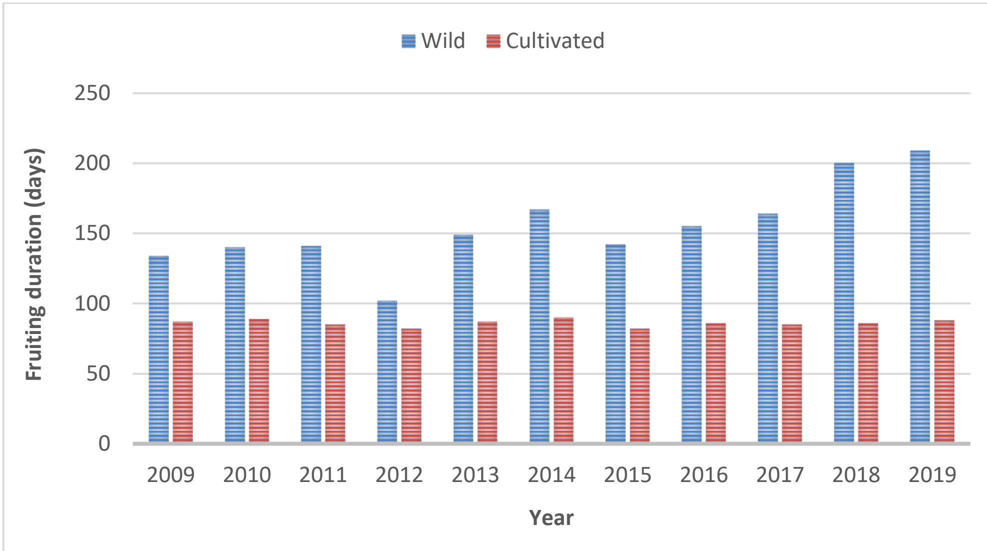

Figure 5. Variations in fruiting duration (*Pleurotus ostreatus*)

3.4. Weight of fruiting bodies

Figures 6-8 show variations in weight of fruiting bodies of wild and cultivated *L. subnudus*, *P. tuberregium* and *P. ostreatus* with mean weights of 9.7 & 11.4; 75.6 & 90.7, and 84.7 & 94.5 g respectively. The mean weights for wild and cultivated species of *L. subnudus*, *P. tuberregium* and *P. ostreatus* were 9.7 & 11.4; 75.6 & 90.7, and 84.7 & 94.5 g, respectively. There was significant ($p<0.05$) difference in weight between cultivated and wild species of the three mushroom species.

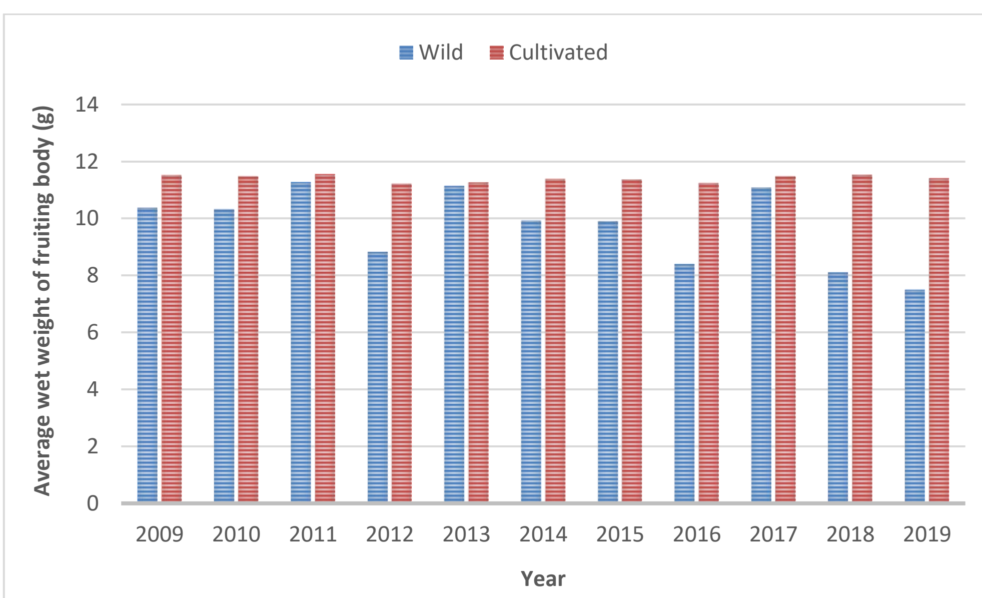

Figure 6. Variations wet weight of fruiting bodies (*Lentinus subnudus*)

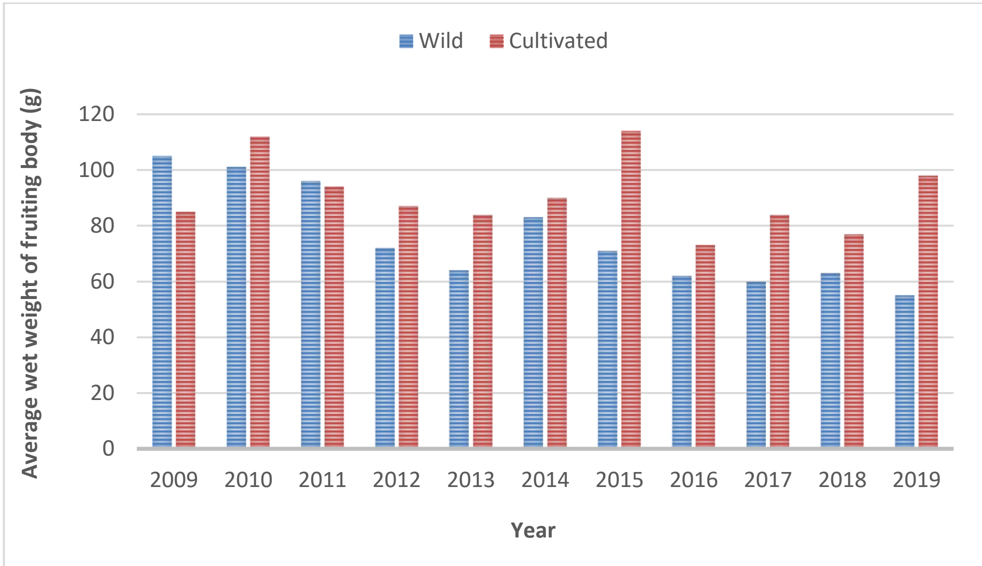

Figure 7. Variations weight of fruiting bodies (*Pleurotus tuberregium*)

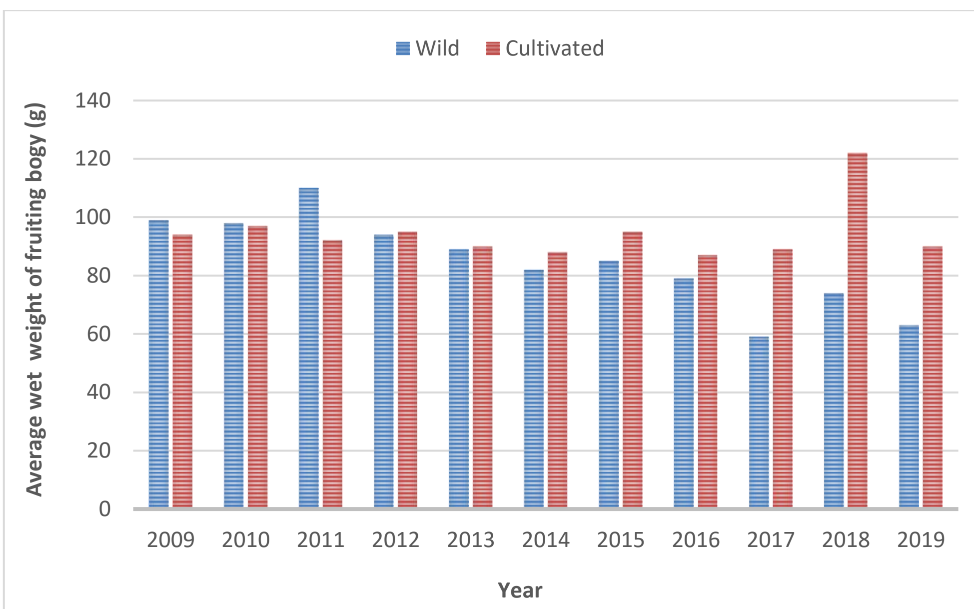

Figure 8. Variations in wet weight of fruiting bodies (*Pleurotus ostreatus*)

3. 5. Relationship between climatic variables and mushroom yield

Figure 9-11 show relationship between temperature and fruiting duration of wild and cultivated *L. subnudus*, *P. tuberregium* and *P. ostreatus* while Figure 12-14 show relationship between temperature and weight of fruiting bodies of *L. subnudus*, *P. tuberregium* and *P. ostreatus* respectively. Figure 15-17 show relationship between rainfall and fruiting duration of wild and cultivated *L. subnudus*, *P. tuberregium* and *P. ostreatus* while Figure 18-20 show relationship between rainfall and weight of fruiting bodies of *L. subnudus*, *P. tuberregium* and *P. ostreatus* respectively. Maintaining optimal temperature and moisture conditions is critical in mushroom production [3].

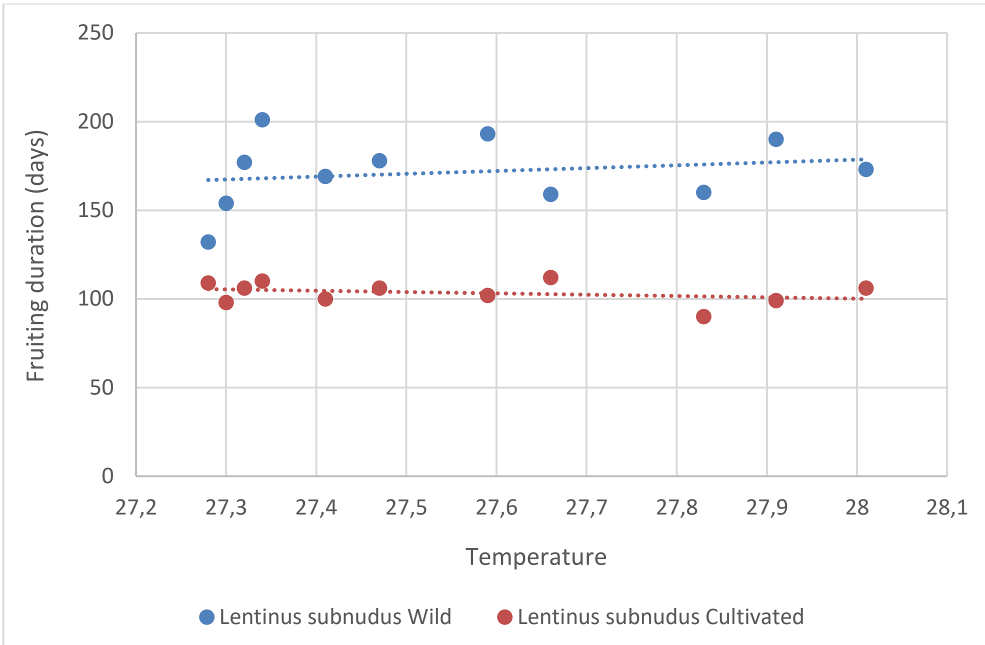

Figure 9. Relationship between fruiting duration of *L. subnudus* and temperature

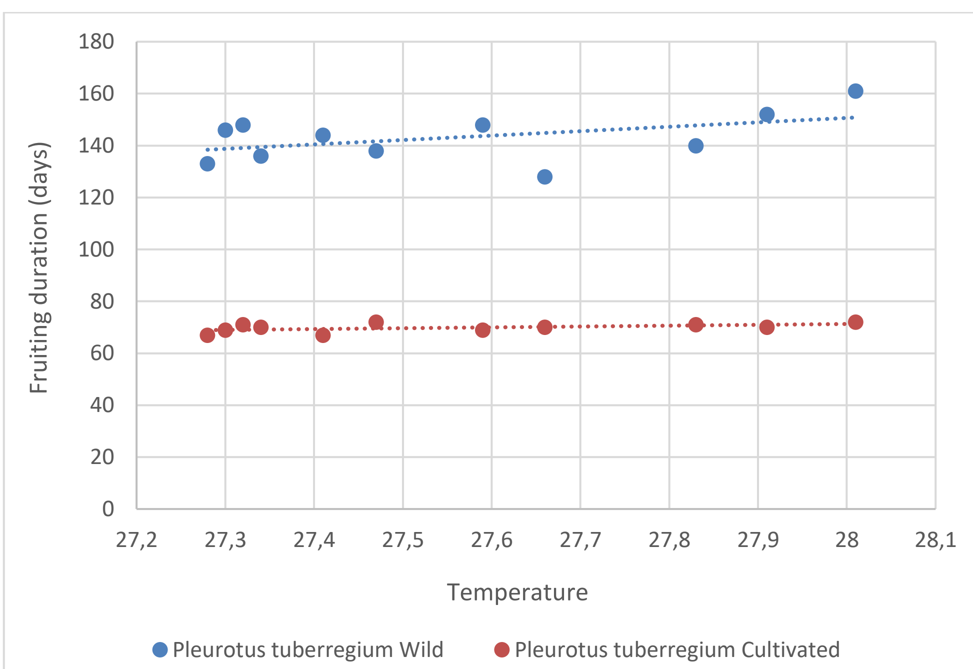

Figure 10. Relationship between fruiting duration of *P. tuberregium* and temperatur

The relationship between rainfall, temperature and fruiting duration was determined, and the regression coefficients for the wild and cultivated *L. subnudus*, *P. tuberregium* and *P. ostreatus* were 0.42 & 0.095; 0.37 & 0.43, and 0.42 & 0.095, respectively. The relationship between rainfall, temperature and weight of fruiting body was also determined, and the regression coefficients for the wild and cultivated *L. subnudus*, *P. tuberregium* and *P. ostreatus* were 0.53 & 0.082; 0.019 & 0.69, and 0.52 & 0.25, respectively.

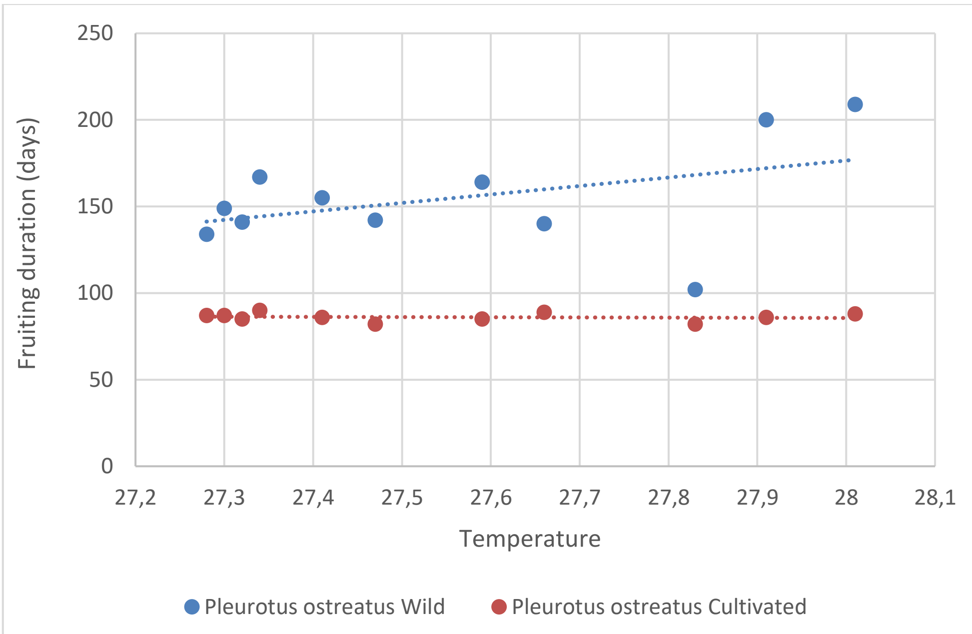

Figure 11. Relationship between fruiting duration of *P. ostreatus* and temperature

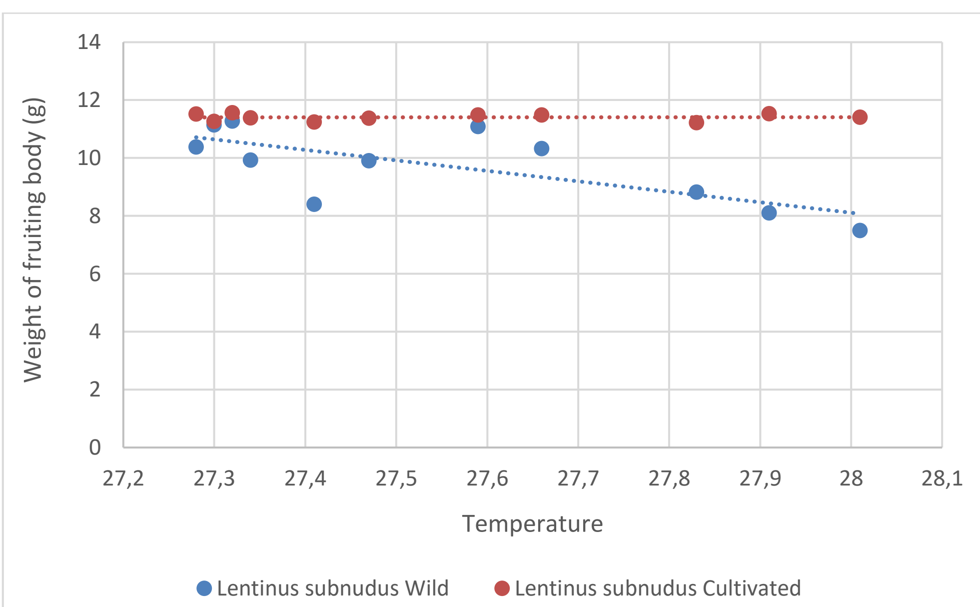

Figure 12. Relationship between weight of fruiting body of *L. subnudus* and temperature

The mushroom species varies in their tolerance to climatic variations. *Pleurotus* species, for example, have been found to grow well in areas with high rainfall, but prolonged drought and heat periods can significantly reduce their growth and fruiting bodies [21].

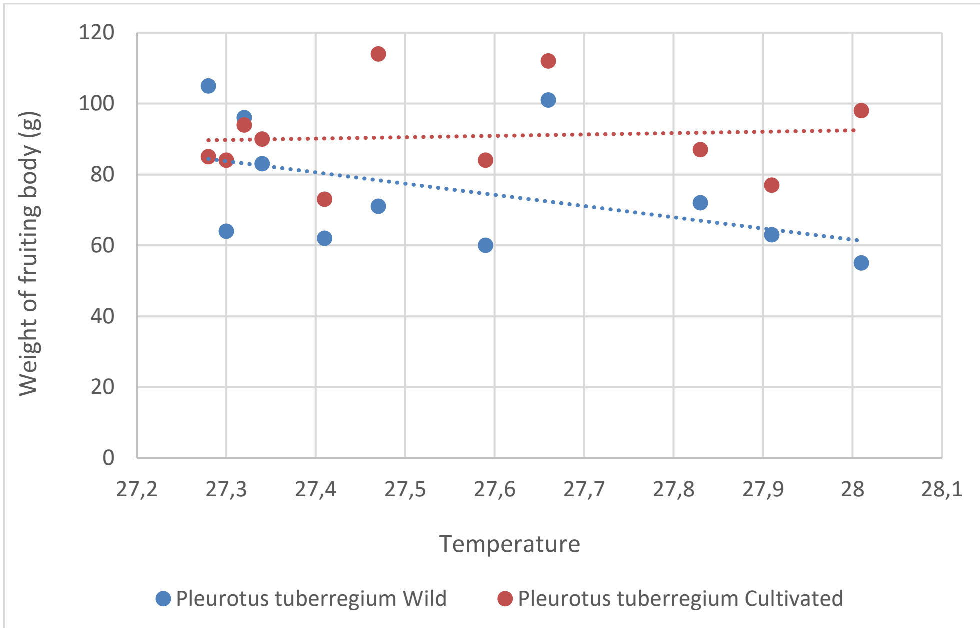

Figure 13. Relationship between weight of fruiting body of *P. tuberregium* and temperature

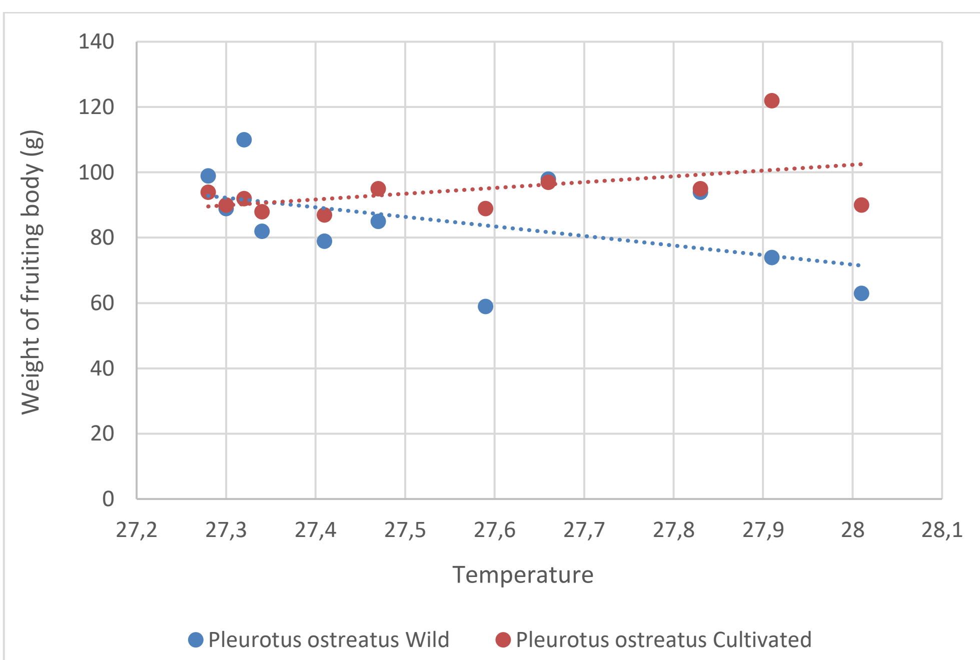

Figure 14. Relationship between weight of fruiting body of *P. ostreatus* and temperature

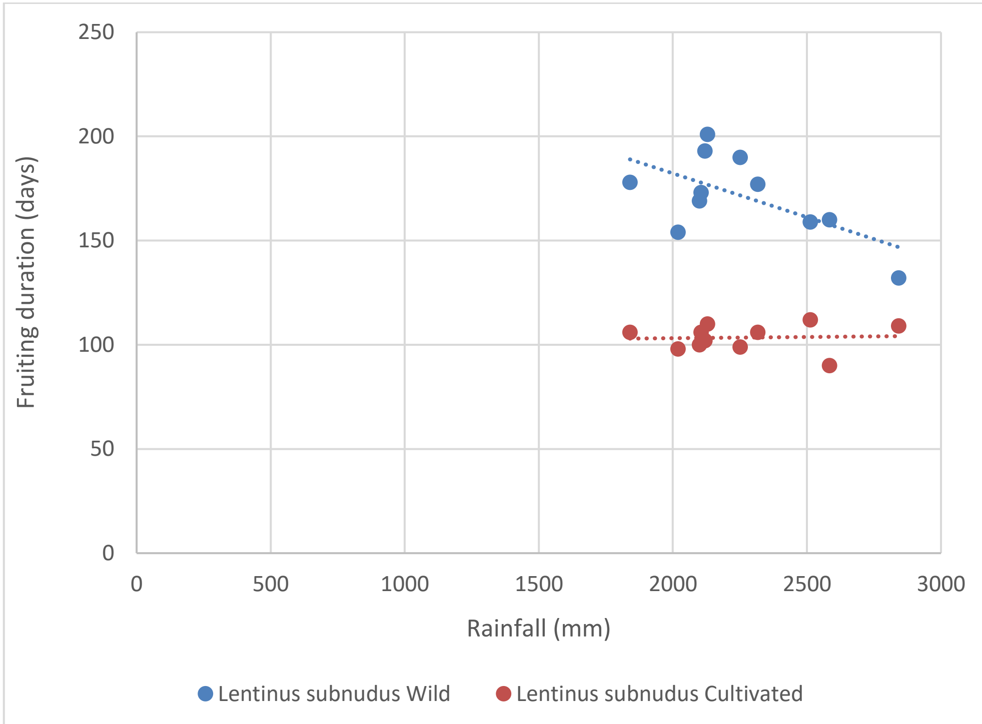

Figure 15. Relationship between fruiting duration of *L. subnudus* and rainfall

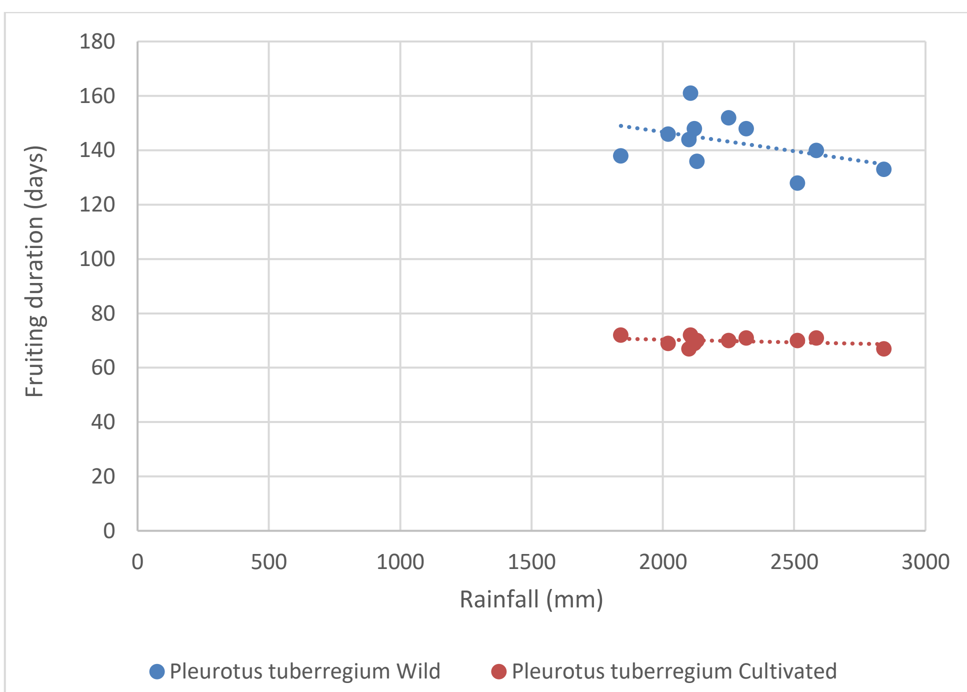

Figure 16. Relationship between fruiting duration of *P. tuberregium* and rainfall

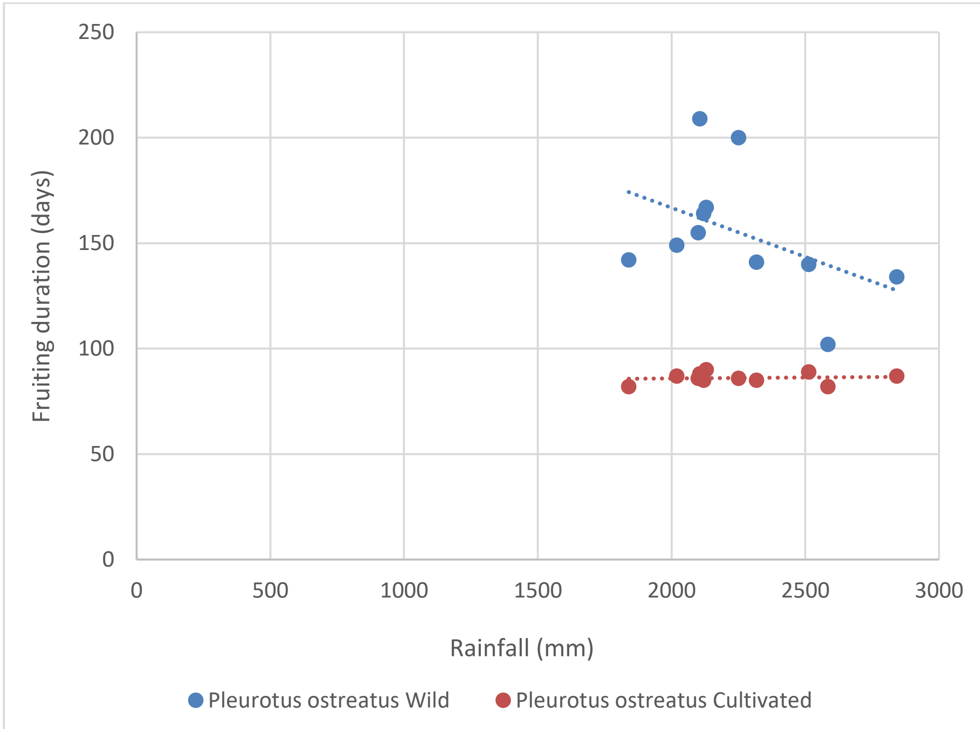

Figure 17. Relationship between fruiting duration of *P. ostreatus* and rainfall

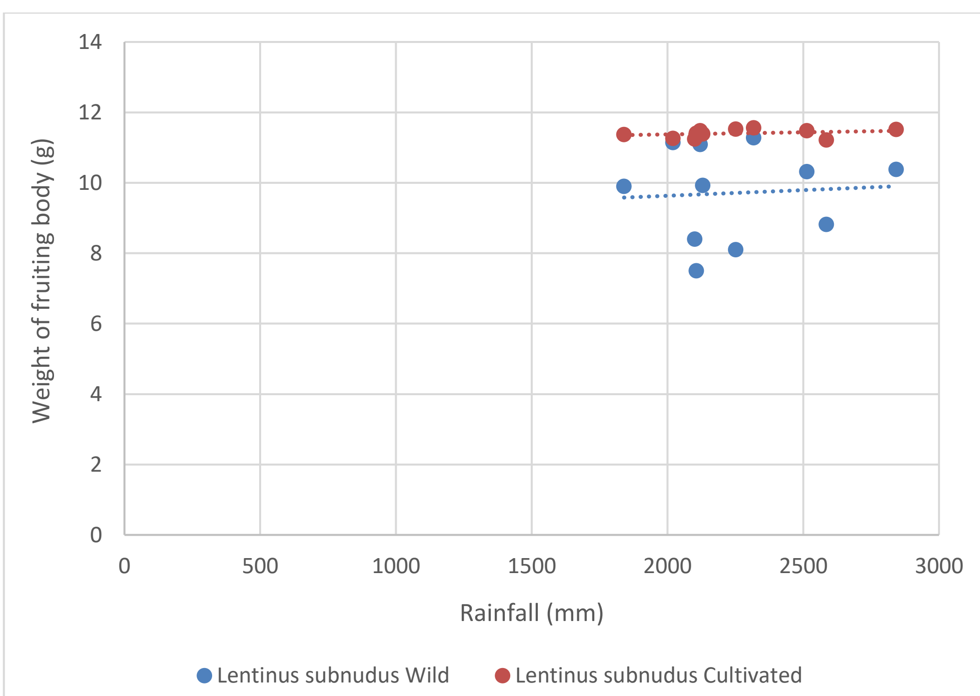

Figure 18. Relationship between weight of fruiting body of *L. subnudus* and rainfall

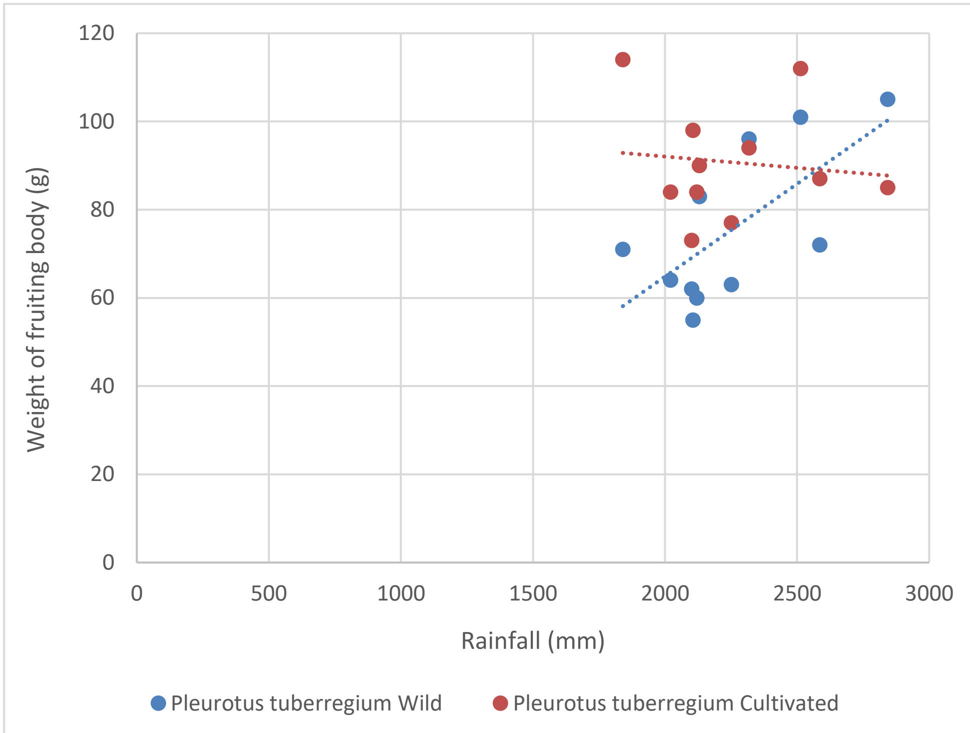

Figure 19. Relationship between weight of fruiting body of *P. tuberregium* and rainfall

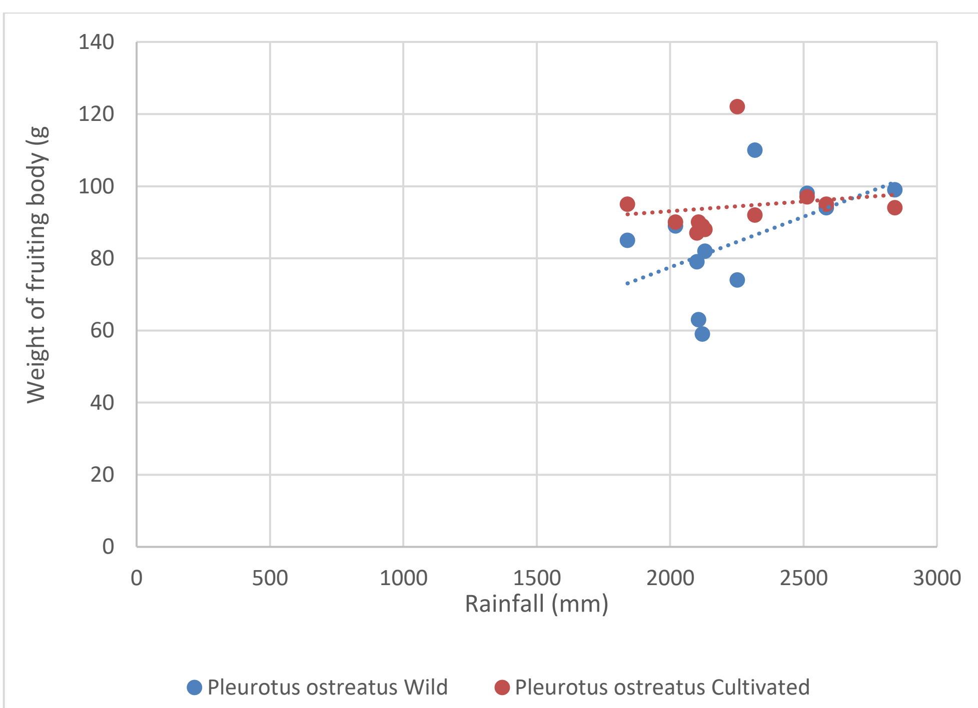

Figure 20. Relationship between weight of fruiting body of *P. ostreatus* and rainfall

4. CONCLUSION

The general climatic trend in the study area shows that temperature and rainfall patterns are changing in Rivers State. The study established that rainfall pattern is moving in a negative direction and temperature in the positive. These changes are linked to variations in wild mushroom yields. Thusly, if measures are not put in place check these trends, the impact on food security could be dire, and for fungi, their complete disappearance from the rain forest is imminent.

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