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ORGANIC ALFALFA PRODUCTION USING DIFFERENT EM.1 COMPOSTS

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ABSTRACT

Organic agricultural production systems are favored as they avoid the soil, air, and water contamination. Cow and poultry manure composts are key sources of fertilizer for organic crop production, but their natural degradation is slow that result in the loss of nitrogen. Therefore, the current study aimed to improve the composting process of cow and poultry manures through the addition of effective microorganisms (EM.1), a different exploitation from its normally intended use. Cow and poultry manures, with ($CM_{EM.1}$ and $PM_{EM.1}$) and without (CM_{plain} and PM_{plain}) EM.1 were composted and evaluated for organic alfalfa production. Compost analysis indicated superiority of EM.1 compost over plain compost. Significant ($p < 0.05$) variation between treatment groups was found for most parameters, including plant height, leaf to stem ratio, fresh and dry forage yields, and mineral (N, P, Ca, B, Mn, Fe, Cu, and Zn) composition. Only nodulation and some mineral compositions (K, Mg, S, Na, Co, and Mo) were not significantly different between treatments. Overall superiority of the treatments was in the order of $CM_{EM.1} > CM_{plain} > PM_{EM.1} > PM_{plain}$. We conclude that EM.1 enhances compost quality and alfalfa crop yield. These findings are hoped to encourage sustainable organic alfalfa production and may be applicable to other crops. Furthermore, the article includes analysis for manures, soil, and alfalfa crops that may be useful as reference.

Key words: composting, crop growth, kitchen waste, manure, nodulation

INTRODUCTION

Organic agricultural products are well liked owing to their reputation for being healthier and better tasting than non-organic products (Caliskan et al. 2013). Additionally, while non-organic/conventional production systems utilize chemical fertilizers that are thought to disturb natural soil processes, organic agriculture is more eco-friendly and uses fertility systems mainly dependent on composted animal manures. Composting transforms raw organic residues into a stable product, free of germs and unpleasant odors, and must be undertaken for manure before its application in a field. The composting process occurs naturally in a heap of manure, but it is generally slow, results in nitrogen loss in the form of ammonia and nitrification. There are many additives, including hydrated lime, aluminum sulfate, biotal, phosphoric acid, perlite, zeolite, and various cellulose-degrading bacteria, are reported or commercially advertised for improving or enriching compost quality for use in organic agriculture (Brito et al., 2015). However, thus far, many have not been scientifically evaluated for their effectiveness.

Some studies such as that by Himanen and Hänninen (2009), report commercial additives to be ineffective. Others, for example, Gabhane et al. (2012), Yousefi et al. (2013), and Sanchez-Garcia et al. (2015), found some additives to be effective, whereas others were ineffective. Therefore, as new products and techniques are continuously being developed and implemented, it is important that their efficacy and effects on crops be assessed. Moreover, as intensive conventional agriculture has been associated with documented ecological concerns and food contamination problems, people are looking for a safer and more environmentally friendly production system. Organic farming has become widely supported as an alternative to conventional agricultural methods because it embodies a food production system with minimal harmful effects on ecosystems, animals, or humans. In addition, organic produce is known for higher nutritive values relative to traditionally grown produce. However, organic agriculture is criticized for issues such as low yields and lack of efficient organic fertilizers. To address these limitations, various scientists worldwide are working toward advancement of organic agriculture through the development of good agronomic practices, selection of suitable crop varieties, and improvement of organic fertilizers (Rembiałkowska, 2007; Badgley et al., 2007; Seufert et al., 2012). To contribute to this global endeavor, we examined the utilization of EM.1 for improvement of organic manure, and consequently, enhancement of organic agriculture. EM.1 is a mixture of co-existing microorganisms, including lactic acid bacteria, yeast, and phototrophic bacteria, Thus far, it has primarily been used to degrade and clean indoor pollutants (Shalaby, 2011; Boga et al. 2014; Daur et al., 2015). Inadequate data are available regarding its effects on organic fertilizers and crop production (Khaliq et al., 2006).

The primary aim of this study was to assess the efficacy of EM.1, an environmentally friendly and worldwide easily available product, for the improvement of compost, and ultimately, organic agriculture. The findings of this study are expected to enhance organic alfalfa production and may be applicable to other crops. In addition, it is thought that the expected findings will be useful to other researchers as a reference and that they will open a venue for further research on EM.1.

MATERIALS AND METHODS

Study site and experimental treatments

The experiment was conducted at the agriculture research station of King Abdulaziz University in the Hada-A'Sham area of Jeddah over two consecutive, annual growing seasons in randomized complete block design with four replications. Each sub-plot size was 2 x 2.5 m^2. In this study, EMRO (EMRO, Okinawa, Japan) branded, commercially available effective microorganisms (EM.1), a mixture of co-existing microorganisms including lactic acid bacteria, yeast, and phototrophic bacteria, was used for compost enhancement and subsequently berseem crop yield. A new section of the study field was used each year. Soil properties were measured initially and after completion of each season's experiment. For each soil property, the values from both years were averaged. This two-year average of each soil property, initially and for each respective treatment, is shown in Table 1. Climatic conditions of the experimental site are shown in Table 2.

Table 1. Soil properties (0-30 cm) initially and after final cut of the experiment

Soil properties	Initial values	After final cut of the experiment			
		PM	CM	$PM_{EM.1}$	$CM_{EM.1}$
Bulk density (g cm^{-3})	1.43	1.42	1.27	1.40	1.26
pH	7.74	7.78	7.20	7.64	7.04
Organic matter (%)	1.98	1.20	2.17	1.19	2.15
CEC ($cmol_c$ kg^{-1})	14.13	14.14	16.41	12.89	16.80
EC (*dS/m*)	1.75	1.86	1.56	1.83	1.55
Soil texture	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand
		Quantity (g kg^{-1})			
N	1.21	0.92	1.21	1.11	1.20
P	0.049	0.047	0.048	0.048	0.048
K	0.285	0.129	0.335	0.145	0.369
Ca	4.114	4.079	4.101	4.112	4.100
Mg	0.238	0.208	0.265	0.265	0.234
S	0.052	0.054	0.058	0.060	0.060
		Quantity (mg kg^{-1})			
B	4.39	4.20	4.49	4.27	5.14
Mn	10.69	9.31	11.09	11.88	12.71
Fe	45.64	17.82	44.15	45.64	48.84
Co	3.99	3.70	4.16	4.12	4.74
Cu	1.62	1.40	1.84	1.86	1.99
Zn	2.82	2.57	2.89	3.07	3.29

Two-year averages for initial soil conditions and respective experimental treatments. PM = composted poultry manure; CM = composted cow manure; $PM_{EM.1}$: composted poultry manure with EM.1; $CM_{EM.1}$: composted cow manure with EM.1.

Plots were treated with four types of composts: viz. 6 tones ha^{-1} poultry manure with ($PM_{EM.1}$) and without (PM_{plain}) effective microorganisms (EM.1) and 18 tones ha^{-1} cow manure with ($CM_{EM.1}$) and without (CM_{plain}) effective microorganisms (EM.1). Composts were prepared from poultry and cow manures through a procedure similar to that described by Daur et al (2015) for some other types of EM.1 compost. The aforementioned compost application rates were calculated on the basis of average N content of composts following MWPS (1985) guidance and considering N requirements of alfalfa for 7 cuts according to Racca et al. (Racca et al., 1998). The average N contents were calculated using the formula: ($PM_{EM.1+}PM_{plain}$)/2 and ($CM_{EM.1+}CM_{plain}$)/2 for composted poultry manure and composted cow manure, respectively. Analytical results for cow and poultry manures before and after composting are shown in Table 3. The effects of composts on alfalfa crops were evaluated using a randomized complete block design.

Table 2. Mean monthly temperature (°C) and precipitation at experimental sites.

Weather Parameters	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min. T °C (2013)	15.6	17.4	19.2	21.4	23.5	24.2	26.0	27.5	25.0	23.0	22.9	19.6
Min. T °C (2014)	14.8	18.2	18.0	21.0	23.0	24.6	26.2	27.4	25.3	23.1	22.2	19.2
Min. T °C (2015)	15.4	18.8	19.5	20.2	22.6	24.4	27.4	27.4	25.2	23.4	22.2	19.0
Long term min. T °C	15.6	18.1	19.2	21.0	23.2	24.0	26.1	27.0	25.2	23.5	22.1	19.0
Max. T °C (2013)	28.2	29.0	29.1	33.4	35.2	36.5	37.1	37.9	36.2	35.2	30.2	28.2
Max. T °C (2014)	28.2	29.1	28.2	32.5	34.6	35.8	36.8	37.0	36.1	35.6	30.2	28.0
Max. T °C (2015)	28.0	29.1	29.4	33.2	35.4	36.2	37.0	38.0	35.5	34.2	30.0	27.9
Long term max. T °C	28.1	29.0	30.4	32.8	35.0	36.0	37.1	37.5	36.2	35.0	39.8	28.1
2013 Rainfall (mm)	4.7	1.15	-	-	-	-	-	-	-	0.50	3.4	3.6
2014 Rainfall (mm)	4.5	2.04	-	-	-	-	-	-	-	1.89	3.2	2.8
2015 Rainfall (mm)	4.6	1.10	-	-	-	-	-	-	-	2.11	3.0	3.3
Long term Rainfall (mm)	4.5	1.18	1.2	0.5	-	-		-	-	0.89	3.2	3.3

Table 3. Some properties of the cow and poultry manures before and after composting.

Characteristics	Before composting		After composting			
	PM$_{BC}$	**CM$_{BC}$**	**PM$_{Plain}$**	**CM$_{Plain}$**	**PM$_{EM.1}$**	**CM$_{EM.1}$**
pH	7.86	7.20	7.40	7.20	7.00	6.90
N (g kg^{1})	38.2	12.4	33.0	10.0	33.2	11.1
P (g kg^{1})	9.64	3.20	13.00	5.55	11.22	4.77
K (g kg^{1})	6.84	14.22	11.37	18.96	8.88	17.50
Ca (g kg^{1})	7.11	5.36	9.62	7.15	8.29	6.60
Mg (g kg^{1})	3.22	3.50	4.36	4.66	3.76	4.35
S (g kg^{1})	3.10	2.60	4.19	3.47	3.62	3.20
Na (g kg^{1})	3.60	2.46	4.87	3.28	4.20	3.06
B (mg kg^{1})	110	124	148	165	130	156
Mn (mg kg^{1})	312	310	422	415	365	380
Fe (mg kg^{1})	686	592	924	790	800	729
Co (mg kg^{1})	0.10	0.10	0.14	0.13	0.12	0.12
Cu (mg kg^{1})	30.2	18.4	40.86	24.53	35.23	22.67
Zn (mg kg^{1})	94.50	88.4	127.80	117.10	110.22	108.92
E. coli detection	+	+	-	-	-	-
Salmonella detection	+	+	-	-	-	-

PM$_{BC}$ = poultry manure before composting; CM$_{BC}$ = cow manure before composting; PM$_{plain}$ = poultry manure compost without EM.1; CM$_{plain}$ = Cow manure compost without EM.1; PM$_{EM.1}$ = poultry manure compost with EM.1; CM$_{EM.1}$ = cow manure compost with EM.1

Soil and composts analysis

Soil bulk density (BD) was determined according to the method described by Blake & Hartge (1986). To determine other soil properties, each year at the start of the experiment, 12 soil samples were taken from the experimental field at a depth of 0-30 cm. These were mixed as a composite sample to determine the initial soil properties. After completion of the experiment, random soil samples were collected from subplots treated with the PM$_{plain}$, CM$_{plain}$, PM$_{EM.1}$, and CM$_{EM.1}$ for comparative analysis of various soil properties. Similarly, representative composite samples were collected before and after from the various types of composts. The samples for both soil and composts were oven-dried at 65°C for 48h, and ground to a size of approximately 2mm. Samples were then stored in Ziploc bags, which were subsequently used in triplicate for the analysis (described later in this section). Soil texture was determined using a standard procedure (Daur, 2013). The cation exchange capacity of soil was measured following the method described by Page et al. (1982), and organic matter in the soil was determined according to the Walkley-Black method (Nelson and Sommers, 1996). EC and pH for both compost and soil were measured from a soil/compost suspension (soil/compost and deionized water at a ratio of 1:2) using pH and salinity meters. N and S contents in both soil and compost samples were quantified using a Perkin-Elmer CHNS/O Analyzer (Model 2400) according to the manufacturer's instructions. For all other elements (P, K, Ca, Mg, S, B, Mn, Fe, Co, Cu, and Zn), soil/compost samples (0.5g each), were digested with nitric–perchloric acid following the recommended procedure outlined by AOAC (1990), then measured using inductively coupled plasma-optical emission spectroscopy (ICP-OES) according to the manufacturer's instructions. The presence or absence of *Escherichia coli* and *Salmonella* bacteria was detected using test kits from Bio Scientific Corporation (Austin, USA) according to the recommended instructions.

Sowing and cultural practices

During 2013-15, a 2-year field experiment was conducted. Each year, compost treatments were applied to the soil 15 days before sowing. The crop was sown each year at the beginning of October using CUF 101 variety of alfalfa inoculated with N-DURE™ inoculant of root nodulating bacteria. The first harvest was performed 46 days after sowing (DAS), and subsequent harvests were carried out at 40-day intervals. Although alfalfa is a perennial crop, data collection for each crop was discontinued after seven harvests, and data were not collected on the first crop during the second year. Instead, during year two of the study, the sowing and harvesting processes were repeated in a new location in the same field to validate the results. The cuttings were done during early-bloom stage. Except for the intended experimental variation (i.e. compost treatments), all agronomic practices were conducted uniformly throughout field experimentation. For example, seeds were sown on both sides of drip irrigation lines by distance of 10 cm while between drip line distance was 30 cm. The crop was uniformly irrigated daily in the morning for 10 min with saline water of EC 3.12 dS m^{-1} using automatic control drip irrigation. Always hand weeding was practiced—first weeding was done 20 days after sowing while subsequent weeding were done 5 days after each cutting.

Crop efficiency parameters

To assess the effects of the composts on alfalfa crop performance, data was collected regarding plant height, nodulation, leaf to stem ratio, fresh and dry forage yields, and mineral (N, P, K, Ca, Mg, S, Na, B, Mn, Fe, Co, Cu, and Zn) composition. The number 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 according to the procedure of Abusuwar and Daur (2015) through visual examination for a pink–red color, which indicates the presence of red pigment (leghemoglobin). Leaf-to-stem ratio and fresh and dry yields were determined following standard procedures (Daur et al., 2011; Daur, 2013). For plant mineral analysis, the oven-dried, powdered subsamples of approximately 200 g for each treatment from each cut were combined according to treatment structure and mixed. These composite mixtures of powdered samples were used for mineral analysis. From each composite sample, a 0.5-g sub-sample was digested in triplicate with nitric–perchloric acid following the procedure recommended by AOAC (1990) and analyzed using instrumentation as described earlier in this manuscript for soil and composts analysis.

Statistical analysis

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

RESULTS

The results of different treatments were compared by combining two years means of each cut so that to identify that what happened in each cut. In addition, grand means of all cuts over two year were compared to know concluding effect of the treatments. Thus, for each parameter, results of different cuts and grand means were put in same graphs to streamline comparison of treatments. Moreover, overage results for triplicate analysis of soil, composts and mineral analysis are presented in tables.

Plant height

Plant height was significantly different ($p < 0.05$) between the treatments as indicated in Fig. 1. $CM_{EM.1}$ was observed with significantly ($p < 0.05$) taller plants across all cuts. Grand means indicated highest plant height (59.88 cm) for $CM_{EM.1}$ compared to all the other types of composts treatments. Plant heights for CM_{plain} (53.83cm), $PM_{EM.1}$ (52.09 cm), and PM_{plain} (48.72 cm) were statistically similar, but could be ordered as follows: $CM_{plain} > PM_{EM.1} > PM_{plain}$ based on their differences in the recorded data.

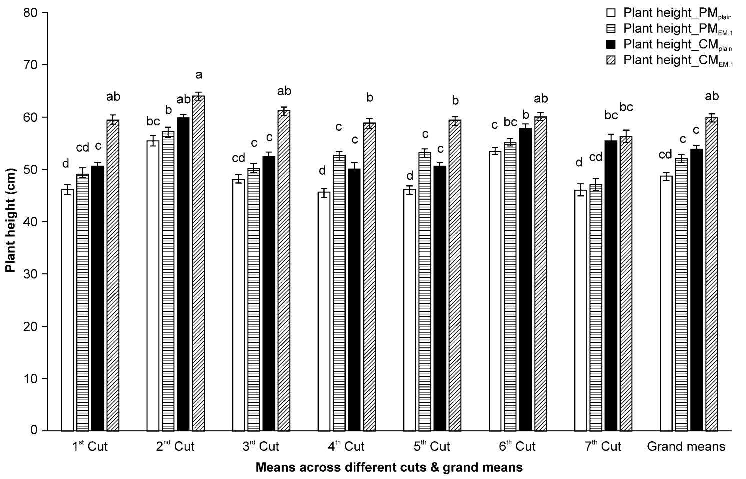

Fig. 1. Means of plant heights carrying different letters significantly differ ($p < 0.05$) between the compost types. Error bars indicate standard deviation.

Nodulation

The numbers of effective nodules per plant were observed non-significantly different ($p < 0.05$) between compost treatments across different cuts. Consequently, grand means of nodulation number per plant for various composts was also observed non-significant (Fig 2) that ranged between 13.23—14.40. However, here we are not interested in comparison of data between cuts but that is just to authorize our grand means but we found that number of nodules increased by the second cut and remained constant until the fifth cut, after which it slightly decreased.

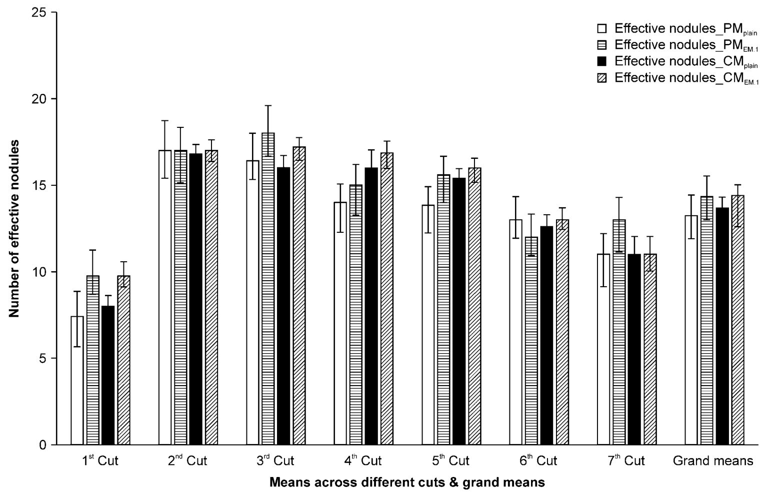

Fig. 2. Means for number of nodulations carrying different letters significantly differ ($p < 0.05$) between the compost types. Error bars indicate standard deviation.

Leaf-to-stem ratio

The leaf-to-stem ratio of alfalfa (Fig 3) showed significant ($p < 0.05$) superiority for $CM_{EM.1}$ over other types of composts during the third, fourth, and fifth cuts. However, during the first, second, sixth, and seventh cuts, and for grand means, the values of $CM_{EM.1}$ were statistically non-significant ($p < 0.05$) in comparison to CM_{plain}, $PM_{EM.1}$ and PM_{plain}, though $CM_{EM.1}$ showed superiority. The maximum value of grand mean for $CM_{EM.1}$ was 1.67, which subsequently declined in CM_{plain} (1.47), $PM_{EM.1}$ (1.34), PM_{plain} (1.27).

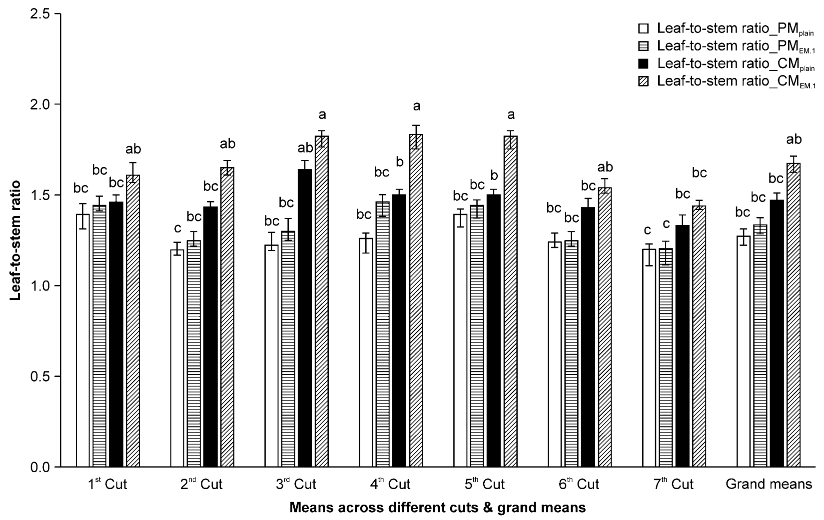

Fig. 3. Means of leaf-to-stem ratio carrying different letters significantly differ ($p < 0.05$) between the compost types. Error bars indicate standard deviation.

Fresh and dry forage yield

Results corresponding to fresh and dry forage yields of alfalfa are shown in Fig 4 and Fig 5, respectively. These parameters are closely related and indicate patterns for compost treatments that are similar to those observed earlier for plant height and leaf-to-stem ratio. For both parameters, a similar trend was observed ($CM_{EM.1}$ > CM_{plain} > $PM_{EM.1}$ > PM_{plain}) throughout cuts as well as for their grand means, as that observed for other parameters that contributed to the yield, such as plant height and leaf-to-stem ratio. Grand means for fresh weights (tons ha^{-1}) was 7.79 for $CM_{EM.1}$ 6.99 for CM_{plain} 6.18 for $PM_{EM.1}$ and 5.38 for PM_{plain} while grand means for dry weights (tons ha^{-1}) was 2.64 for $CM_{EM.1}$ 2.43 for CM_{plain} 2.26 for $PM_{EM.1}$ and 2.05 for PM_{plain}.

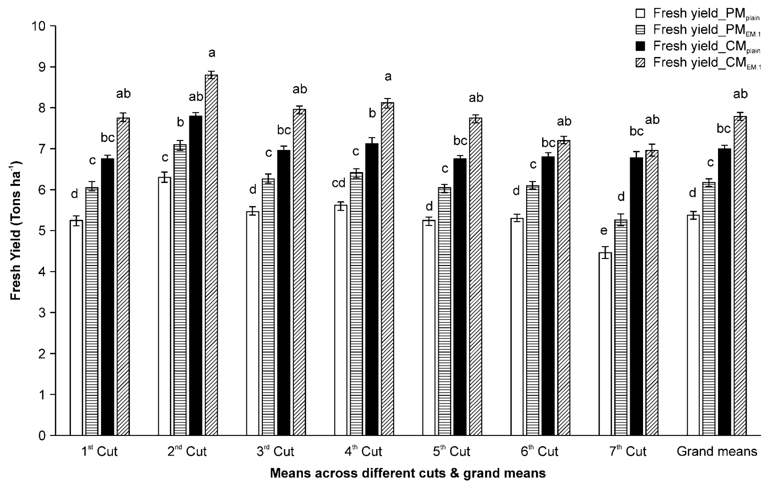

Fig. 4. Means of fresh yield (t ha^{-1}) carrying different letters significantly differ ($p < 0.05$) between the compost types. Error bars indicate standard deviation.

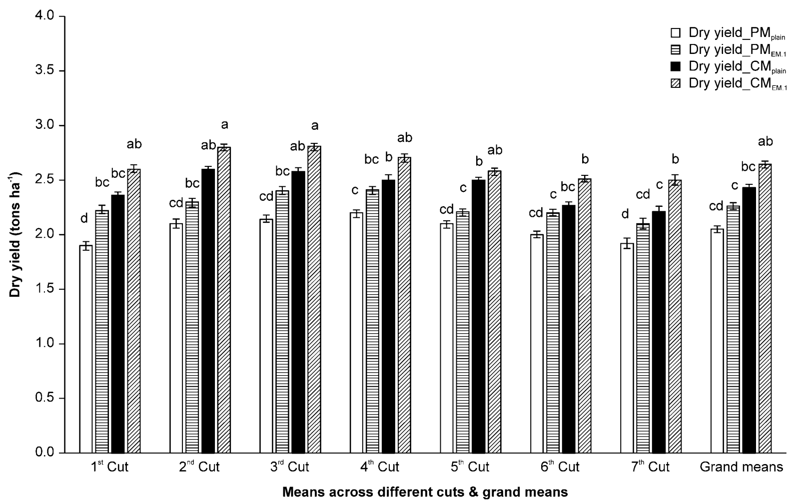

Fig. 5. Means of dry yield (t ha^{-1}) carrying different letters significantly differ ($p < 0.05$) between the compost types. Error bars indicate standard deviation.

Mineral analysis

Mineral analysis of alfalfa DM for various compost treated plots is shown in Table 4. It presents significant ($p < 0.05$) variation for N, P, Ca, B, Mn, Fe, Cu, and Zn contents in alfalfa DM for the different compost treatments. The variation between minimum and maximum for the above mentioned minerals contents in plant dry matter ranged as follows: N (28.66—31.88 g kg^{-1}), P (3.00—3.31 g kg^{-1}), Ca (15.60—18.64 g kg^{-1}), B (16.00—19.26 mg kg^{-1}), Fe (176.00—186.40 mg kg^{-1}), Cu (10.06—13.24 mg kg^{-1}),and Zn (23.79—26.46 mg kg^{-1}). The contents of K, S, Na, Co, and Mo in alfalfa DM were non-significant ($p < 0.05$) between the different composts treatments. Minimum and maximum ranges of these elements in plant dry matter under different compost treatments were as follows: K (25.28—25.90 g kg^{-1}) , S (2.66—2.88 g kg^{-1}), Na (1.32—1.52 g kg^{-1}), Co (0.09—

0.12 mg kg^{-1}), and Mo (0.84—0.97 mg kg^{-1}). Generally, alfalfa DM from $CM_{EM.1}$ treated plots was found to contain the highest mineral content (except Na) followed by CM_{plain} and $PM_{EM.1}$ treated plots, which were more or less similar. Alfalfa DM from PM_{plain} treated plots generally had lower mineral contents.

Table 4. Mineral compositions of alfalfa dry biomass under different types of composts.

Treatments	Macro-minerals (g kg^{-1} DM)						
	N	P	K	Ca	Mg	S	Na
PM_{plain}	28.66^{b}	3.00^{b}	25.28	15.60^{b}	3.00	2.66	1.52
$PM_{EM.1}$	30.40^{ab}	3.12^{ab}	25.90	17.00^{ab}	3.00	2.76	1.42
CM_{plain}	30.40^{ab}	3.22^{ab}	25.40	17.40^{ab}	3.02	2.88	1.35
$CM_{EM.1}$	31.88^{a}	3.31^{a}	25.90	18.64^{a}	3.11	2.88	1.32
	Micro-minerals (mg kg^{-1} DM)						
	B	Mn	Fe	Co	Cu	Zn	Mo
PM_{plain}	16.00^{b}	30.38^{c}	176.00^{c}	0.09	10.06^{c}	23.79^{b}	0.84
$PM_{EM.1}$	17.59^{ab}	32.58^{b}	178.20^{b}	0.12	12.48^{b}	24.08^{ab}	0.84
CM_{plain}	19.10^{a}	30.54^{c}	178.11^{b}	0.09	12.22^{b}	26.00^{a}	0.85
$CM_{EM.1}$	19.26^{a}	36.88^{a}	186.40^{a}	0.12	13.24^{a}	26.46^{a}	0.97

Mean values with different superscript letters differ significantly *($p < 0.05$)*. PM_{plain} = poultry manure compost without EM.1; CM_{plain} = Cow manure compost without EM.1; $PM_{EM.1}$ = poultry manure compost with EM.1; $CM_{EM.1}$ = cow manure compost with EM.1

DISCUSSION

In this study, we examined the effects of different compost treatments on various parameters that significantly affected the alfalfa crop, including plant height, leaf-to-stem ratio, fresh and dry forage yields, and mineral composition in the form of a perceived trend [$CM_{EM.1}$ > CM_{plain} > $PM_{EM.1}$ > PM_{plain}]. Furthermore, we evaluated the effect of compost type on nodulation.

Many studies have shown that yield parameters are correlated with each other and with mineral composition (Daur et al, 2011; Egodawatta et al., 2012; Singh et al., 2014). In our results, superiority of yield-contributing parameters (plant height, leaf-to-stem ratio, fresh and dry forage yields) and mineral composition in plots treated with cow manure compost ($CM_{EM.1}$ and CMplain) compared to poultry manure composts ($PM_{EM.1}$ and PMplain) may be due to the fact that a larger amount of cow manure was used in order to provide a similar amount of N as in poultry manure. The increased bulk may have resulted in favorable soil bulk density as indicated by the soil analysis (Table 1), and might ultimately have increased the soil moisture-holding capacity and water infiltration rates. Both are considered important factors for enhanced yield in the region (Goulding et al., 2008; Hashim et al., 2012).

Superiority of yield parameters and mineral composition of alfalfa in plots with EM.1 composts ($PM_{EM.1}$ over PM_{plain} and $CM_{EM.1}$ over CM_{plain}) are thought to be attributed to various qualities of EM.1. Precisely, the microbial species included in EM.1, are thought to result in rapid degradation that may help in timely liberation of essential nutrients from the compost, subsequently fulfilling the nutrient demand of crop when needed (Shalaby, 2011; Bell et al., 2013; Boga et al., 2014; Daur et al., 2015). In addition, compost analysis (Table 3) showed that EM.1 lowered the pH of the compost, which subsequently resulted in favorable soil pH, enhancing nutrient uptake and composition of the crop. The enhancement of nutrient uptake and plant nutrient composition certainly improved all yield-contributing parameters of the crop as supported by previous studies (Rajkovich et al., 2012; Hu et al., 2013). In addition to the reasoning presented here, the microbes included in EM.1 produce various enzymes as previously reported (Bhalla et al., 2013; Khan et al., 2013), which were not focused in this study. However, these enzymes are thought to enhance crop growth. Additionally, based on the microbial species included in EM.1, we can suggest that EM.1 is expected to protect crop roots from disease (Berendsen et al., 2012; Schenk et al., 2012). Based on the present experiment, we speculate that the superiority of EM.1 composts for various alfalfa parameters was due to EM.1 exerting a positive effect on composting by enhancing its fertilizer efficiency, thus positively affecting the crop as supported by previous studies of Daur et al. (2015) and Castellanos-Navarrete et al. (2015). Furthermore, our results for yield parameters, especially leaf-to-stem ratio, are supported by Feller et al. (2015), who reported that plants divert their biomass to leaves, shoots, or roots as a result of modified rhizosphere/environmental conditions.

In our study we perceived neither positive nor negative effects of compost on nodulation in alfalfa, while previously, Pei-Sheng and Hui-Lian (2002) reported a closely related product, EM bokashi, to increase the number of nodules per plant and the fresh weight per nodule in peanuts. Our finding may differ owing to differences in the crops. We otherwise have no logic to explain this finding, but hope that our present findings will inspire additional research to resolve this contradictory result by further research.

CONCLUSIONS

Based on this study, EMRO (EMRO, Okinawa, Japan) branded, commercially available effective microorganisms (EM.1), may be suggested for compost enhancement and subsequently alfalfa crop yield. In this study, cow manure was found superior to poultry manure, using them at 6 and 18 tons ha^{-1}, respectively, on the basis of their nitrogen content.

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