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# Effect of some Organic Applications on Biological Efficiency and Productivity of Mushroom (*Pleurotus columbines*) Grown under Uncontrolled Conditions

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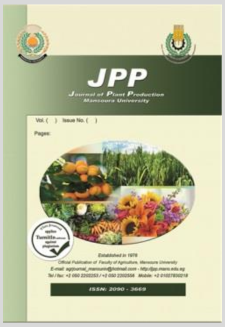


## ABSTRACT

Some organic supplements i.e., vermicompost which mixed with mushroom growth substrate (rice straw) at different levels 0.0, 2.5, 5, 10% beside compost tea at concentrate of (1:10) and Azolla plants extract at concentrate of 5% as organic spraying were used to enhance both of biological efficiency and productivity of *Pleurotus columbines* grown under uncontrolled conditions during the two seasons of 2019 and 2020. The results indicated the ability of vermicompost at high concentrate 10% to encourage mushroom fruiting phases, total yield/bag, biological efficiency, fruit chemical content and all fruit properties except the number of fruit per cluster which appears superior with rice straw sole without any additive (control treatment). On the other side, compost tea as organic spraying was the most influenced to obtain earlier primordial initiation and reduce the days required for both of fruit formation and fruit duration furthermore the high fruit content of protein, carbohydrate, P, K as well as fruit dry matter accumulation. While, Azolla plants extract resulted in the highest fruit characteristic expressed as average number of cluster/bag, weight of cluster/bag, weight of fruit/cluster and weight of basidiocarp but it had a negative effect on number of fruit per cluster. The interaction of vermicompost at rate 10% and Azolla plants extract was the most effective to obtain maximum values of total yield/bag and fungus biological efficiency.

***Keywords:*** Mushroom, vermicompost and Azolla spp.

## INTRODUCTION

*Pleurotus. Spp.*, commonly known as oyster mushrooms, spread in the worldwide jungle and considered the second largest commercially produced mushroom after *Agaricus bisporus* in the world (Mohamed *et al.*, 2011). *Pleurotus. Spp.*, account a primary decomposer to trees, plants and any lignin and cellulose materials and vegetable wastes as well as food industry wastes. It converts a high percentage of the organic substrates to fruiting bodies (Naraian *et al.*, 2008). Oyster mushrooms are a good source of protein, dietary fiber and the essential amino acid. Nevertheless, oyster mushrooms modulate the immune system, inhibit tumor growth and inflammation, have hypoglycaemic and antithrombotic activities, anti-genotoxic, antioxidant, hypo-cholesterolaemic, lower blood lipid concentrations, prevent high blood pressure and atherosclerosis, and have antimicrobial and antiviral as well as polysaccharides which appear to be immune-enhancing substances Cimerman (1999); Nayana and Janardhanan (2000); Gregori (2007) and Nuhu *et al.* (2008). Oyster mushroom is very simply production technology, thus it can be grown on various agricultural wastes such as rice straw, wheat hay, maize and cotton refuse. The total biomass of the agricultural residues can be use in different ways such as biogas product, composting operation, silage for cattle feed, mushroom production and incorporating rice straw into the soil is another option. All these common management's practices prevent farmers from burning rice straw in open fields. In Egypt only about 20% of rice straw which is produced from rice cultivated was used for previous purposes and the remaining amount burns causing environmental pollution. Mushroom cultivation turns these residuals into a food source rich in minerals, protein and carbohydrates (Emtenan *et al.*, 2012). Rice straw is considered the main media utilized for oyster mushroom cultivation in Egypt. Rice straw has low nutritional value and is considered a lignocellulosic biomass that contains 38% cellulose, 25% hemicellulose, and 12% lignin in addition to a small amount of protein, which makes it high in C/N ratio. Therefore, it is resistant to microbial decomposition compared to straw from other protein-rich grains such as wheat and barley (Parr *et al.*, 1992).Wherefore, cultivate mushroom by using rice straw as growing media raising its economic value due to that after completing the mushroom production cycle the remaining organic substrate which partially degraded as a result of mushroom growing and development is named spent mushroom substrate (SMS) which assume a good source of organic matter, carbon, nitrogen and micro-elements which help to increase the soil biological and used as plant organic fertilizers (Debosz *et al.*, 2002). Also, SMS consider a soil conditioner which improved its quality by having a direct influence on soil aggregation, aeration and water movements in addition to increasing availability of insoluble sources of phosphorus which enhances plant growth (Rillig *et al.*, 2002 and Roy *et al.*, 2013).

Therefore, the goal of this study is enhancing the biological efficiency of oyster mushroom *Pleurotus columbinus* by using vermicompost at different concentrations mixed with rice straw beside, using compost

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tea and Azolla plants extract as sprayed in order to increase fruit productivity and quality.

## MATERIALS AND METHODS

This investigation was arranged in an uncontrolled greenhouse located in El-Kassasein Research Farm**,** Ismailia Governorate at 5th and 20th January during the winter growing seasons of 2019 and 2020 respectively.

**Spawn production:**

The pure fungal culture of *Pleurotus columbinus* was obtained from the Faculty of Agriculture, Ain Shams University, Qalubiya governorate. Spawn was prepared by using sorghum grains. The grains were washed and boiled for 20 min. Thereafter, the excess water was drained off then the grains were spread on muslin cloth for cooling. The grains were mixed with 4% $CaCo_3$ and 2% $CaSo_4$ (basis on grains dry weight) to maintain grains pH. The mixture was filled in polypropylene thermal bags (500g/bag), the bags plugged with non-absorption cotton stopper and wrapped with robber to save from the contamination and autoclaved at 121°C, (1.2 p.s.i, for 1h). The sterilized bags were cooled at room temperature and inoculated with a small bit of pure fungal culture (15 day old) under aseptic conditions, subsequently incubated at 24 ± 2 °C for a 15 days period until the mycelia fully invaded the grains. (Figure, 1).


**Figure 1. Preparation of mushroom spawn.**

**Substrate and spawning processing**

Rice straw was used as growing media for mushroom cultivation; the substrate was washed well by running water and soaked in water for 24h, after the excess the water was drained off and the substrate has been pasteurized using hot water (90 C$^o$, for 1h). On a sterilized plastic sheet (1.5m long x 1.5m wide) and spread until its temperature cools down and humidity becomes between 65-70%. Following this, the substrate was filled in polyethylene bags at 40x70 cm size (5kg wet weight/bag) and inoculated with previously prepared spawn (15 day old) which mixed with upper third from substrate surface (2% wet weight basis). Bags were closed carefully and immediately transferred to an uncontrolled glasshouse for 15 days (incubation period). When mycelia holly colonized the substrate, five holes were done in different directions of the bags surface to facilitate cross-sectional ventilation and allow the mushroom pinhead to appear and grow savely (Figure, 2). The chemical composition of rice straw before cultivated the mushroom was registered as followed pH= 6.8, E.C= 2.3dSm$^{-1}$, O.M= 91.40%, O.C= 53.9%, C/N= 37:1, N= 0.05%, $P_2O_3$= 0.07%, $K_2O$= 1.30, S= 0.1% and Si= 4.0%.

The average temperature and relative humidity of mushroom incubation and fruit productivity are arranged in Table (1).

**Table 1. Mean of meteorological data of Ismailia governorate region during the winter seasons of 2019 and 2020.**

| Months | Average temperature C$^0$ | | | | Relative humidity (RH %) | |
|---|---|---|---|---|---|---|
| | Max. | Min. | Max. | Min. | | |
| | 2019 | | 2020 | | 2019 | 2020 |
| January | 18.5 | 10.1 | 19.0 | 9.3 | 58 | 55 |
| February | 19.2 | 13.7 | 21.2 | 11.0 | 50 | 54 |
| Marc | 25.4 | 14.9 | 23.8 | 12.6 | 53 | 55 |
| April | 32.0 | 16.0 | 28.7 | 14.8 | 40 | 47 |


**Figure 2. Mushroom growth substrate and the fruit shape.**

Agricultural Research Center, Central Laboratory for Agricultural Climate, Ministry of Agricultural and Land Reclamation.

**The treatments were as follow:**

The organic supplements which used in this experiment containing

1- The vermicompost at concentration (0.0, 2, 5, and 10%) was mixed with mushroom growth substrate.

2- Compost tea at concentrate of (1:10L).

3- Azolla plants extract at concentrate of (5%).

Both compost tea and Azolla plants extract were used as spraying applications after finishing the mushroom incubation period immediately. The treatments were sprayed twice in a day until the ending of mushroom productivity period.

The experiment was arranged in a split plot with three replicates, each replicates containing 12 treatments, 8 bags in each treatment. However, rice straw plus vermicompost treatments (0.0, 2.5, 5 and 10%) were set as the main plot and the other sprayed treatments (water, compost tea and Azolla plants extract) were distributed within the sub plot.

**Vermicompost and compost tea preparation:**

Vermicompost was obtained from Central Laboratory for Agricultural Climate, Agricultural Research Center, Giza governorate. The vermicompost was watered carefully till its humidity reached 60%, then autoclaved at (121°C, 1.2 p.s.i, for 1.5h). Three concentrates of the previous cooled and sterilized vermicompost which were 0.0, 2.5, 5 and 10% were taken and individually mixed well with the pasteurized mushroom substrate before its inculcation with fungal culture. The chemical composition of vermicompost was as shown pH= 7.6, E.C= 3.1dSm$^{-1}$, O.M= 57.10%, O.C= 32.9%, C/N= 12:1, $NO_3$-N= 357ppm, total N= 3.1%, total $P_2O_3$= 2.08% and total $K_2O$= 1.1%, Fe= 313mg/kg, Zn= 40.2mg/kg and Mn= 63mg/kg.

Compost tea was prepared by mixing one kg of vermicompost with five L of tap water (w/v) with the addition of one cup (200 ml) of molasses to encourage the activity of microbial growth. The mixture was stirred every day to induce aeration and fermentation for seven days. After that, the mixture was filtered through using cheese cloth and diluted to a rate of (1:10L) compost tea: water respectively and saved at 4C$^0$ until further use. The chemical composition of compost tea at diluted rate of (1:10) was as followed pH= 6.2, E.C= 1.2dSm$^{-1}$, O.M= 14.40%, O.C= 12.9%, C/N= 8:1, total N= 1.9%, total $P_2O_3$= 1.02% and total $K_2O$= 0.91%, Fe= 13mg/L, Zn= 10.2mg/L and Mn= 0.4mg/L.

**Azolla plants extract preparation:**

An Azolla plant (*Azolla pinnata* L.) which was used in this study was obtained from Soil, Water and Environment Research Institute, Agriculture Research Center, Giza governorate. One kg of Azolla plants were soaked in one liter of ethanol (90% conc.) for 24h, and then mixed by the blender. The mixture filtered twice through two layers of gauze cloth. The obtained crud solution was considered as 100% concentrate of Azolla plants extract. 5ml of crude solution was taken and diluted with 95ml distilled water to prepare Azolla plants extract at concentrate of 5%. The obtained concentrate was kept in the refrigerator at 4C$^0$ till use. The chemical composition of Azolla plants extracted at concentrate of 5% was as follows N= 3.0%, P= 0.7%, K= 2%, Mg= 1.5%, Mn= 0.11%, Fe= 0.04% and starch=5.1%.

**Measurements:-**

**A- Fruiting phases and duration:**

1- Primordial initiation: Days after finished incubation period until pinhead appears.
2- Fruiting formation: Days from pinhead appearing to bike the fruits.
3- Duration: Days between first picking and next one

**B- Fruit characteristic:**

1- Average number of cluster/bag
2- Average weight of cluster.
3- Average number of fruits/cluster.
4- Average fruit weight.
5- Average weight of basidiocarp.

**C- Total yield and biological efficiency (BE):**

**1- Total yield/bag.**

Harvesting of clusters was done by hand pulling. Each bag was harvested separately and the mass of the cluster was recorded in grams using a digital scale.

**2- Biological efficiency (BE)**

Yield of mushroom per kg substrate on dry wt. basis was calculated by the following formula.

**BE (%) = (Mushroom fresh weight / Substrate dry weight X100**. (Royse *et al.*, 2004).

**D- Chemical fruit composition**:

Ten fruit of fresh mushroom was taken randomly from each treatment (Second flash) which weighted and dried in an oven at 70 C$^0$ till a constant weight for estimation of dry matter accumulation then grinded and preserved for subsequent chemical analysis. Dry matter accumulation was calculated by the following formula.

**Dry matter accumulation (%) = (Dry weight / Fresh weight) x 100** (Ponmurugan *et al.*, 2007).

Nutrient elements including P and K (%) were determined in mushroom fruits according to Chiappmann and Pratt (1961). Also, fruit protein and carbohydrate content (%) according to A. Q. A. C. (1990).

**Statistical analysis:**

The collected data was subjected to analysis for variance (ANOVA) using Statistix 8 software program and their means were separated by least significance ($P < 0.05$).

## RESULTS AND DISCUSSION

**A-Fruiting phases and duration:**

Data in Table (2) illustrated that Fruiting phases i.e., primordial initiation, fruit formation and duration were influenced positively with respect to various levels of the vermicompost, it was noticed earlier development in few days with an increasing of organic fertilizer levels especially using rate 10% which causes a decrease in the number of days reached about 4.66, 1.32 and 9.92 days in the first growing season and 3.53, 1.1 and 5.21 days in the second season for previous measurements respectively compared to the control (tap water). These results may be due to that vermicompost is considered source of micro and macro-nutrients, hormones, vitamins, enzymes and also organic chelating factors which increase nutrients availability therefore, has the ability to provide more energy for primordial initiation and formation moreover Ashraf *et al.* (2013) concluded that mixed mushroom substrate with rich sources of nitrogen content produce early primordial initiation.

As per the findings of this study, compost tea as organic spray was more effective to obtained fewer days for fruiting phases which were relatively faster where, the days required for primordial initiation, fruit formation and duration were approximately 38.00, 19.07 and 8.51% less than the control (tap water) respectively in first season while recorded 24.60, 9.70 and 6.88% through second season. Our results may be attributed to that compost tea is characterized by the availability of an appropriate amount of nutrients as mentioned in (material and method section) that encourage and push the fungus to early fruit initiation thereby rapid fruit formation, as well as reduce the number of days for produce new flashes (fruit duration). Merrill and McKeon (1998) reported that vermicompost tea as a spray promotes healthy growth, increases sustainability against pests and diseases and accelerates degradation of toxic materials. On the other hand, Azolla plants extract was not efficient to obtain promising results for this stage of pleurotus growth as shown in Table (2). This negative effect may be returned to that Azolla extract is rich in nitrogen contents as explained before thereby, the presence of a high amount of nitrogen causes slow pleurotus fruiting phases. It was known that for an induction oyster mushroom fruiting body it's important to maintain a balance between carbon and nitrogen sources (Khan and Chandra, 2017). Furthermore, excessive amounts of N cause slow down in mushroom development (Fasehaha and Shah, 2017).

In concern to the interaction, obtained data revealed that the number of days required for fruit phases and duration were different according to treatments (Table, 2). It was noticed the encouraged effect due to application vermicompost at 10% combined with sprayed compost tea which causes a reduction in the number of days required for primordial initiation ranged between 11.46, 17.00 and 3.36, 3.76 days for fruit formation in the first and second growing seasons respectively. These ranges were shorter than observed by control treatment (without any applications) 27.53, 26.83 days for primordial initiation and 5.66, 5.73 days for fruit formation in the first and second season respectively. The time required for fruit phases in control treatment was comparable with other similar study where many researchers Khanna *et al.* (1992); Ragunathan *et al.* (1996); Yildiz et al. (1998) revealed that the primordial initiation of *Pleurotus spp*., generally require 20 to 30 days. While, Bughio (2001) stated that the number of days for pinhead initiation is required 25 to 50 days and formation of fruiting bodies took 5 to 6 days from the pinhead initiation. These observable differences may be returned to the composition of substrate. Narain *et al.* (2008) attributed the earlier pin head initiation to release enough nutrients in substrate which push fungus to growth and development. Thereby, both vermicompost and compost tea as organic applications provide the optimal nutrients that supported *Pleurotus columbinus* fruiting phases evolution.

**Table 2. Effect of some organic applications on *Pleurotus Columbines* fruiting phases and duration grown under uncontrolled conditions at the two seasons of 2019 and 2020.**

| Treatments | | Primordial initiation | | Fruit formation | | Fruit duration | |
|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Rice straw | Tap water | 27.53 | 26.83 | 5.66 | 5.73 | 24.23 | 25.13 |
| | Azolla extract at concentrate of 5% | 21.53 | 24.20 | 5.33 | 5.40 | 24.20 | 24.00 |
| | Compost tea at concentrate of (1:10) | 19.36 | 19.26 | 5.06 | 5.06 | 23.93 | 22.60 |
| Rice straw plus vermicompost at (2.5%) | Tap water | 27.30 | 23.77 | 5.50 | 5.33 | 22.33 | 22.66 |
| | Azolla plants extract at concentrate of 5% | 20.20 | 21.01 | 4.49 | 5.20 | 21.60 | 22.00 |
| | Compost tae at concentrate of (1:10) | 17.65 | 19.00 | 4.36 | 5.05 | 20.53 | 22.00 |
| Rice straw plus Vermicompost at (5%) | Tap water | 25.86 | 25.10 | 5.00 | 5.23 | 20.26 | 20.93 |
| | Azolla plants extract at concentrate of 5% | 20.00 | 23.33 | 4.53 | 5.02 | 17.40 | 20.46 |
| | Compost tea at concentrate of (1:10) | 15.83 | 17.30 | 4.00 | 4.73 | 17.20 | 20.20 |
| Rice straw plus vermicompost at (10%) | Tap water | 23.00 | 20.55 | 4.60 | 4.33 | 14.93 | 20.13 |
| | Azolla plants extract at concentrate of 5% | 20.00 | 22.16 | 4.13 | 4.00 | 14.53 | 18.03 |
| | Compost tea at concentrate of (1:10) | 11.46 | 17.00 | 3.36 | 3.76 | 13.13 | 17.93 |
| L.S.D at 5% | | 0.95 | 0.49 | 0.40 | 0.15 | 0.84 | 0.80 |
| Rice straw. | | 22.81 | 23.43 | 5.35 | 5.40 | 24.12 | 23.91 |
| Rice straw plus vermicompost at (2.5%) | | 21.71 | 21.91 | 4.93 | 5.19 | 21.48 | 22.22 |
| Rice straw plus vermicompost at (5%) | | 20.56 | 21.26 | 4.51 | 4.99 | 18.28 | 20.53 |
| Rice straw plus vermicompost at (10%) | | 18.15 | 19.90 | 4.03 | 4.30 | 14.20 | 18.70 |
| L.S.D at 5% | | 0.50 | 0.26 | 0.14 | 0.11 | 0.47 | 0.38 |
| Tap water | | 25.92 | 24.06 | 5.19 | 5.15 | 20.44 | 22.21 |
| Azolla plants extract at concentrate of 5% | | 20.43 | 22.67 | 4.73 | 4.90 | 19.43 | 21.12 |
| Compost tea at concentrate of (1:10) | | 16.07 | 18.14 | 4.20 | 4.65 | 18.70 | 20.68 |
| L.S.D at 5% | | 0.47 | 0.24 | 0.20 | 0.07 | 0.42 | 0.40 |

**B- Fruit characteristic:**

The obtained data in Table (3) revealed that fruit characters viz, average number of cluster/bag, weight of cluster/bag, weight of fruit/cluster and weight of basidiocarp significantly positively influenced as resulting to increase vermicompost concentrate in substrate from 2.5 to 10% except the number of fruit per cluster which appears a cleared decrease especially with high concentrate of vermicompost (10%).

The stimulative impact of vermicompost as a supplement may be due to that additive organic matter to mushroom substrate with different concentrate has been reported to improve mushroom fruit characters Onyango *et al.* (2011). Where, the various levels of organic matter provide balance requirements of elements, thereby the vermicompost which used in current study was observed as a better supplement, because it is rich in minerals and is supposed to increase mushroom fruit characters. On the other side, rice straw as growth media without any additive (control treatment) was sufficient to produce the highest number of fruit bodies (8.77 and 7.52/cluster) in both seasons respectively. The outcomes obtained from this study are similar to those findings by Rajak *et al.* (2011) on *Pleurotus sajor caju*, Kotb *et al.* (2012) on *P. ostreatus and P. columbines* and Nayak *et al.* (2015) on *P. ostreatus.* They illustrate the maximum fruit number obtained when previous *P. spp.,* grown on rice straw sole compared with rice straw supplied with various organic mixtures.

This study also cleared the affectivity of Azolla plants extract (5%) as spray in improving all aforementioned fruiting characteristics whereas it has a negative impact on the number of fruits per cluster (Table, 3). Azolla plants extract is rich in nutrients especially nitrogen content (material section), which in turn improves the properties of the fruits. Our result is in accordance with that reported by Loss *et al.* (2009) and Salama *et al.* (2019).

With regard to the effect of interaction between vermicompost at high levels and Azolla plants extracted as stimulant sprayed on fruit characters the obtained data in Table (3) revealed enhancement in weights of clusters, fruits and basidiocarp. It may be attributed to that mushroom growth media must contain appropriate amounts of carbon and nitrogen achieved optimal C/N ratio to produce vigor yield and healthy fruit characteristic Philippoussis and Diamantoppoulou (2011). It was established that the main components of rice straw are cellulose, hemicelluloses and lignin which consider sources of carbon. However, its nitrogen content is very poor and is not available until it is released enzymatically through mushroom growth and development (Lin, 2000). Nitrogen is an essential element for cellular functions for mushroom growth and various metabolic activities particularly protein and enzymes synthesis responsible for the analysis of the straw and the formation of fruit bodies Upadhyay *et al.* (2002) and Abdul-Qader *et al.* (2019). Therefore, additive vermicompost at concentrate 10% to rice straw provides sufficient amount of organic carbon beside sprayed Azolla plants extracted as source of organic nitrogen which becomes easier to absorb and available by mushrooms allowing fungus to have more energy to use for growth and formation of healthy fruit bodies. Nunes *et al.* (2012) stated that the effective absorption capacity of organic nitrogen is easier and faster by mushrooms which in turn, prompt fungi to grow and produce robustly.

**Table 3. Effect of some organic applications on *Pleurotus Columbines* fruit characteristic grown under uncontrolled conditions at the two seasons of 2019 and 2020.**

| Treatments | | Ave. number of clusters /bag | | Ave. Weight of cluster(g) | | Ave. number of fruits /cluster | | Ave. weight of fruit (g) | | Ave. weight of basidiocarp (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Rice straw | Tap water | 2.10 | 2.56 | 111.32 | 106.87 | 9.23 | 8.16 | 10.93 | 11.96 | 8.22 | 9.13 |
| | Azolla extract at concentrate of 5% | 2.00 | 2.76 | 163.84 | 151.02 | 8.06 | 7.53 | 18.26 | 18.50 | 14.31 | 13.56 |
| | Compost tea at concentrate of (1:10) | 2.33 | 2.93 | 143.64 | 115.58 | 9.03 | 6.86 | 14.13 | 14.36 | 11.99 | 9.96 |
| Rice straw plus vermicompost at (2.5%) | Tap water | 2.50 | 3.11 | 121.56 | 119.53 | 8.46 | 6.74 | 13.53 | 15.78 | 10.30 | 11.68 |
| | Azolla plants extract at concentrate of 5% | 2.73 | 3.18 | 169.83 | 159.93 | 7.80 | 6.34 | 19.26 | 21.78 | 17.44 | 18.45 |
| | Compost tae at concentrate of (1:10) | 2.94 | 3.20 | 157.38 | 134.09 | 8.20 | 6.50 | 18.07 | 18.26 | 16.38 | 15.77 |
| Rice straw plus Vermicompost at (5%) | Tap water | 3.06 | 3.08 | 124.97 | 126.44 | 7.46 | 6.20 | 14.53 | 18.19 | 11.42 | 13.71 |
| | Azolla plants extract at concentrate of 5% | 3.08 | 3.33 | 173.79 | 161.80 | 6.50 | 4.93 | 24.34 | 29.16 | 20.19 | 24.28 |
| | Compost tea at concentrate of (1:10) | 3.16 | 3.60 | 164.33 | 143.55 | 6.80 | 6.16 | 21.00 | 21.26 | 17.35 | 17.95 |
| Rice straw plus Vermicompost at (10%) | Tap water | 3.23 | 3.60 | 134.58 | 154.45 | 6.22 | 5.73 | 19.41 | 25.88 | 16.18 | 21.54 |
| | Azolla plants extract at concentrate of 5% | 4.40 | 4.50 | 193.17 | 180.87 | 3.80 | 3.43 | 44.17 | 46.24 | 38.78 | 38.39 |
| | Compost tea at concentrate of (1:10) | 3.80 | 3.93 | 169.84 | 158.22 | 4.90 | 4.16 | 31.33 | 33.62 | 26.17 | 28.97 |
| L.S.D at 5% | | 0.38 | 0.30 | 3.38 | 3.64 | 0.35 | 0.30 | 1.00 | 0.88 | 0.05 | 0.16 |
| Rice straw. | | 2.14 | 2.75 | 139.60 | 124.49 | 8.77 | 7.52 | 14.44 | 14.94 | 11.50 | 10.88 |
| Rice straw plus vermicompost at (2.5%) | | 2.72 | 3.16 | 149.59 | 137.85 | 8.15 | 6.52 | 16.95 | 18.59 | 14.71 | 15.30 |
| Rice straw plus vermicompost at (5%) | | 3.31 | 3.34 | 154.36 | 143.93 | 6.92 | 5.76 | 19.95 | 22.87 | 16.32 | 18.65 |
| Rice straw plus vermicompost at (10%) | | 3.81 | 4.01 | 165.86 | 164.51 | 4.97 | 4.44 | 31.64 | 35.24 | 27.04 | 29.63 |
| L.S.D at 5% | | 0.21 | 0.22 | 1.59 | 1.61 | 0.20 | 0.29 | 0.55 | 0.79 | 0.03 | 0.12 |
| Tap water | | 2.72 | 3.09 | 123.10 | 126.83 | 7.84 | 6.71 | 14.60 | 17.95 | 11.53 | 14.01 |
| Azolla plants extract at concentrate of 5% | | 3.06 | 3.44 | 175.16 | 163.41 | 6.54 | 5.56 | 26.51 | 28.91 | 22.68 | 23.67 |
| Compost tea at concentrate of (1:10) | | 3.05 | 3.41 | 158.80 | 137.86 | 7.23 | 5.92 | 21.13 | 21.86 | 17.97 | 18.16 |
| L.S.D at 5% | | 0.19 | 0.15 | 1.69 | 1.82 | 0.17 | 0.15 | 0.50 | 0.44 | 0.02 | 0.08 |

**C- Total yield and biological efficiency (BE):**

Data in Table (4) revealed that the yield and biological efficiency (BE) of *Pleurotus columbines* were influenced by raising levels of vermicompost from 2.5 to 10%). Thus, additive high level (10%) of vermicompost to mushroom substrate was significantly the most effective for obtained the highest yield (728.87&749.32g/bag) with biological efficiency ranged of (36.44 & 37.46%) in the first and second seasons respectively compared to using the lower levels. It was established that mushroom production is depended on the nutritional content of substrate Patil *et al.* (2010), so additive organic matter as supplement performing best in mushroom substrate and providing slow releasing nutrient thereby, improve the biological efficiency and yield of various species of mushroom Moonmoon *et al.* (2011); Adenipekun and Omolaso (2015). Moreover, *Pleurotus spp.*, requires growing less nitrogen and more carbon beside the availability of minerals as phosphorus, potassium and nitrogen in the substrate, that become more suitable for biological efficiency and its production. Mangat *et al.* (2008); Chang and Miles (1989) and Besufekad *et al.* (2020). From this concern, the outcome of our results may be due to the addition of the various levels of vermicompost to rice straw that led to change in the chemical formula of the substrate and increased its nutrient content which led to enhance both BE and the productivity. The present results are agreement with Kaur *et al.* (2004); Loss *et al.* (2009); Alananbeh *et al.* (2014); Sivagurunathan and Sivasankari (2015) and Khan *et al.* (2017).

Data in Table (4) showed that Azolla plants extract had the potential effect to encourage both mushroom yield and its biological efficiency (BE) during the two experimental seasons compared to either compost tea or tap water (control treatment). This results may be attributed to the fact that mushroom substrate is poor in its nitrogen content ranging between 0.5 and 0.8% (Lin, 2000). Azolla plants extract is a rich source of essential amino acids and minerals like nitrogen, calcium, phosphorus, magnesium, potassium, iron and zinc (Chatterjee *et al.*, 2012). Hence, the availability of these minerals increases the metabolic capacity of mushroom in turn helps in achieving higher mushroom yield (Azizi *et al.*, 1990; Gupta and Vijay, 1991and Silva *et al.*, 2007).

Regarding the interaction treatments, data in Table (4) showed that the obtained results of mushroom yield and its biological efficiency was differed according to different combinations, however, vermicompost at concentrate 10% in addition to Azolla plants extract at 5% as sprayed were found to be the best treatment related to increasing yield and the biological efficiency as comparison to other applications. This result may be return to that rice straw mixed with different amounts of vermicompost therefore the chemical composition of substrate formula was differed in its mineral component, pH, EC and particular C:N ratio which considers one of the important factors influencing on the biological efficiency and consequently the yield as stated by (Hoa *et al.,* 2015), In addition the nutrient content in mushroom substrate is contributed in yield production (Baldrian and Valaskova, 2008), our result is confirmed with (Badu *et al.,* 2011) who illustrated that oyster mushrooms productivity depending on the chemical and nutritional content of substrates. Lignocellulosic materials which are used for mushroom production are poor in its mineral contents, so the various sources of supplement to mushroom substrate save amount of several minerals which due to enhancing mushroom yield (Mangat *et al.,* 2008). Also, the importance of adding nitrogen as an external supplier in increasing yield production was explained by (Siqueira *et al.,* 2012). In our investigation the chemical composition of either vermicompost or Azolla plants extract explained their richness in nutrients which provide enough energy reflected on fungus biological efficiency thereby the yield. This previous finding is supported by Samuel and Eugene (2012) who demonstrate that the supplementation of mushroom substrate or the use of new combination may promote increased productivity and mushroom biological efficiency.

**Table 4. Effect of some organic applications on *Pleurotus Columbines* total yield and biological efficiency grown under uncontrolled conditions at the two seasons of 2019 and 2020.**

| Treatments | | Total yield/bag (g) | | Biological efficiency (%) | |
|---|---|---|---|---|---|
| | | 2019 | 2020 | 2019 | 2020 |
| Rice straw | Tap water | 339.20 | 314.46 | 16.93 | 15.72 |
| | Azolla extract at concentrate of 5% | 517.55 | 458.31 | 25.88 | 22.91 |
| | Compost tea at concentrate of (1:10) | 473.33 | 345.75 | 23.66 | 17.73 |
| Rice straw plus vermicompost at (2.5%) | Tap water | 362.33 | 392.65 | 18.11 | 19.63 |
| | Azolla plants extract at concentrate of 5% | 616.52 | 584.57 | 30.82 | 29.22 |
| | Compost tae at concentrate of (1:10) | 488.83 | 474.50 | 24.44 | 23.72 |
| Rice straw plus Vermicompost at (5%) | Tap water | 514.03 | 415.17 | 25.70 | 20.75 |
| | Azolla plants extract at concentrate of 5% | 713.67 | 694.67 | 35.63 | 34.74 |
| | Compost tea at concentrate of (1:10) | 672.00 | 636.73 | 33.60 | 31.83 |
| Rice straw plus vermicompost at (10%) | Tap water | 537.16 | 585.12 | 26.85 | 29.25 |
| | Azolla plants extract at concentrate of 5% | 885.33 | 874.50 | 44.26 | 43.72 |
| | Compost tea at concentrate of (1:10) | 764.13 | 788.33 | 38.20 | 39.41 |
| L.S.D at 5% | | 2.22 | 1.51 | 0.11 | 0.08 |
| Rice straw. | | 443.36 | 375.84 | 22.16 | 18.78 |
| Rice straw plus vermicompost at (2.5%) | | 489.23 | 483.80 | 24.46 | 24.19 |
| Rice straw plus vermicompost at (5%) | | 633.23 | 582.19 | 31.66 | 29.10 |
| Rice straw plus vermicompost at (10%) | | 728.87 | 749.32 | 36.44 | 37.46 |
| L.S.D at 5% | | 1.14 | 1.34 | 0.05 | 0.05 |
| Tap water | | 438.18 | 426.85 | 21.90 | 21.34 |
| Azolla plants extract at concentrate of 5% | | 683.27 | 653.01 | 34.16 | 32.64 |
| Compost tea at concentrate of (1:10) | | 599.57 | 563.58 | 29.97 | 28.17 |
| L.S.D at 5% | | 1.11 | 0.75 | 0.05 | 0.04 |

**D- Chemical fruit composition**:

Data in Table (5) showed the increase of protein, carbohydrate, potassium and phosphorus as well as dry matter accumulation in pleurotus fruit grown in rice straw mixed with varied concentrations of vermicompost; the high values were noticed by level 10% of vermicompost. The obtained results may be due to the gross chemical contents of rice straw supplemented with vermicompost at high level 10% resulting in the highest chemical content in fruit bodies. Our outcomes were confirmed by Gupta *et al.* (2013) and King *et al.* (2016) who declared the chemical contents of mushroom fruit are related to the nutritional composition of growth substrate. In addition, rice straw mixed with various levels of organic additive increasing fruit protein content and nutrient elements as reported by Rajarathnam *et al.* (2001) and Adenipekun and Omolaso (2015).Also, it was observed boosted effect of various sprayed treatments on encourage fruit chemical contents as shown in Table (5) whereas the greatest results were obtained through using compost tea, then Azolla plants extract respectively comparison with tap water (control treatment). Our additive used in current study as sprayed had contained a suitable amount of nutrient elements consequently, reflected in the accumulation of these elements in the fruits. From this concern (Chang & Miles, 1984) established that potassium is one of the most abundant minerals in mushrooms, followed by phosphorus and magnesium. It is well known that the compositions of substrate or supplementation effects on the accumulation of minerals in mushrooms as mentioned by (Li *et al.,* 2017 and Carrasco *et al.,* 2018). Moreover, the high nitrogen content that is characteristic of these additives resulted in increment in fruit protein content Chandel *et al.* (2010); Elattar *at al.* (2019) and Ashraf *et al.* (2013) reported that the amount of nitrogen supplied in the growth media might enable increase protein contents in fungi basidiocarp.

With regard to the interaction effects on the chemical contents of fruits, rice straw supplemented with vermicompost at (10%) and sprayed by compost tea found to be the most influential to obtain utmost chemical content in fruit bodies (Table, 5). Depending on the results which were decided by Ahmed *et al.* (2009) and Abdul-Qader *et al.* (2019) the growth substrate rich in its nitrogen content produces higher fruiting bodies protein. Our experiment showed that both of vermicompost and compost tea contain an appropriate amount of N which was probably enough to increase protein content in the fruit, furthermore other nutritional contents as showed through their chemical analysis (material section) were sufficient to increase fruits nutrient elements i.e., P and K.

**Table 5. Effect of some organic applications on *Pleurotus Columbines* chemical fruit composition grown under uncontrolled conditions at the two seasons of 2019 and 2020.**

| Treatments | | P (%) | | K (%) | | Protein (%) | | Carbohydrate (%) | | Dry matter Accumulation (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Rice straw | Tap water | 0.62 | 0.77 | 1.08 | 1.14 | 18.11 | 18.100 | 31.57 | 32.35 | 9.19 | 9.72 |
| | Azolla extract at concentrate of 5% | 0.73 | 0.08 | 1.10 | 1.19 | 18.18 | 18.17 | 31.84 | 33.08 | 9.67 | 10.15 |
| | Compost tea at concentrate of (1:10) | 0.90 | 1.81 | 1.17 | 1.24 | 18.31 | 18.20 | 32.32 | 33.38 | 11.29 | 11.61 |
| Rice straw plus vermicompost at(2.5%) | Tap water | 0.68 | 0.83 | 1.10 | 1.22 | 18.17 | 18.12 | 31.54 | 32.74 | 9.70 | 10.00 |
| | Azolla plants extract at concentrate of 5% | 0.77 | 0.86 | 1.18 | 1.29 | 18.20 | 18.21 | 32.34 | 33.79 | 15.30 | 12.53 |
| | Compost tae at concentrate of (1:10) | 1.02 | 1.13 | 1.22 | 1.35 | 18.34 | 18.23 | 32.64 | 34.87 | 17.52 | 17.88 |
| Rice straw plus Vermicompost at(5%) | Tap water | 0.69 | 1.09 | 1.26 | 1.33 | 18.25 | 18.26 | 33.00 | 33.42 | 10.04 | 10.28 |
| | Azolla plants extract at concentrate of 5% | 0.82 | 1.12 | 1.32 | 1.34 | 18.34 | 18.30 | 33.46 | 34.31 | 10.27 | 10.30 |
| | Compost tea at concentrate of (1:10) | 1.09 | 1.17 | 1.36 | 1.41 | 18.42 | 18.38 | 34.17 | 35.30 | 19.20 | 20.05 |
| Rice straw plus Vermicompost at(10%) | Tap water | 0.74 | 1.13 | 1.30 | 1.38 | 18.31 | 18.32 | 33.59 | 33.50 | 13.22 | 13.00 |
| | Azolla plants extract at concentrate of 5% | 0.99 | 1.20 | 1.35 | 1.40 | 18.39 | 18.36 | 34.08 | 35.40 | 8.09 | 9.73 |
| | Compost tea at concentrate of (1:10) | 1.20 | 1.28 | 1.38 | 1.47 | 18.50 | 18.41 | 34.40 | 36.31 | 22.18 | 22.62 |
| L.S.D at 5% | | 0.04 | 0.04 | 0.03 | 0.02 | 0.03 | 0.03 | 0.30 | 0.43 | 0.15 | 0.27 |
| Rice straw. | | 0.75 | 0.89 | 1.11 | 1.19 | 18.20 | 18.15 | 31.91 | 32.94 | 10.03 | 10.49 |
| Rice straw plus vermicompost at (2.5%) | | 0.82 | 0.94 | 1.17 | 1.29 | 18.23 | 18.18 | 32.17 | 33.80 | 13.17 | 13.47 |
| Rice straw plus vermicompost at (5%) | | 0.86 | 1.13 | 1.31 | 1.36 | 18.40 | 18.31 | 33.54 | 34.35 | 14.18 | 13.54 |
| Rice straw plus vermicompost at (10%) | | 0.98 | 1.20 | 1.34 | 1.41 | 18.43 | 18.36 | 34.02 | 35.07 | 14.49 | 15.17 |
| L.S.D at 5% | | 0.02 | 0.03 | 0.03 | 0.01 | 0.28 | 0.02 | 0.20 | 0.17 | 0.06 | 0.16 |
| Tap water | | 0.68 | 0.95 | 1.18 | 1.27 | 18.21 | 18.20 | 32.42 | 33.00 | 10.53 | 10.75 |
| Azolla plants extract at concentrate of 5% | | 0.83 | 1.00 | 1.24 | 1.30 | 18.39 | 18.26 | 32.93 | 34.15 | 10.83 | 10.68 |
| Compost tea at concentrate of (1:10) | | 1.05 | 1.16 | 1.28 | 1.37 | 18.28 | 18.30 | 33.38 | 34.96 | 17.54 | 18.04 |
| L.S.D at 5% | | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.15 | 0.21 | 0.07 | 0.13 |

## CONCLUSION

From the present data, it was evident that both of vermicompost as organic supplement mixed with basic substance (rice straw) at various concentrations showed favorable influence according to *Pleurotus Columbines* fungus fruiting phases, duration, total yield/bag and the biological efficiency. On the other side the two organic spraying were differed in their effects on fungus, fruiting phases and duration, fruit characteristic and chemical content, whereas the superior results recorded for average number of cluster/bag, weight of cluster/bag, weight of fruit/cluster and weight of basidiocarp were related to Azola plants extract. Meanwhile, compost tea was resulting in earlier primordial initiation, shortage period for both fruit formation and duration. Furthermore, produce highly fruits chemical contents of P, K, protein, carbohydrate and dry matter accumulated. These obtained data highlighted the importance of the organic additive which was used in this investigation for fungus *Pleurotus Columbines* productivity grown under uncontrolled condition**.**

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## تأثير بعض المعاملات العضوية على القدرة الحيوية والإنتاجية للمشروم (بلوروتس كولومبينس) النامي تحت الظروف غير المتحكم فيها

**هالة حسن ابوالنور وعبد العزيز ابراهيم محمد**

**أقسام بحوث الخضر- معهد بحوث البساتين- مركز البحوث الزراعية – الجيزة- مصر.**

بعض الإضافات العضوية التى تشمل الفيرم كمبوست والذى خلط مع بيئة نمو المشروم (قش الأرز) بمستويات مختلفة صفر ، 2.5، 5، 10% الى جانب شاى الكمبوست بتركيز (10:1) و مستخلص نباتات الأزولا بتركيز 5% كرش عضوى واستخدمت مستويات الاضافة او الرش لتحسين كلا من القدرة الحيوية والإنتاجية للبلوروتس كولومبينس النامى تحت الظروف غير المتحكم فيها أثناء موسمي عامين 2019 و 2020. النتائج أوضحت قدرة الفيرم كمبوست بالتركيز العالي 10% لتشجيع مراحل الإثمار المختلفة، المحصول الكلى/الكيس، القدرة الحيوية، المحتوى الكيميائى للثمار، وكل الصفات الثمرية ما عدا عدد الثمار للكلستر والتى أوضحت أعظم نتائج بواسطة قش الأرز بمفرده بدون اى اضافات (معاملة الكنترول). على الجانب الأخر، شاى الكمبوست كرش عضوى كان الأكثر تأثيرا للحصول على تبكير في تكوين رأس الدبوس و تقليل الأيام المطلوبة لكلا من تكوين الثمار والفترة بين القطفة والأخرى علاوة على المحتوى العالى للثمار من البروتين، الكربوهيدرات، الفوسفور، البوتاسيوم الى جانب تراكم المادة الجافة. بينما، مستخلص نباتات الأزولا نتج عنه أعلى صفات ثمرية معبر عنها بمتوسط عدد الكلستر/كيس، وزن الكلستر/كيس، وزن الثمرة/كلستر و وزن البازيديوكارب لكن كان له تأثير سلبى على عدد الثمار للكلستر. تفاعل الفيرم كمبوست بمعدل 10% و مستخلص نباتات الأزولا كان الأكثر تأثيرا للحصول على أعظم قيم للمحصول الكلى/كيس و القدرة الحيوية للفطر.

***الكلمات الدالة:*** المشروم – الفيرم كمبوست – الأزولا