Influence of enriched spent mushroom substrate on microbial population, nutrient availability and yield of radish (*Raphanus sativus* L.)

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Abstract

A field experiment was conducted to ameliorate the quality of spent mushroom substrate by enriching it with biofertilizers like *Azotobacter*, PSB and KMB and its beneficial effect on soil health and yield of radish crop. Influence of enriched spent mushroom substrate on soil was estimated in terms of microbial activities and nutrient availability of soil to plant. The treatment T1 - SMS + Consortium of AZT + PSB + KMB was significantly superior over other treatments in terms of microbial population, nutrient availability of soil and yield of radish followed by treatment T5 - FYM + Consortium of AZT + PSB + KMB. The minimum observations were recorded in treatment T0 - Absolute control. The increased microbial activities positively showed increase in nutrient availability of soil to plant and yield attributes in radish crop.

Keywords: Spent mushroom substrate, biofertilizers, enrichment, microbial population, radish

Introduction

Radish (*Raphanus sativus* L.) belongs to genus *Raphanus*, family Brassicaceae originated from the Central and Western China and India (Thamburaj and Singh 2005) [9]. Radish is grown for its young tender fusiform root (Brickell, 1992) [5]. For the production of good quality radish, optimum nutrition through organic, inorganic and bio-fertilizers are essential for sustainable production. Organic agriculture practices rely upon recycling of crop residues, animal manure, farm organic residues and wastes etc. (Choudhary *et al.*, 2002) [6]. The substrate released after mushroom crop harvest, better known as “SMS” is also the subject of great importance (Tewari, 2007) [18]. Spent mushroom substrate possesses the quality of good organic manure for raising healthy crops of cereals, fruits, vegetables and ornamental plants, in addition to its ability of reclaiming the contaminated soil (Ahlawat and Sagar, 2007) [1]. Therefore the quality of spent mushroom substrate can be improved by enriching it with biofertilizers. In order to produce high quality compost, biofertilizers promotes growth by increasing the availability of primary nutrients to the host plant. Also they improve soil structure improving soil fertility. (Sudjana *et al.*, 2017) [10]. Enriched SMS is capable of improving the physical, biological and chemical properties of soil when it is added to the soil. SMS can improve the structure of soils, soil aeration, reduces surface crusting and compaction, promote drainage these improvements promote faster crop growth establishment and increased rooting. Also, it increases the population of beneficial microorganisms in soil which are necessary for plant growth and good yield. It also minimizes the use of chemical fertilizers (Gumus and Seker, 2017) [9]. Accordingly, the experiment on influence of enriched spent mushroom substrate (SMS) was carried out during *Rabi* 2019 with the objectives as to enrich spent mushroom substrate with biofertilizers (*Azotobacter*, PSB and KMB) and to evaluate the effect of enriched spent mushroom substrate on growth and yield of radish crop.

Material and Methods

Experimental details

A field experiment was conducted to study the influence of enriched spent mushroom substrate on growth and yield of radish (*Raphanus sativus* L.) during *Rabi* 2019 at the Plant Pathology Research Farm, College of Agriculture, Pune as detailed below.
Crop was calculated at the time of harvest irrespective of each treatment. Enrichment of SMS and FYM was done as per the treatments. Azotobacter, PSB and KMB were enriched prior to the application of SMS and FYM were enriched before addition of enriched spent mushroom substrate to it and also after addition of enriched spent mushroom substrate to the soil, i.e. at the time of harvest irrespective of each treatment. For this, serial dilution plate count technique was followed (Skinner et al., 1952) [14]. The total number of Azotobacter, PSB and KMB were calculated by using following formula.

\[ \frac{\text{No. of Azotobacter/PSB/KMB per g soil}}{\text{Average plate count x dilution factor}} = \frac{\text{oven dry weight of 1g of soil}}{\text{Initial microbial count of total bacteria, fungi and actinomycetes was estimated from soil before addition of enriched spent mushroom substrate to it and also after addition of enriched spent mushroom substrate to the soil i.e. at the time of harvest irrespective of each treatment.}} \]

\[ \frac{\text{No. of bacteria/fungi/actinomycetes per g soil}}{\text{Average plate count x dilution factor}} = \frac{\text{oven dry weight of 1g of soil}}{\text{Nutrient status of soil}} \]

Available nutrient status of soil before incorporation of enriched spent mushroom substrate and after harvest of radish crop was calculated by following standard methods viz., alkaline KMNO4 method by Subbiah and Asija (1956) [15] for available N (kg ha\(^{-1}\)), Olsen’s method by Olsen et al. (1954) [12] for available P (kg ha\(^{-1}\)) and ammonium acetate extractable method by Knudsen et al. (1982) [13] for available K (kg ha\(^{-1}\)).

### Result and Discussion

The microbial population of Azotobacter, PSB and KSB from soil before incorporation of SMS and after harvesting of radish crop was estimated. The initial microbial count of Azotobacter, PSB and KMB from soil before incorporation of enriched spent mushroom substrate in soil was 29.33 \times 10^6, 22.67 \times 10^6 and 19.67 \times 10^6 respectively.

A) Influence of enriched spent mushroom substrate on microbial count of Azotobacter, PSB and KMB in soil after harvest of radish

**Azotobacter population**

The result specified in Table 1, Fig.1 showed that among the different treatments, treatment T\(_4\) i.e. SMS + Consortium of AZT + PSB + KMB recorded significantly highest Azotobacter population (67.00 \times 10^6 per g soil) over rest of the treatments followed by treatment T\(_5\) i.e. FYM + Consortium of AZT + PSB + KMB (61.11 \times 10^6 per g soil). The lowest Azotobacter population (29.67 \times 10^6 per g soil)) was recorded in treatment T\(_8\) i.e. Absolute control.

**PSB population**

Among the different treatments (Table 1, Fig.1), treatment T\(_4\) i.e. SMS + Consortium of AZT + PSB + KMB recorded significantly highest PSB population (48.89 \times 10^6 per g soil)) over rest of the treatments followed by treatment T\(_5\) i.e. FYM + Consortium of AZT + PSB + KMB (43.11 \times 10^6 per g soil)). The lowest PSB population (23.00 \times 10^6 per g soil)) was recorded in treatment T\(_8\) i.e. Absolute control.

**KMB population**

The results (Table 1, Fig.1) showed that among different treatments, treatment T\(_4\) i.e. SMS + Consortium of AZT + PSB + KMB recorded significantly highest KMB population (44.11 \times 10^6 per g soil)) over rest of the treatments followed by treatment T\(_5\) i.e. FYM + Consortium of AZT + PSB + KMB (39.55 \times 10^6 per g soil). The lowest KMB population (20.00 \times 10^6 per g soil)) was recorded in treatment T\(_8\) i.e. Absolute control.

The results are comparable with Mallesha (2008) who reported that N\(_2\) fixing microorganism population was significantly more in rhizosphere soil amended with mushroom spent substrate compared to rhizospheric soil amended with substrates such as coffee pulp, areca husk, paddy straw and coir pith. The results are also close accordance with Kedar et al., (2019) [10] who also reported that application of enriched spent mushroom substrate significantly increased the population of Azotobacter and PSB in soil after harvest of cabbage crop.

**Table 1: Influence of enriched spent mushroom substrate on microbial population of Azotobacter, PSB and KMB in soil after harvesting of radish**

| Tr. No | Treatment details | Azotobacter (cfu 10^6) | PSB (cfu 10^6) | KMB (cfu 10^6) |
|--------|-------------------|------------------------|----------------|----------------|
| T\(_1\) | SMS + Azotobacter (AZT) | 54.44 | 33.00 | 27.00 |
| T\(_2\) | SMS + Phosphate Solubilizing Bacteria (PSB) | 46.44 | 37.78 | 29.89 |
| T\(_3\) | SMS + Potash Mobilizing Bacteria (KMB) | 39.56 | 29.67 | 34.44 |
| T\(_4\) | SMS + Consortium of AZT + PSB + KMB | 67.00 | 48.89 | 44.11 |
| T\(_5\) | FYM + Consortium of AZT + PSB + KMB | 61.11 | 43.11 | 39.55 |
| T\(_6\) | SMS (20 t/ha) | 36.00 | 32.56 | 25.56 |
| T\(_7\) | FYM (20 t/ha) | 34.56 | 30.00 | 24.33 |

*Further details and information can be found at http://www.chemijournal.com*
B) Influence of enriched spent mushroom substrate on microbial population in soil after harvest of radish.

The initial microbial population of bacteria, fungi and actinomycetes from soil before incorporation of enriched spent mushroom substrate in soil was $19.67 \times 10^6$, $8.00 \times 10^6$ and $5.33 \times 10^3$ respectively.

**Bacterial population**
The results specified in Table 2, Fig.2 showed that among the different treatments, treatment $T_4$ i.e. SMS + Consortium of AZT + PSB + KMB recorded significantly highest population of bacteria ($52.44 \times 10^6$ per g soil) over rest of the treatments followed by treatment $T_5$ i.e. FYM + Consortium of AZT + PSB + KMB ($47.22 \times 10^6$ per g soil). The lowest population of bacteria ($20.11 \times 10^6$ per g soil) was recorded in treatment $T_8$ i.e. Absolute control.

**Fungi population**
Among the different treatments, treatment $T_4$ i.e. SMS + Consortium of AZT + PSB + KMB recorded significantly highest population of fungi ($27.89 \times 10^6$ per g soil) over rest of the treatments followed by treatment $T_5$ i.e. FYM + Consortium of AZT + PSB + KMB ($23.56 \times 10^6$ per g soil)). The lowest population of fungi ($8.33 \times 10^6$ per g soil) was recorded in treatment $T_8$ i.e. Absolute control (Table 2, Fig.2).

**Actinomycetes population**
The result (Table 2, Fig.2) showed that among the different treatments, treatment $T_4$ i.e. SMS + Consortium of AZT + PSB + KMB was found to be the most effective as it recorded significantly highest population of actinomycetes ($20.78 \times 10^3$ per g soil)) over rest of the treatments followed by treatment $T_5$ i.e. FYM + Consortium of AZT + PSB + KMB ($17.78 \times 10^3$ per g soil)). The lowest population of actinomycetes ($5.44 \times 10^3$ per g soil)) was recorded in treatment $T_8$ i.e. Absolute control.

The results are comparable with Borah et al. (2014) [4] who stated that microbial population significantly increased in the compost by about 35 to 133% during the 30 days incubation period with different consortia. Taha et al. (2016) [17] accomplished that, using compost tea combined with nitrogen fertilizers significantly increased the population of bacteria, aerobic $N_2$ fixing bacteria and fungi in sandy soil as well as promoting growth of radish plant.

### Table 2: Influence of enriched spent mushroom substrate on microbial population of bacteria, fungi and actinomycetes in soil after harvest of radish

| Tr. No | Treatment details | Bacteria ($\text{cfu} \times 10^6$) | Fungi ($\text{cfu} \times 10^6$) | Actinomycetes ($\text{cfu} \times 10^3$) |
|--------|------------------|---------------------------------|---------------------------------|--------------------------------------|
| $T_1$  | Treatment details | 40.78                           | 19.11                           | 14.67                                |
| $T_2$  | SMS + Azotobacter (AZT) | 37.00                           | 15.22                           | 9.22                                 |
| $T_3$  | SMS + Phosphate Solubilizing Bacteria (PSB) | 36.11                           | 12.56                           | 2.22                                 |
| $T_4$  | SMS + Potash Mobilizing Bacteria (KMB) | 52.44                           | 27.89                           | 20.78                                |
| $T_5$  | SMS + Consortium of AZT + PSB + KMB | 47.22                           | 23.56                           | 17.78                                |
| $T_6$  | FYM + Consortium of AZT + PSB + KMB | 32.33                           | 12.89                           | 8.22                                 |
| $T_7$  | SMS (20 t/ha) | 30.33                           | 11.89                           | 7.66                                 |
| $T_8$  | FYM (20 t/ha) | 20.11                           | 8.33                            | 5.44                                 |
| S.Em (±) | Treatment details | 1.61                            | 1.05                            | 0.93                                 |
| CD at 5% | Treatment details | 4.98                            | 3.22                            | 2.85                                 |
C) Influence of enriched spent mushroom substrate on nutrient status of soil after harvest of radish.

Available nutrient status of soil was calculated before incorporation of enriched spent mushroom substrate and after harvest of radish crop. The results are presented in Table 3. The initial soil available N, P and K (kg/ha) before incorporation of enriched SMS was 139.98 kg/ha, 9.95 kg/ha and 118.67 kg/ha respectively.

Available nitrogen in soil (kg/ha)
The result specified in Table 3, Fig.3 showed that among the different treatments, treatment T₄ i.e. SMS + Consortium of AZT + PSB + KMB recorded significantly highest available nitrogen (210.73 kg/ha) in soil over rest of the treatments followed by treatment T₅ i.e. FYM + Consortium of AZT + PSB + KMB (193.83 kg/ha). The lowest available nitrogen (140.41 kg/ha) in soil was recorded in treatment T₈ i.e. Absolute control.

Available phosphorus in soil (kg/ha)
The results (Table 3, Fig.3) also showed that among the different treatments, treatment T₄ i.e. SMS + Consortium of AZT + PSB + KMB was found to be the most effective as it recorded significantly highest available phosphorus (16.95 kg/ha) in soil over rest of the treatments, however it was statistically at par with treatment T₅ i.e. FYM + Consortium of AZT + PSB + KMB (16.25 kg/ha). The lowest available phosphorus (10.25 kg/ha) in soil was recorded in treatment T₈ i.e. Absolute control.

Available potassium in soil (kg/ha)
Among the different treatments, the treatment T₄ i.e. SMS + Consortium of AZT + PSB + KMB recorded significantly highest available potassium (195.83 kg/ha) in soil over rest of the treatments, however it was statistically at par with treatment T₅ i.e. FYM + Consortium of AZT + PSB + KMB (180.75 kg/ha). The lowest available potassium (120.36 kg/ha) in soil was recorded in treatment T₈ i.e. Absolute control (Table 3, Fig.3).

The results are comparable with Ashrafi et al., (2015) [3] who reported that the N, P and K (kg/ha) uptake was increased due to the influences of different treatments of SMC. Gumus and Seker (2017) [9] found that the use of SMC contributed to enhancing the level of organic carbon and nitrogen in the soil. The results are close accordance with Kedar et al., (2019) [10] who also reported that application of enriched spent mushroom substrate significantly increased the available nitrogen, phosphorus and potassium in soil after harvest of cabbage crop.

### Table 3: Influence of enriched spent mushroom substrate on soil available NPK (kg/ha) after harvest of radish

| Tr. No | Treatment details | Available N kg/ha | Available P kg/ha | Available K kg/ha |
|--------|-------------------|------------------|------------------|------------------|
| T₁     | SMS + Azotobacter (AZT) | 181.45           | 12.44            | 158.84           |
| T₂     | SMS + Phosphate Solubilizing Bacteria (PSB) | 167.08           | 15.52            | 150.56           |
| T₃     | SMS + Potash Mobilizing Bacteria (KMB) | 128.82           | 12.55            | 177.63           |
| T₄     | SMS + Consortium of AZT + PSB + KMB | 210.7            | 16.95            | 195.83           |
| T₅     | FYM + Consortium of AZT + PSB + KMB | 193.82           | 16.25            | 180.75           |
| T₆     | SMS (20 t/ha) | 169.64           | 12.30            | 150.87           |
| T₇     | FYM (20 t/ha) | 159.08           | 11.47            | 149.67           |
| T₈     | Absolute control | 140.31           | 10.25            | 120.36           |
| S.Em (±) |                      | 3.12             | 1.07             | 1.82             |
| CD at 5% |                    | 9.45             | 3.24             | 5.58             |
D) Influence of enriched spent mushroom substrate on root yield (kg/plot) and yield (t/ha)

The root yield per plot and per hectare was noted immediately after harvest of radish crop. The results are presented in the Table 4, Fig.4.

Root Yield (kg/plot)

The data presented in Table 4, Fig.4 showed that among the different treatments, the treatment T4 i.e. SMS + Consortium of AZT + PSB + KMB was found to be the most effective as it recorded significantly highest root yield (10.52 kg/plot) over rest of the treatments followed by treatment T5 i.e. FYM + Consortium of AZT + PSB + KMB (9.39 kg/plot). The lowest root yield (4.82 kg/plot) was recorded in treatment T8 i.e. Absolute control.

Similar trend of results was also reported by Taha et al., (2018) who stated that PGPR-bacteria + SMC tea and KH present within the soil can reduce the requirement of nitrogen fertilizer applications and lead to highest yield of tomato. Yildirim et al. (2009) also reported that the use of the inoculants (Azotobacter + Pseudomonas) on compost, used as radish growing medium provided high-yield crops and highest plant weight compared to that of without enrichment or singly enrichment. Gautum Singh (2018) envisaged that (T3) 60 per cent RDF + Azotobacter + VAM was found significantly superior to improve the growth, yield and quality of radish root.

Root Yield (t/ha)

The data (Table 4, Fig.4) showed that among all the different treatment, treatments T4 i.e. SMS + Consortium of AZT + PSB + KMB recorded significantly highest root yield (32.48 t/ha) over rest of the treatments followed by treatment T5 i.e. FYM + Consortium of AZT + PSB + KMB (28.98 t/ha). The lowest root yield (14.88 t/ha) was recorded in treatment T8 i.e. Absolute control.

Similar trend of results was also reported by Seran et al., (2017) who reported that higher marketable radish yield was obtained with application of compost 20 t/ha + half dose of NPK fertilizers. Ashgar et al., (2006) also reported that yield increased by integrated fertilizer usages in radish cultivation by using compost as a combination with chemical fertilizer.

| Tr. No | Treatment details | Root yield (Kg/plot) | Root yield (t/ha) |
|--------|-------------------|---------------------|------------------|
| T1     | SMS + Azotobacter | 8.31                | 25.66            |
| T2     | SMS + Phosphate Solubilizing Bacteria | 6.15 | 18.99 |
| T3     | SMS + Potash Mobilizing Bacteria | 7.23 | 22.13 |
| T4     | SMS + Consortium of AZT + PSB + KMB | 10.52 | 32.48 |
| T5     | FYM + Consortium of AZT + PSB + KMB | 9.39 | 28.98 |
| T6     | SMS (20 t/ha) | 6.00 | 18.44 |
| T7     | FYM (20 t/ha) | 5.89 | 18.19 |
| T8     | Absolute control | 4.82 | 14.88 |
| S.Em (±) |                      | 0.29 | 0.90 |
| CD at 5% |                      | 0.88 | 2.76 |
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References
1. Ahlawat OP, Sagar MP. Spent mushroom substrate-properties and recycling for beneficial purpose. In Fortinera, Mushroom Biotechnology, National Research Centre for Mushroom, Solan. India 2007, 314-334.
2. Asghar et al., Response of radish to integrated use of nitrogen fertilizer and recycled organic waste. Pak. J of Botany 2006;38(6):855-863.
3. Ashrafi et al., Effect of spent mushroom compost on yield and fruit quality of tomato. Asian J Med. Biol. Res 2015;1(3):471-477.
4. Borah Nilhay et al., Enrichment of compost through microbial inoculation - Effect on quality. Int. J Curr. Res 2014;6(08):8026-8031.
5. Brickell C (ed). The Royal Horticultural Society Encyclopedia of Gardening. London: Dorling Kindersley 1992, 356-357. ISBN, 978-086318-979-1.
6. Choudhary et al., Role of growth hormones in chilies: A review. Agric. Rev 2002;23(2):145-148.
7. Dixon GR. Vegetable Brassicas and related Crucifers (Print). Crop Production Science in Horticulture. 14. Wallingford: CAB International 2007. ISBN 978-1-84593-138-4.
8. Gautam Singh et al., Effect of fertilizer and biofertilizers on vegetative growth, yield and quality of radish. Ann. of Pt. and Soil Res 2018, 20-23.
9. Gumus Ilknur, Ceydet Seker. Effect of spent mushroom compost application on the physiochemical properties of a degraded soil. Solid Earth 2017;8:1153-1160.
10. Kedar et al., Influence of enriched button mushroom spent compost on growth and yield of cabbage. Int. J Curr. Microbial. App. Sci 2019;8(11):1658-1663.
11. Knudsen et al., Sodium and Potassium. Pages 225-246 in A. L. Page et al. Eds. Methods of soil analysis. Part 2, 2nd ed. Agronomy no. 9. Am. Soc. Agron., Madison, Wis 1982.
12. Olsen et al., Estimation of available phosphorus in soil by extraction with NaHCO₃, USDA Cir. 939. U.S. Washington 1954.
13. Shinde et al., Effect of enriched city compost with rock phosphate on yield of mung. J of Maha. Agril. Uni 1985;10(3):346-347.
14. Skinner et al., A comparison of a direct- and a plating-counting technique for the quantitative estimation of soil microorganisms. J Gen. Microbial 1952;6:261-271.
15. Subbiah BV, Asija GL. Alkaline method for determination of mineral nitrogen. Current science 1956;25:259-260.
16. Sudjana et al., Enrichment of mushroom compost heap quality using Azotobacter and Pseudomonas as a renewable ameliorant. Int. J of Agril. Inno and Res 2017, 5(5), ISSN (Online) 2319-1473.
17. Taha et al., Potential impact of compost tea on soil microbial properties and performance of radish under sandy soil condition. Aus. J of Basic and Appl. Sci 2016;10(8):158-165.
18. Tewari RP. Mushroom industry and its export potential Indian Horticulture 2004, 18-19.
19. Thamburaj S, Singh N. Vegetables, Tuber crops and Species. New Delhi: Indian Council of Agriculture Research 2005, 40.
20. Yildirim E, Karlidag H, Turan M, Donmez MH. Potential of use plant growth promoting rhizobacteria in organic broccoli (Brassica oleracea L.) production, www. Ecofruit.net/downloaded28 Agustus 2009-2016.
21. Seran et al., Marketable tuber yield of radish as influenced by compost and NPK fertilizer. Res. J of Agril. and Forestry Sci 2017,5(11):1-4.

Fig 4: Influence of enriched spent mushroom substrate on root yield (kg/plot) and root yield (t/ha) of radish

Root yield (kg/plot and t/ha)

Treatments

Root yield kg/plot and t/ha

Root yield (Kg/plot)

Root yield (t/ha)