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Effect of fly ash and bagasse ash on physico-chemical properties of soil and yield 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 carbonat 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 K_2O through fly ash in soil noticed negative effect on physical properties of soil *viz*., increased in bulk density, COLE value and decreased in hydraulic conductivity of soil. 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 organic carbon content in soil as influenced by application of fly ash and bagasse ash showed non significant results at all the growth stages of wheat crop.The highest agronomic efficiency 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 grain and straw yield of wheat was significantly higher (42.92 and 53.88 q ha^{-1}) in treatment of application of 125 % K_2O through bagasse ash along with recomonded dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM. However, this treatment was at par with the application of fly ash and GRDF treatment.

Keywords: Fly ash, bagasse ash, physical properties, chemical properties, yield of wheat, agronomic efficiency

Introduction

Every year Indian thermal power plants produce more than 100 million tones of fly ash, which is expected to reach 200 million tonnes in near future and their disposal is a major problem all over the world due to limited use and possible toxic outcomes. While having look on recent fly ash production (2016-17) in India, we will found it is around 180 million tonnes and its utilization is around 62 per cent. The management of fly ash has been troublesome in view of its disposal because of its potential of causing pollution of air and water

Fly ash has a great potentiality in agriculture due to its efficacy in modification of soil health and performance.

Practical value of fly ash in agriculture especially in wheat can be established after repeated field experiments. Bakri *et al.* (2012) [3] reported 0.85 per cent K_2O in fly ash. Arivazhagan *et al*. (2011) [2] studied the effect of coal fly ash on agricultural crops. They stated that use of coal fly ash in agriculture is one way of disposal of fly ash and at the same time it improves the yield of variety of agricultural crops and physico-chemical properties of soil Bagasse ash is one of the organic waste obtained from sugar industries during the process of sugar manufacturing. After crushing and extracting juice from sugar cane, the remaining pulp (bagasse) is burnt under boilers for heating the juice and power generation. The material left behind after burning of bagasse, the ash obtained is called as 'Cogenerated Bagasse Ash' which 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 soil additive in agriculture due to its capacity to supply the plants with small amounts of nutrients (Carlson and Adriano, 1993) [4]. Bagasse ash contains high concentrations of K and P without nitrogen (Page *et al*., 1979) [10], therefore, its use in agriculture for crop production will be proved more beneficia

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 3.6 m. x 3.2 m. and net plot size was 3.15 m. x 3.0 m. 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 the physical and chemical properties of soil, before the beginning of the experiment, a representative composite soil sample was collected from experimental field. Surface soil samples (0-15 cm) were drawn before sowing, at crown root initiation and after harvest of the wheat crop.

Results and Discussion
The bulk density, hydraulic conductivity and COLE values as influenced by application of fly ash and bagasse ash at initial, CRI and harvest stage are presented in table 1 and fig.1.

The bulk density of soil did not show any significant difference at CRI stage however, singnificantly influenced at harvest. The bulk density of soil showed significantly higher in application of fly ash treatment of T_3 (1.36 Mg m^{-3}) over all the treatment except treatment T_4 (1.33 Mg m^{-3}) and T_7 (1.34 Mg m^{-3}) which were at par. The incresed in bulk density of soil at harvest due to application of higher level of fly ash in soil may be due to fine particles of fly ash resulted in clogging of micropores of soil. Which also reflected in slight decreased in hydraulic conductivity of soil in same treatment.

Table 1: Physical properties of soil as influenced by application of fly ash and bagasse ash in soil

Tr. No.	Bulk density (Mg m^{-3})			Hydraulic conductivity (cm h^{-1})			COLE value		
	Initial	CRI	Harvest	Initial	CRI	Harvest	Initial	CRI	Harvest
T_1	1.28	1.26	1.28	0.61	0.60	0.58	0.20	0.19	0.20
T_2	1.28	1.27	1.26	0.62	0.62	0.60	0.19	0.22	0.21
T_3	1.29	1.32	1.36	0.61	0.51	0.48	0.20	0.31	0.32
T_4	1.28	1.30	1.33	0.62	0.56	0.50	0.19	0.29	0.29
T_5	1.28	1.28	1.30	0.61	0.56	0.49	0.20	0.30	0.31
T_6	1.29	1.27	1.28	0.59	0.58	0.51	0.20	0.27	0.29
T_7	1.28	1.31	1.34	0.60	0.68	0.67	0.20	0.28	0.30
T_8	1.28	1.29	1.30	0.62	0.64	0.62	0.19	0.26	0.28
T_9	1.29	1.31	1.32	0.61	0.61	0.58	0.20	0.26	0.26
T_{10}	1.28	1.28	1.29	0.61	0.62	0.56	0.19	0.22	0.24
SE($\pm$)		0.01	0.01		0.01	0.01		0.01	0.01
CD at 5%		NS	0.04		0.05	0.04		0.03	0.04

The hydraulic conductivity of initial soil was moderately low (0.61 cm h^{-1}) however, it was significantly decreased due to application of fly ash treatment of T_3 (0.51 cm h^{-1}) at CRI stage over all the treatments. The hydraulic conductivity was slightly increased in treatments of bagasse ash as compared to treatments of application of fly ash however, the treatment T_7 (0.68 cm h^{-1}) showed the highest hydraulic conductivity as compared to all treatments. The same trend was also found at harvest stage.

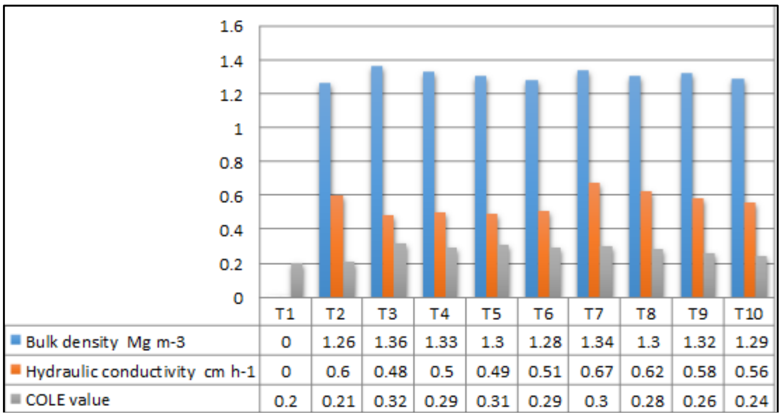

Fig. 1: Physical properties of soil as influenced by application of fly ash and bagasse ash in soil at harvest of wheat.

The COLE value of soil showed swell-shrink nature of soil (0.20), it was significantly increased in treatment of fly ash and bagasse ash at CRI and harvest stage. The COLE value was found significantly higher in treatments of T_3 (0.31) at CRI and harvest satge, respectively over all treatments except T_3 which was at par with T_4 (0.29) and T_7 (0.30) at CRI and also treatment T_3 (0.32) was at par with T_4 to T_7 at harvest. The COLE value of soil was found higher in treatments of application of fly ash as compared to the treatments of application of bagasse ash. This might be due to very strongly alkaline pH, low electric conductivity and finess of fly ash particle. These findings are in concomitance with Salahudeen and Ochepo (2015) [12], Raymohapatra (2015) [11] and Sharma and Rajwar (2016) [13].

The soil pH, EC and organic carbon content in soil as influenced by application of fly ash and bagasse ash at initial, CRI and harvest stage are presented in table.2

The soil pH was found non significant at initial stage however, the significant results were found in CRI and harvest stage, the soil pH at CRI stage was significantly increased in treatment T_3 (8.40) over all treatments except T_4 to T_7 which were at par. Slightly increased in soil pH might be due to presence of secondary and small quantities of micronutrients with oxides forms in fly ash and bagasse ash. Application of bagasse ash treatment showed comparatively low pH value as compared to treatments of application of fly ash. This might be due to high electrolyte concentration of bagasse ash (EC 2.50 dS m^{-1}). The same trend was also found at harvest stage.

Table 2: Soil chemical properties as influenced by application of fly ash and bagasse ash in soil

Tr. No.	pH (1:2.5)			EC (dS m^{-1})			Organic carbon (%)		
	Initial	CRI	Harvest	Initial	CRI	Harvest	Initial	CRI	Harvest
T_1	8.32	8.30	8.31	0.25	0.24	0.26	0.58	0.58	0.56
T_2	8.30	8.27	8.28	0.26	0.30	0.29	0.60	0.62	0.61
T_3	8.32	8.40	8.41	0.25	0.39	0.37	0.58	0.60	0.60
T_4	8.31	8.38	8.40	0.27	0.36	0.34	0.58	0.60	0.60
T_5	8.32	8.36	8.38	0.26	0.32	0.31	0.58	0.61	0.58
T_6	8.30	8.38	8.40	0.25	0.30	0.29	0.60	0.62	0.60
T_7	8.31	8.34	8.36	0.27	0.44	0.41	0.56	0.64	0.62
T_8	8.30	8.32	8.33	0.26	0.43	0.39	0.58	0.62	0.61
T_9	8.30	8.32	8.30	0.25	0.40	0.37	0.58	0.61	0.60
T_{10}	8.31	8.30	8.32	0.25	0.38	0.35	0.60	0.62	0.58
SE($\pm$)		0.02	0.01		0.02	0.02		0.01	0.01
CD at 5%		0.07	0.04		0.06	0.06		NS	NS

The EC of soil showed normal in value (0.26 dS m^{-1}) at initial stage however, it significantly influenced at CRI and harvest. The EC of soil significantly increased in treatment of T_7 (0.44 dS m^{-1}) over all the treatments except T_3, T_8 and T_9, which were at par. The higher EC in soil application of bagasse ash treatment of T_7, T_8 and T_9 may be due to higher EC of bagasse ash (EC 2.50 dS m^{-1}), the same trend was also found at harvest stage. The increase in soil pH and EC was also reported by Slims (1993) in acid soils.

The grain and straw yield of wheat as influenced by application of fly ash and bagasse ash are presented in table 3. and depicted in fig.2.

The grain yield of wheat was found significantly higher (42.92 q ha^{-1}) in treatment of N and P as per recommended dose and 125 % K_2O kg ha^{-1} through bagasse ash (13.02 q ha^{-1}) over T_1 and T_6. However, treatments T_2, T_3, T_4, T_8, T_9 and T_{10} were at par with T_7 treatments. This indicated that bagasse ash at increasing levels in combination with GRDF can be an alternative source of potassium nutrition to wheat crop.

Table 3: Grain and straw yield of wheat as influenced by application of fly ash and bagasse ash in soil

Tr. No.	Treatment	Yield (q ha^{-1})		Agronomic efficiency (kg kg^{-1})
		Grain	Straw	
T_1	Absolute control	27.61	43.03	-
T_2	GRDF (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM)	40.34	51.87	5.78
T_3	GRDF of N & P_2O_5 + 125% K_2O through fly ash	41.34	50.99	5.96
T_4	GRDF of N & P_2O_5 + 100% K_2O through fly ash	40.66	52.97	5.93
T_5	GRDF of N & P_2O_5 + 75% K_2O through fly ash	38.84	48.71	5.34
T_6	GRDF of N & P_2O_5 + 50% K_2O through fly ash	38.06	49.65	5.22
T_7	GRDF of N & P_2O_5 + 125% K_2O through bagasse ash	42.92	53.88	6.65
T_8	GRDF of N & P_2O_5 + 100% K_2O through bagasse ash	41.88	52.51	6.48
T_9	GRDF of N & P_2O_5 + 75% K_2O through bagasse ash	41.40	49.39	6.56
T_{10}	GRDF of N & P_2O_5 + 50% K_2O through bagasse ash	40.28	51.65	6.33
	SE ($\pm$)	1.46	1.67	
	CD at 5%	4.34	4.99	

In respect of fly ash at higher levels also found at par results for increased in grain yield of wheat but it has detrimental effect on soil chemical and physical properties of soil.

Matte and Kene (1995) [9], Selvakumari *et al*. (2000), Murugan and Vijayarangam. (2013) and Yeledhalli *et al*. (2008) were also reported similar increase in yield due to addition of fly as in several crops in acidic and lateritic soils.

Jamil *et al*. (2004) [8] also reported that, the application of bagasse ash @ 2.0 t ha^{-1} was found to be the most appropriate dose for higher yield of wheat in calcareous soil.

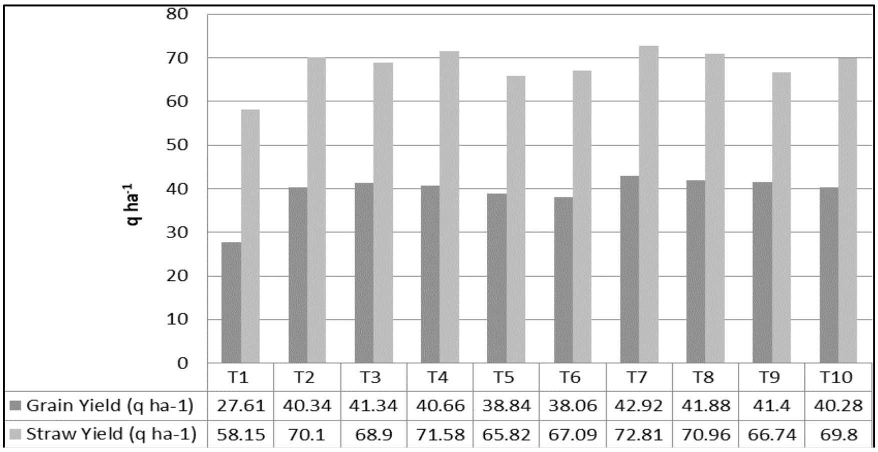

Fig 2: Grain and straw yield of wheat as influenced by application of fly ash and bagasse ash in soil

The straw yield of wheat was found significantly higher (53.88 q ha^{-1}) in treatment of T_7 (application of N and P as per recommended dose and K @ 50 kg ha^{-1} through bagasse ash) over T_1 and T_5 treatments, however, rest of the treatments were at par with T_7.

The agronomic efficiency is also one of the criteria for assessing the nutrient use efficiency which are reported in table 3. Which revealed that, the highest agronomic efficiency 6.65 kg kg^{-1} was obsereved in treatment of application of 125 % K_2O through bagasse ash followed by 75 % K_2O through bagasse ash. Application of higher levels of bagasse ash treatments were found increase in the agronomic efficiency as compared to GRDF and fly ash treatments.

Summary and Conclusion

The bulk density at CRI stage, showed non significant differences, however, at harvest it significantly increase (1.36 Mg m^{-3}) in treatment of T_3 (GRDF of N & P_2O_5 + 125 % K_2O through fly ash). The hydraulic conductivity of soil significantly decresed due to application of various levels of fly ash in soil. The higher levels of application of bagasse ash significantly increased the hydraulic conductivity of soil at crown root initiation and harvest stage.

COLE value of soil showed swell-shrink characteristics of soil and it was significantly higher in treatment of application of fly ash as compared to bagasse ash application treatment.

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 organic carbon content in soil as influenced by application of fly ash and bagasse ash showed non significant results at all the growth stages of wheat crop.

The grain and straw yield of wheat was significantly higher (42.92 and 53.88 q ha^{-1}) in treatment of application of 125 % K_2O through bagasse ash along with recomonded dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM. However, this treatment was at par with the application of fly ash and GRDF treatment.

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