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Valuation of Spent Mushroom Substrate extracts to enhance rice yield and rice grain quality

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ABSTRACT

This study builds upon a previous one that aimed to determine the effect of spent mushroom substrate extract (SMSE) as a biofertilizer on the growth of Sakha 103 rice verity. A useful method to extract Plourotus mushrooms is to use water. These result in highly nutritious organic fertilizers that can improve rice growth, quality, and yield. The study involved soaking rice grains in SMSE, followed by application through three methods: spraying on the rice shoot system, soil drenching, and a combination of both spray and soil drenching. The most effective method to add fertilizer is to use a combination of spraying and amendment with irrigation water. Spent extract (SMSE) contains a significant amount of phenolic compounds, reducing sugars, and other macro- and micro-elements that can be beneficial for the growth of rice. Eight different treatments were selected based on their productivity and evaluated for their rice quality assessment. Treatments (P3Ss) and (P3Sw) scored significantly higher in protein, ash, and fiber but showed a significant decrease in amylose content. The cooking time for all grains ranged between 17 and 20 minutes. There were no significant differences in the thousand grain weight for most treatments, except for P3Sw and P3Ss, which had a high significant value of 28.5 g for both. All treatments were grouped based on their length and L/W ratio and were classified as either short or bold grains. In terms of color, there were noticeable distinctions between all treatments and the control group. Also, treatments (P3Ss) and (P3Sw) were found to have higher levels of whiteness and lightness compared to other treatments. Additionally, T3 (P3Ss) and T7 (P3Sw) treatments received the highest ratings for overall acceptability in terms of sensory attributes.

1.Introduction

Rice is considered one of the most essential crops in Egypt and in the world, in addition to wheat and maize as cereal crops. The total cultivated area is about 1.40 million acres (2011 season), which produces about 5.66 million tons (R.N.C. 2012). Rice plants consume great amounts of mineral nutrients for their growth, development, and grain production. Cost and availability are the main barriers to the usage of chemical fertilizers (Akanbi et al., 2005). So, there is a need to investigate the combined effects of organic fertilizer with inorganic fertilizers and also to find a suitable ratio of inorganic fertilizers and compost that could yield an economic yield. It is utilized in compost, and the issue could be resolved by applying animal feed made from mushroom cultivation directly as an organic fertilizer (Rinker 2002). The mushroom species produce biotic resistance substances that elicit plant

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defense responses (Silva et al., 2013). Mushroom farms started to be widely established in Egypt and partially replaced the animal protein. (Siddhant and Ayodhya 2009) used to SMS from oyster mushrooms strains as a fertilizer to enhance the yield of *Spinacea Oleracea* plant (Sendi et al., 2013). The type Pleurotus stratus is common on farms because of its low cost of production. Residues of mushroom agriculture contain highly effective and nutritive compounds resulting from the metabolic activity of the fungus These residues are considered waste materials, which contains valuable organic materials and is convenient for recycling in different forms and caused) a major problem for the environment such as air and water people used to pilt or burn or just bury it in some out-of-the-way place and forget about it (Danny, 1992; Szmidt and Convay, 1995). There is a good opportunity to reuse spent mushroom substrate through composting to produce vegetable crops. Research interest in tropical countries has shifted to the utilization of agro-based industrial wastes and farm waste products, which, if not converted to other economic uses such as fertilizers, might pose environmental hazards, also the use of agriculture waste as a source of plant nutrients serves as environmental sanitation as well as a reduction in the craving for mineral fertilizers by farmers (Ayeni, 2014) alternative to the Present day's environmental degradation is to make proper use of the unutilized organic biodegradable wastes available to convert them into compost within a short period (Chanda et al., 2011). (SMC) Spent mushroom compost generated from post-harvest process, it is a residue substrate for edible mushroom cultivation (Nakatsuka et al*.,* 2016). The SMC required suitable management other than burning or dumping (Pérez et al., 2019). Moreover, the rising concern about the sustainable economy recently increased the interest in recycling the SMC (Jasińska 2018). The main components are lignocellulose materials, such as wood, cotton sawdust, wheat, rye, maize and rice straw (Zhang et al., 2012; Hackett, 2015). Many researches have shown the benefits of SMS as bio fertilizer and/or a soil conditioner (Courtney & Mullen, 2008 and Hackett, 2015). Compost tea is a liquid extract of SMC prepared by mixing compost with water. It contains soluble nutrients and beneficial microorganisms, including bacteria, fungi, protozoa and nematodes (Szmidt and Dickson 2001). In organic farming, it is important to use organic fertilizer that is safe for the environment. Creation of large amounts of SMS , an organic waste material, which is a problem for the producers. However, it is an extremely valuable organic fertilizer material that can be potentially used in agriculture as a good fertilizer (Jankowski and Jodelka 2000). The grain quality of rice is tested by many factors, such as grain appearance, nutritional value, cooking, and eating quality. (Juliano et al., 1990). Quality is very important determinant of market price, consumer acceptance, and usage. Consumer preference based on appearance, grain shape, milling and cooking processes, and size. (Subudhi et al., 2012). The size and shape of the kernel are yet another determining factor in rice quality. Long-grain rice kernels are is7 mm long and 3 times longer than they are wide after milling. When cooked, this grain is light and easily separates. Medium-grain rice kernels are 5 to 6 mm long and 2 to 2.9 times longer than wide, making them shorter and wider than the long grain. Short or round-grain rice kernels are 4 to 5 mm long and 1.9 or less times longer than wide. (Bergman et al., 2004*).* The amount of water absorbed by a known quantity of rice when cooked in boiling water for a given time is expressed as the "water absorption ratio" (grams of water absorbed per gram or 100 grams of rice). The objectives of the study are more than one: first, getting rid of mushroom farm wastes, which represent a big problem affecting the economy and environment as an pollution factor and utilize spent mushroom substrates instead of disposing of them as undesirable waste. Second, maximize the utilization and recycling of this waste as economic biofertilizer to enhance productivity and the quality of Sakha 103 rice variety.

2. Materials and Methods

Materials

Eight untreated and treated rice samples of sakha103 rice verity are represented in Figure 1., rice samples were milled with a laboratory hammer mill and sieved through an 850 µm sieve to prepare rice flour, which was kept in plastic bags at room temperature. Batter, corn oil, salt, vanilla, and water. Baking powder was purchased from the local market.

Methods

(SMS) analysis

The EC, pH, organic matter (Walkley and Black, 1934), and phenolic compound content (Singleton et al., 1999) of spent mushroom substrate extract (SMSE) were measured.

Field experiment

According to a previous study, the effect of Spent Mushroom Substrate Extract (SMSE) as a biofertilizer on the growth improvement of Rice Sakha 103 was conducted at the experimental farm of the Rice Research and Training Center (RRTC), Kafr El Sheikh, Egypt. In addition to the control, seven treatments were selected according to their productivity and quality. Are found in Figure 1., The experimental study looks at how various SMSE application techniques affect the Sakha 103 rice cultivar's performance. The Rice Research and Training Center (RRTC) advised fertilizing and preparing the experimental soil.

Treatments

Treatments of the field experiment using a split design (where the treatments were a combination of grain soaking and plant treatments) were selected to evaluate their quality as shown in Table 1.

Table 1. An explanatory diagram of the experiment, the names of samples & the methods of addition

Key of treatments	Explanation
Grain Soaking	
S_s	Seeds soaked in SMSE (10% W/V)
S_w	Seeds soaked in Water
Plant treatment	
P0	Plants sprayed with water
P1	Plants sprayed with (SMSE 10 %) at ratio f 10 L fed^{-1} at 40, 60 days of plant age
P2	Plants amended with (SMSE10 %) at ratio of 10 L fed^{-1} at 40, 60 days of plant age with irrigating water
P3	Combination between P1+P2
8 treatments were selected to evaluated its quality	Combination between grains soaking and plant treatment
(Control)	Sw + P0
T1	Ss + P1
T2	Ss + P2
T3	Ss + P3
T4	Ss + P0
T 5	Sw + P1
T6	Sw + P2
T7	Sw + P3

Plant and yield biometrics Plant

Growth parameters, such as dry weight of plant, number of branches, height, spike length, spike weight, full seeds, empty seeds, 1000 grain weight, grain and straw yield, in addition to NPK in grain and straw, were estimated.

Physical properties

Broken rice %, hundred grams of rice grain that had no visible breakage, and 3/4-sized grains were used to determine the head rice recovery (Delacruze and Khush, 2000).

Morphological properties of rice

Kernel length (L) and kernel breadth (B) were measured using a dial micrometer, and the L/B ratio was calculated. Milled rice is first classified into three classes based on length: long (>6mm in length), medium (5–6 mm in length), and short (<5 mm in length). Then classified into three classes based on the L /B ratio: slender (ratio more than 3); bold (ratio 2–3); and round (ratio less than 2) to estimate size and shape (Dipti, et al., 2002). The cooking quality characteristics: concluded the minimum cooking time, water uptake determined according to (Yadav et al., 2007)

Color Measurement of Rice

The colorimetric measurements of all (control and treaded treatments) rice varieties were measured in triplicate using a colorimeter (CR-10, Konica Minolta Sensing Inc., Japan), according to McGurie (1992). The color values were recorded as L* =lightness (0=black, 100=white), a*(-a* = greenness+a* = redness) and b*(-b* = blueness, +b*=yellowness). The whiteness (W) was calculated as equation (1):

$$W = 100 - \sqrt{(100 - L)^2 + a^2 + b^2} \qquad (1)$$

Chemical and quality evaluation

Chemical analysis

Moisture, protein, crude fiber, ash, and fat contents were determined according to (A.O.A.C. 2019) and were used in the present study, where the carbohydrate content was determined by difference.

Amylose content

The evaluation method described by (Juliano 1971) was used to determine amylose content, while amylopectin content was calculated by difference.

The volumes of cooked and milled rice were determined by the water displacement method (Diptie et al., 2002).

Aroma

The cooked rice was smelled by a random panel as mild (MS), non-scented (NS), and strongly scented (SS) (Sood and Sadiq, 1979).

Production of Gluten-Free Rolled Papers

Preparation of rice flour (RF)

Raw rice (RR) was cleaned to remove dirt and other undesirable materials, then dried in a cabinet dryer separately at 60±2°C for 4 hours, and then ground into powder in a grinder and sieved through an 850 µm sieve, then added to in ingredients, according to (Cameron & Hosseinian 2013).

Preparation of Gluten-Free Rolled Papers

The proper composition to formulate the batter is rice flour (64 g/100 g), corn starch (30 g/100 g), corn oil (3.5 g/100 g), salt (2 g/100 g), vanilla (0.5 g/100 g), and water. The batter was mixed with a whisk to a proper consistency, spread thinly with a ladle on a tightly stretched cloth, then covered with a lid and steamed for 1-2 minutes over a water bath. The rice paper skins were allowed to cool and kept in plastic films to make the sensory evaluation.

Sensory Evaluation of Gluten-Free Rolled Papers

Gluten-free rolled papers were prepared and baked on an oven grill till a golden surface appeared. A 9-point hedonic scale was used for determining the sensory attributes color, taste, aroma, firmness, freshness, roll ability, and overall liking of gluten-free rolled papers, according to (Cameron & Hosseinian 2013), **by** ten members from the staff of the Food Technology Research Institute, Agricultural Research Center, Al-Giza, Egypt. For each sample, panelists scored their liking of these characteristics using the 9-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely). An average of 10 scores for each attribute was reported.

Statistical analysis

The field experiment was designed as a split design, and the collected data were subjected to statistical analysis using the analysis of variance. Duncan's multiple range tests at the ($P \leq 0.05$) level to compare between means. The analysis was carried out using the PRO ANOVA procedure of the (SAS 1996) program.

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3. Results and Discussion

Analysis of spent mushroom extract (Table 1.) revealed that it contains diverse forms of bioactive compounds, including sugars resulting from the action of the cellulose system of mushrooms and phenols, which act as ideal antioxidants. In addition, the pH of the water extract was near neutral, with an earthy smell. This unique formula is promising and expected to enhance plant growth, especially because of its phenolic contents.

Table 1. Ascent mushroom extract analysis (10 %W/V)

Parameter	Result
Color	Brown
Odor	Earthy
pH	7.6
EC	7.4
Organic matter	11 g/kg-¹
Reducing sugars	0.6 gl^{-1}
N	0.6 gl^{-1}
P	0.07 gl^{-1}
K	1.1 gl^{-1}

Table 2. Effect of spent mushroom extract on rice vegetative and yield parameters

	Rice vegetative parameters			yield parameters Rice			
Sample	N. branches (of leaves)	Height Plant (cm)	Flag leave area (cm^2)	No. branches (of Spike)	Spike weight (g) plant	Spike length (cm)	Straw yield (T/H^{-1})**
Control	17.23	83.19	17.63	8.47	2.42	18.20	8.54
T1	18.30	85.22	18.12	9.10	2.71	19.23	10.46
T2	17.96	84.70	18.08	8.70	2.68	18.77	9.80
T3	20.31	85.78	18.50	9.27	2.81	19.93	12.55
T4	17.30	84.07	17.84	8.60	2.51	18.50	9.58
T5	18.26	84.87	18.31	8.73c	2.63	18.98	10.32
T6	17.81	84.63	17.99	8.63	2.57	18.63	9.76
T7	20.00	85.36	18.31	9.20	2.75	19.50	12.33
L.S.D.0.05	0.47**	n.s	n.s	n.s	n.s	0.56**	0.54**

Where the key of treatments * represents in Table 1. (a-1)**= T/H^{-1}

Field experiment

Spent mushroom substrate extract (SMSE) of oyster mushroom was tested for its effect on the growth promotion of rice (Oriza sativa) variety Sakh 103 under field conditions (Table 2.). Spent mushroom substrate extract was prepared and applied as mentioned earlier. Rice vegetative parameters, such as growth promotion in terms of height, number of branches, flag area, and rice yield parameters (spike weight, spike length, and straw yield), in addition to NPK in grain, were evaluated. The soaking treatment showed a significant effect on the number of full spikes, spike length, empty seeds, nitrogen percent in grains, and yield, while the other parameters did not significantly respond to the soaking treatment. On the other hand, the treatments of growing plants with spent extract significantly enhanced rice growth and yield parameters except plant height, flag leaf area, number of branches, 1000 grain weight, and spike weight in all treatments. Polyphenols are important because they are antioxidant-active compounds. These compounds have established higher in vitro antioxidant capacity than others such as α-tocopherol and ascorbic acid (Pulido et al., 2000). The combined use of both spraying and soil amendment of spent mushroom extract (T3) had the greatest effect on the number of branches (20.31), followed by T7 (20) compared to other treatments and presented about 17.8% and 16.07% increment over control, respectively. The effect of different treatments was not significant in the cases of high plant, flag leaf, and spike weight. Concerning the straw yield parameter, T3 and T7 treatments scored the highest significant scores ($12.55T/H^{-1}$) and ($12.33T/H^{-1}$) compared to other treatments and controls.

On the other hand, the control treatment presented the lowest score in all parameters. *(*Roy et al., 2015) studied the potential of spent mushroom substrate (SMS) of oyster mushrooms on the improvement of the growth of *Capsicum annuum* L. The analysis of growth parameters in terms of height, yield, number of branches, and number of leaf drops showed that the use of SMS of oyster mushrooms had a positive effect on the overall growth of the tested plants. Also, the data presented in Table 2. shows that the effect of soaking rice seeds in spent mushroom extract on spike weight was not significant, but spikes with the highest spike length values were recorded by T3 (19.93), followed by T7 (19.50) treatments. In the case of spike length and straw yield, the responses to all treatments, including soaking, were significantly higher at all treatments.

Table 3. Response of rice yield parameters; full and empty grains, 1000-seed weight (gm) and harvest to different treatments with spent mushroom extract

Treatments	Full grains %	Empty grains %	Grain yield (T/H^{-1})
	Interaction		
Control	76.84	7.77	7.71
T1	84.85	6.59	9.63
T2	79.65	7.60	8. 56
T3	87.21	4.95	10.19
T4	77.60	8.47	8.28
T5	80.42	6.80	9.19
T6	78.27	7.61	8.43
T7	86.49	6.22	10.16
L.S.D.0.05	2.23**	0.81**	0.45**

Where the Key of treatments represents in Table 1. (T/H^{-1}) means ton per hectare
**Data with different superscript are significantly different at P≤ 0 .05. n.s. Non-significant at 0 .05 level

When assessing the effectiveness of fertilization, the grain parameters' quality is crucial. It is influenced by a wide range of variables, including biotic and abiotic stressors, pollination efficiency, and the availability of macro- and microelements. The treatment with spent mushroom extracts enhanced rice grain properties (Table 3.), where T3 treatment recorded a significant increase (87.21%) followed by treatment T7 (86.49%), where the percent of full seeds increased by 13.49% and 12.55% over control, respectively. In the case of dual application with spray and soil amendment. Significant empty seed decreased (36.29 and 19.9%) were found for sequences. Concerning grain yield, all treatments recorded a high significant score compared to the control treatment. The highest significant increase was found in treatments T3 and T4, which recorded 10.19 (T/H^{-1}) and 10.16 (T/H^{-1}) with an increase percent of 32.16% and 31.7 % compared to the control treatment. (Tuhy et al., 2015). studied the use of spent mushroom substrate (SMS) of *Agaricus bisporous* and found that the grain yield of maize treated with micronutrients delivered with SMS was higher than the traditional treatment. (Ashrafi et al., 2015) established that the application of SMS compost at a rate of 2.5T/H^{-1} along with an approved dose of mineral fertilizer showed the best performance for fruit number, fruit yield, and fruit quality (total protein, total sugar, vitamin C, and reducing sugar), in addition to nutrient uptake by tomatoes.

Physical Properties of Rice Grains

Physical quality characters from the bulk samples: 1000 individual rice grains were weighed and measured for length, width (length from dorsal to ventral sides), and thickness (length from both lateral sides). The samples have been analyzed for grain weight, broken and whale rice percentage, and different quality traits, which include kernel length (mm), kernel breadth (mm), and length/breadth ratio (repressed in Table 4.).There were no significant differences recorded with respect to the weight of the thousand grains, except treatments T3 and T7, which showed the lowest fraction (3.12%) and the highest significant increase in the whale rice (96.88%) in both of them. These results reflect a high quality or high grad of rice. So both of two treatments T3 and T7, were considered high-quality rice with less than 10% broken rice, and the rest treatments were considered medium-quality, except T2 treatment (low quality which was recorded 37.5% broken rice) . These results are in agreement with (UNCTAD 2006). The percentage of broken kernels in milled rice also determines the quality. High-quality rice is known to have less than 10% broken grains; medium-quality rice is 15% to 20% broken grains; and low-quality rice is 25% to 100% broken grains, where all grains over all treatments were classified according to length and L/W as short and bold grains. These results were in agreement with (Jennings et al., 1979). The L&W values were calculated and used to classify the grain categories of extra-long grains (>7.50 mm), long grains (6.61–7.50 mm), medium grains (5.51–6.50 mm), and short grains (<5.50 mm). The L/W ratio was classified for grain shapes as slender (>3.0), medium (2.0–3.0), bold (1.1–2.0), and round (<1.1) (Jennings et al., 1979). Also, it was reported that the combination of organic and chemical fertilizers increased the grain weight, protein content, and quality parameters of rice compared with chemical fertilizer alone (Walia et al., 2014). Rice yield quality is the result of a combination of rice genetics, various environmental factors, fertilization modes, and nitrogen application rates; thus, the factors affecting yield are diverse and complex (Chakravorty & Ghosh 2014).

Table 4. Effect of addition spent mushroom extract treatments on Physical Properties of rice grains treatments

Treatments	1000 seeds Weight (g)	Broken rice %	whale rice %	Length (mm)	Width (mm)	L/W (mm)
Control	26 ^{b} ±0.5	17.35 ^{c}±2.4	82.65 ^{b}±2.9	4.5 ^{bc} ±0.5	2.8 ^{a} ±0.1	1.86 ^{bc} ±0.01
T1	26.5 ^{b} ±1.0	18.52 ^{c}±5.9	81.48 ^{b} ±8.4	5 ^{ab}± 0.2	2.63 ^{ab} ±0.55	1.59 ^{bc} ±0.19
T2	26. 6 ^{b}±0.1	37.5 ^{d}±3.7	62.5 ^{c} ±3.7	4.7 ^{abc}±0.4	2.65 ^{ab} ±0. 18	2.35 ^{a} ±0.049
T3	28.6 ^{a} ±1.8	3.12 ^{a}±0.95	96.88 ^{a} ±2.3	5.2 ^{a} ±0.2	2.85 ^{a} ±0.05	1.64 ^{bc} ±0.039
T4	28.5 $^{a\,b}$±0.1	14.6 ^{b} ±5.4	85.4 ^{b} ±5.95	4.23 ^{c} ±0.25	2.76 ^{a} ±0.06	1.53 ^{c} ±0.064
T5	27.5 ^{ab} ±0.1	15.5 ^{b}±6.02	±.06 84.5 ^{b}	4.7 ^{abc} ±0.2	2.42 ^{ab} ±0.29	2.01 ^{ab} ±0.06
T6	27.5 ^{ab} ±0.1	15.5 ^{b}±3.15	84 .5 ^{b} ±2.8	5.1 ^{a} ±0.2	2.16 ^{b} ±0.05	1.61 ^{bc} ±0.065
T7	28.5 ^{a} ±0.1	3.12 ^{a}±0.95	96.88 ^{a} ±2.3	5 ^{ab} ±0.2	2.8 ^{a} ±0.3	2.01 ^{ab} ±012

Where Key of treatments represents in Table 1.
SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$

Table 5. Effect of spent mushroom extract on chemical analysis of rice grains treatments

Treatments	Protein %	Fat%	Fiber%	Ash%	Carbohydrate %
Control	7.4 ^{b} ±0,17	0.63^{a} ±0.55	0.79^{c} ±0.17	0.55 ^{bc} ±0.14	90.63 ^{ab} ±0.61
T1	6.68 ^{c} ±0.06	0.77^{a} ±0.25	0.87 ^{bc} ±0.11	0.58 ^{bc} ±0.14	9 1.1 ^{a} ±1.4
T2	7.88 ^{ab}±0.56	0.69^{a} ±0.49	1.23 ^{a} ±0.1	0.61 ^{abc} ±0.08	8 9.59 ^{a} ±0.77
T3	8.32 ^{a} ±0.82	0.95 ^{a} ±0.04	0.99 ^{abc} ±0.23	0.81 ^{ab} ±0.8	88.93 ^{ab} ±0.51
T4	7.65 ^{ab} ±0.4	0.86 ^{a} ±0.07	1.04 ^{abc} ±029	0.45 ^{c} ±0.05	90.93 ^{ab} ±0.41
T5	7.72 ^{ab}±0.28	0.87 ^{a} ±0.21	1.07 ^{abc} ±0.03	0.46 ^{c} ±0.34	9 0.00 ^{ab} ±0.78
T6	7.9 ^{ab} ±0.44	0.90 ^{a} ±0.05	1.07 ^{abc} ±0.03	0.66 ^{ab} ±0.64	8 9.47 ^{ab} ±1.51
T7	8.3 ^{a} ±0.13	0.66 ^{a} ±0.46	1.16 ^{ab} ±0.01	0.89 ^{a} ±0.07	8 8.99 ^{ab} ±0.24

**Key of treatments represents in Table 1. Data with different superscript are significantly different at $P \leq 0\ .05$

Chemical analysis of the tested rice grains showed a significant increase in all treatments compared to the control treatment, except for the T1 treatment, which recorded a significant decrease (6.68% protein content). Also, treatments T3 and T7 showed a significant increase in ash and protein content. The highest values of protein and ash were found in T3 (8.32 and 0.81%), followed by T7 (8.3 and 0.89%), respectively. Vice Versa T4 recorded the lowest score value in ash (0.45%). No significant differences were found in both carbohydrates and fat among all treatments.

The maximum and minimum values were recorded (91.1–88.93) and (0.63–0.95) in carbohydrates and fat content, respectively. This result is in agreement with (Ravindra et al., 2013), who found no significant differences in fat, carbohydrate, or fiber percentage between treatments and controls.

Table 6. N P K content of different treatments treated with spent mushroom extract

Treatments	N %		P%		K%	
	grain	Straw	grain	straw	Grain	straw
Control	0.93	0.46	0.18	0.07	0.26	0.97
T1	1.04	0.51	0.19	0.07	0.26	1.05
T2	1.11	0.55	0.21	0.07	0.27	1.11
T3	1.22	0.66	0.26	0.11	0.34	1.46
T4	0.85	0.45	0.18	0.06	0.25	0.94
T5	0.90	0.50	0.19	0.06	0.26	1.01
T6	0.98	0.58	0.20	0.08	0.30	1.09
T7	1.12	0.63	0.24	0.11	0.33	1.40
L.S.D.0.05	0.06**	0.04**	0.09*	0.01*	0.022*	0.1*

**Key of treatments represents in Table 1.

Table 6. shows the aggregation of macro elements, such as NPK in rice seeds, as a perfect sign for successful crop management; it also reflects the nutritive value of the seeds. The use of spent mushroom extract improves the accumulation of such elements in rice grains, especially when treated by spraying plus soil amendment. Grains soaking prior to sawing was not significant in the case of phosphorous and potassium percent but was significant in the case of nitrogen percent. The soaking treatment had a minor impact on the NPK percentage of the straw, but the post-treatments of spraying and adding spent mushroom extract to the soil had a significant impact (Table 6). General observations from all previous results indicated that the soaking of rice seeds in the extract of spent mushrooms is not effective alone in most cases and should be combined with post-sawing treatments, including spraying and/or soil amendment. SMS spraying on rice definitely repressed the development of lesions caused by the Pyoryze infection. The aggregation of phytoalexins, momilactones A and B, oryzalexin A, and sakuranetin was markedly enhanced by the spraying of extracts. (Ishihara et al., 2019)

Table 7. Effect of spent mushroom extract treatments on Amylose% & Amylopectin %content of rice grains treatments

Treatments	Carbohydrate%	Amylose%	Amylopectin %
Control	90.63^{ab} ±0.61	24.97^{a} ±0.45	75.03^{d}±0.45
T 1	90.79^{a} ±1.4	24.96^{a} ±1.213	75.04^{d}±0.40
T2	89.59^{ab} ±0.77	24.98^{a} ±0.44	75.02^{d}± 0.13
T3	90.53^{ab} ±0.51	18.54^{de} ±.0001	81. 46^{a}±0.44
T4	90.04^{ab} ±0.41	22.26^{b} ±2.6	77.74^{c}±0.41
T5	89.88^{ab} ±0.78	20.50^{c} ±0.41	79.5^{b}±.0001
T6	88.9^{ab} ±1.51	22.4^{b}±0.13	77.58^{c}±0.40
T7	89.22^{ab} ±0.24	18.77^{d} ±0.40	81.23^{a}±1.213

Key of treatments represents in Table 1.

Data with different superscript are significantly different at P≤ 0 .05

Amylose content showed significant differences among treatments, where the highest value was found in T1, T2, and control, while the lowest value was in T3, and T7. On the contrary, an inverse relationship was found concerning amylopectin and amylose over other treatments. The application of nitrogen fertilizer delayed the accumulation of starch during the early stage of grain filling and significantly reduced the amylose content. The lowest amylose value was correlated with the highest protein gain, and customers prefer rice that has less amylose because it is softer and more palatable. However, rice grains with higher amylose content tend to have a harder and less sticky texture after cooking (Zeng et al., 2019). This is because, through entanglement and/or co-crystallization with amylopectin, amylose molecules limit the swelling and leaching of starch during cooking (Li and Gilbert 2018). This affects the viscosity between cooked rice grains, giving the rice a harder texture, less starch leaching, and decreased eating quality (Li & Prakash, 2016 and Li et al., 2017). Although the application of nitrogen fertilizer reduced the amylose content and improved the cooking and eating quality, excessive nitrogen application significantly increased.

Table 8. Effect of spent mushroom extract on the quality parameters of cooked rice grains

Treatment	Weight Increase%	Size Increase%	Cooking time (min)	Oder
Control	$151^{c}\pm16$	$250^{abc}\pm10$	$18^{b}\pm0.18$	$8^{c}\pm0.\ 02$
T1	$167^{b}\ \pm3.0$	$300^{ab}\pm20$	$20^{c}\pm0.1\ 6$	$10^{a}\pm0.01$
T2	$163.6^{b}\pm7.6$	$314^{a}\pm10.3$	$20^{c}\pm0.\ 16$	$8^{c}\pm0.02$
T3	$276^{a}\ \pm4$	$383^{a}\pm10$	$18^{b}\pm0.10$	$10^{a}\ \pm0.01$
T4	$154^{c}\pm4$	$226^{bc}\pm12.5$	$17^{a}\pm0.11$	$9^{b}\pm0.05$
T5	$73.4^{d}\pm0.196$	$200^{c}\pm10$	$17^{a}\pm0.11$	$9^{b}\pm0.05$
T6	$73.13^{d}\pm0.3$	$185^{c}\pm10$	$20^{c}\pm0.16$	$9^{b}\pm0.05$
T7	$273^{a}\ \pm0.8$	$316^{a}\pm10$	$18^{b}\pm0.10$	$10^{a}\pm0.01$

Table 8. declares that shown data of the quality rice grains parameters, where T3 and T7 showed the highest increase in weight after cooking (276 % and 273%) and size (383% and 316% compared to control treatment (151% and 250% weight and size increase % after cooking, respectively. The increment values of weight and size increase in rice grains after cooking are highly significant compared to other treatments. The cooking time ranged from 17 to 20 minutes for all grains, and the T3 and control treatments scored 18 minutes. The highest significant cooking time was found in T1, T2, and T6 treatments (20 minutes) for all three treatments. While T4 and T5 recorded (17 minutes), The combination of organic and chemical fertilizers increased the quality parameters of rice compared with chemical fertilizer alone (Chakravorty and Ghosh 2014). Nitrogen application resulted in a significant increase in protein content in rice, and rice with a lower protein content is higher in taste value and the best cooking rice quality. This is due to the structure formed by the bond of protein that effects the starch pasting and makes the rice texture less viscous and more hard, resulting in a weak taste quality for the rice. (Martin & Fitzgerald 2001 and Baxter et al., 2014)

Table 9. Effect of spent mushroom extracts treatments on the Color measurements of rice grains

Treatments**	L*	A*	B*	W*
Control	$93.72\ ^{b}\pm\ \ 0.83$	$0.39\ ^{a}\pm0.02$	$38.02\ ^{a}\pm0.48$	$60.7\ ^{b}\pm0.\ 47$
T1	$94.47\ ^{a}\pm0.45$	$0.20\ ^{bc}\pm\ 0.1$	$10.18\ ^{b}\pm0.16$	$8\ 8.41\ ^{a}\pm0.12$
T2	$92.076^{d}\pm0.37$	$0.12\ ^{cde}\pm0.04$	$11.02\ ^{ab}\pm0.15$	$86.9\ ^{ab}\pm0.18$
T3	$93.85\ ^{b}\pm0.20$	$0.\ 24\ ^{b}\pm\ 0.02$	$10.72\ ^{ab}\pm0.11$	$87.64\ ^{ab}\pm0.23$
T4	$93.5\ ^{b}\pm0.157$	$0.\ 48\ ^{a}\pm0.\ 20$	$11.48\ ^{a}\pm0.\ 4$	$86.87\ ^{ab}\pm0.14$
T5	$92.05\ ^{d}\pm0.52$	$0.036\ ^{e}\pm0.25$	$10.43\ ^{b}\pm0.\ 16$	$86.87\ ^{ab}\pm0.28$
T6	$91.32\ ^{e}\pm0.12$	$0.153\ ^{bcd}\pm0.92$	$10.77\ ^{ab}\pm0.07$	$86.01\ ^{ab}\pm0.13$
T7	$89.42\ ^{f}\pm\ \ 0.70$	$0.4\ 7\ ^{a}\pm0.07$	$9.43\ ^{b}\pm0.08$	$85.82\ ^{ab}\pm0.3$

L* = lightness (0 = black, 100 = white), a* (-a* = greenness, +a* = redness) and b* (-b* = blueness, +b* = yellowness). Data are presented as means SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$.

$W^{*} = 100 - \sqrt{(100 - L)^{2} + a^{2} + b^{2}}$ (whiteness) **Key of treatments represented in Table 1.

Table 9. shows the color of rice treatments. Color is imperative for sensory as white rice or completely milled rice has more consumer acceptance as well as market value (Bhattacharya, 1985 and Wadsworth, 1994). No significant differences in whiteness were recorded all over the treatment except the control treatment, which recorded the lowest significant differences, where T1 and T3 scored the highest scores (88.41 and 87.64, respectively). As for L*, a significant increase was found in T1 (94.47%), which differs significantly from others. Concerning A* and B* measuring parameters, control and T4 treatments tend to have redness and yellowness. Variations in the color of rice depend upon the amount of bran present on rice kernels. The color of the rice kernels varies according to environmental conditions, pre- and post-harvesting conditions, and variety. The use of compost may have led to an increase in the size and weight of the treated grains, their strength, and their resistance to milling. During milling, brown rice is subjected to abrasive and friction pressure to remove aleuronic layers, resulting in low milling degrees or high medium depending on the removed layer of bran (Chen and Siebenmorgen, 1997), where degree of milling (DOM) and whiteness are positively correlated (Park et al., 2001).

Table 10. Effect of spent mushroom treatments extracts treatments on the Sensory evaluation of gluten-free rolled rice papers

**Treatment	Taste	Color	Aroma	Firmness	Roll ability	Freshness	OAA*
Control	$6.9^{ab}\pm0.73$	$6.9^{bc}\pm1.37$	$6.8^{bc}\pm0.92$	$7.1^{abc}\pm1.3$	$7.4^{ab}\pm 1.71$	$6.9^{abc}\pm0.73$	$7.1^{ab}\pm0.73$
T1	$7.5^{ab}\pm0.84$	$7.9^{ab}\pm1.55$	$7.3^{ab}\pm0.9$	$5.7^{d}\pm1.6$	$5.2^{d}\pm 1.88$	$5.2^{d}\pm 1.7$	$7.1^{ab}\pm 0.94$
T2	$7.56^{ab}\pm1.18$	$6.6^{c}\pm1.07$	$7.1^{abc}\pm1.4$	$7.4^{abc}\pm1.35$	$5.8^{b}\pm 1.55$	$7.1^{abc}\pm1.4$	$6.5^{bc}\pm 0.849$
T3	$7.9^{a}\pm1.52$	$8.1^{a}\pm1.10$	$7.5^{ab}\pm1.43$	$7.9^{ab}\pm1.37$	1.49 ± 8.0^{a}	$7.3^{ab}\pm0.9$	$8.1^{a}\pm1.7$
T4	$7.8^{a}\pm1.237$	$8.2^{a}\pm2.4$	$8.1^{a}\pm1.2$	$7.1^{abc}\pm1.1$	$8.1^{a}\pm1.66$	$7.3^{abc}\pm1.35$	$7.3^{abc}\pm1.5$
T5	$6.5^{b}\pm1.5$	$6.4^{c}\pm1.49$	$6.4^{bc}\pm1.17$	$6.9^{bcd}\pm1.5$	$6.0^{b}\pm 1.77$	$6.8^{bcd}\pm 1.4$	$6.3^{bc}\pm 1.41$
T6	$6.4^{b}\pm1.42$	$6.3^{c}\pm1.05$	$6.1^{c}\pm1.1$	$6.3^{cd}\pm2.00$	$5.8^{b}\pm1.9$	$6.2^{cd}\pm 1.00$	$7.31^{ab}\pm0.56$
T7	$7.9^{a}\pm 1.47$	$8.4^{a}\pm1.1$	$7.5^{ab}\pm1.3$	$8.0^{a}\pm1.33$	$8.0^{a}\pm1.69$	$8.3^{a}\pm1.0$	$8.1^{a}\pm 0.875$

*OAA- overall acceptability. (n= 10, 9 points structured scale) **Key of treatments represents in Table 1.
SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$.

Table 10. shows the results of a sensory evaluation of gluten-free rolled rice papers. The study found that there were some differences in the sensory qualities of the rice papers produced from different treatments of rice grains that were subjected to experimental field testing ($P \leq 0.05$). The study found no significant differences in taste, color, and aroma between the treatment and control groups, except for a slight decrease in T5 and T6 treatments (recorded as 6.5–6.4, 6.4–6.3, and 6.4-6.1). Conversely, a slight increase was found in T3 and T7 (recorded as 7.9–7.9, 8.1–8.4, and 7.5–7.5) in the same sensory parameters of taste, color, and aroma, respectively. Regarding other sensory parameters, the study found a significant decrease in firmness, roll ability, and freshness in T1 and T6 treatments (recorded as 5.7–5.2-5.2 and 6.3-5.8–6.2) compared to the control treatment (7.1–7.4 and 6.9), respectively. The study also found a direct relationship between firmness and freshness values in all treatments. Overall, T3 and T7 had the highest increase in firmness, freshness, and overall acceptable scores (OAA*) in the sensory test, while T2 and T5 treatments were recorded as the least acceptable (OAA*) compared to the control and other treatments.

4. Conclusion

Extracting spent mushrooms of the Plourotus variety with water is an efficient method of obtaining highly nutritious organic fertilizers that improve rice growth and yield parameters. For rice quality, the most effective application method is the dual use of soaking, spraying, and amendment with irrigation water. T3(P3Ss) and T7(P3Sw) treatments showed the highest significant score in all chemical composition and cooking quality parameters. The T3 and T7 treatments demonstrated a significant decrease in amylose content. The cooking time for all treatments ranged between 17 and 20 minutes. There were no significant differences in the weight of the thousand grains, except for treatments T3 and T7, which recorded a significant increase for both. All treatments were classified as short and bold grains based on their length and width. The use of compost did not affect or cause any change in the color of the rice grains. The T3 and T7 treatments had more whiteness and lightness compared to other treatments. Additionally, T3 and T7 treatments scored the highest value concerning overall acceptability in the sensory evaluation and were classified as high-quality grains compared to other treatments.

References

AOAC (2019) Official Method of Analysis The Association of Official Analytical Chemists (21st Ed.) Benjamin Franklin Station, Washington, D.C., U.S.A.

Akanbi, W.B., Akande, M.O., and Adediran, J.A. (2005). Suitability of composted maize straw and mineral nitrogen fertilizer for tomato production. Journal of Vegetable Science, 11: 57–65.

Ashrafi, R., Rajib, R.R., Sultana, R., Rahman, M., Mian, M.H., & Shanta, F.H. (2015). Effect of spent mushroom compost on yield and fruit quality of tomatoes. *Asian J. Med. Biol. Res*., 1 (3): 471-477; doi: 10.3329/ajmbr.v1i3.26464.

Ayeni, L.S. (2014) Effect of manufactured organic fertilizers on soil chemical properties and yield of tomato *(Lycopersicum lycopersicon)* in Alfisol, Southwestern Nigeria Molecular Soil Biology Vol. 5, No. 6, 1-6 (doi: 10.5376/msb.2014.05.0006)

Baxter, G., Blanchard, C., and Zhao, J. (2014). Effects of glutelin and globulin on the physicochemical properties of rice starch and flour J Cereal Sci, 60:414–420.

Bhattacharya, K.R. (1985). Parboiling of rice. In: Rice Chemistry and Technology, 2nd ed. American Association of Cereal Chemists, Inc., St. Paul,Amsterdam, pp. 289–348.

Bergman, C.J., Bhattacharya, K.R. and Ohtsubo, K. (2004). Rice end-use quality analysis In Champagne E. T. (Ed.), Rice chemistry and technology, 3rd edn (pp. 415–472). St. Paul, MN, USA: American Association of Cereal Chemists;
https://doi.org /10.1094/1891127349

Cameron, S.J., and Hosseinian, F. (2013) Potential of flaxseed in the development of omega-3 rice paper with antioxidant activity. LWT, Food Science and Technology, 53:170–175.
https://doi.org/10.1016/j.lwt.2012.12.004

Chakravorty, A., and Ghosh, P. (2014) Interrelationship and cause-and-effect analysis among panicle yield-attributing traits in low-land traditional rice Journal of Control Europe and Agriculture, 15(4):213–224.

Chanda, G.K., Bhunia, G.G. and Chakraborty, S.K. (2011) The effect of vermicompost and other fertilizers on the cultivation of tomato plants Journal of Horticulture and Forestry, 3:42–45.

Chen, H. and Siebenmorgen, T.J. 1997. Effect of rice thickness on degree of milling and associated optical measurements. Cereal.Chemistry., 74:821-82553, 170-175.

Courtney, R.G. & Mullen, G.J. (2008) . Soil quality and barley growth as influenced bythe land application of two compost types. Bioresour. Technol., 99: 2913-2918

Danny, L.R. (1992). Commercial mushroom production. Horticultural Research Institute of Ontario, Vineland Station Ontario Ministry of Agriculture and Food Publication, 350: 37–38

Delacruze, N. and Khush, G.S. (2000). Rice grain quality evaluation procedures. In Aromatic Rices (eds. R.K. Singh, U.S. Singh, and G.S. Khush), pp. 15–28, Publisher: Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, Calcutta.

Dipti, S.S., Hossain, S.T., Bari, M.N., and Kabir, K. A. (2002)Physicochemical and Cooking Properties of Some Fine Rice Varieties Pakistan Journal of Nutrition, 1(4): 188–190.

Hackett, R. (2015) Spent mushroom compost as a nitrogen source for spring barley. Nutr. Cycl. Agroecosys, 102 : 253-263.

Ishihara, A., Ando, K., Yoshioka, A., Murata, K., Kokubo, Y., Morimoto, N., Ube, N., Yabuta, Y., Ueno, M., Tebayashi, S., Ueno, K., & Osaki-Oka, K. (2019). Induction of defense responses by extracts of spent mushroom substrates in rice *J. Pestic. Sci.,* 44(2): 89–96 (2019). DOI: 10.1584/jpestics.D18-063.

Jankowski, K., & Jodełka (2000) Analysis of the influence of climate on feeding and nutritive value of fourth-grass-legume mixtures. Zesz. Nauk. AP Siedlcach. Rolnictwo, 57: 93–101.

JasińskaA (2018) . Spent mushroom compost (SMC)–retrieved added value product closing loop in agricultural production.Acta Agar. Debhttps://doi.org/10.34101/actaagrar/150/1715

Jennings, P. R., Coffman, W. R., and Kauffman, H. E. (1979). Rice improvement. IRRI: Los Banos, Philippines: IRRI. Lacy, J. M., & Clampett, W. 2000.

Juliano, B.O. (1971). A simplified assay for milled rice amylose Cereal Science Today (16):338,360

Juliano, B. O., Perez, C. M., & Kaosa, M. (1990). Grain quality characteristics of export rice in selected markers Cereal Chemists, 67:192–197.

Li, H.Y., Fitzgerald, M.A., Prakash, S., Nicholson, T.M., & Gilbert, R.G. (2017 a.) The molecular structural features controlling stickiness in cooked rice are a major palatability determinant. Sci Rep, 7 : 43713.

Li, H.Y., and Gilbert, R.G. (2018) Starch molecular structure: the basis for an improved understanding of cooked rice texture Carbohyd Polym, 195:9–17.

Li H.Y. & Prakash, S. (2016) Nicholson TM, Fitzgerald MA, and Gilbert RG The importance of amylose and amylopectin fine structure for the textural properties of cooked rice grains Food Chem., 196:702–711.

Martin, M., and &Fitzgerald, M.A. (2001). Proteins in rice grains influence cooking properties. J. Cereal Sci., 36: 285–294.

McGurie, R.G. (1992). Reporting of objective color measurements. HortScience, 27:1254–1255.

Nakatsuka, H., Oda, M., Hayashi, Y., and Tamura, K. (2016). Effects of fresh-spent mushroom substrate from Pleurotus ostreatus on soil micromorphology in Brazil Geoderma, 269:54–60.

Park, J.K., Kim, S.S., and Kim, K.O. (2001). Effect of milling ratio on sensory properties of cooked and onphysicochemical properties of milled and cooked rice. Cereal Chem., 78:151–156.

Pérez-Chávez A.M., Mayer L, Albertó E. (2019). Mushroom cultivation and biogas production: a sustainable reuse of organic resources. Energy Sustain Dev 50:50–60. https://doi.org/10.1016/j.esd.2019.03.002.

Pulido, R. Bravo, L., and Saura-Calixto, F. (2000). Antioxidant activity of dietary polyphenols as determined by a modified ferric reducing/ antioxidant power assay J Agric Food Chem, 48, 3396–3402.

Ravindra B., Shreya K., Kuldeep S.D., Usharani G. and Nagesh P. (2013). Evaluation of Popular Rice (Oryza sativa L.) Hybrids for Quantitative, Qualitative and Nutritional Aspects. International Journal of Scientifi c and Research Publications, Vol.3, Issue 1,

Rinker, D.L. (2002). Handling and using “spent” mushroom substrate around the world. Sanchez, J.E., Huerta, G., and Montiel, E. (Eds.), Proceedings of the 4th International Conference on Mushroom Biology and Mushroom Products. February 20–23. Cuernavaca.

Roy, S., Barman, S., Chakraborty, U., and &Chakraborty, B. (2015). Evaluation of spent mushroom substrate as biofertilizer for growth improvement of *Capsicum annuum* L. *J.* Appl. Biol. Biotechnol., 3: 22–27 Conference on Mushroom Biology and Mushroo Products, Cuernavaca, Mexico, pp. 43–60.

Rice National Campaign (R.N.C.) (2012) Annual Report at R.N.C., Agricultural Research Center

Ministry of Agriculture & Land Reclamation, Egypt

SAS (1996). SAS/STAT1 user's guide, version 8. Cary, NC: SAS Inst., Inc.

Sendi, H., Mohamed, M.T.M., Anwar, M.P. & Saud, H.M. (2013). Spent mushroom waste as a media replacement for peat moss in kailan (*Brassica oleracea var. Alboglabra)* production. Sci. World J., 1-8./ http://dx.doi.org/10.1155/2013/258562 258562

Siddhant, C.S.S., and Ayodhya, F. (2009). Recycling of spent oysters mushroom substrate to recover additional value. Kathmandu Univ. J. Sci. Eng. Technol., 5(2):66–71.

Silva, R.F., Pascholati, S.F., and Bedendo, I.P. (2013) Induced resistance in tomato plants to Clavibacter michiganensis subsp. Michiganensis by *Lentinula edodes* and *Agaricus subrufescens* (*syn. Agaricus brasiliensis)* J. Plant Pathol, 95(2):285–297.

Subudhi, H.N., H.N., Swain, D., Sanjukta D. Sharma, S.G., and Singh, O.N. (2012). Studies on grain yield, phytochemicals, and cooking characters of Elite Rice varieties *(Oryza sativa L.)* in Eastern India J. Agri. Sci., 4 (12), 269–275.

Singleton, V.L., Orthofer, R., and Lamuela-Raventos, R.M. (1999). Analysis of total phenols and other oxidation substances by means of the Folin-Ciocalteu reagent. Methods Enzymol., 299:152–178.

Sood G.B. and Sadiq E.A. (1979), Geographical distribution of kernel elongation gene(s) in rice, Indian Journal of Ge-netics and Plant Breeding 40, 339–342.

Szmidt, R.A.K., and Convay, P.A. (1995). Leaching of recomposted spent mushroom substrates (SMS) Science and Cultivation of Edible Fungi, II: 901–905.

Szmidt R.A.K., Dickson A.W. (2001). Use of compost in agriculture.Scottish Agric. College

Tuhy, L., Samoraj, M., Witkowska, Z., Wilk, R., & Chojnacka, K. (2015). Using spent mushroom substrate as a base for organic mineral micronutrient fertilizer field tests on maize *Bioresources*, 10 (3):5709–5719.

UNCTAD (United Nations Conference on Trade and Development) (2006) Marke Information in the Commodities Area. Available form: http://runcatd.org.InfoComm/anglais/ricesitemap.htm.Accessed.2006 April

Wadsworth, J.I. (1994). Rice: Science and Technology (1st ed.) Marcel Dekker, Inc., New York, pp. 139–176.

Walia, M.K., Walia, S.S., Sharma, S., & Dhaliwal, S.S. (2014) Effects of integrated nutrient management approaches on the nutritional quality of rice grains Jour Pl Sci Res, 30(1):33–38.

Walkley, A., & Black , I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid filtration method Soil Sci., 37: 29–38

Yadav, R.B., Khtkar, B.S., and Yadav, B.S. (2007).Morphological, physicochemical, and cooking properties of some Indian rice *(Oryza sativa L.)* cultivars Journal of Agricultural Technology, 3 (2):203–210

Zeng, Y.H., Tan, X.M., Zeng, Y.J., Xie, X.B., Pan, X.H., & Shi, Q.H. (2019) . Changes in the rice grain quality of different high-quality rice varieties released in southern China from 2007 to 2017 J. Cereal Sci., 87:111–116.

Zhang, R.H., Duan, Z.Q., and Li, Z.G. (2012) Use of spent mushroom substrate as growing media for tomato and cucumber seedlings Pedosphere 22, 333–342.