Original Research Article

Influence of Enriched Spent Mushroom Substrate on Growth and Yield of Radish (*Raphanus sativus* L.)

Pritam Anantrao Bhosale, A. C. Jadhav* and D. H. Phalke

Department of Plant Pathology and Agricultural Microbiology, College of Agriculture, Pune, Mahatma Phule Krishi Vidyapeeth, Maharashtra State, India

*Corresponding author

A B S T R A C T

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 growth and yield of radish crop. The treatment (T₄) of SMS + consortium of AZT + PSB + KMB recorded significantly maximum values in the number of leaves (25.73), plant height (45.20 cm), root length (42.35 cm), root diameter (4.24 cm), fresh weight of whole plant (375.41 g), fresh weight of root (288.11 g), fresh weight of leaves (87.07 g), dry matter weight of plant (52.36 g) and yield of radish (32.48 t/ha) crop. The treatment T₄ was significantly superior over other treatments in terms of growth and yield followed by treatment T₅ – FYM + consortium of AZT + PSB + KMB.

Key words
Spent Mushroom Substrate, Biofertilizers, Enrichment, Radish, Yield

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 growth and yield of radish crop. The treatment (T₄) of SMS + consortium of AZT + PSB + KMB recorded significantly maximum values in the number of leaves (25.73), plant height (45.20 cm), root length (42.35 cm), root diameter (4.24 cm), fresh weight of whole plant (375.41 g), fresh weight of root (288.11 g), fresh weight of leaves (87.07 g), dry matter weight of plant (52.36 g) and yield of radish (32.48 t/ha) crop. The treatment T₄ was significantly superior over other treatments in terms of growth and yield followed by treatment T₅ – FYM + consortium of AZT + PSB + KMB.

Introduction

Radish (*Raphanus sativus* L.) is grown for its young tender fusiform root (Brickell, 1992). 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). The substrate released after mushroom crop harvest, better known as “Spent Mushroom Substrate” (SMS) is also the subject of great importance (Tewari, 2007). The SMS 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). 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).

Enriched SMS is capable of improving the physical, biological and chemical properties
of soil when it is added to the soil. Also it increases the population of beneficial microorganisms in soil which are necessary for plant growth and good yields. It also minimizes the use of chemical fertilizers (Gumus and Seker, 2017). Keeping this in view, the experiment on influence of enriched spent mushroom substrate (SMS) on growth and yield of radish (*Raphanus sativus* L.) was undertaken.

**Materials 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.) on local variety during *Rabi* 2019 with three replications and eight treatments at a spacing of 30 cm X 15 cm in Randomised Block Design at the Plant Pathology Research Farm, College of Agriculture, Pune with treatments detailed below.

**Treatment details**

| Treatment | Description |
|-----------|-------------|
| T₁        | SMS + Azotobacter (AZT) |
| T₂        | SMS + Phosphate Solubilizing Bacteria (PSB) |
| T₃        | SMS + Potash Mobilizing Bacteria (KMB) |
| T₄        | SMS + Consortium of AZT + PSB + KMB |
| T₅        | FYM + Consortium of AZT + PSB + KMB |
| T₆        | SMS (20 t/ha) |
| T₇        | FYM (20 t/ha) |
| T₈        | Absolute control |

The fresh weight of plant, leaves and roots was recorded immediately after harvest of plant. Dry matter weight of root was also recorded.

**Enrichment of SMS and FYM**

The SMS and FYM were enriched prior to the application of individual treatments with biofertilizers *viz.*, Azotobacter, PSB and KMB. The enrichment of SMS and FYM was done as per the treatments. Azotobacter, PSB and KMB were enriched @10 kg/ha basis. After enrichment, the SMS and FYM were kept for 4 weeks for the proper growth of microorganisms and for improving nutrient status of compost (Shinde *et al.*, 1985) and (Borah Nilay *et al.*, 2014).

**Results and Discussion**

**Number of leaves per plant**

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 number of leaves per plant (10.5, 17.73 and 25.73) at 30, 45 days of sowing and at time of harvesting respectively over rest of the treatment, followed by the treatment T₅ i.e. FYM + Consortium of AZT + PSB + KMB (9.53, 15.20 and 21.23) respectively (Table 1, Fig. 1). The lowest number of leaves (6.20, 9.23 and 11.03) at 30, 45 days of sowing and at time of harvesting respectively were recorded in treatment T₈ i.e. absolute control. The obtained results were in accordance with Khalid *et al.*, (2015) and Shruthi *et al.*, (2016) concluded that the combination of inorganic, organic and biofertilizers had given good results which attributed to maximum increase in the height of plant and number of leaves in radish crop.

**Plant height (cm)**

The treatment T₄ i.e. SMS + Consortium of AZT + PSB + KMB was found to be the most effective as it recorded significantly highest plant height (26.09, 35.53 and 45.20 cm)
respectively at 30, 45 days of sowing and at time of harvesting over rest of the treatments (Table 2, Fig. 2), followed by treatment $T_5$ i.e. FYM + Consortium of AZT + PSB + KMB (24.15, 31.80 and 41.33 cm) respectively at 30, 45 days of sowing and at time of harvesting. The lowest plant height (14.06, 18.03 and 23.02 cm) was recorded in treatment $T_8$ i.e. Absolute control at 30, 45 days of sowing and at time of harvesting. The obtained results are in accordance with Roshni et al., (2019) and Naik and Sreedhar (2019) who reported that application of biofertilizers PSB + KSB + Azospirillum + Azotobacter + VAM combination with RDF recorded the highest plant height.

Table 1 Influence of enriched spent mushroom substrate on number of leaves at 30, 45 DAS and at harvest of crop

| Tr. No. | Treatment details                      | 30 DAS | 45 DAS | At Harvest |
|---------|----------------------------------------|--------|--------|------------|
| $T_1$   | SMS + Azotobacter (AZT)                | 8.70   | 14.97  | 20.10      |
| $T_2$   | SMS+ Phosphate Solubilizing Bacteria (PSB) | 7.90   | 12.70  | 16.57      |
| $T_3$   | SMS+ Potash Mobilizing Bacteria (KMB)  | 8.13   | 13.53  | 18.53      |
| $T_4$   | SMS+ Consortium of AZT+ PSB+ KMB       | 10.50  | 17.73  | 25.73      |
| $T_5$   | FYM+ Consortium of AZT+ PSB+ KMB       | 9.53   | 15.20  | 21.23      |
| $T_6$   | SMS (20 t/ha)                          | 7.67   | 11.83  | 15.03      |
| $T_7$   | FYM (20 t/ha)                          | 7.17   | 11.37  | 14.20      |
| $T_8$   | Absolute control                       | 6.20   | 9.23   | 11.03      |

SEm (±) 0.30 0.55 0.77
CD at 5% 0.90 1.67 2.33

Table 2 Influence of enriched spent mushroom substrate on plant height at 30, 45 DAS and at harvest of crop

| Tr. No | Treatment details                      | 30 DAS | 45 DAS | At Harvest |
|--------|----------------------------------------|--------|--------|------------|
| $T_1$  | SMS + Azotobacter (AZT)                | 22.28  | 29.35  | 37.59      |
| $T_2$  | SMS+ Phosphate Solubilizing Bacteria (PSB) | 19.82  | 24.93  | 31.84      |
| $T_3$  | SMS+ Potash Mobilizing Bacteria (KMB)  | 20.55  | 26.50  | 33.36      |
| $T_4$  | SMS+ Consortium of AZT+ PSB+ KMB       | 26.09  | 35.53  | 45.20      |
| $T_5$  | FYM+ Consortium of AZT+ PSB+ KMB       | 24.15  | 31.80  | 41.33      |
| $T_6$  | SMS (20 t/ha)                          | 18.55  | 24.23  | 30.50      |
| $T_7$  | FYM (20 t/ha)                          | 17.71  | 22.72  | 29.27      |
| $T_8$  | Absolute control                       | 14.06  | 18.03  | 23.02      |

SEm (±) 0.57 0.78 1.01
CD at 5% 1.73 2.37 3.05
Table 3 Influence of enriched spent mushroom substrate on root length and root diameter of radish (cm)

| Tr. No | Treatment details                                      | Root length (cm) | Root diameter (cm) |
|--------|--------------------------------------------------------|------------------|--------------------|
| T1     | SMS + Azotobacter (AZT)                                | 34.57            | 3.58               |
| T2     | SMS+ Phosphate Solubilizing Bacteria (PSB)             | 31.20            | 3.10               |
| T3     | SMS+ Potash Mobilizing Bacteria (KMB)                  | 33.13            | 3.40               |
| T4     | SMS+ Consortium of AZT+ PSB+ KMB                       | 42.35            | 4.24               |
| T5     | FYM+ Consortium of AZT+ PSB+ KMB                       | 38.93            | 3.83               |
| T6     | SMS (20 t/ha)                                         | 28.23            | 2.87               |
| T7     | FYM (20 t/ha)                                         | 27.23            | 2.72               |
| T8     | Absolute control                                      | 21.73            | 2.02               |

SEm (±) 1.04 0.13
CD at 5% 3.16 0.38

Table 4 Influence of enriched spent mushroom substrate on fresh weight of whole plant, fresh weight of leaves, fresh weight of roots and dry matter weight of roots of radish (g)

| Tr. No | Treatment details                                      | Fresh weight of plant (g) | Fresh weight of leaves (g) | Fresh weight of root (g) | Dry weight of plant (g) |
|--------|-------------------------------------------------------|---------------------------|----------------------------|--------------------------|-------------------------|
| T1     | SMS + Azotobacter (AZT)                                | 229.93                    | 52.90                      | 176.10                   | 39.15                   |
| T2     | SMS+ Phosphate Solubilizing Bacteria(PSB)             | 208.97                    | 39.20                      | 168.90                   | 27.01                   |
| T3     | SMS+ Potash Mobilizing Bacteria (KMB)                 | 217.70                    | 44.30                      | 172.67                   | 32.93                   |
| T4     | SMS+ Consortium of AZT+ PSB+ KMB                      | 375.41                    | 87.07                      | 288.11                   | 52.36                   |
| T5     | FYM+ Consortium of AZT+ PSB+ KMB                      | 327.80                    | 76.03                      | 251.77                   | 45.50                   |
| T6     | SMS (20 t/ha)                                         | 189.13                    | 34.29                      | 154.84                   | 25.91                   |
| T7     | FYM (20 t/ha)                                         | 183.20                    | 31.83                      | 151.37                   | 23.35                   |
| T8     | Absolute control                                      | 123.90                    | 23.43                      | 100.47                   | 18.41                   |

SEm (±) 1.69 1.43 1.97 1.15
CD at 5% 5.12 4.34 5.98 3.50

Fig.1 Influence of enriched spent mushroom substrate on number of leaves at 30, 45 DAS and at harvest of crop
**Fig. 2** Influence of enriched spent mushroom substrate on plant height (cm) at 30, 45 DAS and at harvest of crop

**Fig. 3** Influence of enriched spent mushroom substrate on root length and diameter (cm) of radish

**Fig. 4** Influence of enriched spent mushroom substrate on fresh wt. of plant, leaves, root and dry wt. of plant (g)

**Fig. 5** Influence of enriched spent mushroom substrate on root yield (kg/plot) and root yield (t/ha) of radish
Plate 1 Influence of enriched SMS on yield parameters of radish in different treatments

**Root length at harvest (cm)**

The significantly highest root length (42.35 cm) at time of harvest over rest of the treatments was recorded by the treatment T₄ i.e. SMS + Consortium of AZT + PSB + KMB and was found to be the most effective followed by treatment T₅ i.e. FYM + Consortium of AZT + PSB + KMB (38.93 cm) (Table 3, Fig. 3). The lowest root length (21.73 cm) was recorded in treatment T₈ i.e. Absolute control at the time of harvest. These results are comparable with the reports of Vithwel Kanaujia (2013); Khalid et al., (2015) and Gautum Singh (2018) who also reported increase in root length in carrot and radish crops respectively.

**Root diameter at harvest (cm)**

The data presented in Table 3, Fig. 3, 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 root diameter (4.24 cm) at time of harvest over rest of the treatments followed by treatment T₅ i.e. FYM + Consortium of AZT + PSB + KMB (3.83 cm). The lowest root diameter (2.02 cm) was recorded in treatment T₈ i.e. absolute control at the time of harvest. The results obtained are in agreement with Khalid et al., (2015), Shruthi et al., (2016) and Jaishankar (2018) who concluded that the combination of inorganic, organic and biofertilizers attributed to the increase in the diameter/thickness/root girth of main root in radish.

**Fresh weight of plant (g)**

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 fresh weight of plant (375.41 g) at time of harvest over rest of the treatments followed by treatment T₅ i.e.
FYM + Consortium of AZT + PSB + KMB (327.80 g). The lowest fresh weight of plant (123.90 g) was recorded in treatment T₈ i.e. Absolute control at the time of harvest (Table 4, Fig.4). These findings are in line with reports of Singh et al., (2017), Kirad et al., (2010), Vithwel Kanaujia (2013) in carrot and Khalid et al., (2015) and Gautum Singh (2018) in radish crop.

**Fresh weight of leaves (g)**

The data presented in Table 4, Fig. 4 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 fresh weight of leaves (87.07 g) at time of harvest over rest of the treatments followed by treatment T₅ i.e. FYM + Consortium of AZT + PSB + KMB (76.03 g). The lowest fresh weight of leaves (23.43 g) was recorded in treatment T₈ i.e. absolute control at the time of harvest. Similar trend of results was also reported by Espiritu (2011) who stated that fresh and dry weight of pechay was significantly increased by combined inoculation of *Azotobacter* sp. and *T.harzianum*. The results are comparable with those of Singh et al., (2017) in carrot; Khalid et al., (2015) and Gautum Singh (2018) in radish crop.

**Fresh weight of root (g)**

The data shown in Table 4, Fig. 4 showed that among the different treatments, treatment T₄ i.e. SMS + Consortium of AZT + PSB + KMB was found to be the most effective and recorded significantly highest fresh weight of root (288.11 g) at time of harvest over rest of the treatments followed by treatment T₅ i.e. FYM + Consortium of AZT + PSB + KMB (251.77 g). The lowest fresh weight of root (100.47 g) was recorded in treatment T₈ i.e. absolute control at the time of harvest. The results are comparable with Khalid et al., (2015) and Shruthi et al., (2016) who also concluded that the combination of inorganic, organic and bio fertilizers had attributed to the increase in the leaf: root weight ratio, fresh weight of root and ultimately yield in radish.

**Dry matter weight of root (g)**

The data (Table 4, Fig. 4) 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 dry weight of plant (52.36 gm) over rest of the treatments followed by treatment T₅ i.e. FYM + Consortium of AZT + PSB + KMB (45.50 g). The lowest dry weight of plant (18.41 g) was recorded in treatment T₈ i.e. absolute control. The obtained results are in accordance with Roshni et al., (2019) who concluded that application of biofertilizers PSB + KSB + *Azospirillum + Azotobacter + VAM* combination with 100% RDF recorded the highest dry matter weight of root (34.25 g) in carrot.

**Root Yield (kg/plot)**

The data presented in Table 4, Fig. 4 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 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.

**Root Yield (t/ha)**

Among all 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 (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 (Table 5, Fig. 5, Plate 1). 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.

In conclusion, the experiment showed that SMS could be converted into enriched compost as a value added product rich in plant nutrient by enriching with biofertilizers like *Azotobacter*, PSB and KSB. Microbial consortium enhances the process of composting and enriches nutrient content to the soil. Application of SMS + Consortium of AZT + PSB + KMB (T₄) influence on growth and yield parameters of radish crop.

**Acknowledgements**

Authors are thankful to the staff of the Professor of Plant Pathology and Agril. Microbiology Section, Soil Science and Agril. Chemistry Section, College of Agriculture, Pune (MS) for providing necessary facilities during the investigations.

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**How to cite this article:**

Pritam Anantrao Bhosale, A. C. Jadhav and Phalke, D. H. 2021. Influence of Enriched Spent Mushroom Substrate on Growth and Yield of Radish (*Raphanus sativus* L.). *Int.J.Curr.Microbiol.App.Sci.* 10(01): 271-279. doi: https://doi.org/10.20546/ijcemas.2021.1001.033