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Effect of Graded Levels of Incineration Ash as a Source of Manure on Growth, Yield and Nutrient uptake in Paddy (*Oryza sativa*)

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Abstract

Incineration ash is a by-product of sugar industry produced during cogeneration process to produce heat and electrical energy by burning concentrated spent wash at higher temperature in a multi-fuel boiler along with supporting fuel bagasse or coal was used to study its effect on growth and yield of paddy (KRH-4). The present study was conducted in sandy clay soil imposed with graded levels of incineration ash and FYM (5 and 10 t ha^{-1}) in different combinations along with recommended dose of fertilizers during *Kharif* 2017 consisting of seven treatments, each with three replications and laid out in a randomized complete block design. The incineration ash had high pH and EC with appreciable amounts of plant nutrients *i.e.,* K (14.25%), Ca (1.80%), Mg (2.80%), S (3.94%) and micro nutrients. The results of the experiment indicated that the number of tillers at 60 days after transplanting, yield attributes like number of tillers per hill (17.67), number of productive tillers per hill (12.93), number of filled grains per panicle (317), grain yield (9056 kg ha^{-1}), straw yield (10154 kg ha^{-1}) and uptake of major nutrients like N, P and K by both grain and straw were found to be significantly higher with application of recommended dose of fertilizers along with 10 t ha^{-1} of incineration ash and 10 t ha^{-1} of FYM. Thus, combined application of incineration ash and FYM along with recommended dose of fertilizers found to increase the growth, yield and nutrient uptake in paddy.

Keywords: Incineration ash, FYM, Paddy, Growth, Yield

Sugar industry, being one of the largest agro-based industries in India, generating large quantity of spent wash. Spent wash being used in cogeneration process to meet the zero liquid discharge, from the sugar industry wherein the burning of it at higher temperature results in production of byproduct called incineration ash, wherein the disposal of this is a major problem. This ash was mainly used in manufacturing bricks, cement, ceramic industry (Jun et al., 2017) and other civil construction materials.

It is anticipated that by 2025 A.D, India will need around 310 MT of food grain to feed 1500 million people and the greater production in future has to come from higher productivity per unit land. Approaches have to be developed to get higher productivity and also sustain it in the long run. Development of technologies which could use the incineration ash for crop production will simultaneously answer the issue of disposal of incineration ash and also increasing the agricultural productivity. Application of chemical fertilizers in combination with organic manures is often recommended for the farmers in order to maintain soil fertility & productivity. Traditionally, farm yard manure is the major organic source, but now its availability is limited. On the other hand, the price of commercial fertilizers has been increasing year by year.

Under such conditions complementary use of plant nutrients from locally available waste materials along with mineral fertilizers attained greater importance to reduce input cost and to sustain soil fertility. It is to be proved that incineration ash is a source of plant nutrient with respect to type of crop and soil with possible research. Hence, this experiment is designed to study the effect of integrated use of incineration ash and FYM at different levels on growth, yield and nutrient uptake in paddy.

Material and Methods

The incineration ash collected from sugar factory and FYM were analyzed for physico-chemical properties

like pH and EC by following potentiometric and conductometric method (Jackson, 1973). The ash was digested and analyzed for total major, secondary and micronutrients. Total N concentration was determined using Kjeldahl digestion and distillation method. The ash was subjected to diacid digestion and estimated for total P (Colorimentry using vanadomolybdate reagent), K and Na (Flame Photometry), Ca and Mg (Versenate titration method), S (Turbidometric method) as given by Piper (1966). Micronutrients (Atomic Absorption Spectrophotometry) and B (Colorimetry using Azomethane-H reagent with continuous flow analyzer) analyzed by standard procedures as given by Lindsay and Norvell (1978) and Page *et al.* (1982), respectively.

The incineration ash used in the experiment contained more of silt sized particles with alkaline reaction. Electrical conductivity of 7.3 dS m^{-1} with low in OC, total N and P but it contains appreciable amount of total K, Ca, Mg, S and micronutrients (Table 2).

Soil sample from the experimental site (initial and after harvest of crop) was collected, processed and analysed for physical parameters (Table 1) [soil texture (International pipette method), Bulk density (Core sampler method)] as given by Piper (1966) and CEC by Sodium acetate leaching method (Jackson, 1973). The chemical parameters like pH and EC were determined by Potentiometric and Conductometric methods, respectively (Jackson, 1973), while OC content was estimated by wet oxidation method (Walkley and Black, 1934). Available N, P_2O_5, K_2O and Na were determined by alkaline potassium permanganate method (Subbiah and Asija, 1956), Olsen's extractant method, Flame photometry, respectively. The secondary nutrients like exchangeable Ca, Mg and available S were analyzed by Versenate titration method (Jackson, 1973) and Turbidometric method (Black, 1965), respectively. DTPA extractable micronutrients like Fe, Mn, Cu and Zn were determined using Atomic absorption spectrophotometry (Lindsay and Norvell, 1978) and hot water extractable B by Colorimetry using Azomethine-H reagent (John *et al.,* 1975).

TABLE 1

Initial physical and chemical properties of the experimental soil

Particulars	Value	Particulars	Value
Textural class	Sandy clay	Exchangeable Ca (c mol (p^+) kg^{-1})	12.10
pH (1:2.5)	8.37	Exchangeable Mg (c mol (p^+) kg^{-1})	3.90
EC (dS m^{-1})	0.23	Available S (mg kg^{-1})	25.39
Organic carbon (g kg^{-1})	8.30	DTPA extractable Fe (mg kg^{-1})	49.68
Available Nitrogen (kg ha^{-1})	226	DTPA extractable Mn (mg kg^{-1})	5.49
Available P_2O_5 (kg ha^{-1})	179	DTPA extractable Cu (mg kg^{-1})	5.00
Available K_2O (kg ha^{-1})	212	DTPA extractable Zn (mg kg^{-1})	1.76
Exchangeable Sodium (%)	0.04	Hot water extractable B (mg kg^{-1})	0.68

TABLE 2

Physico-chemical properties of incineration ash and FYM

Particulars	Incineration ash	FYM
pH (1:10)	10.77	7.65
EC (dS m^{-1}) (1:100)	7.30	0.61
Total N (%)	0.45	0.67
Total P (%)	0.23	0.44
Total K (%)	14.25	0.59
Total Na (%)	0.92	-
Total Ca (%)	1.80	0.60
Total Mg (%)	2.80	0.16
Total S (%)	3.94	0.21
Total Fe (mg kg^{-1})	14290	0.24
Total Mn (mg kg^{-1})	406.8	164.5
Total Cu (mg kg^{-1})	37.80	25.23
Total Zn (mg kg^{-1})	53.40	19.25
Total B (mg kg^{-1})	175.5	6.35
Texture	Silt Loam	-
Bulk density (Mg m^{-3})	0.60	-
MWHC (%)	65.10	-

Field experiment was conducted during the year 2017 in *kharif* season at M/s Chamundeshwari Sugars Ltd. Bharathinagar, Maddur taluk, located in Mandya District, Southern Dry Zone of Karnataka with an altitude of 662 meters above the mean sea level to study the effect of incineration ash on crop growth and yield in paddy. Paddy (KRH-4) was chosen as a test crop applied with recommended dose of fertilizers 125:62.5:62.5 kg N:P_2O_5:K_2O ha^{-1} FYM at the rate of 10 t ha^{-1}.

Twenty-five-days-old paddy seedlings of KRH-4 hybrid were transplanted at a spacing of 22.5 cm between the rows and 10 cm between the plants. The incineration ash was used in the treatments contained more of silt sized particles, alkaline in reaction with high EC was applied 15 days before transplanting. Experiment was conducted with seven treatments, replicated thrice and the treatment details as mentioned below.

Treatment details

T_1 : RDF + 5 t IA ha^{-1}

T_2 : RDF + 10 t IA ha^{-1}

T_3 : RDF + 5 t of FYM ha^{-1}+ 5 t IA ha^{-1}

T_4 : RDF + 5 t of FYM ha^{-1}+ 10 t IA ha^{-1}

T_5 : RDF + 10 t of FYM ha^{-1}+ 5 t IA ha^{-1}

T_6 : RDF + 10 t of FYM ha^{-1}+ 10 t IA ha^{-1}

T_7 : POP (RDF + FYM at 10 t ha^{-1})

Note: RDF- Recommended Dose of Fertilizers
IA- Incineration Ash
FYM- Farmyard Manure
POP - Package of Practice

Growth observations were recorded at an interval of 30, 60, 90 DAT (Days After Transplanting) and at harvest of the paddy crop. Grain and straw yields, yield attributes like panicle length, number of panicles hill^{-1}, number of filled and unfilled grains panicle^{-1} and test weight were recorded after harvest of the crop. Per cent increase in yield by treatments over control was assessed by F- test and harvest index was calculated as given by Donald and Humblin, 1976.

$$\text{Harvest Index (HI)} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

The identified and labeled plant samples (grain and straw) used for recording growth and yield observations were sampled and analyzed for nutrient content. Samples were dried in hot air oven at 65°C and were powdered using micro willey mill. The samples were estimated for major nutrients content by adopting standard methods and procedure as mentioned for incineration ash and FYM. The nutrient uptake was calculated using the following formula,

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%)}}{100} \times \text{Biomass (kg ha}^{-1}\text{)}$$

The analysis and interpretation of the data was done using Fisher's method of analysis and variance technique as given by Panse and Sukhatme (1967).

Results and Discussion

Results obtained during the investigation are presented here with the supported discussions.

Plant Growth Parameters

The data pertaining to plant height (cm), number of tillers and productive tillers per hill as influenced by graded levels of incineration ash and FYM were presented in the Table 3. No significant variation in the plant height was noticed at different growth stages of paddy.

However, plant heights at different intervals were slightly higher in the treatments with recommended dose of fertilizers and higher rates of incineration ash with 100 per cent recommended dose of FYM, followed by 50 per cent recommended dose of FYM which might be due to balanced supply of nutrients. Buddhe *et al.* (2014) also reported increase in plant height of three native species of wheat treated with bagasse ash.

The number of tillers per hill was found to be non-significant at 30 DAT. However, higher number of tillers and productive tillers per hill (17.67 and 12.93) were noticed with the application of 10 t ha^{-1} of FYM

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TABLE 3

Effect of graded levels of incineration ash and FYM on growth parameters of paddy at different intervals

Treatments	Plant height (cm)				No. of tillers per hill		No. of productive tillers per	
	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest
T_1	21.86	69.73	71.97	74.93	7.01	14.14	10.27	10.27
T_2	22.07	71.20	72.21	75.17	7.12	14.93	10.73	10.73
T_3	21.90	71.53	72.30	75.27	7.27	15.60	11.20	11.20
T_4	22.90	73.37	73.73	76.33	8.93	17.27	12.33	12.33
T_5	23.67	72.77	75.50	75.73	7.60	16.93	12.07	12.07
T_6	24.87	74.61	76.27	77.58	7.67	17.67	12.93	12.93
T_7	22.47	72.30	72.70	75.27	8.00	15.31	10.73	10.73
S. Em. ±	1.30	2.82	1.46	1.46	0.92	0.68	0.62	0.62
CD @ 5%	NS	NS	NS	NS	NS	2.08	1.90	1.90

and 10 t ha^{-1} of IA along with RDF (T_6) both at 60 DAT and at harvest followed by T_4 (17.27) and T_5 (16.93) which were imposed with RDF + 5.0 t of FYM + 10 t ha^{-1} IA and RDF + 10 t of FYM + 5.0 t ha^{-1} IA, respectively. The lower number of tillers and productive tillers (14.14 and 10.27) were noticed in T_1 (RDF + 5.0 t ha^{-1} IA) at 60 DAT and at harvest, respectively. The increase in number of tillers m^{-2} and number of productive tillers m^{-2} in paddy was not only due to the improvement in soil physical and chemical properties due to application of FYM but also due to correction of deficiency of some of the essential major and micronutrients after application of incineration ash to soil (Hamsa, 2017).

Grain yield, straw yield, yield parameters, harvest index and crude protein content of paddy as affected by graded levels of IA and FYM are presented in Table 4.

The yield and yield parameters of paddy were increased with increased rates of incineration ash application along with RDF and the increase was further improved with the combined application of FYM and incineration ash. However, significantly higher grain and straw yield

TABLE 4

Effect of graded levels of incineration ash and FYM on yield and yield attributes of paddy

Treatments	Panicle length(cm)	No. of grains filledpanicle^{-1}	No. of unfilled grains panicle^{-1}	Test weight (g)	Harvest Index	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Crude protein (%)
T_1	20.05	223	57	19.51	0.47	4986	5574	8.25
T_2	19.34	247	44	19.25	0.46	6381	7486	8.69
T_3	19.46	269	48	20.09	0.47	8095	9193	8.88
T_4	20.01	304	44	19.82	0.47	8823	9861	9.69
T_5	18.59	283	45	20.16	0.48	8662	9548	10.19
T_6	20.00	317	43	20.33	0.47	9056	10154	10.56
T_7	20.10	225	45	19.76	0.47	5539	6358	9.13
S. Em. ±	0.55	13	2.06	1.18	0.018	90.17	111.8	0.98
CD @ 5%	NS	40	NS	NS	NS	270.5	343.3	NS

(9056 and 10154 kg ha^{-1}) was recorded in T_6 with combined application of 10 t ha^{-1} of IA and 10 t ha^{-1} of FYM along with RDF, the increase in grain and straw yield with the treatment T_6 over control treatment T_7 (POP) was found to be 63.55 and 59.70 per cent, respectively. Yields obtained from control plot imposed with RDF and FYM (POP) was found to be significantly higher compared to application of 5 t ha^{-1} of incineration ash along with RDF and it showed 9.98 and 12.33 per cent decrease in grain and straw yield, respectively over the control treatment. The lowest grain and straw yield (4986 and 5574kg ha^{-1}) was recorded in T_1 (RDF + 5.0 t ha^{-1} IA) (Table 4).

The yield attributes like panicle length, number of unfilled grains per panicle, test weight, harvest index and crude protein content were found statistically non-significant. However, the number of filled grains per panicle were found statistically significant wherein, higher (317) value was recorded with the application of 10 t ha^{-1} of IA and 10 t ha^{-1} of FYM along with RDF (T_6) and lower value (223) was recorded with the application of RDF and 5 t ha^{-1} of incineration ash (T_1).

The positive effect on yield and yield parameters due to combined use of incineration ash, chemical fertilizers and FYM might be due to improvement in the availability of plant nutrients and balanced supply of nutrients through organic manures and inorganic fertilizers (Das *et al.,* 2013) that might have induced the cell division, expansion of cell wall, meristematic activity, photosynthetic efficiency, increased nutrient absorption by increased root activity. This resulted in better growth and development of crop, increased fertile panicles and number of filled grains per panicle and this led to increased grain and straw yield of crop.

The results were also in accordance with that of Jamil *et al.* (2007) who reported that increased number of tillers m^{-2} as well as productive tillers m^{-2}, number of grains spike^{-1} and 1000 grain weight in wheat were attributed to improvement in soil physical and chemical conditions and nutrients availability, which ultimately resulted in enhanced grain and straw yield and alleviation of deficiency of some of the essential nutrients. The lower yields were obtained in the absence of FYM and with lower rates of incineration ash, this might be because of insufficient amount of carbon and nutrient supply resulting in decreased activity of micro organisms to mineralize the organic matter and solubilize the unavailable or insoluble forms of nutrients.

Nutrient uptake by grain and straw of paddy

The results pertaining to uptake of N, P and K by both grain and straw were presented in Table 5. The N, P

TABLE 5

Effect of graded levels of incineration ash and FYM on major nutrient uptake by paddy grain and straw

Treatments	Total N uptake (kg ha^{-1})		Total P uptake (kg ha^{-1})		Total K uptake (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1	65.82	40.69	11.47	7.80	70.30	121.5
T_2	88.70	79.35	19.78	11.98	96.99	163.9
T_3	114.9	91.01	22.67	13.79	120.6	204.1
T_4	136.8	116.4	36.17	18.74	136.8	224.8
T_5	141.2	114.6	31.18	16.23	129.9	214.8
T_6	153.0	138.1	47.09	21.32	148.5	233.5
T_7	80.87	61.04	14.40	8.90	69.79	119.5
S. Em. ±	18.30	16.80	2.96	1.68	6.81	12.93
CD @ 5 %	56.40	50.40	8.89	5.03	20.92	39.83

and K uptake by paddy increased with increased levels of incineration ash and FYM. Significantly higher N (153.0 kg ha^{-1} and 138.1 kg ha^{-1}), P (47.09 kg ha^{-1} and 21.32 kg ha^{-1}) and K (148.5 kg ha^{-1} and 233.5 kg ha^{-1}) uptake by both grain and straw, respectively were recorded with the application of 10 t ha^{-1} of FYM and 10 t ha^{-1} IA along with RDF. Lower N and P uptake by both grain and straw was recorded with application of 5 t ha^{-1} of incineration ash along with RDF, whereas lower K uptake by both grain and straw was recorded with application of RDF along with RD of FYM (POP).

The nutrient uptake (N, P and K) is influenced by productive capacity of soil, nutrient concentration of plant and plant biomass. As the crop yields were higher in the treatments applied with higher rates of incineration ash and FYM along with chemical fertilizers, it is obvious that uptake was also higher. In addition, incineration ash and FYM contained appreciable amount of N, P and K and the addition of those in large quantity (10 t ha^{-1}) along with RDF might have increased the content of these nutrients in the soil and their uptake by the crop. The production of organic acids, increased mineralization rates associated with the application of incineration ash and FYM might have increased the dissolution, release and uptake of both native and applied nutrients by the crop. The above results were in conformity with those reported by Surekha (2005) and Hamsa (2018).

Thus, the present study revealed that growth, yield and nutrient uptake of paddy crop was superior with integrated use of chemical fertilizers, organic manures and incineration ash treated compared to other treatments which clearly revealed that incineration ash can act as a good source of plant nutrients.

Incineration ash could be a source of plant nutrients and it could be used in agriculture for crop production. The major attribute which makes incineration ash suitable for agriculture is its composition where it contains almost all the essential plant nutrients which helped to improve the soil fertility and crop productivity.

The present study showed significant increase in growth and yield without any adverse effect on soil health or crop. Thus, the overall study indicates an ample scope for utilization of incineration ash as an input material for agriculture application but care should be taken on the quantity applied. If incineration ash use is recommended, it would improve soil health and crop productivity in the long run and at the same time the problem of disposal of huge amount of incineration ash from sugar industry will also be minimized.

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