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Intergradation of Different Fertilizers for Sustainable Agriculture Enhanced Growth and Yield of Wheat (*Triticum aestivum* L.)

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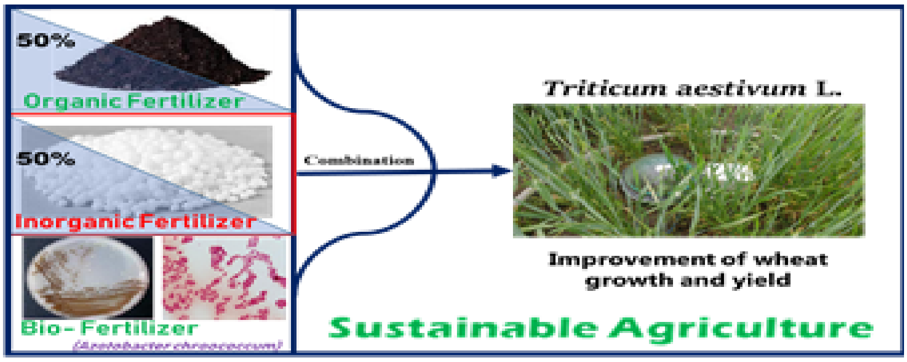
Graphical Abstract



ORGANIC farming is an advantageous agricultural system that enhances agro-ecosystem health, including biogeochemical cycles, biological activity and biodiversity in soils. In this regard, pots and lyzemeter experiments were conducted to evaluate eight compost preparations, and to investigate the combined effect of compost- *Azotobacter chroococcum* on growth and yield of wheat (*Triticum aestivum* L.) Cv. Misr 2 under different nitrogen levels (25, 50, 75 and 100% of full dose of nitrogen fertilizer). In pot experiment, application of compost treatment No. 8 (produced by mixture of rice straw, cattle dung and inoculated with *Bacillus licheniformis* and *Bacillus sonorensis*) attained the highest vegetative growth parameters at 46.3 cm plant height, 8.92 g plant fresh weight and 2.96 g dry weight of wheat plants at 30 days after sowing comparing with control. On the other hand, results in lyzemeter experiment showed that treatment No. 9 (50% of full dose of nitrogen fertilizer + 50% compost (pile 8) + inoculation with *A. chroococcum*), is the most effective treatment for enhancing growth dynamics, enzyme activity and microbial populations. Also, the highest data of biological yield, grain yield and straw yield were recorded 22.5, 8.64, and 13.92 ton ha^{-1}, compared to traditional N-fertilizer, respectively. Therefore, this study could establish the successive uses of cellulase producing microbes, *B. licheniformis* and *B. sonorensis*, and N_2-fixing bacteria *A. chroococcum* as friendly microorganisms to improve wheat production.

Keywords: Organic fertilizer; *Bacillus licheniformis*; *Bacillus sonorensis*; *Azotobacter chroococcum;* Wheat growth.

Introduction

In Egypt, wheat is the most important grain and is grown throughout the Delta region, along the branches of the Nile, as well as in the newly reclaimed areas. In 2012, wheat was grown on 4.3 million farms and it alone accounted for USD 3.7 billion, around 9 % of the total value of agricultural production and over one-fifth (22 %) of the total value of field crops (USD 17.3 billion). Wheat has managed to increase its share of the winter cropped area from around 41 to 47 %. Egypt remains the world's largest wheat importer at about 12 million tonnes (www.fao.org/giews/countrybrief/country.jsp?code=EGY).

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The macro and micro plant nutrients play an important role in the productivity of agricultural crops as well as for the environment (Tsai et al. 2007). Since, the advent of green revolution and high input agriculture practices, chemical fertilizer have become the major source of nitrogen for crop plants (Peoples et al. 1995), although continuous use of chemical fertilizers has led to the environmental pollution and contamination of the soil, pollution of water basins, and disruption of flora-fauna of ecosystem and ultimately reduced soil fertility (Mishra et al. 2013). Therefore, uses of organic and biofertilizers or bio inoculants in agriculture protect the environment as they are eco-friendly and economic for the farmers (Khosro and Yousef 2012). This should reduce the negative impact of chemical fertilizers with beneficial effect on the growth of plants and responsible for enhanced crop yield.

Rice straw is the most abundant lignocellulosic agro-residues in Egypt of about 3.1 million tons are produced annually (Abdelhady et al. 2014). These biomasses can be utilized for production of various value-added products via microbial fermentation processes (Abdel-Rahman et al. 2011; Sakdaronnarong and Jonglertjunya 2012; Abdel-Rahman et al. 2015). Composting is one of the useful methods that can directly consume large amount of wastes for compost production that can be used as a source of nutrients to improve soil structure, increase its organic matter, and enhance plant growth (Liu et al. 2011). The compost must be in a high degree of maturity and stability for safe application in agriculture without any adverse effects on plants (Qian et al. 2014). Inoculation of microbial additives that can tolerate composting condition, accelerate the composting process and increase nutrients have been used by several authors (Kausar et al. 2014; Abdel-Rahman et al. 2015; Jiang et al. 2015). Compost with beneficial microorganisms achieved higher available N,P,K, and Fe contents as compared to compost without microorganisms and increases the macro and micronutrient content of the soil.

The microbial activity has a huge importance in weathering and soil formation, through the mineralization and immobilization processes of nutrients. Therefore, the application of organic fertilizers (e.g. manure, crop residues or compost) has been practiced for a long time in order to increase the amount of microorganisms, soil fertility, soil quality and health, as well as enhancing the productivity, yield, and quality of crops (Cooperband and Wisconsin 2002; Mariangela and Francesco 2010). These microorganisms can release beneficial soluble substances such as amino acids, sugars, alcohol, hormones and similar organic compounds that can be easily absorbed by plants and can significantly increase the grain and biomass production (Ndona et al. 2011; Lindani and Brutsch 2012; Dehghani et al. 2013; Jusoh et al. 2013).

On the other hand, free living bacteria are highly beneficial for plant growth. They are collectively known as plant growth promoting rhizobacteria (PGPR) (Kloepper, 1994). These PGPRs are mainly involved in metabolic process related to nitrogen fixation, phosphate solubilization and overall plant growth promotion. Among those, the non-symbiotic free living *Azotobacter* and *Azospirillum* are largely associated with nitrogen fixation in plant rhizosphere and enhancement of plant yield (Lakshminarayana et al. 2000) which can have applied either as combined or as single inoculation which input of soil ranges from 0–60 kg ha^{-1} $year^{-1}$ (Bandhu and Parbati 2013). Maize and wheat crops inoculated with *Azotobacter* significantly showed increased plant height, grain weight and yield over the non-inoculated treatment (Barik and Goswami 2003). This is due to its capability of biological nitrogen fixation, synthesis of antibiotics, plant growth hormones production, vitamins production and plant hormones like indole acetic acid, gibberellins, and cytokinins (Gebrejewergs and Daniel 2016), exopolysaccharides and pigments (Jimenez et al. 2011). Therefore, the development of sustainable agricultural use of *Azotobacter* as biofertilizer has great importance to improve nutrient profile of plant and soil and increase crop yield accompanied by protection of environmental pollution and soil contamination (Namvar et al. 2012 and Rana et al. 2012).

Therefore, this study aims at smart use of friendly microorganisms to improve wheat production. Studying the effect of different compost materials prepared with/without inoculation of cellulase producing microbes, *Bacillus licheniformis* 1-1v and *Bacillus sonorensis* 7-1v on wheat growth will be investigated. Also, we will evaluate the effect of different fertilizers (organic, inorganic, and biofertilizer) either separately or in mixture on the growth parameters and yield of wheat plants (*Triticum aestivum* L.).

Materials and methods

Compost piles

Eight compost piles (T1–T8) obtained from previous study by Abdel-Rahman et al. (2016) at Microbiology Department, Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt were kindly provided to conduct this study. The composition of different composts is shown in Table 1, as well as their chemical and biological analysis are shown in Table 2.

Grains used

The used grains of Wheat (*Triticum aestivum* L.) C.V. Misr 2 were kindly supplied by Field Crops Research Institute, Sakha, Agricultural Research Station, Egypt.

Preparation of Azotobacter chroococcum culture

Azotobacter chroococcum (SARS 10) strain was grown in 500-ml flask containing 250-ml using Jensen's liquid media at 30^{o}C. After 7 days of incubation, the number of cells ml^{-1} were determined using total viable count on plates conducted by Jensen (1951).

TABLE 1. Composition of composts used in pot experiment

No.	Pile content
C1	Rice straw[a] + cattle dung[b]
C2	Rice straw+cattle dung + 5 kg from feldspar ore powder (0.75%, w/w)
C3	Rice straw+cattle dung + 5 kg from feldspar ore powder + *Bacillus licheniformis*
C4	Rice straw+cattle dung + isolate *Bacillus licheniformis*
C5	Rice straw+cattle dung + 5 kg from feldspar ore powder + *Bacillus sonorensis*
C6	Rice straw+cattle dung + *Bacillus sonorensis*
C7	Rice straw+cattle dung + 5 kg from feldspar ore powder + Mixture of *Bacillus licheniformis* and *Bacillus sonorensis* (1:1)
C8	Rice straw + cattle dung + Mixture of isolates *Bacillus licheniformis* and *Bacillus sonorensis* (1:1)

[a] Rice straw, 80 kg; [b] Cattle dung, 288 kg; source; Abdel-Rahman et al., 2016

Pot experiment

Pot experiment was carried out to evaluate the effect of different composts to improve the vegetative growth of Wheat plant. Pots (25 cm in diameter and 28 cm in high) were filled with 5 kg clay soil mixed with 50 g pot^{-1} of compost. Physical, chemical and biological properties of soil used are showed in Table 3. A completely randomized design experiment comprised of 10 treatments (eight different composts and two control, one with chemical fertilizer 100% N and one without fertilizer), with nine replicates. Plants were collected and subjected to the following analyses at 30, 60 and 90 days after sowing: Plant height (cm plant^{-1}), Fresh and dry weight (g plant^{-1}), and N% in root and shoot.

Lyzemeter experiment

Lyzemeter experiment was carried out during winter-growing season of 2016/2017 to evaluate the effect of different fertilizers (organic, inorganic, and biofertilizer) either separately or in mixture on the growth parameters and yield of wheat plants. Before preparation of soil, some physical, chemical and biological analysis of the experimental site (0-30 cm) were conducted and the results showed in Table 3. The experiment undertaken composed of 36 unit each of 80 × 80 cm, and it was carried out as complete randomized block designed comprised 12 treatment, with 3 replicates for each treatment. Every unit of soil lyzemeter was prepared then mixed with compost No.8 with different rates of 100, 75, 50 and 25% as shown in Table 4. This process mixed the compost fertilizer with the top 20 cm of soil lyzemeter that suitable for the root system of wheat plant.

Physical, chemical and biological properties were determined according to the standard methods reported by Black et al., (1965) and Jackson (1967), and Allen (1959), respectively.

Wheat grains were sown by broadcasting method at the rate of 7.2 g unit^{-1} (recommended for wheat cultivation per hectare). For mineral treatments, different rates of Urea fertilizer (100, 75, 50 and 25%) were used and for biofertilizer treatment, wheat grains were mixed just before sowing with 30 g of sterilized carrier containing

TABLE 2. Chemical analysis of different composts used in the study

Compost type Parameters	C1	C2	C3	C4	C5	C6	C7	C8
pH	6.8	6.9	7.1	6.9	7.4	7.2	7.4	7.8
EC	10.1	10.5	11.15	10.3	11.3	11.7	11.5	11.7
MC (%)	39.1	38.1	36.1	35.7	36.3	36.5	32.5	34.5
BD kg/m3	550	518	518	550	580	580	550	580
TOC (%)	25.8± 1.03	25.8 ±0.0	24.3±0.0	24.7± 0.02	23.7 ±0.29	23.5±0.68	22.9± 0.0	24.1 ±0.56
TNC (%)	1.63 ±0.12	1.54±0.32	1.68±0.12	1.64 ±0.02	1.7±0.17	1.84± 0.7	1.75±0.12	1.84±0.12
C/N ratio	15.8 ±1.84	16.7± 3.66	14.6±1.1	15.1 ±0.24	13.9±1.50	12.8±0.89	13.1± 0.0	13.4±0.56
N (ppm)	106.4±3.96	124.6±17.8	120.4±7.92	123.2±0.0	116.9±16.8	124.6±17.8	117.6±15.3	124.6±9.9
P(ppm)	699.0± 3.73	635.1± 19.5	675.2±4.37	746.7± 22.8	736.0± 18.5	751.5± 9.40	760.2± 18.4	754.8± 3.36
K(ppm)	558.9± 7.58	514.3± 20.2	535.7± 0.0	532.1± 7.14	513.0± 32.8	544.1± 58.9	558.9± 27.7	607.1± 10.1
Germination %	86.11	88.88	97.22	91.66	94.44	97.22	97.22	100
TCB CFU g^{-1} (× 10^8)	3.4	3.9	6.2	5.9	5.8	5.3	6.2	6.4
TCF CFU g^{-1} (× 10^5)	4.9	3.9	4.1	3.5	3.9	3.7	3.8	4.1
TCA CFU g^{-1} (× 10^6)	3.8	3.6	3.4	3.6	3.5	3.3	3.6	3.2
E. coli	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salmonella sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shegella sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source; Abdel-Rahman et al., 2016; TCB: Total Count of Bacteria; TCF: Total Count of Fungi; TCA: Total Count of Actinomycetes

15 ml of 10^8 CFU ml^{-1} from *A. chroococcum* (SARS 10) strain using a sticking material. Water requirements and all cultural practices were applied according to the recommendations of Ministry of Agriculture and Land Reclamation.

Experimental parameters

Vegetative growth

At 60, 90 and 130 days after sowing, plants were collected and subjected to the following analyses: plant height (cm $plant^{-1}$), fresh and dry weight (g $plant^{-1}$), and flag leaf area (cm^2).

Chemical constituents

Nitrogen, phosphorus and potassium were determined in the dry matter of plant at different periods times 60, 90 and 130 days after sowing according to the methods described by Pregl (1945), Trough and Mager (1939) and Browns and Lilliland (1946), respectively.

Microbial estimations

In the rhizosphere of soil samples, total count of bacteria was estimated by soil extract agar media according to Allen (1959), but the most probable number of *A. chroococcum* was estimated using modified Ashby's media according to Abdel-Malek and Ishac (1968), and calculated using tables of Cochran (1950).

Enzyme activity

Dehydrogenase and urease activities in the soil samples were determined as described by Casida et al. (1964) and Pancholy and Rice (1973), respectively.

TABLE 3. Some physical, chemical and biological properties of the pot and lyzemeters experimental soil

Parameters	Value	
	Pot	lyzemeters
Physical properties Particle size distribution		
Clay %	53.61	52.60
Silt %	21.93	23.10
Coarse sand %	5.24	6.30
Fine sand %	19.22	18.00
Texture grade	Clayey	Clayey
Some chemical properties		
pH (1:2.5 water suspension)	7.19	7.35
EC (ds.m-1 in soil paste)	3.14	3.06
Soluble Cations (meq. L^{-1})		
Ca^{++}	3.94	4.18
Mg^{++}	7.15	7.78
Na^{+}	7.38	8.14
K^{+}	0.18	0.22
Soluble Anions (meq. L^{-1})		
SO_4^{--}	9.32	10.27
Cl^{-}	6.21	6.52
HCO_3^{-}	3.12	3.53
CO_3^{--}	0.0	0.0
Available macro element (ppm)		
N	35.21	34.70
P	8.23	8.08
K	210	200.7
Biological properties		
Total count of bacteria	159 x 10^7 CFU g^{-1}	179x 10^7 CFU g^{-1}
Total count of fungi	85 x 10^4 CFU g^{-1}	66 x 10^4 CFU g^{-1}
Total count of actinomycetes	55 x 10^5 CFU g^{-1}	71 x 10^5 CFU g^{-1}

Yield

Plants were harvested after 130 days from sowing, biological yield, grain yield and straw yield were estimated and transformed to ton per hectare (ton ha^{-1}).

Statistical analysis

Data were analyzed by one-way analysis variances (ANOVA) using statistical software SPSS 14.0 for windows. Duncan's multiple range test was used for comparison among the treatment means (Duncan 1955).

Results and Discussion

In this study, two experiments were conducted, the first experiment was carried out to evaluate the effect of different composting piles prepared by Abdel-Rahman et al., (2016) on the growth of wheat (*Triticum aestivum* L.) Cv. Misr 2. The second

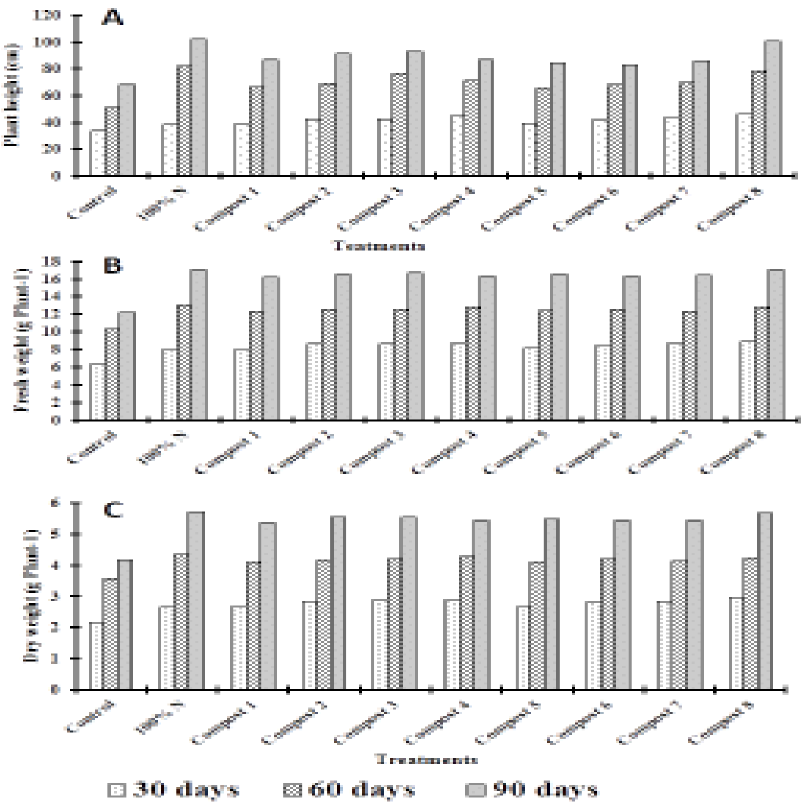

Fig. 1. Effect of different compost treaem and mineral fertilizer on whea plants beight

TABLE 4. Treatments used for lyzemeters experiment

No.	Treatment
T1	Full dose of nitrogen fertilizer
T2	100 % of compost No. 8 fertilizer (1.6 kg unit^{-1})
T3	Inoculation with *A. chroccoucum*
T4	75% of full dose of nitrogen fertilizer + 25% of compost No. 8 fertilizer (0.4 kg unit^{-1})
T5	25% of compost No. 8 fertilizer (0.4 kg unit^{-1}) + Inoculation with *A. chroococcum*
T6	75% of full dose of nitrogen fertilizer + 25% of compost No. 8 fertilizer (0.4 kg unit^{-1}) + Inoculation with *A. chroococcum*
T7	50% of full dose of nitrogen fertilizer + 50% of compost No. 8 fertilizer (0.8 kg unit^{-1})
T8	50% of compost No. 8 fertilizer (0.8 kg unit^{-1}) + Inoculation with *A. chroococcum*
T9	50% of full dose of nitrogen fertilizer + 50% of compost No. 8 fertilizer (0.8 kg unit^{-1})+ Inoculation with *A. chroococcum*
T10	25% of full dose of nitrogen fertilizer + 75% of compost No. 8 fertilizer (1.2 kg unit^{-1})
T11	75% of compost No. 8 fertilizer (1.2 kg unit^{-1})+ Inoculation with *A. chroococcum*
T12	25% of full dose of nitrogen fertilizer + 75% of compost No. 8 fertilizer (1.2 kg unit^{-1})+ Inoculation with *A. chroococcum*

experiment was carried out at lyzemeters, where the best quality compost structure was selected and compared with the inoculation with nitrogen fixing bacteria *A. chroococcum* and applied with different rates of nitrogen fertilizer on wheat productivity.

Pot experiment

Effect of different composts on wheat growth

The effect of different compost treatments on the vegetative growth parameters (plant height [Fig. 1A], fresh weight [Fig. 1B], and dry weight [Fig. 1C] of wheat plants), at 30, 60 and 90 days after sowing as compared to the control (one with recommended nitrogen fertilizer and one without fertilizer dose). The data showed that application of compost prepared using inoculation of cellulase-producing bacterial increase the wheat growth parameters (plant height, fresh and dry weight of wheat plants at 30 days after sowing) as compared to the control. Application of compost treatment No. 8 (produced by mixture of rice straw, cattle dung and inoculated with *Bacillus licheniformis* and *Bacillus sonorensis*) attained the highest vegetative growth parameters at 46.3 cm plant height, 8.92 g plant fresh weight and 2.96 g dry weight of wheat plants at 30 days after sowing comparing with control with increment by 19.9 % and 11.15% for fresh and dry weight, respectively, comparing with control. These results are followed by compost treatment No. 4 (Rice straw + cattle dung + *Bacillus licheniformis*) and compost treatment No. 6 (Rice straw + cattle dung + *Bacillus sonorensis*). On the other hand, treatment with mineral nitrogen exhibited the best effect on the growth parameters at 60 and 90 days after sowing.

This result is in accordance with that obtained by Jamilu and Samina (2013) who found that the application of 4% parthenium green manure with EM increased shoot dry biomass of wheat. This is due to the ability of stimulating the mineralization of nutrients when the microorganisms are integrated with organic materials like compost (Fatunbi and Ncube 2009). Moreover, as the study site is drought prone area, the addition of compost to a soil increases the mean water holding capacity of a soil (Vengadaramana et al. 2012) and this could influence the production of wheat grains.

Effect of different composts on chemical analysis of wheat plants

Data presented in Table 5, revealed the effect of different compost treatments on the N content of shoot and root of wheat plants at 30, 60 and 90 days after sowing as compared to the control (recommended nitrogen fertilizers dose). At 30 days after sowing treatment with pile 8 treatment achieved the highest N_2 (%) in shoot and root content compared with control, while at 60 and 90 days after sowing treatment with mineral nitrogen exhibited the best effect on the same parameter.

This is due to the ability of stimulating the mineralization of nutrients when the microorganisms are integrated with organic materials like compost (Fatunbi and Ncube 2009). Moreover, addition of compost to a soil increases the mean water holding capacity of a soil (Vengadaramana et al. 2012) and this could influence the production of wheat grains. According to Govedarica et al. (2004) inoculation of wheat seed with diazotrophs increased the 1000-seed weight from 2 to 14% under conditions of a greenhouse.

Lyzemeter experiment

growth parameters

Data presented in Table 4 showed the 12 treatments used for conducting this experiment as indicated in "Material and Method" section either by using nitrogen fertilizer, compost, bio-fertilizer (*Azotobacter chroococcum)* separately or mixture of them at different ratio. The effect of different treatments on the vegetative growth parameters of wheat plants (plant height, flag leaf area (cm^2), fresh and dry weight (g $plant^{-1}$) at 60, 90 and 130 days after sowing) was recorded in Table 6.

In general, the co-inoculation treatments with compost, mineral N and N_2-fixation microorganisms with different dose are more efficient than using each fertilizer alone or compared to traditional N_2-fertilizer dose. The data showed that application of compost pile 8 and N_2-fixing bacteria increased wheat growth parameters (plant height (cm), flag leaf area (cm^2), fresh and dry weight (g $plant^{-1}$) of wheat plants at 60, 90 and 130 days after sowing), as compared to the control. At 90 and 130 days of sowing effect of N_2-fertilizer on growth parameters is more efficient than biological fixation alone. Treatment No. 9 (contained 50% of full dose of nitrogen fertilizer + 50% of full dose of compost (pile 8) + inoculation with biofertilizer (*A. chroococcum*) achieved the highest results at 60, 90 and 130 days compared to other treatments. The inoculation of wheat with single N_2- fixers either alone or with compost gave less activity than the compound ones (El- Hamahmy et al. 2014).

TABLE 5. Effect of different treatments on N % in root and shoot of wheat plants

Treatment	30 day		60 day		90 day	
	Root	Shoot	Root	Shoot	Root	Shoot
Control	0.66 d	1.34 f	0.70 f	1.36 f	0.75 g	1.49 e
100% N	0.72 c	1.47 d	0.91 a	1.80 a	0.99 a	1.99 a
Compost 1	0.66 d	1.39 e	0.71 f	1.42 e	0.76 g	1.51 e
Compost 2	0.80 a	1.57 bc	0.82 c	1.58 c	0.89 d	1.74 d
Compost 3	0.82 a	1.62 b	0.87 b	1.69 b	0.93 c	1.82 c
Compost 4	0.81 a	1.62 b	0.85 b	1.67 b	0.93 c	1.80 c
Compost 5	0.74 bc	1.48 d	0.78 d	1.52 d	0.84 e	1.73 d
Compost 6	0.76 b	1.55 c	0.80 d	1.58 c	0.84 e	1.75 d
Compost 7	0.69 d	1.46 d	0.73 e	1.52 d	0.80 f	1.72 d
Compost 8	0.83 a	1.71 a	0.89 a	1.79 a	0.96 b	1.95 b
L.S.D. (0.05)	0.03	0.04	0.02	0.02	0.02	0.03

TABLE 6. Effect of organic, inorganic and biofertilizer treatments on wheat vegetative growth

Treatment	Plant height (cm Plant^{-1})	Fresh weight (g Plant^{-1})	Dry weight (g Plant^{-1})	Flag leaf area (cm^2)
		60 day		
T1	50.33 gh	7.96 f	2.64 f	24.00 ghi
T2	49.00 h	7.71 g	2.57 g	23.66 hi
T3	47.33 i	7.45 h	2.48 h	23.33 i
T4	50.66 fg	7.99 f	2.65 f	24.66 efg
T5	50.33 gh	7.99 f	2.65 f	24.33 fgh
T6	59.00 b	9.25 b	3.08 b	26.33 bc
T7	52.33 e	8.34 e	2.78 e	25.33 de
T8	56.33 c	8.90 c	2.97 c	26.00 cd
T9	61.33 a	9.49 a	3.18 a	27.66 a
T10	52.00 ef	8.20 e	2.73 e	25.00 ef
T11	54.00 d	8.64 d	2.85 d	25.33 de
T12	59.33 b	9.30 b	3.11 b	27.00 ab
L.S.D. (0.05)	1.34	0.14	0.05	0.79
		90 day		
T1	76.33 g	12.07 j	4.01 h	35.00 g
T2	75.66 g	12.00 j	3.98 h	34.00 h
T3	74.00 h	11.83 k	3.91 i	33.66 h
T4	78.00 f	12.30 h	4.09 g	36.00 ef
T5	77.66 f	12.20 i	4.08 g	35.33 fg
T6	84.33 c	13.36 c	4.43 c	38.33 abc
T7	80.66 e	12.86 f	4.27 e	37.33 d
T8	84.00 c	13.21 d	4.40 c	38.00 bcd
T9	87.66 a	13.88 a	4.63 a	39.00 a
T10	78.33 f	12.42 g	4.13 f	36.33 e
T11	82.33 d	13.04 e	4.34 d	37.66 cd
T12	85.66 b	13.61 b	4.54 b	38.66 ab
L.S.D. (0.05)	0.84	0.07	0.03	0.74
		130 day		
T1	93.33 fg	14.80 i	4.94 i	42.00 ef
T2	92.33 g	14.68 j	4.88 j	41.33 f
T3	90.33 h	14.33 k	4.76 k	40.33 g
T4	95.33 e	15.11 h	5.03 h	42.33 de
T5	94.00 f	14.80 i	4.92 i	42.00 ef
T6	103.00 b	16.24 c	5.41 c	43.66 bc
T7	97.66 d	15.44 f	5.14 f	43.00 cd
T8	100.33 c	15.91 d	5.30 d	43.00 cd
T9	105.00 a	16.68 a	5.54 a	45.00 a
T10	97.00 d	15.31 g	5.10 g	42.66 de
T11	99.33 c	15.73 e	5.24 e	43.00 cd
T12	103.66 b	16.37 b	5.47 b	44.33 ab
L.S.D. (0.05)	1.15	0.05	0.03	0.84

Chemical parameters

Results shown in Table 7, indicated the effect of different treatments on the minerals contents of wheat plants (NPK %) at 60, 90, 130 days after sowing as compared to the control (recommended nitrogen fertilizers dose). In general, the co-inoculation treatments with compost, mineral nitrogen and N_2-Fixation microorganisms with different dose are more efficient than using each fertilizer separately. Interestingly, the highest NPK values were obtained using treatment No# 9 that contained 50% of full dose of nitrogen fertilizer + 50% of full dose of compost (pile 8) fertilizer, plus inoculation with biofertilizer (*A. chroococcum*).

The increase in available nitrogen due to organic amendment application resulted in the greater multiplication of soil microbes, which caused and enhanced the conversion of organically bound N to inorganic forms. Therefore, litter addition might have resulted in marked improvement in the organic carbon and available N content in soil. The favorable soil condition under organic amendment might have helped in the mineralization of soil N leading to build up higher available N (Nour El-Din et al. 2017; Singh et al. 2017).

Combined application of fertilizers and manures increased available K content over control. The beneficial effect of organic amendments on available potassium may be described to the reduction of potassium fixation and release of potassium due to the interaction of organic matter with clay, the direct potassium addition to the potassium pool of the soil. Thus, it concluded the integrated nutrient management with organic manure, green manure, bio fertilizers and inorganic fertilizers enhances the productivity of wheat and fertility of soil. Organic manure enhanced the available P in soil through complexation of cations like Ca^{++} and Mg^{++} when it is applied in combination with inorganic fertilizer. Generally, addition of organic amendments with inorganic fertilizers had the beneficial effect in increasing the phosphate availability. (Nour El-Din et al. 2017; Singh et al. 2017).

To study the mechanism of productivity enhancement, microbial community (total bacterial count and total *Azotobacter*) in the soil was investigated for all treatments as shown in Table 8. As indicated in the table, treatment # 9 exhibited the highest total microbial and *Azotobacter* count among other treatments with a maximum value obtained after 90 days and decreased after that. The existence of *Azotobacter* microbes in different counts has improved growth and yield of cereal crops like wheat (Zahra et al. 2013).

Soil enzymes activities were also investigated as shown in Table 9. The highest dehydrogenase (mg TPF g^{-1} soil d^{-1}) and urease (mg NH_4-N g^{-1} soil d^{-1}) activities were also obtained using treatment # 9. Lower enzyme activities were obtained with other treatments. The activity of dehydrogenase reflects the oxidative capacity of the microbial biomass and it has been suggested as a good indicator of soil quality. The inoculation with beneficial microorganisms and organic matter represented in compost and its extracts helped in increasing the respiration and consequently increase in dehydrogenase enzyme (El- Hamahmy et al. 2014; Omara et al. 2017).

In addition, the effect of different treatments on biological yield (ton ha^{-1}), grain yield (ton ha^{-1}) and straw yield (ton ha^{-1}) was shown in Table 10 in more efficient than using each one alone with compared to traditional N-fertilizer dose with the highest data of 22.5, 8.64, and 13.92 ton ha^{-1}, respectively with treatment #9.

Enriched compost along with 50% of the recommended dose of nitrogen fertilizer significantly improved the plant height, no. of tillers pot^{-1}, no. of spikelets $spike^{-1}$, straw and grain yield. Our findings were in line with the results of a field experiment conducted to evaluate the influence of compost fertilizer mixed with chemical fertilizer on growth and yield of wheat agree with (Akhtar 2007)

The analysis of variance of the yield showed that statistically significant differences existed for all major sources of variation and all interactions. The application of microorganisms increased the availability of nutrients, which had a positive impact on yield parameters (Milosevic et al. 2008). The enhancing effect of seed inoculation with N_2-fixing bacteria on the growth and yield of wheat was reported by many researchers (Bhattarai and Hess 1993; Ozturk et al. 2003). This improvement may be attributed to the high nitrogen uptake by the inoculated plants and the ability of bacterial strains to produce growth promoting substances (Haahtela et al. 1988).

TABLE 7. Effect of organic, inorganic and biofertilizer treatments on NPK % of wheat plants

Treatment	N (%) Days			P (%) Days			K (%) Days		
	60	90	130	60	90	130	60	90	130
T1	2.05 g	2.19 j	2.30 i	0.068 i	0.078 i	0.093 i	2.77 g	2.81 g	2.08 i
T2	1.99 h	2.11 j	2.24 j	0.067 i	0.075 j	0.090 j	2.72 h	2.79 h	2.05 j
T3	1.97 h	2.09 j	2.19 k	0.066 j	0.073 k	0.087 k	2.69 i	2.77 h	2.01 k
T4	2.12 e	2.31 g	2.41 h	0.071 h	0.083 g	0.098 g	2.80 f	2.85 f	2.17 g
T5	2.09 f	2.28 h	2.40 h	0.070 h	0.081 h	0.095 h	2.77 g	2.84 f	2.15 h
T6	2.34 b	2.48 c	2.63 c	0.084 c	0.096 b	0.107 c	2.91 bc	3.04 a	2.36 c
T7	2.28 d	2.39 e	2.51 f	0.077 f	0.089 e	0.102 e	2.83 e	2.94 d	2.24 f
T8	2.31 c	2.44 d	2.60 d	0.082 d	0.093 c	0.105 d	2.90 c	3.01 b	2.32 d
T9	2.38 a	2.54 a	2.69 a	0.090 a	0.098 a	0.111 a	2.95 a	3.05 a	2.45 a
T10	2.27 d	2.36 f	2.45 g	0.073 g	0.086 f	0.101 f	2.82 e	2.90 e	2.19 g
T11	2.29 d	2.42 d	2.56 e	0.080 e	0.092 d	0.104 d	2.87 d	2.96 c	2.27 e
T12	2.36 b	2.51 b	2.65 b	0.087 b	0.097 a	0.108 b	2.92 b	3.04 a	2.39 b
L.S.D. (0.05)	0.02	0.02	0.01	0.001	0.001	0.001	0.019	0.018	0.020

TABLE 8. Influence of organic, inorganic and biofertilizer treatments on Log number of total bacterial count and *Azotobacter* count (CFU g^{-1}) of soil at different time of sowing

Treatment	Total count of bacteria CFU g^{-1} Days			Total count of *Azotobacter* CFU g^{-1} Days		
	60	90	130	60	90	130
T1	5.26 g	6.80 f	4.70 g	3.13 c	4.56 g	2.36 d
T2	5.66 de	7.43 c	5.23 de	3.40 b	5.10 e	2.70 c
T3	5.50 f	7.03 e	5.10 ef	3.33 b	4.83 f	2.66 c
T4	5.56 ef	7.23 d	5.23 de	3.40 b	5.13 de	2.73 c
T5	5.50 f	7.03 e	5.06 f	3.40 b	4.90 f	2.63 c
T6	6.03 b	7.70 ab	5.63 b	3.80 a	5.66 ab	2.96 b
T7	5.66 de	7.46 c	5.26 cd	3.33 b	5.36 c	2.63 c
T8	5.80 c	7.60 b	5.40 c	3.46 b	5.60 b	2.73 c
T9	6.16 a	7.80 a	5.83 a	3.86 a	5.76 a	3.16 a
T10	5.60 ef	7.36 c	5.16 def	3.46 b	5.23 d	2.66 c
T11	5.73 cd	7.60 b	5.30 cd	3.46 b	5.63 b	2.63 c
T12	6.10 ab	7.76 a	5.76 ab	3.76 a	5.66 ab	2.93 b
L.S.D. (0.05)	0.12	0.10	0.14	0.13	0.12	0.12

TABLE 9.Influence of organic, inorganic and biofertilizer treatments on dehydrogenase (mg TPF g^{-1} soil d^{-1}) and urease (mg NH4-N g^{-1} soil d^{-1}) activities at different time of sowing

Treatment	Dehydrogenase (mg TPF g^{-1} soil d^{-1}) Days			Urease (mg NH4-N g^{-1} soil d^{-1}) Days		
	60	90	130	60	90	130
T1	87.20 h	112.95 h	66.54 i	82.44 i	96.99 i	90.19 h
T2	82.00 i	110.27 i	65.32 ij	76.41 j	94.85 i	89.13 h
T3	80.36 i	107.64 j	64.03 j	73.85 k	92.06 j	85.39 i
T4	91.65 g	117.14 g	71.61 g	89.47 g	104.29 g	94.96 f
T5	90.18 g	114.40 h	69.07 h	87.37 h	100.32 h	91.63 g
T6	107.48 c	127.92 c	84.77 bc	102.07 bc	119.49 bc	105.06 b
T7	97.52 e	123.26 e	77.25 e	95.33 e	110.43 e	97.67 e
T8	105.93 c	125.34 d	83.09 c	100.62 c	117.66 c	102.48 c
T9	116.07 a	132.68 a	87.74 a	105.65 a	123.51 a	110.52 a
T10	94.63 f	119.99 f	73.36 f	93.11 f	106.64 f	97.28 e
T11	100.66 d	124.39 de	80.41 d	98.36 d	113.89 d	100.03 d
T12	111.52 b	130.58 b	86.52 ab	103.10 b	120.87 b	109.29 a
L.S.D. (0.05)	2.01	1.96	1.74	1.81	2.21	1.37

TABLE 10. Effect of organic, inorganic and biofertilizer treatments on biological yield, grain yield and straw yield of wheat plant

Treatment	Biological yield (ton ha^{-1})	Grain yield (ton ha^{-1})	Straw yield (ton ha^{-1})
T1	21.39 j	8.09 h	13.30 j
T2	21.30 k	8.05 i	13.25 k
T3	21.13 l	7.96 j	13.16 l
T4	21.57 h	8.15 g	13.42 h
T5	21.46 i	8.10 h	13.35 i
T6	22.33 c	8.52 b	13.80 c
T7	21.90 f	8.30 e	13.59 f
T8	22.17 d	8.44 c	13.73 d
T9	22.57 a	8.64 a	13.92 a
T10	21.76 g	8.24 f	13.52 g
T11	22.03 e	8.37 d	13.66 e
T12	22.49 b	8.62 a	13.86 b
L.S.D. (0.05)	0.05	0.03	0.03

Barik and Goswami (2003), reported that grains inoculation with *A. chroococcum* strains significantly influenced the growth and yield of wheat. These strains have the ability to produce vitamins like thiamine and riboflavin and plant hormones *viz.*, indole acetic acid, gibberellins and cytokinins. For example, IAA production by *Azotobacter* sp. strains lead to vigorous root growth resulting in more surface area and thus enabling access to more nutrients in the soil (Singh et al. 2013).

The superior effect resulted from the treatment No. 9 on increasing plants' vegetative growth as well as value for all flowering and yield parameters may be due to attributed the beneficial microorganisms with 50% NPK + compost that break down and release minerals from organic manure treatments and uptake by plants (Weaam, 2017).

Conclusion

In this study, the effect of different fertilizers on the growth and yield of wheat (*Triticum aestivum* L.) Cv. Misr 2 were compared and evaluated. Different organic fertilizers were compared, and the pile No.8 exhibited the best effect on the wheat plant in pot experiment. This compost was mixed with inorganic and biofertilizer at different ratio and examined in lyzemeters experiment. Use of 50% of full dose of compost supplemented with 50 % nitrogen fertilizer and *A. chroococcum* exhibited the highest effect on wheat growth, yield as well as enzymatic activities (dehydrogenase and urease) in soil compared to other treatments.

So, this approach may also improve soil health, reduce dependence on chemical fertilizer and most likely be helpful in reducing huge piles of organic waste, thus cleaning our environment.

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