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A consequence of enriched municipal solid waste on root growth and water use efficiency of direct-seeded rice

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Abstract
A field experiment was planned and carried out with entitled "Consequence of enriched municipal solid waste on root growth and water use efficiency of direct-seeded rice" for two successive years from 2017-18 to 2018-19 at Research farm of BHU, Varanasi. This experiment was carried out in split-plot design with three replications with the objective to study root length performance under different water regimes, varieties and municipal solid waste enriched with different microorganisms. The result revealed that irrigation scheduling at 75 mm cumulative pan evaporation and Sahbhagi had produced significantly higher root length; among the nutrient treatments, MSW compost enriched with consortia was found distinctly superior over rest of the treatments in term of root length at all crop growth stage in addition to water use efficiency.

Keywords: DSR, root length, MSW WUE, etc.

Introduction
Direct seeded rice is a smart alternative to Indian farmer where availability water is diminishing owing to mounting demand by other sectors. Being staple food its demand either exit at the same rate or accelerate. Hence to meet the demand of ever-increasing population, the only alternative left to make direct-seeded rice more efficient with respect to water use efficiency (WUE). Roots play a key role in enhancing water use efficiency. Through deep and later penetration into the soil and increasing the root density; WUE can be increased considerably. A developed root system leads to better crop growth and performance. The root growth plays an important role in controlling senescence, prolong the grain-filling stage and finally enrich the grain (*Shi et al*., 2006). According to the Central Pollution Control Board, 1,27,486 TPD (tons per day) of municipal solid waste (MSW) was generated in India during 2011. Out of the total municipal solid waste produced, nearly 89,334 TPD (70%) of municipal solid waste was gathered and only 15,881 TPD (12.45%) was processed for further use (Anonymous, 2012) [2]. Municipal Solid Waste management is becoming a dangerous issue which escorts to loss of resources and increased environmental dangers. Being organic waste, the best way to deal it is by making compost. This way dual purpose can the meet out one side bulk waste will become compost at the same time compost demand can also be resolved. Municipal solid wastes are poor in nutrient this problem can be dealt with enriching the MSW with microorganisms. Keeping in view this experiment was planned to enhance the water use efficiency of direct-seeded rice and performance of root.

Method and Material
The present examination entitled "Consequence of enriched municipal solid waste on root growth and water use efficiency of direct-seeded rice**"** was carried out for two consecutive years 2017-18 and 2018-19 at the Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The rice was sown as direct-seeded on 26th June during both the years. The experiment was laid out in a split plot design. The main field consists of two factors, a-Irrigation scheduling; 50 mm cumulative pan evaporation (I_1) & 75 mm cumulative pan evaporation (I_2) and b-Varieties: Swarna (V_1) & Sahbhagi (V2) and subplot had eight treatments i.e. 100% RDF (N_1), 75% RDF (No compost) Control (N_2), 75%RDF & Municipal Solid Waste compost @ 10t/ha (N_3), 75%RDF & Enriched Municipal Solid Waste compost (NFB) @ 10t/ha (N_4), 75%RDF & Enriched

Municipal Solid Waste compost (PSB) @ 10t/ha (N_5), 75% RDF & Enriched Municipal Solid Waste compost (ZSB) @ 10t/ha (N_6), 75% RDF & Enriched Municipal Solid Waste compost (*Trichoderma* sp.) @ 10t/ha (N_7), 75%RDF & Enriched Municipal Solid Waste compost (Consortia bio-inoculants) @ 10t/ha (N_8). The RDF used at the rate of 120 kg nitrogen, 60 kg phosphorus, 60 kg potash and 20kg zinc sulphate per hectare. Municipal solid waste compost was used at rate 10 t ha^{-1} before sowing and after mixing with respective bio inoculants. Irrigation to both varieties was given as per treatment of irrigation scheduling; one after 50 mm of cumulative pan evaporation (CPE) and second after 75 mm of CPE. The five-centimetre irrigation was applied at each time. The periodical data on root was taken. The water use efficiency was worked out using formula

$$\text{Water Use Efficiency} = \frac{\text{Crop Yield}}{\text{Pot. ET (ETcrop)}}$$

Potential Evapotranspiration (ET_0) worked out by multiply the pan evapotranspiration with 0.70 (pan coefficient)

Formula: ETo = K pan × E pan (FAO)

and Potential evapotranspiration crop was calculated by using crop coefficient factor for rice.

ETo × Kc = ET crop (FAO)

The periodical raw root length was taken at 30 days interval from the experimental plot. The root length was taken from five random locations in the distinguish plots. Thereafter average plant root length was calculated. During the first year of trial (2017), the total rainfall received during crop growth was 606.10 mm and succeeding year total rainfall 777.7 mm was recorded.

Result

Root study

There was distinct variation in root length was noticed in all the crop growth stage from 30 days after sowing (DAS) till harvesting of the crop. The nonsignificant difference in root length was institute at 30 DAS however, higher plant length was noticed with irrigation scheduling with 75 mm CPE in the main plot, during both the season no significant difference was found. With regard to second factor i.e. varieties which also failed to impact significantly in terms of root length during both the season and also on mean basis. Subplot treatment had significant persuade on root length during each year of experiment besides on two years average basis. Application of 75% RDF & E-MSWC (Consortia) @ 10t/ha had detected statistically higher root length compare to rest of the treatments of subplot except 75%RDF & E- MSWC (*Trichoderma*) @ 10t/ha which was followed by 75% RDF & E-MSWC (PSB) @ 10t/ha.

At 60 DAS all the factors were got success in creating a marked difference in root length of direct-seeded rice. In the main field; statistically, longer root length was found with irrigation scheduling after 75 mm CPE in both the season of trial and also based on average. Another factor of main had also exerted statistically difference; Sahbhagi had produced the significantly longer root then Swarna during both the season besides based on two years average. The subplot treatments were also created distinct difference; the utilization of 75% RDF & E-MSWC (Consortia) @ 10t/ha made conducive environment for better growth of root which resulted in longest root among subplots which was significantly superior over remaining treatment except 75% RDF & E- MSWC (*Trichoderma*) @ 10t/ha which was closely followed by 75%RDF & E-MSWC (PSB) @ 10t/ha during both the season of trial besides based on two year average.

Among main plot treatments at 90 DAS; artificial application of water after 75 mm CPE had produced significantly longer crop root than 50 mm CPE during both the season of experiment besides based on two-year average. Similarly, Sahbhagi had also produced significantly longer crop root during both the years and also on the base of two-year average. The nutrient factor of subplot had visible effect on crop root; significantly longer crop root was produced with utilization of 75%RDF & E-MSWC (Consortia) @ 10t/ha during both season and it remains statistically at par with 75%RDF & E- MSWC (*Trichoderma*) @ 10t/ha but on average basis it was clear that 75%RDF & E-MSWC (Consortia) @ 10t/ha was significantly superior over rest of the treatments.

At harvest in main both factor was found significant. The irrigation scheduling after 75 mm of CPE had able to produce significantly longest crop root compared to 50 mm CPE during both the season and also based on two-year average. The second factor of main plot i.e. varieties had also marked difference in their root length; Sahbhagi was able to produce statistically longest crop root than Swarna during both season and also based on two years average. Among subplot treatments; use of 75% RDF & E-MSWC (Consortia) @ 10t/ha produced the statistically longest crop root during both the season beside two years average basis.

Water Use Efficiency (WUE)

The highest WUE in the main field was calculated with irrigation scheduling after 50 mm CPE which also significantly higher than 75 mm CPE during both the season of experiment besides two years average. Another factor of main also showed its significance; Sahbhagi had used the water more effectively, therefore, it was able to produce significantly higher WUE than Swarna during both the season of experiment and on two years average based too. Amid subplot; use of 75%RDF & E-MSWC (Consortia) @ 10t/ha had produced significantly higher WUE than rest of the treatment except 75%RDF & E- MSWC (*Trichoderma*) @ 10t/ha during both the years of trial and also on two years mean basis.

Discussion

A critical scrutiny of periodical root length data it could be concluded that root length growth was higher with less available water in root vicinity viz. treatment 75 mm CPE water was applied after longer frequency than 50 mm CPE hence less water was utilized by treatment 75 mm CPE; this finding confirmed by Dahiya and Saini, 2017 [5], they reported that aerobic rice varieties (MAS25 and MAS26) showed a significant decline in root length under well watered conditions. Similarly, Babapoor *et al*. (2015) [3] also reported that with excessive nitrogen to 120 kg/ha there was not significant increase in root growth and activity in terms of length. There was no significant difference between the highest root length with root length in 70% water and nitrogen 60 kg/ha. WUE of treatment 50 mm CPE was found higher because WUE is the ratio of yield and water used as evapotranspiration and it is well-established fact that rice is a hydrophilic crop. Sahbhagi had longer root at all stage; it had used very less water (50 mm CPE- 841.9 mm and 75 mm CPE-741.9 mm) owing to this Shabhagi had higher WUE than Sahbhagi.

The careful examination of nutrient data of root it may be concluded that application of compost (MSWC) to field facilitate the root growth compared to chemical fertilizer which leads to longer crop root at all the crop growth. This result was in confirmation with Yang *et al.* (2004) experimental finding which showed Incorporation of organic sources into paddy soil markedly improved root morphological characteristics of the rice plant. In the alternate wetting and drying (AWD), root length density (RLD) and root weight density (RWD) for organic fertilization treatments (CS and CM) increased by 30 and 40%, respectively, as compared with the sole chemical fertilization (CF). The MSWC was enriched with different microorganisms which had played a significant role in root elongation in addition to improvement in WUE of rice. This experimental result verify by Anbumalar & Ashokumar (2016) [1] they reported that Halobacterium help in the seed germination, root and shoot length promotion and also increase the biomass of the tested plants and also by Rêgo *et al*. (2014) [7] who reported that treatment with *T. asperellum* (mix of four *T. asperellum* isolates: T-06, T-09, T-12, and T-52) and the combination of rhizobacteria (*B. pyrrocinia* + *P. fluorescens*) resulted in in58 and 43% gain in root length of rice seedlings, respectively.

Conclusion

Based on two-year experimental data it may be concluded that Sahbhagi performance was better in term of root growth whereas Swarna had utilized the water more efficiently. The compost enriched with consortia was found more suitable for varieties with regards to root length growth and water use efficiency.

Table 1: Effect of irrigation scheduling, varieties and nutrient on root length at 30 and 60 DAS

Treatments		Root Length (cm)					
	Main Plot (A- Irrigation x B- Varieties)	30 DAS			60 DAS		
		2017	2018	Mean	2017	2018	Mean
A	Irrigation scheduling (5cm)						
I_1	50 mm CPE	14.58	14.25	14.42	16.14	15.72	15.93
I_2	75 mm CPE	15.06	14.66	14.86	17.39	17.02	17.20
	SE m+	0.21	0.26	0.18	0.23	0.27	0.21
	CD (P=.05)	NS	NS	NS	0.80	0.94	0.73
B	Varieties						
V_1	Swarna	14.68	14.38	14.53	16.21	15.58	15.89
V_2	Sahbhagi	14.97	14.53	14.75	17.32	17.16	17.24
	SE m+	0.21	0.26	0.18	0.23	0.27	0.21
	CD (P=.05)	NS	NS	NS	0.80	0.94	0.73
C	Sub-plot: Nutrient						
N_1	100% RDF	13.18	12.93	13.05	14.70	14.43	14.56
N_2	75%RDF (No compost) Control	12.10	11.90	12.00	13.05	12.83	12.94
N_3	75%RDF & MSWC @ 10t/ha	13.05	12.70	12.88	16.33	15.90	16.11
N_4	75%RDF & E- MSWC (NFB) @ 10t/ha	14.93	15.05	14.74	17.70	17.13	17.41
N_5	75%RDF & E-MSWC (PSB) @ 10t/ha	15.53	14.55	15.29	18.18	17.78	17.98
N_6	75%RDF & E- MSWC (ZSB)@ 10t/ha	14.73	14.33	14.53	15.85	15.38	15.61
N_7	75%RDF & E- MSWC (*Trichoderma*) @ 10t/ha	17.33	16.78	17.05	18.80	18.40	18.60
N_8	75%RDF & E-MSWC (Consortia) @ 10t/ha	17.75	17.43	17.59	19.53	19.13	19.33
	SE m+	0.29	0.36	0.25	0.33	0.38	0.30
	CD (P=.05)	1.01	1.26	0.88	1.14	1.33	1.03
	I X V	NS	NS	NS	NS	NS	NS
	I X N	NS	NS	NS	NS	NS	NS
	V X N	NS	NS	NS	NS	NS	NS
	I X V X N	NS	NS	NS	NS	NS	NS

Table 2: Effect of irrigation scheduling, varieties and nutrient on root length at 90 DAS and at harvest

Treatments		Root Length (cm)					
	Main Plot (A- Irrigation x B- Varieties)	90 DAS			At harvest		
		2017	2018	Mean	2017	2018	Mean
A	Irrigation scheduling (5cm)						
I_1	50 mm CPE	18.93	18.13	18.53	24.08	23.65	23.87
I_2	75 mm CPE	19.78	19.91	19.84	26.33	26.04	26.18
	SE m+	0.22	0.29	0.21	0.35	0.38	0.16
	CD (P=.05)	0.76	1.02	0.73	1.20	1.31	0.54
B	Varieties						
V_1	Swarna	18.29	18.08	18.18	23.96	23.53	23.74
V_2	Sahbhagi	20.42	19.96	20.19	26.46	26.16	26.31
	SE m+	0.22	0.29	0.21	0.35	0.38	0.16
	CD (P=.05)	0.76	1.02	0.73	1.20	1.31	0.54
C	Sub-plot: Nutrient						
N_1	100% RDF	15.75	15.43	15.59	20.33	20.03	20.18
N_2	75%RDF (No compost) Control	14.83	14.45	14.64	18.15	17.88	18.01
N_3	75%RDF & MSWC @ 10t/ha	18.18	17.80	17.99	25.28	24.85	25.06

N_4	75%RDF & E- MSWC (NFB) @ 10t/ha	20.39	19.05	19.72	26.40	25.98	26.19
N_5	75%RDF & E-MSWC (PSB) @ 10t/ha	20.08	20.35	20.21	28.03	27.65	27.84
N_6	75%RDF & E- MSWC (ZSB)@ 10t/ha	19.43	19.60	19.51	25.70	25.30	25.50
N_7	75%RDF & E- MSWC (*Trichoderma*) @ 10t/ha	22.65	22.03	22.34	28.88	28.40	28.64
N_8	75%RDF & E-MSWC (Consortia) @ 10t/ha	23.53	23.45	23.49	28.90	28.68	28.79
	SE m+	0.31	0.41	0.30	0.49	0.54	0.22
	CD (P=.05)	1.07	1.44	1.04	1.70	1.86	0.76
	I X V	NS	NS	NS	NS	NS	NS
	I X N	NS	NS	NS	NS	NS	NS
	V X N	NS	NS	NS	NS	NS	NS
	I X V X N	NS	NS	NS	NS	NS	NS

Table 3: Effect of irrigation scheduling, varieties and nutrient on water use efficiency

Treatments		**WUE (kg/ha- mm)**		
Main Plot (A- Irrigation x B- Varieties)		**2017**	**2018**	**Mean**
A	Irrigation scheduling (5cm)			
I_1	50 mm CPE	18.45	19.82	19.13
I_2	75 mm CPE	16.42	18.01	17.21
	SE m+	0.17	0.18	0.12
	CD (P=.05)	0.59	0.64	0.41
B	Varieties			
V_1	Swarna	17.13	18.52	17.83
V_2	Sahbhagi	17.74	19.30	18.52
	SE m+	0.17	0.18	0.12
	CD (P=.05)	0.59	0.64	0.41
C	Sub-plot: Nutrient			
N_1	100% RDF	17.19	18.58	17.89
N_2	75% RDF (No compost) Control	14.08	15.08	14.58
N_3	75% RDF & MSWC @ 10t/ha	16.61	18.06	17.34
N_4	75% RDF & E- MSWC (NFB) @ 10t/ha	18.01	19.83	18.92
N_5	75% RDF & E-MSWC (PSB) @ 10t/ha	17.96	19.47	18.72
N_6	75% RDF & E- MSWC (ZSB)@ 10t/ha	17.62	18.88	18.25
N_7	75% RDF & E- MSWC (*Trichoderma*) @ 10t/ha	18.71	20.37	19.54
N_8	75% RDF & E-MSWC (Consortia) @ 10t/ha	19.29	21.02	20.15
	SE m+	0.24	0.26	0.17
	CD (P=.05)	0.83	0.90	0.58
	I X V	NS	NS	NS
	I X N	NS	NS	NS
	V X N	NS	NS	NS
	I X V X N	NS	NS	NS

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