ENGINEERING AND TECHNOLOGY IN INDIA
Volume 2 Issue (1&2); (April & October, 2011); Page : 32-36

RESEARCH ARTICLE

Received: *may, 2011;* ***Revised :*** *Aug., 2011;****Accepted:*** *sep.., 2011*

Influence of industrial wastes on growth, yield and yield attributing characters of rice

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ABSTRACT

The present investigation was undertaken with an objective to study the utilization of industrial solid and liquid wastes in the cultivation of rice (*Oryza sativa* L.) in the net house of Agricultural and Food Engineering department, I. I. T., Kharagpur. The results revealed that the growth, yield attributing characters and yield increased considerably by the combined application of rice mill water with chemical fertilizer and FYM @ 5 t ha^{-1}. However, combined application of industrial solid wastes with MW and CF was found to be more effective than their individual application alone. Among the treatments, the maximum grain yield was recorded under MW + FYM + CF. The increase in grain yield was associated with increase in number of panicles per pot and grains per panicle. The maximum uptake of N and P by rice was found in case of CF alone whereas for K it was in case of MW + FYM. The results further revealed that application of chemical fertilizer could be dispensed with by the application of rice mill water in required quantity and at regular interval during the growing period of the crop.

Gaikwad, S.P. and Kaute, M.H. (2011).Influence of industrial wastes on growth, yield and yield attributing characters of rice. *Engg. & Tech. in India,* **2** (1&2) : 32-36.

Key words : Completely randomized design,Yield, Yield attributing characters, Fly ash, Rice husk ash, Mill waste water

INTRODUCTION

Industrial wastes which are often the cause of environmental pollution can be used after treatment or mixing with organic sources as soil amendment or enrichment to improve the land productivity. Wastes of rice mills and fly ash of thermal power plants are now available in abundance. Among the available industrial wastes, only 3 to 5 per cent are being utilized in our country, whereas in many developing countries about 50 to 60 per cent of these industrial wastes are being utilized. It is found that rice mill waste water is a source of essential plant nutrients.

Its proper utilization can prevent environmental pollution as well as help to improve agricultural production by increasing the nutrient uptake and ultimately the yield. Properly planned use of waste water alleviates surface water pollution problems and not only conserves valuable water resources but also takes advantage of the nutrients contained in it to grow crops. The availability of this additional water near population sources will increase the choice of crops which farmers can grow. The nitrogen and phosphorus content of this water might reduce or eliminate the requirements for chemical fertilizers. It is generally accepted that wastewater use in agriculture is justified on agronomic and economic grounds but care must be taken to minimize adverse health and environmental impacts. Rice (*Oryza sativa* L.) is the most important crop grown in rainfed lowland areas of the sub-continent and also of south East Asia. Cost of fertilizers constitutes about 50 to 60 per cent of the cost of production of rice under different conditions (Mandal *et al.*, 1990). This necessitates use of low cost or zero cost industrial wastes as source of nutrients for enriching soil to increase production at a reduced cost of cultivation. Keeping this in mind and also the importance of industrial wastes and waste water, the present experiment was carried out to

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study the influence of industrial wastes on growth, yield and yield attributes and nutrient uptake of rice.

MATERIALS AND METHODS

The present investigation was carried out in pots in the net house of the Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur. The climate in this part of the country is tropical, warm and humid. The average annual rainfall ranges from 1000 to 1500 mm. The soil is classified as acid-lateritic and sandy-clay-loam type. Rice variety IR-36 was grown as a test crop. The study included the use of rice mill waste water as well as solid industrial wastes *viz.,* fly ash (0.05 % N, 0.03 % P, 0.12% K and 0.97% OC), rice husk ash (0.06 %N, 0.26 %P, 0.12 %K and 6.97 % OC), farm yard manure (1.28 %N, 0.35 %P, 0.46 %K and 27.0 % OC) and inorganic fertilizers were applied with or without chemical fertilizers (CF) and farm yard manure (FYM) to supply a uniform recommended dose of nutrients *i.e.* 100 kg N, 26.2 kg P and 33.33 kg K, per hectare, to rice crop in all the treatments except control. The fertilizers N, P and K were supplied through urea, single super phosphate and muriate of potash, respectively. Urea was applied in three splits (half at the time of transplanting as a basal dose and the remaining half in two equal splits after 1 month and 2 months, as top dressing) whereas, phosphorus and potassium were applied at the time of transplanting as a single basal dose. The quantity of rice-mill waste water was decided on the basis of nitrogen content in it and was applied at 7 days interval, to meet the required quantity of nitrogen. The design adopted was completely randomized block with three replications. The treatment (T_1 to T_{12}) details are given below:

T_1 = Control, T_2 = CF (N_{100} P^*_{60} K^*_{40} kg ha^{-1}), T_3 = FA_{10} + CF (N_{95} $P^*_{53.2}$ $K^*_{25.6}$ kg ha^{-1}), T_4 = RHA_5 + CF (N_{97} $P^*_{30.25}$ $K^*_{32.8}$ kg ha^{-1}), T_5 = FYM_5 + CF (N_{36} $P^*_{19.95}$ $K^*_{12.4}$ kg ha^{-1}), T_6 = FA_{10} + FYM_5 + CF (N_{31} $P^*_{13.15}$ kg ha^{-1}), T_7 = RHA_5 + FYM_5 + CF (N_{33} $K^*_{5.2}$ kg ha^{-1}) T_8 = MW (28.57 l) + CF (N_{50} P^*_{35} kg ha^{-1}), T_9 = MW (14.28 l) + FYM_5 + CF ($N_{11.01}$ $P^*_{7.45}$ kg ha^{-1}), T_{10} = MW (57.14 l), T_{11} = MW (28.57 l) + RHA_5 + CF (N_{47} P^*_5 kg ha^{-1}), T_{12} = MW (20.57 l) + FYM_5

(Values as suffix for FA, RHA and FYM are in t ha^{-1})

$P^* = P_2O_5$, $K^* = K_2O$

Mill-water was applied at 7 day's interval to supply 8.33 kg per hectare nitrogen each time. It contains micronutrients in ppm *viz*., Zn (0.129), Mn (1.452), Cu (0.037) Fe (0.437) Ca (1.2) and Mg (4.648). Fly ash and rice husk ash were incorporated into the soil 10 days before transplanting. Required quantity of waste water was collected from the rice mill at regular interval. The waste water was applied soon after it was brought from the rice mill. Application commenced from the date of puddling (transplanting) and continued till 80 DAT (maturity of the crop).

In all 36 glazed, China-clay big size (diameter = 45 cm and height = 60 cm) pots were selected and all the pots were cleaned and arranged in three rows. Equal quantity of air-dry soil, by weight, was filled in each pot by keeping top 10 cm portion free for maintaining required depth of submergence (5 ± 2 cm). The soil was puddle by hand 2 days before transplanting. Four healthy, uniform size seedlings of 27 days age were transplanted per hill. Five hills were accommodated with 15 cm hill-to-hill spacing in each pot. Fertilizer dose of 100 kg N, 26.2 kg P and 33.33 kg K per ha, were common in all the treatments except control. Nitrogen was applied in three splits, while phosphorus and potassium were applied as basal dose at the time of transplanting. Fly ash and rice husk ash as well as FYM were incorporated into the soil 10 days before transplanting. In all the pots rain water was not allowed to enter by providing a cover with transparent polythene on the net house top. Irrigation was stopped 7 days before the maturity of the crop and all the water was allowed to recede to facilitate the harvesting operation. Preventive plant protection measures were taken by applying phorate granules @ 10 kg ha^{-1} at the time of transplanting. Dusting was done with B.H.C. 10 per cent @ 25 kg ha^{-1} twice during flowering stage at an interval of 5 to 7 days to protect the crop from gandhi bug (*Leptocoriza varicornis*). Biometric observations on plant height, tillers, and grains per panicle, test weight, grain and straw yield were recorded periodically. Chemical analysis of plant samples was carried out for uptake studies. Harvesting was done at about 20 per cent moisture content of rice grain. Each pot harvest was kept separately and was dried under sun for two days. Thereafter, each pot harvest was threshed manually by hand. The threshed produce was cleaned and weighed and the grain and straw yields were recorded.

Statistical analysis:

The data recorded from the pot experiments were subjected to statistical analysis by the standard analysis of variance technique.The treatments differences were tested at 5 per cent level of significance by F- test.

RESULTS AND ANALYSIS

the results of the present study as well as relevant discussions have been presented under following sub heads:

Table 1: Plant height (cm) and number of tillers (per pot) of rice as affected by different treatments

Treatments	Plant height (cm)			Number of tillers/pot		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Control	48.46	73.36	84.66	44.0	43.33	43.33
CF	53.06	79.56	89.03	47.33	46.66	47.0
FA + CF	51.63	77.16	88.43	49.33	48.33	48.33
RHA + CF	52.13	77.23	89.16	49.0	48.33	48.33
FYM + CF	51.36	77.56	87.63	48.33	48.33	48.66
FYM + FA + CF	42.46	77.43	90.36	50.0	48.33	48.33
FYM + RHA + CF	51.9	77.3	87.6	46.33	45.0	45.33
MW + CF	53.76	79.66	91.3	53.0	51.66	51.66
MW + FYM + CF	52.9	80.43	91.83	52.0	50.0	50.0
MW	53.7	80.1	91.86	50.33	50.0	50.33
MW + RHA + CF	53.3	79.6	90.83	49.66	48.33	48.33
MW + FYM	52.2	78.53	90.36	47.66	46.66	47.0
SEM (±)	0.5	0.76	0.65	1.53	0.31	1.53
C. D (0.05)	1.45	2.22	1.91	4.49	0.92	4.49

In all the treatments balanced $N_{100,}$ P^*_{60} and K^*_{40} was supplied through chemical fertilizer
Values as suffix in each treatment are in t ha^{-1}, except N, P and K, $P^* = P_2O_5$, $K^* = K_2O$

Growth characters of rice:

Plant height and tiller number as growth parameters were considered to study the performance of rice. Data on plant height and number of tillers per pot recorded at 30, 60 and 90 days after transplanting are presented in Table 1. It is revealed from the data that there was significant increase in both the growth parameters in all the treatments as compared to that of control. These observations clearly indicate the beneficial effect of combined application of either mill water or other industrial wastes like fly ash or rice husk ash along with chemical fertilizer and /or farm yard manure in promoting the growth of rice. The growth of the plants with respect to plant height and number of tillers per pot improved by the application of mill water and / or FA @ 10 t/ha or RHA @ 5 t/ha in combination with FYM @ 5 t/ha and / or CF. The increase application of FA_{10}, FYM_5 and RHA_5 in combination with CF indicated that the plants remained photo-synthetically most active and utilized the available N, P and K very efficiently. In the process of puddling of the soil, the fly ash, FYM and rice husk ash could be incorporated and mixed with the soil, might have stimulated bio-chemical activities and improved soil nutrient supplying capacity. Moreover, under submerged and reduced field condition of rice, slow but steady rate of solubilization of essential plant nutrients possibly maintained a desired level of available nutrients and met the requirements of the crop during its active growing period and hence proved to be beneficial.

Yield and yield attributing characters:

The data on yield contributing characters like number of panicles per pot, number of grains per panicle and test weight (1000grain weight) are presented in Table 2. The number of panicles considerably increased in all the treatments as compared to control. Maximum number of panicles (51.66 per pot) was recorded in MW + CF which was significantly superior to the other treatments. Also, industrial waste treatments with mill water showed greater number of panicles than other treatments and control. The highest number of grains (73.00) per panicle was observed in the treatment MW + FYM + CF. It also observed that

Table 2: Yield attributing characters of rice as affected by different treatments

Treatments	Number of panicles per pot	Number of grains per panicle	Test weight, (g)*
Control	43.33	56.33	19.81
CF	47.0	71.0	20.1
FA + CF	48.33	70.66	20.03
RHA + CF	48.33	71.33	19.95
FYM + CF	48.66	71.33	19.85
FYM + FA + CF	48.33	71.66	19.97
FYM + RHA + CF	45.33	71.0	20.2
MW + CF	51.66	70.66	20.14
MW + FYM + CF	50.0	73.0	19.91
MW	50.33	71.66	20.5
MW + RHA + CF	48.33	71.0	20.01
MW + FYM	47.0	69.66	19.96
SEM (±)	1.53	1.49	0.09
C. D (0.05)	4.49	4.36	0.27

In all the treatments balanced $N_{100,}$ P^*_{60} and K^*_{40} was supplied through chemical fertilizer
Values as suffix in each treatment are in t ha^{-1}, except N, P and k
*1000 grain weight, $P^* = P_2O_5$, $K^* = K_2O$

there was significant increase in number of grains per panicle in all treatments as compared to control. However, the test weight did not show any significant variation owing to the treatments. Improvement in growth and nutrient uptake of the crop under combined sources of fertilization with industrial liquid or solid wastes obviously improved the important yield contributing characters.

Yield performance:

Data on the effect of different treatments on grain and straw yield and grain: straw ratios of rice are presented in Table 3.

Table 3: Grain and straw yield, g (per pot) and grain: straw ratio of rice as affected by different treatments

Treatments	Grain yield	Straw yield	Grain : Straw ratio
Control	48.95	75	0.65
CF	67.34 (37.57)	92.5	0.73
FA + CF	69.89 (42.78)	94.7	0.74
RHA + CF	69.83 (42.66)	94.5	0.74
FYM + CF	68.99 (40.94)	92.9	0.74
FYM + FA + CF	71.72 (46.52)	96.1	0.75
FYM + RHA + CF	66.02 (34.87)	91.7	0.72
MW + CF	75.09 (53.40)	100.1	0.75
MW + FYM + CF	76.33 (55.93)	100.3	0.76
MW	73.94 (51.05)	99.7	0.74
MW + RHA + CF	70.37 (43.76)	95.1	0.74
MW + FYM	66.69 (36.24)	94.2	0.71
SEM (±)	2.91 (1.55)	3.06	0.06
C. D (0.05)	8.53 (4.32)	4.32	0.18

In all the treatments balanced $N_{100,}$ P^*_{60} and K^*_{40} was supplied through chemical fertilizer
Values as suffix in each treatment are in t ha^{-1}, except N, P and k
Observation at harvest
Values in parenthesis are in per cent increase over control.
$P^* = P_2O_{5,}$ $K^* = K_2O$

Grain and straw yield:

It is apparent from the observations that the yield under different treatments was significantly higher over control. The increase in yield ranged from 34.87 to 55.93 per cent. However, highest grain yield of 76.33 g per pot (55.93 % increase) was observed in MW + FYM + CF. Also there was increase in yield in treatments with rice mill waste water than in those without it. The straw yield followed almost a similar trend as that of grain yield in all the treatments. It is clear from the observations of yield performance of the crop that application of mill water benefited the crop most. Also it is revealed from the observations that application of fly ash @ 10 t ha^{-1} rice husk ash @ 5 t ha^{-1} and FYM @ 5t ha^{-1} along with chemical fertilizers improved the rice yield significantly over control. The effect of these treatments could be supported by the increase in number of panicles per pot, number of grains per panicle and grain and straw yield. It was further observed that, as compared to control, the improvement in yield components and yield was of varying degree in all the treatments even though the total fertilizer dose of N was maintained uniformly (100 kg ha^{-1}). This may be due to differential supply of P, K and other essential plant nutrients which were supplied differently by different sources as is evident from the analysis.

It is revealed that mill water improved soil fertility by alleviating deficiency of nutrients of the soil. Improved crop performance and nutrient uptake of the crop in acid-lateritic soil can be an indication of the same. There was significant improvement in growth as well as yield when fly ash or rice husk ash and FYM were added in addition to CF or MW. Thus justifying the need of organic matter addition to the acid lateritic soil.

The treatment MW alone or MW + CF was found to be most effective in increasing plant height as well as number of tillers over all other treatments. The other promising combinations for increasing these growth parameters were MW + FYM + CF, MW + RHA + CF and FYM + FA + CF. The maximum plant height and number of tillers were 91.86 cm and 51.66 with treatments MW and MW + CF, respectively.

Application of MW + FYM + CF was found to be better over all the other treatments in increasing number of panicles, grains per panicle and test weight. The maximum number of panicles per pot was 51.66 and grains per panicle 73.0 as noted under the treatment MW + FYM + CF. The treatments MW + CF, MW, FYM + FA + CF, FYM + CF and RHA + CF were also found to be very effective in increasing all the yield attributing characters of rice.

The maximum grain yield 76.33 g per pot (55.93 per cent increase over control) and straw yield 100.3 (33.73 per cent increase over control) was under MW + FYM + CF. The other promising treatments in increasing grain and straw yield were MW + CF, MW, FYM + RHA + CF, MW + RHA + CF and MW + FYM. The increase in yield under CF alone was significant as compared to control. However, this treatment was comparatively inferior to the combined treatments. In other words, under integrated fertilization including MW, there was increase in yield by 9.8 per cent over CF alone. It was interesting to note that under the treatment MW alone, the rice yield was comparable to CF alone to a large extent.

The results further revealed that application of chemical fertilizer can be dispensed with by the application of rice mill water alone in required quantity at regular interval of 7 days at the rate equivalent to 8.33 kg N ha^{-1} each time.

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