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Effect of Bulking Agent Levels (Rice Straw) on Compost Quality and Net Return

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Utilization of rice straw through composting are used primarily to increase nutrient availability to plants as well as increased soil microbial biomass and functional diversity. A study was conducted at Bacteriology Lab., Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt to investigate the effect of adding carbonaceous material levels (rice straw bulking agent) on compost quality and net return (L.E ton^{-1}). The results showed that piles temperature increased with time, then gradually decreased till constant at ambient air temperature (ripening feature). The different piles varied in maturity time. The pile number one (without rice straw) firstly matured after 30 days, followed by pile No. two (2 % rice straw), but pile No. five (8 % rice straw) lately matured. All piles showed good chemical and biological characteristics, However, piles No. one and five attained the best characteristics. Pile No. one gave N, P and K concentrations of 2.4, 0.83 and 2.75 % respectively. Pathogenic fecal indicators (*Salmonella* and *Shigella*) not found for different piles at all. All piles, also, did not show toxicity, whereas germination % of *Eruca sativa* seeds ranging from 81.6 to 92.1 %.

Economic evaluation of constructed piles exhibited that pile No. one, economically, was the best which gave maximum net profit (171.5 L.E. ton^{-1}) followed by pile No. two (168.5 L.E ton^{-1}) and then pile No. three (4 % rice straw), that showed the lowest net return (164.5 L.E ton^{-1}).

Application experiment was conducted for studying the influence of compost microbial enrichment,

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after maturation, with Plant Growth Promoting Rhizobacteria (PGPR) on *Zea mays* biological yield and chemical composition. Applying compost of pile No. four and No. five gave the highest biological yield (fresh and dry weight plant^{-1}), and N, P and K content (g shoot^{-1}). PGPR inoculated plants with enriched compost gave the higher growth yield and element concentrations, followed by PGPR inoculated compost (enriched) compared to not inoculated plants. Total chlorophyll and soil dehydrogenase enzyme exhibited highest values at compost addition for piles No. four and No. five either with PGPR inoculated compost or not.

Keywords: Compost; rice straw; PGPR; Zea mays.

1. INTRODUCTION

In Egypt, the rice straw is one of the main agricultural wastes, which can be used as feedstock for compost or ploughed directly into the soil as a source of organic nutrients. Egypt produce about 4 million tons per year can be used in production of good quality compost. Compost is the major component used for organic farming, which is produced from different biodegradable organic wastes like Municipal Solid Waste (MSW), cattle manure, sewage sludge, and agricultural waste [1]. Therefore, preparation of compost from agricultural waste, especially from straw, is a time consuming process due to the high C/N ratio, which slows down the maturation phase. The maturation time for compost could be decreased by addition of bulking agents with high N content [2].

In addition, using of agricultural waste composts to fertilize agricultural land has been positive from the perspective of a recycling economy and their valuable characteristics and ingredients. Compost and biocompost as organic and biofertilizer can improve the chemical, physical and biological characteristics of the soil and increases yield and quality. Several studies point out that the organic fertilizer has a positive effect on the soil fertility [3,4,5,6,7,8].

The effective microorganism can be important to promote the circulation of plant nutrients and reduce the need for chemical fertilizers as much as possible [9]. Therefore, these effective microorganism depends on many factors such as bacterial strains and population, combination of plant-bacterial strain, genotype of plant, growth parameters evaluated, as well as environmental conditions [10,11]. Effective cultures of microorganisms when applied to the soil they stimulate the decomposition of organic wastes and residues thereby releasing inorganic nutrients and enzymes that become available for uptake by the plants [12]. On the other hand, metabolites produced by these microorganisms, *i.e.*, amino acids, nucleic acid, bioactive substance and sugars, are directly absorbed by plants and using as substrate or food for other microorganisms such as, *Azospirillum*, *Azotobactor*, *Trichoderma, Rhizobium*, *Bacillus* and others in the soil [6,13,14,15]. Hence, the number of beneficial microorganisms increases in the soil ecosystem and the ability of plants to uptake the nutrients.

Application of farmyard manure, farmyard manure treated with effective microorganisms and effective microorganism solutions, increased growth, development and yield of rice [15]; chickpea [16]; Tomato [17]; Cowpea [18]; Potato [19]; Okra [20]; Maize, Wheat and Cotton [21]. Also, activate the rhizoshere enzymes ([22,23,24].

The aim of the present study is to investigate the effect of adding bulking agent material levels (rice straw) with farmyard manure on compost quality and net return (L.E. ton^{-1}) as well as, the effectiveness of compost alone or in combination with PGPR inoculation on growth and biochemical characteristics of maize (*Zea mays*) plants.

2. MATERIALS AND METHODS

2.1 Compost Materials

2.1.1 Rice straw

Rice straw was collected from Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate, Egypt to be used for compost production. Rice straw used directly without chopping. The results of the chemical analyses are presented in Table 1.

2.1.2 Farmyard manure

Farmyard manure was collected and moved from dairy cattle farms of Sakha Livestock Production Research Station, Kafr El-Sheikh Governorate, Egypt, to be used in compost production. Farmyard manure was immediately mixed with rice straw just after received at the composting unit. The results of the chemical analyses are presented in Table 1.

2.1.3 Soil

Soil was obtained from Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate, Egypt to be used in compost production. The results of physical, chemical and biological analyses as shown in Table 2.

2.2 Treatments of Compost Processing Experiment

This experiment was carried out during the winter season of 2014 using rice straw, farmyard manure and soil as raw materials. Five treatments of compost piles were prepared as follow:

T1	**FYM (control)**	670 kg farmyard manure (1 m^3) + 50 kg soil (control, without rice straw).
T2	**FYM +2% RS**	670 kg farmyard manure (1 m^3) +14 kg rice straw + 50 kg soil.
T3	**FYM + 4% RS**	670 kg farmyard manure (1 m^3) + 28 kg rice straw + 50 kg soil.
T4	**FYM + 6% RS**	670 kg farmyard manure (1 m^3) + 42 kg rice straw + 50 kg soil.
T5	**FYM + 8% RS**	670 kg farmyard manure (1 m^3) + 56 kg rice straw + 50 kg soil.

Table 1. Chemical and physical analysis of compost raw materials

Parameters	Organic Carbon (%)	Total N (%)	C/N ratio	Total P (%)	Total K (%)	Moisture (%)
Rice straw	54	0.72	75	0.21	0.83	14
Farmyard manure	41.62	2.45	16.98	0.77	3.18	56

Table 2. Some physical, chemical and biological analyses of the experimental soil

Tested characteristics		Value	
pH (1: 2.5 soil water suspension)		7.31	
E.C (dS.m^{-1}, in soil paste)		0.126	
O.M (organic matter %)		1.05	
Particle size distribution (%)			
Sand	**Silt**	**Clay**	**Texture grade**
17.30	47.10	35.60	loam soil
Soluble cations meq L^{-1}			
Ca^{++}	**Mg^{++}**	**Na^{+}**	**K^{+}**
0.86	0.49	0.50	0.12
Soluble anions meq L^{-1}			
$CO3^{--}$	**$HCO3^{-}$**	**Cl^{-}**	**$SO4^{--}$**
-	1.00	0.66	0.31
Available elements (ppm)			
N	**P**	**K**	
6.33	5.70	311.1	
Total count of bacteria (CFU g^{-1} dry weight soil)		123×10^6	
Total count of fungi (CFU g^{-1} dry weight soil)		71×10^4	
Total count of Actinomycetes (CFU g^{-1} dry weight soil)		31×10^5	

2.2.1 Plant growth promoting rhizobacteria (PGPR) used

All PGPR used were provided by Bacteriology Lab., Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt. Each microorganism was growing as follow: *Azospirillum lipoferum* using N-free malate medium [25], *Trichoderma viride* using potato dextrose medium [26], *Bacillus circulans* and *Bacillus megaterium* using nutrient medium [27].

2.2.2 Pile processing

All compost piles were constructed as the following: The third of rice straw amount was spreaded as a first layer, after that, the third of farmyard manure was spreaded as a second layer upon the straw. This process repeated till finishing of materials. After that, spreading the remained amount of farmyard manure mixed with the used amount of fertile soil (50 kg pile^{-1}) over the conducted pile. After each constructed layer, water was sprayed to humidify it. After finishing from piles construction, they sprayed with water twice weekly to reach humidity about 60%. Each pile was turned every two weeks, and temperature degrees were recorded every three days. Inoculum of consortium of some biofertilizers (*Azospirillum lipoferum, Trichoderma viride, Bacillus circulans* and *Bacillus megaterium)* were added to half of each pile after maturation (enriched compost).

2.2.3 The pot experiment

The pot experiment was conducted under greenhouse conditions using loam soil. Results of physical, chemical and biological analyses presented in Table 2.

Pots (30 cm diameter) were filled with loamy soil (6 kg pot^{-1}) for studying the influence of compost enriched with microbial additives, after maturation, with Plant Growth Promoting Rhizobacteria (PGPR) on *Zea mays* biological yield and chemical composition. The experimental plan was based on six main treatments (different compost types), these were T1, (control) – T6, and three sub main treatments, these were C_0, compost only; C_1, compost + microbial additives (PGPR) and C_2, compost + inoculation with PGPR (enriched). The experiment was conducted in a split plot design with three replicates. Compost was added before sowing at a rate of full dose (8.5 ton fed.$^{-1}$, 50 g pot^{-1}). Pots were irrigated and sowed with 3 *Zea mays* grains, seedlings thinned to one healthy in each pot, then inoculated treatments was carried out by adding 1 ml plant^{-1} of liquid culture of PGPR (*Azospirillum lipoferum*, *Trichoderma viride*, *Bacillus circulans* and *Bacillus megaterium*) contain 4 x10^{6} CFU mL^{-1}, 1 x10^{7} spores mL^{-1}, 4.4 x10^{5} CFU mL^{-1} and 5.5 x10^{7} CFU mL^{-1}, respectively.

After 60 days from sowing, rhizosphere samples were taken to determine dehydrogenase (mg TPF g^{-1} soil d^{-1}), then plant samples were taken to measure total chlorophyll, fresh and dry weight of shoot (g plant^{-1}). Also, nitrogen, phosphorus and potassium were determined in shoot as percent and total content.

2.3 Compost Analysis

2.3.1 Physical parameters

Piles temperatures were measured using a digital thermometer. Temperature measurements were taken at different depths around pile center when the ambient temperature was fairly stable in late morning. The moisture content was determined by drying the samples at 105°C until the weight becomes constant. Bulk density of compost is defined as its weight per unit volume. The odor was assessed by smelling. Color change was assessed visually.

2.3.2 Toxicity test

A water extract of each compost was prepared by shaking the samples with distilled water at 1:10 w/v ratio for 1h, and then filtered to be used for seed germination in Petri dishes. Seed germination in distilled water was used as control. The percentage of seed germination of *Eruca sativa* was calculated using the following equation [28].

Seed germination (%)=[(NO.of seeds germinated in compost extract/ NO.of seeds germinated in control)×100]

2.3.3 Chemical analysis

Five randomized samples from each compost pile were collected from the top, middle and bottom of the compost heap during turning the piles at 70 days of composting. Samples were air-dried for 3 days, oven dried at 70°C for 24 h, and then grounded to pass through 0.2 mm sieve screen to be analyzed.

For organic matter and organic carbon determination, ash was determined in a muffle furnace at 550°C for 5h. Organic matter was calculated as the difference between ash and dry weight as a percentage [29]. From values of organic matter, the percentage of organic carbon was calculated as described by [30]. The pH was directly measured in the water extracted sample 1:5 w/v using a glass electrode pH meter (Orion Expandable ion analyzer EA920). Electrical conductivit measurements were run in 1:5 w/v compost water extracts using EC meter (ICM model 71150). C/N ratio was calculated using values of the organic carbon and total nitrogen.

Total nitrogen was determined as described by [31]. Available N was extracted by 1 M K_2SO_4 and determined by MgO and Devarda alloy using Kjeldahl method [32]. Total and available phosphorus was determined spectrophotometerically in the acid solution of the digested samples as described by [33]. Total and available potassium was determined by ammonium acetate method, and measured by Flame-photometer as method described by [32].

2.3.4 Plant observation

Fresh weight and dry weight of shoot were recorded and expressed as (g shoot^{-1}). Also, total chlorophyll was measured by Minolta chlorophyll metter SPAD-502.

2.4 Microbiological Observation

2.4.1 Microbial estimations

It was estimated by counting total count of bacteria, fungi and actinomycetes according to [34], and enumerating coliform bacteria *E. coli*, *Salmonella* sp. and *Shegella* sp. according to [35].

2.4.2 Dehydrogenase activity

Dehydrogenase activity in the soil samples was determined by the procedure described by [36].

2.4.3 Statistical analysis

Data obtained from experiment treatments were subjected to the analysis of variance and treatments means were compared using the L.S.D. method according to [37].

3. RESULTS AND DISCUSSION

Temperature of piles 1 (control without rice straw) nearly did not changed (Table 3), the reason may be regard to the type of farmyard manure which bringing from Sakha Agricultural Research Station farm, which was mostly decomposed. It was noted that temperature of pile increased with the increasing of carbon bulk material (rice straw), this finding was similar to those of [38] and [7], this increase in temperature may regard to increasing bulk carbon materials, which consider an available carbon source for microbial growth and function.

The temperature of piles from 2 to 5 increased with time of decomposition, the maximum temperature appeared after five days of piles construction, then decreased with time till cooling phase after 60 days, this result agreed with those of [39].

3.1 Characteristics of Compost Piles

Data of Table 4 illustrated the characteristics of different compost types. For physical characteristics, pH values ranged from 8.15 to 8.32. Pile 1 (FYM, control), exhibited the lowest value (8.15). The pH of all compost piles were in the normal range, where pH values showed no elevated alkalinity, but were between 6 - 8 [40].

While EC values ranged from 4.63 to 6.27, whereas pile 5 (FYM + 8% RS) and 1 (FYM, control), gave the lowest values (4.63 and 4.70). EC of different piles showed normal levels as shown in results of [41], whereas EC values of piles composed of vegetables wastes and farmyard manure ranged from 4.60 to 6.56 (dSm^{-1}) and the EC values of piles were increase with biodegradation time. Moisture content of piles ranged from 32% for pile 2 to 41% for pile 1 (FYM, control).

For bulk density, the pile 1 (FYM, control), attained a highest bulk density (643 Kg m^{3}) but pile 5 (FYM + 8% RS), gave the lowest value (568 Kg m^{3}). Bulk density of different compost piles was noted to decreased with increasing amount of straw bulking material, thus increase of rice straw material positively affected on physical quality of the final product [42].

Results of chemical characteristics in Table 4 showed that Pile 1 (FYM, control), gave the highest values of N, P and K percentages (2.40, 0.83 and 2.73 %, respectively) over other piles contained different levels of rice straw. The lowest concentrations appeared in piles 3 (FYM + 4% RS) and 4 (FYM + 6% RS). However, all concentrations of N, P and K nutrients were in the range of abrovable levels.

For biological characteristics, the compost piles contained high number of mezophylic and bacteria, whereas pile 5 (FYM + 8% RS), contains the highest count of mezophylic bacteria (45 x 10^5), but count of 31 x 10^5 was recorded for pile 3 (FYM + 4% RS). Thermophylic bacteria ranged from (49 x10^3) for pile 5 (FYM + 8% RS), to 39 x10^3) for pile 4 (FYM + 6% RS).

Most of fungi were mezophylic ranging from (25 x 10^3) for pile 2 (FYM +2% RS), to (46 x10^3) for pile 5 (FYM + 8% RS). But actinomycetes recorded small amounts. Pathogenic microorganisms *E. coli*, *Salmonella* and *Shegella* were not detected, this finding completely agreed with figured of [43], whereas they found that composting process of municipal solid wastes initiated heat reached 60 °C and they discussed that this temperature is the main cause of elimination of *Salmonella* and *Shegella*, but the other pathogenic indicators like total coliforms, faecal coliforms and faecal *Streptococci* were sharply decreased but not completely sanitized. Total counts of bacteria, fungi and actinomycetes exhibited increase with increasing bulking material dose (rice straw), this enrichment microbial counts resulted from increase of energy sources (rice straw) which used by these microorganisms, which reflected on increasing microbial counts as shown from data of table of the present study. Therefor C/N ratio must had an acceptable value around 30 to give the microorganisms their requirement from nutrients as well as energy [44].

Table 3. Piles temperature (°C) records through different period of composting

Date	December (2014)			January (2015)				
Pile treatment	**18**	**23**	**28**	**2**	**7**	**12**	**17**	**22**
FYM (control)	20	20	21	20	21	21	19	18
FYM +2% RS	28	29	29	30	30	31	29	25
FYM + 4% RS	32	33	32	32	36	37	34	24
FYM + 6% RS	33	40	33	28	38	38	35	23
FYM + 8% RS	38	44	36	42	61	54	42	27

Table 4. Physical, chemical and biological characteristics of different types of compost piles

Bile Parameters	FYM (control)	FYM + 2 % RS	FYM + 4 % RS	FYM + 6 % RS	FYM + 8 % RS
pH	8.15	8.17	8.26	8.32	8.32
EC	4.70	5.49	4.80	6.27	4.63
Organic Carbon (%)	37.53	22.59	30.08	19.62	20.65
Bulk density Kg m^3	643	621	632	595	568
Moisture content	40	41	32	38	37
C/N ratio	15.64	18.22	16.53	16.49	15.08
N %	2.40 ± 0.07	1.24± 0.17	1.82 ± 0.14	1.19 ± 0.3	1.37 ± .05
P %	0.83 ± 0.01	0.77± 0.1	0.79± 0	0.7± 0	0.51± 0.02
K %	2.73 ± 1.1	1.54 ± 0.11	1.44 ± 0.39	1.38 ± 0.1	1.69± 0.25
Germination %	92.1 ± 0.5	89.5 ± 1	86.8 ± 0.5	84.2 ± 1	81.6 ± 1.5
TCB at 30 ^{0}C	44 x 10^5	38 x 10^5	31 x 10^5	36 x 10^5	45 x 10^5
TCB at 50 ^{0}C	56 x 10^3	55 x 10^3	48 x 10^3	47 x 10^3	44 x 10^3
TCA at 30 ^{0}C	49 x 10^3	44 x 10^3	47 x 10^3	39 x 10^3	41 x 10^3
TCA at 50 ^{0}C	59 x 10^1	53 x 10^1	55 x 10^1	61 x 10^1	58 x 10^1
TCF at 30 ^{0}C	27 x 10^3	25 x 10^3	33 x 10^3	39 x 10^3	46 x10^3
TCF at 50 ^{0}C	14 x 10^1	13 x 10^1	17 x 10^1	18 x 10^1	22 x 10^1
E. coli	0.0	0.0	0.0	0.0	0.0
Salmonella sp.	0.0	0.0	0.0	0.0	0.0
Shegella sp.	0.0	0.0	0.0	0.0	0.0

TCB: Total count of Bacteria; TCA: Total count of Actinomycetes; TCF: Total count of Fungi

3.2 Pot Experiment

3.2.1 Vegetative growth

Application of compost to soil of maize plants improved its biological yield. Moreover, addition of biofertilizers enriched compost gave more increase in biological yield. Therefore, the different types of compost under study had varied influences on biological yield of the plant. In this context, compost type 4 (FYM + 6% RS) and 5 (FYM + 8% RS), gave the highest yield as shown in Table 5. Also, application of enriched compost increased the plant growth compared to normal compost types. Enriched compost type 4 (FYM + 6% RS), gave the highest values of fresh and dry weight of the plant (193.77 and 75.81 g plant^{-1}) compared to those of control without compost which recorded 91.57 and 33.49 g plant^{-1} respectively, the differences were significant.

However, the plants fertilized with enriched compost and inoculated with the mixed inoculum had the best response, whereas, the treatment of enriched compost type 4 (FYM + 6% RS) + inoculation attained 206.18 and 82.08 g plant^{-1} for fresh and dry weight of the plant respectively. The variations than other between the treatments were significant.

Total chlorophyll was also responded by addition of compost types (Table 5). Enriched compost + inoculation treatments exhibited values > Enriched compost > compost only. The treatments of compost + inoculation type 4 (FYM + 6% RS) and 5 (FYM + 8% RS), gave the greatest values 34.18 and 32.70, respectively.

3.2.2 Enzyme activity

Dehydrogenase activity values of rhizosphere soil of *Zea mays* plants were illustrated in Table 5. Their values showed increases due to addition of different compost treatments. Compost type 4 (FYM + 6% RS) treatment recorded the highest value (200.52 mg TPF g^{-1} soil d^{-1}) compared to unamended control (172.88 mg TPF g^{-1} soil d^{-1}). Enriched compost showed the best effect over normal compost treatments. Enriched compost type 4 (FYM + 6% RS), exhibited the best value over other corresponding compost types as well as normal compost treatments. Lately enriched compost + inoculation treatments showed higher dehydrogenase values, and the enriched compost type 4 (FYM + 6% RS) and 5 (FYM + 8% RS) + inoculation attained the highest values not at all (225.05 and 224.92 mg TPF g^{-1} soil d^{-1}, respectively).

Table 5. Effect of compost types on vegetative growth of *Zea mays* shoot and dehydrogenase activity

Treatment		**Vegetative growth**			**Enzyme activity**
		Fresh weight g shoot^{-1}	**Dry weight g shoot^{-1}**	**Total chlorophyll**	**Dehydrogenase (mg TPF g^{-1} soil d^{-1})**
Normal compost	Control	91.57 ^{m}	33.49 ^{i}	23.44 ^{j}	172.88 ^{j}
	FYM (control)	116.76 ^{l}	39.68 ^{h}	25.73 ^{i}	183.32 ^{ij}
	FYM + 2 % RS	124.50 ^{kl}	41.34 ^{h}	26.98 ^{hi}	189.03 ^{ghi}
	FYM + 4 % RS	145.33 ^{hi}	47.56 ^{g}	28.83 ^{fg}	198.99 ^{efg}
	FYM + 6 % RS	176.06 ^{de}	65.14 ^{d}	30.30 ^{def}	200.52 ^{def}
	FYM + 8 % RS	172.14 ^{e}	62.05 ^{d}	30.33 ^{def}	189.72 ^{ghi}
Enriched compost	Control	91.57 ^{m}	33.49 ^{i}	23.44 ^{j}	172.88 ^{j}
	FYM (control)	132.00 ^{jk}	46.82 ^{g}	26.99 ^{hi}	195.61 ^{fgh}
	FYM + 2 % RS	138.22 ^{ij}	49.22 ^{fg}	27.97 ^{gh}	208.97 ^{cde}
	FYM + 4 % RS	150.21 ^{gh}	57.41 ^{e}	29.19 ^{efg}	210.58 ^{bcd}
	FYM + 6 % RS	193.77 ^{b}	75.81 ^{b}	32.15 ^{bc}	215.22 ^{abc}
	FYM + 8 % RS	182.83 ^{cb}	70.84 ^{c}	31.54 ^{bcd}	213.37 ^{bc}
Enriched compost + Inoculation	Control	137.53 ^{ij}	48.72 ^{fg}	27.18 ^{hi}	188.00 ^{hi}
	FYM (control)	156.96 ^{fg}	52.47 ^{f}	28.87 ^{fg}	202.44 ^{def}
	FYM + 2 % RS	160.95 ^{f}	51.90 ^{f}	28.48 ^{gh}	220.33 ^{ab}
	FYM + 4 % RS	183.13 ^{cd}	62.31 ^{d}	30.74 ^{cde}	225.05 ^{a}
	FYM + 6 % RS	206.18 ^{a}	82.08 ^{a}	34.18 ^{a}	224.92 ^{a}
	FYM + 8 % RS	189.43 ^{bc}	79.07 ^{ab}	32.70 ^{ab}	224.38 ^{a}
L.S.D 0.05		9.23	3.92	1.62	10.57

In a column, means followed by a common letter are not significantly different at 5% level by DMRT

[45], reported that addition of composted fruits and vegetables waste enriched with N_2 – fixing and PGPR bacteria improved compost quality and increased tomato plant yield. This regard to improving effect of microorganisms to physical and chemical characteristics of compost [46].

Compost application to soil improved its physical and chemical characteristics such as water retention capacity, Cation Exchange Capacity (CEC) and aggregation that leads to improve of soil drainage. In addition, compost enriched soil with high number of microbial species and increase microbial counts, thus, soil food web of soil became more potent [47]

Microbial enriched compost causes increase in N_2 – fixing, phosphate and potassium dissolving bacteria in compost which cause increase for these microorganisms in rhizosphere of the plant, which gave the plants some of their needs from available essential elements and release plant growth promoting phytohormones (PGPH). These hormones cause deformations in plant roots, whereas, increase in length and distributed in soil more efficiently.

Water and nutrients absorption of roots increased [45]. The abundance of phosphate and potassium dissolving bacteria save a lot amounts of P and K be available to the plants. In addition, these inoculated biofertilizer microorganisms release antibiotics and phytotoxins in the rhizosphere which became destructive to pathogenic microorganisms [48].

3.2.3 Nitrogen, Phosphorus and Potassium contents

Data of Table 6 showed that application of the different compost types sharply increased N, P and K contents of *Zea mays* shoots over the not amended control treatment. The best treatment gave high contents of N, P and K was compost type 4 (farmyard manure + 56 kg rice straw) which attained 2.13, 0.51 and 2.32 (g shoot^{-1}), while the treatment of control (without compost) exhibited the lowest levels 1.03, 0.23 and 0.97, respectively, and the differences were significant. The microbial biofertilizers added to the mature compost (enriched compost) had a positive effect, whereas, the studied element contents increased over those of unamended compost. For example, the treatment of enriched compost (type 4) gave higher values of N, P and K (2.85; 0.65 and 2.91 g shoot^{-1}) over those of normal compost (type 4) treatment (2.13, 0.51 and 2.31 g shoot^{-1}), respectively with significant differences. The plants received enriched compost and inoculated with the mixed inoculum as seed-based inoculum attained the highest values not at all over other treatments ($p< 0.05\%$), especially plants received enriched compost and inoculated with the mixed inoculum, that gave the highest values (3.26, 0.76 and 3.37) respectively.

In general application of compost, type 4 caused an increase in N, P and K contents in shoot of *Zea mays* plants. Moreover, enrichment compost with biofertilizers had a best effect, in addition to inoculation of seeds with the biofertilizer attained the highest positive influence.

[49], enriched vermicompost and farmyard manure with *Azotobacter* and phosphate dissolving bacteria with incubation for 30 days, after this period they found that C/N ratio significantly reduced and the population of *Azotobacter* and phosphate dissolving bacteria sharply increased. [50], found a similar results. At the same time, [51], showed that fertilization of potato plants with 35.7 tons of compost increased P and K concentrations in leaves but N % did not changed than mineral fertilized control.

3.2.4 Economic evaluation

The economic study based on calculation of net return which represent subtract total costs (fixed costs + changed costs) from final product value (L.E. ton^{-1}). The net return of one ton compost was decreased with the increasing rice straw addition. The lowest net return was shown with the addition of 8 % rice straw, but the highest net value attained by the treatment FYM only, which gave net return of 171.5 L.E. ton^{-1}. However, these variation not big to affect the economy of production. This may be due to addition of rice straw price without increase of the final weight of the pile.

The addition of bulking agent like rice straw increased microbial counts and types which involved in the decomposition process of the raw material, causing full decomposition and eject an energy as a heat (as shown in Table 3).

In spite of nearly stability of product weight with addition of rice straw. The quality of final compost was improved like bulking density decrease of ammonium volatilization, increasing microbial counts and diversity.

Table 6: Effect of compost types on *Zea mays* shoot N, P and K contents (g shoot^{-1})

Treatment		N	P	K
Normal compost	Control	1.03 ^{d}	0.23 ^{d}	0.97 ^{e}
	FYM (control)	1.29 ^{c}	0.30 ^{c}	1.31 ^{d}
	FYM + 2 % RS	1.13 ^{cd}	0.27 ^{cd}	1.24 ^{d}
	FYM + 4 % RS	1.54 ^{b}	0.37 ^{b}	1.58 ^{c}
	FYM + 6 % RS	2.13 ^{a}	0.51 ^{a}	2.32 ^{a}
	FYM + 8 % RS	2.01 ^{a}	0.49 ^{a}	2.07 ^{b}
Enriched compost	Control	1.33 ^{e}	0.29 ^{d}	1.28 ^{e}
	FYM (control)	1.50 ^{de}	0.34 ^{cd}	1.63 ^{d}
	FYM + 2 % RS	1.64 ^{d}	0.37 ^{c}	1.77 ^{d}
	FYM + 4 % RS	1.91 ^{c}	0.47 ^{b}	2.22 ^{c}
	FYM + 6 % RS	2.58 ^{a}	0.65 ^{a}	2.91 ^{a}
	FYM + 8 % RS	2.36 ^{b}	0.61 ^{a}	2.62 ^{b}
Enriched compost + Inoculation	Control	1.56 ^{d}	0.36 ^{c}	1.63 ^{d}
	FYM (control)	1.68 ^{d}	0.41 ^{c}	1.77 ^{cd}
	FYM + 2 % RS	1.73 ^{d}	0.40 ^{c}	1.94 ^{c}
	FYM + 4 % RS	2.16 ^{c}	0.55 ^{b}	2.41 ^{b}
	FYM + 6 % RS	3.26 ^{a}	0.76 ^{a}	3.37 ^{a}
	FYM + 8 % RS	3.00 ^{b}	0.73 ^{a}	3.19 ^{a}
L.S.D. 0.05		0.177	0.040	0.228

In a column, means followed by a common letter are not significantly different at 5% level by DMRT

Table 7. Economic evaluation of compost piles construction as affected by addition of different levels of bulking agents (rice straw)

Treatment	Fixed costs (L. E. ton^{-1})	Changed costs (L. E. Kg^{-1})	Total costs	Final product value (L. E.)	Net return (L. E.)
FYM (control)	128.5	-	128.5	300	171.5
FYM +2% RS	128.5	3.5	132.0	300	168.5
FYM + 4% RS	128.5	7.0	135.5	300	164.5
FYM + 6% RS	128.5	10.5	139.0	300	161.0
FYM + 8% RS	128.5	14.0	142.5	300	157.5

Fixed costs include: FYM, 67.6 (L. E. ton^{-1}); Pile construction, 15 (L. E. ton^{-1}); Turning, 21 (L. E. ton^{-1}) and water spray, 25 (L. E. ton^{-1}),Changed costs: rice straw

[7,38,52], found that addition of bulking agent (rice straw) improved characteristics of the final compost product. In addition, FYM which obtained from Sakha Livestock Research Station was mostly decomposed due to putting a bed of straw beneath the animals every weak, and the overall bed leaved after a long of time, the matter which allow decomposition of these materials.

4. CONCLUSION

Suitable C/N ratio from mixture of farmyard manure and rice straw waste with soil as the effective microorganism source enhance the mineralization and nutrient release into the soil for plant growth promotion.

Therefore, our results showed that the application of different ratio of rice straw waste with farmyard manure has increased the nutrient content, and improvement physicochemical properties of the final compost products indicating an increase in compost quality. Application as an organic fertilizer, enhanced maize growth and biochemical characteristics, results also, attained an increase in N, P and K contents in shoot. Moreover, enrichment compost with biofertilizers had a best effect, in addition to inoculation of seeds with the biofertilizer attained the highest positive influences.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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