Pak. J. Bot., 47(6): 2397-2400, 2015.

EM.1 COMPOST AND ITS EFFECTS ON THE NODULATION, GROWTH, AND YIELD OF BERSEEM (*TRIFOLIUM ALEXANDRINUM*) CROP

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Abstract

To wisely utilize local organic resources and enhance their quality in order to effectively fertilize agricultural crops, a blend of organic resources, comprising cow manure, poultry manure, and kitchen waste (2:1:1 ratio by volume), was composted with (Compost$_{EM.1}$) and without (Compost$_{plain}$) effective microorganisms (EM.1). Various parameters including temperature, pH, carbon (C), nitrogen (N), and the C/N ratio were recorded during composting to assess the effects of EM.1 on this process. After completion of the composting process, the effects of the resultant composts on the nodulation, growth, and yield of berseem (*Trifolium alexandrinum* L.) crop were tested in a field trial. Temperature and pH were lower and the N content was higher in Compost$_{EM.1}$ than in Compost$_{plain}$ throughout composting. C degradation was also faster in Compost$_{EM.1}$ than in Compost$_{plain}$. Consequently, the C/N ratio stabilized faster in Compost$_{EM.1}$, leading to rapid completion of composting. In the field trial, composts showed no significant effect on nodulation or the shoot-to-root ratio. However, in comparison to Compost$_{plain}$, Compost$_{EM.1}$ significantly increased the leaf-to-stem ratio and the fresh and dry yields of berseem. We conclude that EM.1 enhances the composting process and the yield of berseem crop.

Key words: Composting, Manure, Kitchen waste, Nodulation, Crop growth.

Introduction

Composting is historically a well-known method for waste management and fertilization in organic crop production (Haq *et al*., 2014; Anyasi & Atagana, 2014). Compost is made through the decomposition of various organic materials individually or in combination. The composting process is naturally slow, but most people would prefer it to be fast.

Numerous commercial additives are advertised for enhancing the composting process, but the effectiveness of many of them has not yet been scientifically confirmed. Himanen & Hänninen (2009) found 5 different commercial additives to be ineffective. Gabhane *et al.* (2012) reported that some commercial additives they evaluated were useful, whereas others were not. Because of the continuous development of new products and approaches for enhancing the composting process, continuous research is needed to assess their efficacy and effects on crops.

This research evaluated EM.1, a mixture of microorganisms (*Lactobacillus casei*, *Rhodopseudomonas palustris*, and *Saccharomyces cerevisiae*), for its enhancement of the composting process, even though this has never been the intended purpose of the mixture. Previous researchers, including Shalaby (2011), Kale and Anthappan (2012), and Boga *et al.* (2014), proposed using EM.1 to clean indoor pollutants due to its waste-degrading ability. In this study, we explored a new aspect of EM.1—its effects on the composting process and subsequent berseem crop.

Material and Methods

Composting trial and data collection: A mixture of organic resources, comprising cow manure, poultry manure, and kitchen waste (2:1:1 ratio by volume), was composted with (Compost$_{EM.1}$) and without (Compost$_{plain}$) effective microorganisms (EM.1). The 2 blends were composted in 250-L heavy-duty bags. Compost$_{EM.1}$ was maintained in airtight (anaerobic) conditions, which is a prerequisite for the functioning of EM.1, whereas Compost$_{plain}$ was maintained in aerated (aerobic) conditions (control treatment) by drilling holes in the bags. The composting experiment was run 2 times, and during each run, the composting treatment was replicated 4 times. A commercial pack of EM.1 was obtained from EMRO (EMRO, Okinawa, Japan) through the Rashed Establishment for Trading and Agriculture, Riyadh, Saudi Arabia. Inocula of EM.1 were prepared by mixing a commercial pack of EM.1, molasses, and water (1:1:20 ratio by volume). This mixture was kept at room temperature for 5 days to get activated, and then 1 L of the mixture was added per 1 m^3 of the composting material.

Data on the temperature, pH, carbon (C), nitrogen (N), and C/N ratio were collected at the start of the composting trial and then once every 2 weeks. The temperature was measured in the center of the compost by inserting a composting thermometer, and pH was measured by collecting a compost sample from each experimental unit with the help of a sampling probe and evaluating its suspension (compost sample and deionized water at a ratio of 1:2) with a pH meter. The composting mixture in each bag was loosened and agitated for thorough mixing once every 6 weeks, and samples were collected from all the bags at the same time for analysis of C and N. After each mixing, the moisture was adjusted to 50% with the help of a moisture meter probe. N and C contents were analyzed by a Perkin-Elmer CHNS/O Analyzer (Model 2400) according to the manufacturer's instruction manual (PerkinElmer, Inc., Waltham, MA, USA).

Field trial and data collection: In both years of the 2-year field trial, the composts were applied to the soil 2 weeks before sowing. The crop was sown each year in the first week of October, and the 1st harvest was carried out 45 days after sowing (DAS), whereas the subsequent 3 harvests were carried out at 1-month intervals. All other agronomic practices were carried out uniformly in all treatments.

To assess the effects of the composts on the berseem crop, data on its nodulation, leaf-to-stem ratio, shoot-to-root ratio, and fresh and dry yields were compiled. The numbers of total nodules and effective nodules per plant were counted at the time of each cut by uprooting 5 random plants in each subplot. Effective nodules were determined through visual examination for a pink–red color, which indicates the presence of red pigment (leghemoglobin). Leaf-to-stem and shoot-to-root ratios, and fresh and dry yields were determined following standard procedures (Daur *et al.*, 2011; Daur, 2013).

Statistical analysis: MStatC was used for statistical analysis and to calculate a least significant difference (LSD) test ($p<0.05$). Graphs were produced using Microsoft Excel (Microsoft Corp., Redmond, WA, USA).

Results and Discussion

Composting parameters: Parameters that were recorded during the composting process are given as follows. The temperature dynamics during the trial are displayed in Fig. 1. The temperature was higher in $\text{Compost}_{\text{plain}}$ from Week 2 to Week 6, fluctuating between 45°C and 46°C, whereas in $\text{Compost}_{\text{EM.1}}$, it varied between 32°C and 35°C. At Week 8, the temperature decreased, and then remained in the range of 27–33°C until the end of the experiment. The results show that EM.1 inoculation caused the composting process to happen at lower temperatures. This indicates that the breakdown of composting material occurred through the action of enzymes that may produce by EM.1 microbes. In the normal composting process, as presented by $\text{Compost}_{\text{plain}}$, heat was produced which reasoned to the oxidation of carbon to CO_2, and thus the temperature increased, helping in the breakdown of the organic materials. Our results are in accordance with those of Wongwilaiwalin *et al.* (2010) and Gondek *et al.* (2014). The pH dynamics for $\text{Compost}_{\text{plain}}$ and $\text{Compost}_{\text{EM.1}}$ are shown in Fig. 2. In $\text{Compost}_{\text{plain}}$ and $\text{Compost}_{\text{EM.1}}$, the pH decreased to 7.4–6.9 and 7.4–6.7, respectively. Careful observation of the ranges indicates that the pH in $\text{Compost}_{\text{EM.1}}$ remained lower than in $\text{Compost}_{\text{plain}}$. The lower pH of $\text{Compost}_{\text{EM.1}}$ may be due to the organic acids released by the EM.1 microbes for the breakdown of the composting materials. These results are in agreement with those of Himanen & Hänninen (2009), Gondek *et al.* (2014), and Kharrazi *et al.* (2014). Carbon (C) degradation was faster in $\text{Compost}_{\text{EM.1}}$ than in $\text{Compost}_{\text{plain}}$ (Fig. 3). The faster degradation of C was thought to be due to the effect of EM.1, which produces enzymes that initiate decomposition (Hu *et al.*, 2013; Sharma *et al.*, 2014). At the start of the composting process, the total nitrogen content decreased until Week 6 in $\text{Compost}_{\text{EM.1}}$, after which it remained steady, whereas in $\text{Compost}_{\text{plain}}$, it decreased until Week 12 (Fig. 4). These changes in N content indicate that nitrogen loss, in the form of gaseous ammonia and nitrification, was lower in $\text{Compost}_{\text{EM.1}}$ than in $\text{Compost}_{\text{plain}}$, as supported by Himanen & Hänninen (2009). The C/N ratio became stable earlier in $\text{Compost}_{\text{EM.1}}$ than in $\text{Compost}_{\text{plain}}$ (Fig. 5), which is an indication of the completion of the composting process. (Chaturvedi *et al.*, 2010; Nakasaki *et al.*, 2013).

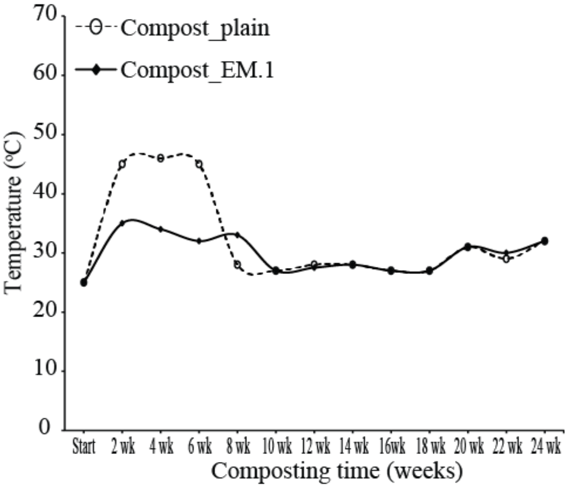

Fig. 1. The changes in temperature during the composting process.

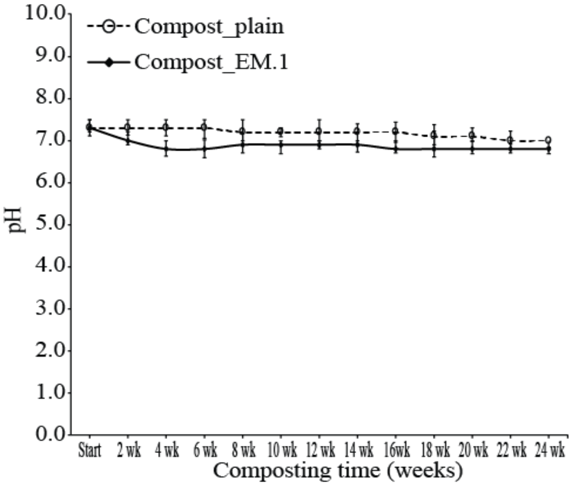

Fig. 2. The changes in pH during the composting process. Each value represents mean ± standard deviation.

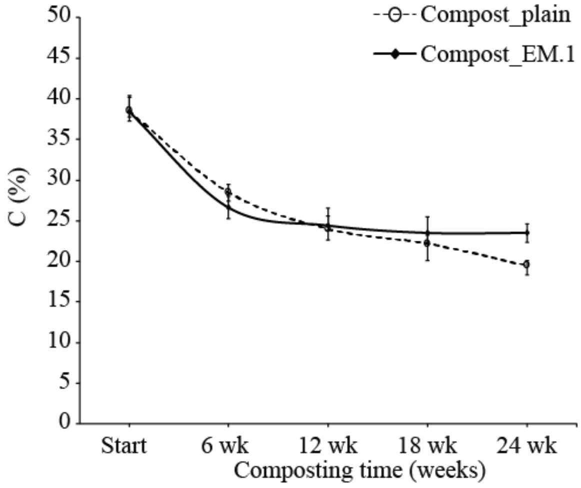

Fig. 3. The changes in C (%) during the composting process. Each value represent mean ± standard deviation.

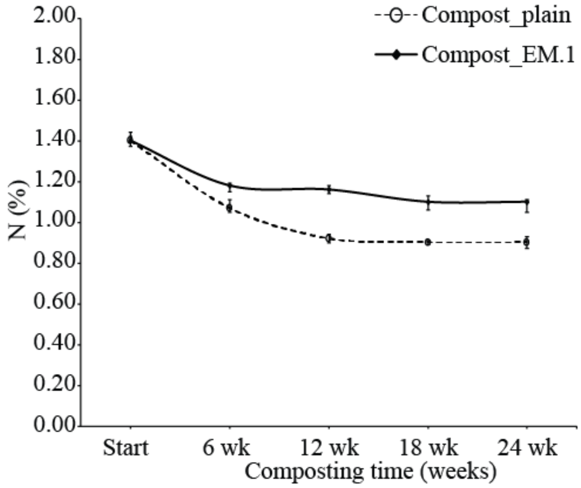

Fig. 4. The changes in N (%) during the composting process. Each value represents mean ± standard deviation.

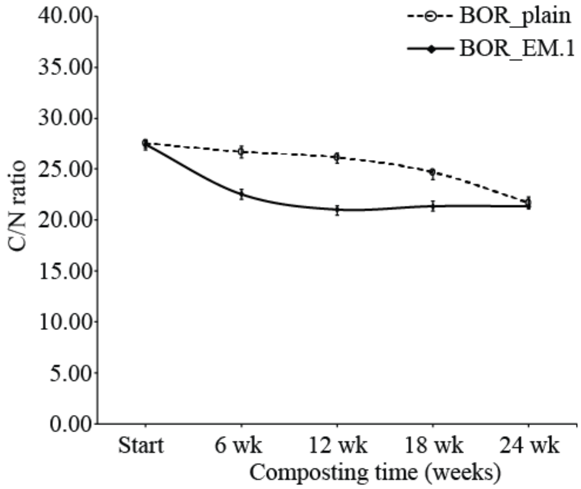

Fig. 5. The changes in C/N ratio during the composting process. Each value represents mean ± standard deviation.

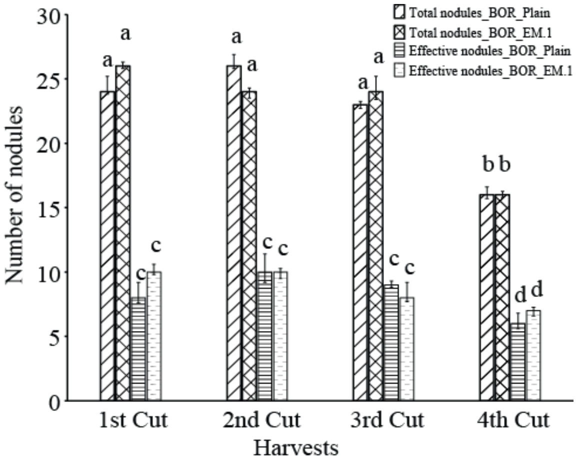

Fig. 6. Dynamics of the berseem crop nodulation under different composts during the crop growth period. Each value represents mean ± standard deviation.

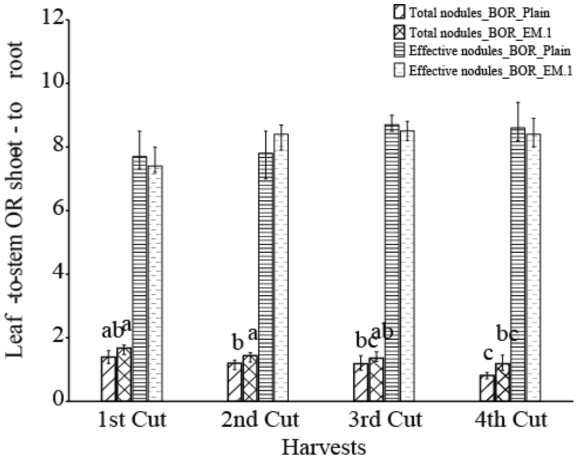

Fig. 7. Dynamics of leaf-to-stem and shoot-to-root ratios under different composts during the berseem crop growth period. Each value represents mean ± standard deviation.

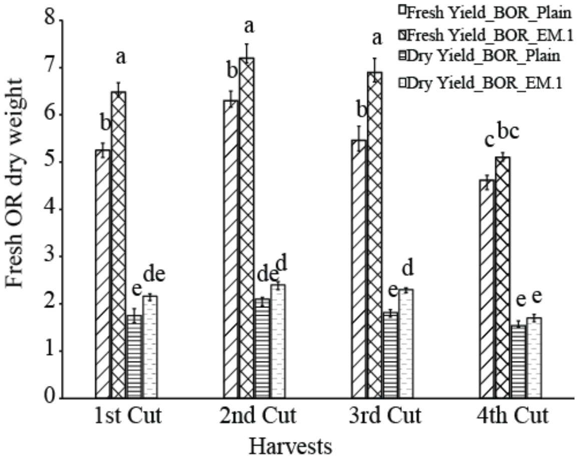

Fig. 8. Dynamics of fresh and dry matter yield for the composts during different cuts of berseem crop. Each value represents mean ± standard deviation.

Berseem nodulation, growth, and yield: The effects of the 2 types of composts on the numbers of total nodules and effective nodules per plant are given in Fig. 6. No significant effect ($p<0.05$) of the composts on the nodulation of berseem was recorded. However, nodulation was significantly different across different cuts. Based on the current results, we can conclude that EM.1 had neither a positive nor a negative effect on the nodulation of alfalfa. Pei-Sheng & Hui-Lian (2002) reported a closely related product, EM bokashi, which increased the number of nodules per plant and the fresh weight per nodule in peanuts. Our finding may be different because of the differences in the crops, but further research is needed to resolve such contradictory results. The leaf-to-stem and shoot-to-root ratios are shown in Fig. 7. The leaf-to-stem ratio was significantly different ($p<0.05$) among the composts and different cuts, but the shoot-to-root ratio was not significantly different ($p>0.05$) between the composts and among different cuts. The leaf-to-stem ratio was probably enhanced by the positive effect of EM.1 on composting in the form of enhancing its fertilizer efficiency. According to Feller *et al.* (2015), plants divert their biomass to leaves, shoots, or roots as a result of modifying environmental conditions. Wilson (1988) supports our results, finding that plants generally do not change their shoot-to-root ratio. The fresh and dry weights of berseem were significantly ($p<0.05$) higher in plots treated with $\text{Compost}_{\text{EM.1}}$ than with $\text{Compost}_{\text{plain}}$ (Fig. 8). We speculate that the increased yield of the berseem crop was due to the timely liberation of essential nutrients by EM.1 activities from the compost. Previous studies support our results that organic manures enhance the yield of crops because they provide all essential nutrients needed for crop growth (Daur, 2013, Castellanos-Navarrete *et al*., 2015).

Conclusion

Based on this study, we suggest that EMRO (EMRO, Okinawa, Japan)-branded commercially available effective microorganisms (EM.1) can be used for rapid composting and for improving berseem crop yield. However, further research is needed because in normal composting, as represented here by $\text{Compost}_{\text{plain}}$, the rise in temperature kills various pathogenic microbes. $\text{Compost}_{\text{EM.1}}$ occurred at a lower temperature, but its producer claims that the microorganisms in it suppress disease-causing microorganisms while enhancing the functioning of each other and of beneficial microbes. Therefore, the fate of pathogenic microbes in EM.1-induced composting and the interactions of EM.1 with rhizosphere microbes are topics for future research.

Acknowledgement

This project was funded by the Deanship of Scientific Research (DSR), King Abdulaziz University, Jeddah, under Grant No. (219-155-1434). The authors, therefore, acknowledges with thanks DSR technical and financial support.

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(Received for publication 24 January 2015)