Effect of graded levels of Treated Sugarcane Distillery Effluent with Soil Test Based NPK on Yield and Nutrient Uptake of Rice (Oryza sativa L.) in Sandy Clay Loam soil

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***Abstract*—** The population growth accelerates at the rate of 1.8 per cent, so the food requirement of growing population should be met out through increasing the yield of rice by hiking the food production to 25-30 per cent from the present level. Adequate plant nutrients supply holds the key for improving the food grain production and sustaining soil health. The molasses is a by-product of sugar industry used for production of alcohol in distilleries result in spent wash. Electricity is generated using spent wash and it is allowed for aeration, by the end of this aeration process Treated Sugarcane Distillery Effluent (TDE) is released which is of plant origin and contains large amount of organic matter and plant nutrients which the sugarcane plant had adsorbed from soil. Hence, the present investigation was carried out by conducting field experiment in sandy clay loam soil with the application of graded dose TDE integrated with NPK on the yield and nutrient uptake of rice (Oryza sativa L.) at Agricultural Engineering College and Research Institute, Kumulur, Tiruchirappalli district, Tamilnadu. India. The investigation revealed that the application of TDE with graded dose of NPK positively influenced the yield of rice. The highest grain yield of 6019 kg ha^{-1} with B: C ratio of 1.82 was recorded by the addition TDE @ 40,000 l ha^{-1} with 100 per cent NPK which was on par with the application of TDE @40,000 l ha^{-1} with 75 per cent NPK (5966 kg ha^{-1}). The control recorded the lowest grain yield of 3222 kg ha^{-1}. Further, the application of TDE @ 40,000 l ha^{-1} with 100 per cent NPK recorded the highest NPK uptake in both grain and straw over rest of the treatments.

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I. Introduction

IN Tamil Nadu, Cauvery delta region is known as "Rice bowl of South India". Rice is the major crop cultivated by the farmers of Tiruchirappalli district. The fertilizer becoming a costlier input for rice production. Hence, there is a need to increase the yield of rice and to decrease the expenditure towards the fertilizer. Sugar cane based distilleries can play a vital role in supplementing crop nutrition. In India, there are 290 distilleries producing 2.75 billion litres of alcohol., The spent wash of 10 to 15 litres is generated from every litre of alcohol production [2], [1]. The spent wash is used for power generation resulting in the release of treated sugarcane distillery effluent (TDE) which has nutrient potential for crops grown in normal soils as it contains large quantities of soluble organic matter and plant nutrients that could be used by crops for their growth and yield [6]. However, the contribution of TDE for nutrient supply to improve rice productivity needs to be studied in detail. Hence, the present investigation was carried out to study the effect of graded levels of TDE with graded levels of soil test based NPK on the growth and yield of rice in sandy clay loam soil under sub-merged condition.

II. Materials And Methods

A field experiment with rice under submerged condition was conducted in field No: B2-B at central farm of Agricultural Engineering College and Research Institute, Kumulur, Tamilnadu, India with latitude of 10° 56' N and longitude of 78° 49' E at the altitude 70 M MSL. The initial characteristics of experimental soil were sandy clay loam texture with pH of 7.4 and EC of 0.1 dS m^{-1}. The initial soil available NPK content was 191.3, 17.8 and 135 kg ha^{-1}, respectively. Based on the above status the NPK requirement for rice, based on DSSIFER (Decision support system for fertilizer recommendation) module was arrived as 88.9 kg ha^{-1} N, 39.5 kg ha^{-1} P_2O_5 and 39.5 kg ha^{-1} K_2O. The experimental plots were randomized based on split-plot design with two replications and each experimental plot size was of 5×4 m (0.5 cents). The main plot treatments imposed were TDE @ 0,

10,000, 20,000, 30,000 and 40,000 l ha^{-1}. The TDE was sprinkled using rose can for uniform distribution. The calculated quantity of NPK @ 0, 25, 50, 75 and 100 per cent based on DSSIFER module was applied to each sub-plot. The 25 days old rice cultivar BPT-5204 seedlings were transplanted in the main field with a spacing of 25 × 25 cm @ two seedlings per hill. The grain and straw yield were calculated based on the plot yield at harvest and expressed at 14 per cent moisture. The initial soil pH and EC was determined by using 1:2 soil water suspension and extract using pH meter and conductivity meter, respectively [3]. The soil texture was determined by international pipette method [5]. The plant samples were collected randomly at harvest stage and cleaned with de-mineralized water and separated grain and straw and oven dried at 65° C for 72 hours and powdered in Wiley mill. The powdered samples were analysed for N, P and K contents using standard procedures [3]. The uptake was calculated by using nutrient content and DMP (Dry matter production) of grain and straw {Nutrient uptake (kg ha^{-1}) = Nutrient content (%) × DMP (kg ha^{-1})/100}.The experimental data were subjected to statistical scrutiny by using SAS software.

III. Results And Discussion

The result of the field experiment revealed that grain yield of rice was significantly influenced by the addition of TDE as well as graded level of soil test based NPK. The grain yield ranged from 3222 kg ha^{-1} to 6019 kg ha^{-1} . The interaction of TDE with graded levels of NPK significantly increased the grain yield. The highest grain yield of 6019 kg ha^{-1} was recorded by the addition of TDE @ 40,000 l ha^{-1} with 100 per cent NPK which was on par with the application of TDE @40,000 l ha^{-1} with 75per cent NPK (5966 kg ha^{-1}). The control recorded the lowest yield of 3222 kg ha^{-1} (Table 1). The increase in grain yield was attributed to the positive influence on the yield parameters viz. number of productive tillers, number of filled grains and thousand grain weight of the rice by the addition of TDE with inorganic fertilizer. The mean yield increase was observed with a tune of 38.6 percent over control. The increase in grain yield was also attributed by the supply and availability of essential nutrient elements in balanced way by the addition of TDE with inorganic fertilizer.

The straw yield was found to be attributed with the influence of growth parameters viz. plant height and number of tillers. The yield response of straw for the different treatment effects in main and interaction were found to be exactly in the same line as found in grain yield. The straw yield ranged from 4571 kg ha^{-1} to 8292 kg ha^{-1} due to the imposition of different treatments. Interaction of graded levels of NPK with different main treatments resulted significant increase in straw yield. Application of 40,000 l ha^{-1} of TDE with 100 per cent NPK recorded the highest yield (8292 kg ha^{-1}) which was on par with the application of TDE@ 30,000 l ha^{-1} + 75 per cent NPK (8139 kg ha^{-1}) (Table 1). Among all the treatments, application of TDE @ 40,000 l ha^{-1} recorded the highest straw yield with the tune of 31.8 percent over control. Similar results were also reported by [2], [4].

The application of TDE @ 40,000 l ha^{-1} with 100 per cent NPK significantly increased the N uptake in grains. The highest N uptake of 43.6 Kg ha^{-1} was obtained in TDE @ 40,000 l ha^{-1} + 100 per cent NPK over control which recorded only 6.2 Kg ha^{-1} . Similar to the grain uptake, the N uptake in straw also gets influenced by the application of TDE with graded levels of NPK. The highest N uptake of 67.6 Kg ha^{-1} in straw was obtained in TDE @ 40,000 l ha^{-1} + 100 per cent NPK over control which recorded only 20.7 Kg ha^{-1} (Table 1). The significant rise in the uptake of N by rice was due to the combined effect of higher yield and increased absorption. The supply of organic form nitrogen from effluent might have enhanced the vegetative growth and increased the N uptake. Organic material acting as slow release helps in increase in uptake. The findings are in line up with the findings of [4].

The highest P uptake of 10.9 Kg ha^{-1} in grains was observed by the addition of TDE @ 40,000 l ha^{-1} with 100 per cent NPK over control which recorded the least uptake of 3.4 kg ha^{-1}. Similar to the uptake of P in grain, the highest P uptake of 17.9 kg ha^{-1} in straw was also recorded by the application of TDE @ 40,000 l ha^{-1} with 100 per cent NPK over control which recorded the lowest uptake of 6.2 kg ha^{-1} (Table 1). The supply of all essential nutrients by TDE might have increased the dry matter production of the crop which was also responsible for increase in uptake of P. The solubilization of native insoluble P due to the organic acids released from the distillery effluent increased the P availability which in turn increased the P uptake by rice crop. These findings were corroborated with the findings of [4].

The K uptake of rice grains was also increased from 7.9 kg ha^{-1} to 34.6 kg ha^{-1} . Application of TDE @ 40,000 l ha^{-1} with 100 per cent NPK recorded the highest K uptake of 34.6 kg ha^{-1} over rest of the treatments. Similarly, the K uptake in straw was also increased from 21.3 to 60.1 Kg ha^{-1}. The highest mean K uptake was recorded in the treatment which received 40,000 l ha^{-1} of TDE (53.0 kg ha^{-1}). In graded level of NPK treatments the uptake of K by straw was high at 100 per cent NPK (46.3 kg ha^{-1}). The highest K uptake of 60.1 kg ha^{-1} in straw was obtained by the addition of TDE @ 40,000 l ha^{-1} + 100 per cent NPK over control which recorded the lowest uptake of 21.3 Kg ha^{-1} (Table 1). In general the TDE is rich in potassium and used as a K nutrient source. This TDE application gradually builds up the potassium content in the soil and the soil pool supplies K as and when the plant needs. The improvement of soil fertility by the application of TDE was also observed by [1]. Similar findings were also reported by [4].

IV. Conclusions

The TDE applied @ 40,000 l ha^{-1} in rice grown in sandy clay loam soil saved 25 per cent of NPK fertilizer costs besides, increasing the yield by 1,038 kg ha^{-1}. The grain yield increase was 38.6 per cent over control Therefore, application of treated sugarcane distillery effluent to rice as a nutrient source helps to improve productivity on sustainable basis.

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TABLE I
EFFECT OF GRADED LEVELS OF TDE WITH GRADED LEVELS OF SOIL TEST BASED NPK ON YIELD AND NUTRIENT UPTAKE OF RICE

Main-plot treatments	Sub-plot treatments	Grain Yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Nitrogen Uptake (kg ha^{-1})		Phosphorus Uptake (kg ha^{-1})		Potassium Uptake (kg ha^{-1})	
				Grain	Straw	Grain	Straw	Grain	Straw
Control	0% NPK	3222	4571	6.2	20.7	3.4	6.2	7.9	21.3
	25% NPK	3776	5675	9.6	27.6	3.9	7.9	9.9	26.9
	50% NPK	4287	6285	12.6	32.9	4.6	8.9	12.6	30.5
	75% NPK	4686	6480	14.2	34.9	5.1	9.2	14.7	32.7
	100% NPK	4981	6630	15.6	36.4	5.5	9.6	16.2	34.9
TDE @ 10,000 l ha^{-1}	0% NPK	3832	5631	12.8	29.1	4.2	8.0	12.7	27.5
	25% NPK	4216	5911	15.7	32.4	4.7	8.6	12.9	30.5
	50% NPK	4673	6265	17.7	36.3	5.2	9.2	14.7	33.5
	75% NPK	4972	6530	19.3	38.8	5.6	9.7	16.1	36.2
	100% NPK	5209	6770	21.1	40.5	5.9	9.8	17.4	38.9
TDE @ 20,000 l ha^{-1}	0% NPK	4429	6263	18.1	35.6	5.6	9.9	15.2	34.2
	25% NPK	4828	6827	20.5	41.9	6.2	10.8	17.6	38.6
	50% NPK	5139	7139	22.8	46.5	6.7	11.4	20.3	41.8
	75% NPK	5342	7262	24.5	48.4	6.9	11.7	22.7	43.2
	100% NPK	5463	7508	25.4	51.4	7.2	12.5	23.7	46.2
TDE @ 30,000 l ha^{-1}	0% NPK	5027	6827	24.6	42.7	7.3	12.7	20.4	40.6
	25% NPK	5207	7285	26.3	48.8	7.7	13.7	22.6	44.9
	50% NPK	5375	7563	28.5	53.4	7.9	14.3	24.4	48.0
	75% NPK	5548	7772	29.9	54.8	8.3	14.8	26.9	50.2
	100% NPK	5698	7882	32.2	57.2	8.6	15.1	29.3	51.7
TDE @ 40,000 l ha^{-1}	0% NPK	5513	7227	32.8	49.9	9.6	14.1	26.2	45.9
	25% NPK	5700	7519	37.3	53.1	10.2	14.7	28.7	49.3
	50% NPK	5878	7913	39.4	59.4	10.5	15.7	31.2	53.4
	75% NPK	5966	8139	41.5	62.3	10.8	27.2	33.1	56.6
	100% NPK	6019	8292	43.6	67.6	10.9	17.9	34.6	60.1
CD (P=0.05)	**TDE**	**146.7**	**133.0**	**1.86**	**1.02**	**0.09**	**0.71**	**0.58**	**1.40**
	NPK	**24.8**	**157.4**	**0.38**	**0.86**	**0.05**	**0.32**	**0.46**	**0.98**
	TDE at NPK	**154.2**	**340.4**	**2.00**	**1.98**	**0.14**	**0.95**	**1.07**	**2.40**
	NPK at TDE	**55.6**	**352.1**	**0.86**	**1.91**	**0.12**	**0.71**	**1.02**	**2.21**