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Effect of fly ash and bagasse ash on biological properties of soil, nutrient uptake and economics of wheat in an Inceptisol

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Abstract
A field experiment was conducted during the year 2016-17 at the Post Graduate Institute Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, to study the "Effect of fly ash and bagasse ash on soil properties, yield and quality of wheat in an Inceptisol". The experimental soil belongs to Masala series of Inceptisol order (*Vertic Haplustept*), the soil was moderately alkaline with medium status of organic carbon and high in calcium carbonate content. Low in available N, medium in available P, very high in available K and deficient in Zn and Fe. Application of various levels of fly ash and bagasse ash significantly increased the pH and EC of soil at crown root initiation stage and at harvest stage. The higher DHA and bacterial population was observed in both the treatments of application of 125% K_2O through bagasse ash at crown root initiation and harvest stage. The highest N, P, K uptake in wheat crop was also observed to be highest in treatment of application of 50 kg ha^{-1} K_2O through bagasse ash along with recommended dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM (T_7). The higher net monetary returns (Rs. 41406/- and Rs. 39028/-) were recorded in treatments of application of bagasse ash @ 13.02 and 10.41 q ha^{-1}, respectively in soil for the supplementation of K_2O @ 50 and 40 kg ha^{-1}, respectively. The same trend was also observed in benefit: cost ratio which was found higher in treatments of T_7 (1.86) followed by T_8 (1.81).

Keywords: Fly ash bagasse ash biological properties DHA NPK uptake economics of wheat

Introduction
Fly ash-a coal combustion residue of thermal power plants has been regarded as the problematic solid waste all over the world. The dust collection system removes the fly ash, as a fine particulate residue, from the combustion gases before they are discharged into the atmosphere.

The management of fly ash has been troublesome in view of its disposal because of its potential of causing pollution of air and water.

They revealed that application of coal ash increase the yield of cereal crops to 15 to 20 per cent, sugarcane to 20 to 30 per cent, maize to 40 per cent, red gram to 50 per cent, potato to 25 per cent, plantation crops to 30 per cent, mustard and vegetable to 10 per cent. Besides increasing the yields of crops it also improved nutrient uptake in plants it improves the yield of variety of agricultural crops and biological properties of soil.

Bagasse ash is one of the organic waste obtained from sugar industries during the process of sugar manufacturing. Bagasse ash poses a significant environmental problem. Sugarcane production in India is over 300 million tons/year leaving about 10 million tonnes of as unutilized and hence, waste material.

Bagasse ash use in agriculture as organic fertilizer for crop production is now-a-days becoming an established practice.

Ash from co-combustion of sugarcane bagasse with wood proved to be providing nutrients to plants. Plants grown on ash amended soils achieved greater biomass production compared to control or treatments using other soil amendments.

Material and Methods
Details of field experiment
The representative soil samples were collected plot wise to assess the initial soil fertility status of experimental plot. The experiment was laid out in a randomized block design (Fig. 1) with 10 treatments and 3 replications.

The gross plot size was 3.6m. x 3.2m. And net plot size was 3.15m. x 3.0m. The recommended inter row spacing of 22.5 cm was adopted.

The general recommended fertilizer dose of wheat is 120:60:40 kg ha^{-1} N, P_2O_5 and K_2O respectively along with FYM @10 t ha^{-1}. All the nutrients, fly ash and bagasse and FYM were added in soil as per treatment. The treatment comprised of:

T_1 : Absolute control
T_2 : GRDF (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM)
T_3 : GRDF of N & P_2O_5 + 125% K_2O through fly ash
T_4 : GRDF of N & P_2O_5 + 100% K_2O through fly ash
T_5 : GRDF of N & P_2O_5 + 75% K_2O through fly ash
T_6 : GRDF of N & P_2O_5 + 50% K_2O through fly ash
T_7 : GRDF of N & P_2O_5 + 125% K_2O through bagasse ash
T_8 : GRDF of N & P_2O_5 + 100% K_2O through bagasse ash
T_9 : GRDF of N & P_2O_5 + 75% K_2O through bagasse ash
T_{10} : GRDF of N & P_2O_5 + 50% K_2O through bagasse ash

Healthy wheat seeds of variety Samadhan, recently released by university obtained from Chief Seed Sale Counter, M.P.K.V, Rahuri.

The recommended dose of fertilizers for wheat was 120:60:40 kg ha^{-1} N, P_2O_5 and K_2O. The N was given through urea, P through single super phosphate and K_2O through muriate of potash in T_2 treatment, however K_2O was given @ 50, 40, 30 and 20 kg ha^{-1} through fly ash in T_3 to T_6 and bagasse ash in treatments of T_3 to $T_{10,}$ respectively. Organic manures i.e. farm yard manure was given @ 10 t ha^{-1} to all the treatments except T_1 treatment (Absolute control).

In order to study biological properties of soil, before the beginning of the experiment, a representative composite soil sample was collected from experimental field. Surface soil samples (0-15cm) were drawn before sowing, at crown root initiation and after harvest of the wheat crop. The soil samples were collected in polythene bags which were used for analysis of biological properties

Results and Discussion

The DHA, total bacterial, total fungal and total actinomycetes population in soil as influenced by application of fly ash and bagasse ash at initial, CRI and harvest stage are presented in table 1. And depicted in fig. 1

The DHA in soil showed 20.97 µg TPF g^{-1} 24 hr^{-1} at initial stage, however, it significantly increased at CRI and harvest stage. The DHA in soil was found significantly higher in treatment of T_7 (25.63 µg TPF g^{-1} 24 hr^{-1}) over all treatments at CRI stage. The same trend was also found at harvest stage. This might be due to higher content of total organic carbon content (3.38%) in bagasse ash which reflected in higher biological activity in soil.

Table 1: Dehydrogenase activity and total bacterial count in soil as influenced by application of fly ash and bagasse ash in soil

T. No	DHA (µg TPF g^{-1} 24 hr^{-1})			Total bacterial count (x 10^6 cfu g^{-1} of soil)		
	Initial	CRI	Harvest	Initial	CRI	Harvest
T_1	21.84	19.80	19.79	21.67	20.67	20.33
T_2	21.10	21.45	20.72	21.67	24.67	24.33
T_3	20.57	24.47	23.56	21.00	45.00	43.00
T_4	21.77	23.33	23.38	22.33	42.00	41.33
T_5	20.08	21.40	23.11	22.67	29.00	31.67
T_6	20.94	20.04	21.44	21.67	30.33	29.00
T_7	20.66	25.63	25.58	21.67	46.00	44.33
T_8	20.06	24.34	21.77	21.33	41.33	35.00
T_9	20.72	21.07	20.08	21.67	35.00	34.67
T_{10}	21.96	20.06	19.33	22.00	31.67	29.33
S.E.(±)		0.38	0.36		1.03	0.78
CD at 5%		1.15	1.09		3.08	2.33

Total bacterial population in soil showed 21.77 x 10^6 cfu g^{-1} of soil at initial stage but it significantly showed difrences at CRI and harvest stage. Total bacterial population in soil was found significantly higher in T_7 (46.00 x 10^6 cfu $g^{-1}$of soil) over all the treatments except treatment T_3 (45.00 x 10^6 cfu g^{-1} of soil) which was at par CRI stage. The same trend was also found at harvest stage. (44.33 x 10^6 cfu g^{-1} of soil).

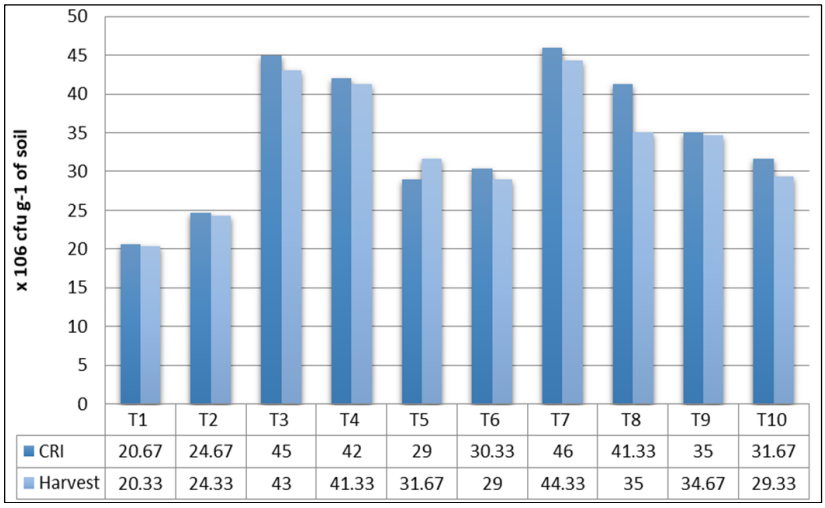

Fig 1: Total bacterial count as influenced by application of Fly ash and bagasse ash in soil at CRI and harvest of wheat.

The total nitrogen, phosphorous and potassium uptake by wheat as influenced by application of fly ash and bagasse ash are presented in table 2 and depicted in fig. 2.

The total nitrogen uptake by wheat was found significantly higher in treatment T_7 (178.24 kg ha^{-1}) over all the treatments except T_3 (167.37 kg ha^{-1}) which was at par. The increase in total uptake of nitrogen by wheat crop may be application of bagasse ash due to increased in K uptake by wheat crop of having synergistic effect of N and K.

Table 2: Total nutrient uptake by wheat as influenced by soil application of fly ash and bagasse ash

T. No	Treatment	Total Uptake (kg ha^{-1})		
		N	P	K
T_1	Absolute control	90.44	14.06	51.98
T_2	GRDF (120:60:40 kg ha^{-1} N:P_2O_5:K_2O + 10 t ha^{-1} FYM)	157.79	21.32	78.73
T_3	GRDF of N & P_2O_5 + 125% K_2O through fly ash	167.37	26.22	108.06
T_4	GRDF of N & P_2O_5 + 100% K_2O through fly ash	157.12	26.04	103.04
T_5	GRDF of N & P_2O_5 + 75% K_2O through fly ash	135.69	22.65	90.73
T_6	GRDF of N & P_2O_5 + 50% K_2O through fly ash	129.56	19.86	85.72
T_7	GRDF of N & P_2O_5 + 125% K_2O through bagasse ash	178.24	36.65	121.64
T_8	GRDF of N & P_2O_5 + 100% K_2O through bagasse ash	165.15	31.02	111.45
T_9	GRDF of N & P_2O_5 + 75% K_2O through bagasse ash	157.06	29.26	104.35
T_{10}	GRDF of N & P_2O_5 + 50% K_2O through bagasse ash	151.57	28.46	106.41
	SE (±)	4.37	0.70	2.76
	CD at 5%	12.99	2.08	8.20

The total phosphorous uptake by wheat was found significantly higher in treatment of T_7 (36.65 kg ha^{-1}) over all the treatments.

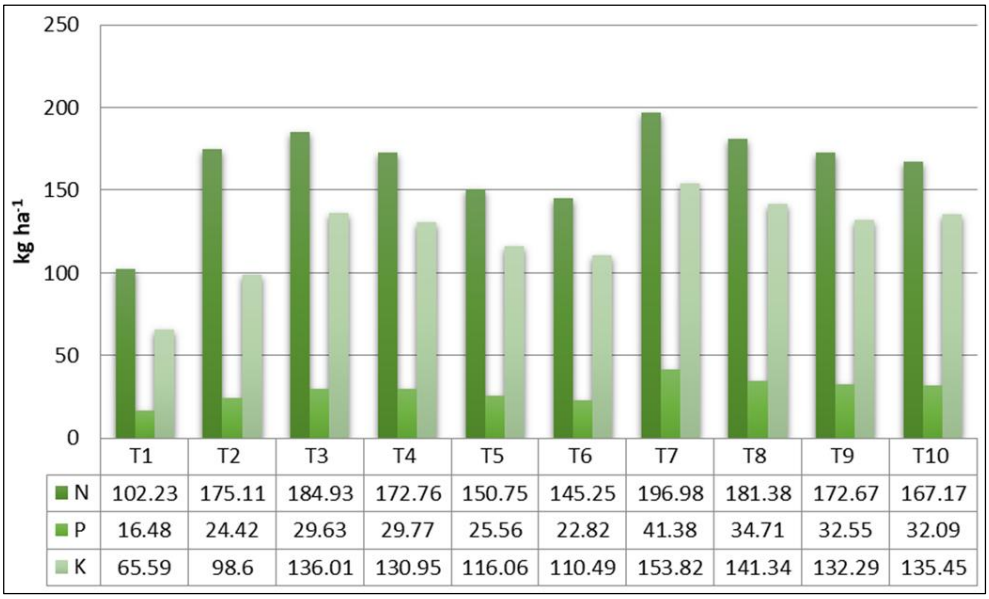

Fig 2: Total N, P and K uptake (kg ha^{-1}) by wheat as influenced by application of fly ash and bagasse ash in soil

The total potassium uptake by wheat was found significantly higher in application of higher levels of bagasse ash in treatment T_7 (121.64 kg ha^{-1}) over all the treatments. This might be due to high content of K_2O in bagasse ash. The similar results were also reported by Pita *et al*. (2012) [9].

Economics of wheat as influenced by application of fly ash and bagasse ash in soil are reported in table 3. The cost of cultivation was found higher in treatment of T_6 and T_{10} (Rs. 48816/-), however it was lowest in control treatment (Rs. 31188/-). The gross monetory return was recorded highest in treatment of T_7 (Rs. 89639/-) followed by treatment T_8 (Rs. 87455/-). The net monetory return was recorded highest in T_8 treatment (Rs. 41406/-), however, it was recorded lowest in control treatment (Rs. 28066/-). The B: C ratio was recorded the highest in treatment of control treatment (1.90) followed by treatment of T_7 and T_8 (1.86 and 1.81, respectively).

Table 3: Economics of wheat as influenced by application of fly ash and bagasse ash in soil

T. No	Treatment	Cost of cultivation	Gross monetory returns	Net monetary returns	Benefit: Cost Ratio
		Rs.ha^{-1}			
T_1	Absolute control	31188	59254	28066	1.90
T_2	GRDF (120:60:40 kg ha^{-1} N:P_2O_5:K_2O + 10 t ha^{-1} FYM)	48454	84485	36031	1.74
T_3	GRDF of N & P_2O_5 + 125% K_2O through fly ash	48233	86166	37933	1.79
T_4	GRDF of N & P_2O_5 + 100% K_2O through fly ash	48427	85285	36858	1.76
T_5	GRDF of N & P_2O_5 + 75% K_2O through fly ash	48622	81108	32486	1.67
T_6	GRDF of N & P_2O_5 + 50% K_2O through fly ash	48816	79844	31028	1.64

T_7	GRDF of N & P_2O_5 + 125% K_2O through bagasse ash	48233	89639	41406	1.86
T_8	GRDF of N & P_2O_5 + 100% K_2O through bagasse ash	48427	87455	39028	1.81
T_9	GRDF of N & P_2O_5 + 75% K_2O through bagasse ash	48622	85974	37352	1.77
T_{10}	GRDF of N & P_2O_5 + 50% K_2O through bagasse ash	48816	84332	35516	1.73
	SE (+)				
	CD at 5%				

Note: Rs.13.04 kg^{-1} N, Rs.48.75 kg^{-1} P_2O_5, Rs 19.43 kg^{-1} K_2O, Rs.1200 t^{-1} FYM, Rs. 1850 q^{-1} grain, Rs 190 q^{-1} straw, Transport cost of Rs.750/50 km for fly and bagasse ash.

Summary and Conclusion

The DHA in soil was significantly higher due to bagasse ash treatment (T_7, 25.63 µg TPF g^{-1} 24 hr^{-1}) at harvest stage. Total bacterial population in soil was significantly higher in (T_7, 46.00 x 10^6 cfu $g^{-1}$of soil) at crown root initiation stage. The same trend was also found at harvest stage. Total fungal population in soil was significantly higher in (T_7, 7.67 x 10^5 cfu g^{-1} of soil) at crown root initiation stage.

Total nitrogen, phosphorous and potassium uptake by wheat crop was found significantly increased (178.24, 36.65 and 121.64 kg ha^{-1}, respectively) due to application of 125% K_2O through bagasse ash with recomonded dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM.

The higher net monetory returns (Rs. 41406/- and Rs. 39028/) were recorded in treatments of bagasse ash @ 13.02 and 10.41 q ha^{-1} in soil for the suplimentation of K_2O @ 50 and 40 kg ha^{-1}, respective. The similar treatment showed the higher benefit: cost ratio of 1.86 and 1.81, respectively.

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