International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; SP-8(6): 121-125

Received: 19-08-2020
Accepted: 21-10-2020

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Effect of fly ash, organic manure and fertilizers on nitrogen, phosphorus and potassium content in grain and straw in rice-wheat cropping system in *Alfisols* and *Vertisols*

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DOI: https://doi.org/10.22271/chemi.2020.v8.i6b.11061

Abstract
Field experiment was conducted under *Alfisols* at KVK, Farm Katghora , Korba and *Vertisols* at Instructional Farm Indira Gandhi Krishi Vishwavidyalaya, Raipur during 2011 and 2012.To assess the effect of different doses of fly ash alone or in combination with manure and fertilizers in rice –wheat cropping system with Sixteen treatments (i.e. T_1-Control, T_2- 10 t FA ha^{-1}, T_3-20 t FA ha^{-1} T_4-STCR (based fertilizer recommendation), T_5-75% NPK ha^{-1}, T_6-100% NPK (100:60:40), T_7-75% NPK ha^{-1}+ 10 t FA ha^{-1}, T_8-75%NPK ha^{-1} + 20 t FA ha^{-1}, T_9-100% NPK ha^{-1}+ 10 t FA ha^{-1}, T_{10}-100% NPK ha^{-1} + 20 t FA ha^{-1}, T_{11}-75% NPK ha^{-1}+ 5 t FYM ha^{-1}, T_{12}-100% NPK ha^{-1} +5 t FYM ha^{-1}, T_{13}- 75% NPK ha^{-1} + 5 t FYM +10 t FA, T_{14}- 75% NPK ha^{-1} + 5 t FYM +20 t FA ha^{-1}, T_{15}-100% NPK ha^{-1} +5 t FYM+10 t FA ha^{-1} and T_{16}- 100% NPK ha^{-1} +5 t FYM+20 t FA ha^{-1}) under Split Plot Design with factorial arrangment of crop and soil in main plot and treatment in sub plot.The nitrogen content significantly increases in grain and straw and treatmentT_{16} recorded highest N content and lowest in T_1. The phosphorus increases in both the crops under *Vertisol* whereas higher phosphorus content in straw was recorded in rice under *Alfisol* and wheat under *Vertisol*. Interaction of crops x soil x treatment is significantly significantly influenced due to application of fly ash alone or in combination with organic manure and fertilizers. Potassium content in grain and straw was significantly increases in rice and wheat. Treatment, T_{16} recorded highest potassium content in grain whereas highest potassium content in straw was recorded in T_{12} and lowest potassium content recorded in T_1.

Keywords: Fly ash, macro nutrient content, Rice-wheat cropping system

Introduction
In India and most of the country's major source of electrical energy is coal based thermal power plant, which produce 175 million tonnes, fly ash which would require about 40,000 hectares of land for the construction of ash ponds (Lal *et al.*, 2012) [3]. The ash production in India is expected to reach about 225 million tonnes per annum by 2017. In Chhattisgarh produces fly ash to the tone of about 26880 metric tons per day i.e. nearly 9.7 million tons of fly ash annually, out of which the four major Thermal Power Plants in Korba district alone generate about 24000 metric tons per day. Fly ash having excellent physico-chemical properties. The particle size distribution of fly ash is similar to silt or silt loam soil. It contains 35% sand, 55% silt, 10% clay with 13g kg^{-1} organic carbon, pH ranged from 4.5 to 12.0 depending on the silica-content of parental coal. Total N, P and K_2O content is 0.3% 1.5%, 0.09% respectively. Total Fe_2O_3 9%, Al_2O_3 2.3%, CaO 1.6% and SiO_2 73% (Maiti *et al*,. 1990) [4]. Fly ash consists of mineral matter which was uptake by plant from the soil. It can act as a secondary source of fertilizer nutrients like P ,K, Ca, Mg, S, Cu, Fe, Zn, Mn, Mo etc. (Totawat *et al*,. 2002) [6].

Material and Methods
The nitrogen content analysis of grain and straw sample was done by taking 0.5 gm uniform prepared sample in digestion tube to which 1 gm salt mixture (K_2SO_4 and $CuSO_4.5H_2O$ in the ratio of 10:1) and 10 ml. of concentrated H_2SO_4 acid was added and material was digested at 350 °C in digestion block till the solution becomes colorless.

Then the nitrogen in digested material was distilled by automatic KEL plus system. The phosphorus content was determined by vanadomolybdo-phosphoric acid yellow color complex method as described by Jackson (1967) [2]. The potassium content was determined by flame photometer as described by Chapman and Pratt (1961) [1].

Nitrogen content in grain and straw

The nitrogen content in grain and straw was significantly influenced due to application of fly ash alone or in combination with organic manure and fertilizers (Table 1). The higher nitrogen content in grain was recorded in both the crops under *Vertisol* during 2011, 2012 and pooled data. The wheat grain contains higher nitrogen content than rice. The treatments, $T_{16,}$ T_{15} recorded significantly highest nitrogen content during 2011 and T_{16} in 2012 and pooled data (Table 3). It was at par with treatment, T_{14}, T_{13} and T_{12} in 2011 however, T_{15}, T_{14}, T_{13} in 2012 and T_{15}, T_{14} in pooled data. The lowest nitrogen content was recorded in treatment T_1.

The higher nitrogen content in straw was recorded in rice under *Alfisol* during 2011, 2012 and pooled data (Table 1). However, higher nitrogen content in wheat straw was recorded in *Vertisol*. Table 4 shows that nitrogen content in straw was increased significantly due to application of fly ash with manure and fertilizers. The higher nitrogen content was recorded in treatment, T_{16} and T_{15} in 2011. It was at par with treatment, T_{14}, T_{13}, T_{12} and T_{10}. Similarly, treatments T_{16}, T_{15} andT_{14} recorded higher nitrogen content in straw in 2012. It was at par with treatment, T_{13}, T_{12} and T_{10}.In case of pooled data treatment, T_{16} recorded highest nitrogen content in straw and it was at par with treatment, T_{15} and T_{14}. The lowest nitrogen content was recorded in treatment T_1. This might be due to complimentary effect on N availability to rice and wheat through its growth. Which could also be attributed to good soil physical environment, thereby better root prolification due to fly ash addition.

Phosphorous content in grain and straw

The phosphorous content in grain was significantly influenced due to application of fly ash alone or in combination with organic manure and fertilizers, is shown in (Table 1). The higher phosphorous content in grain was recorded in both the crops under *Vertisol* during 2011, 2012 and pooled data. Table 5 the treatment, T_{16} recorded significantly highest phosphorous content during 2011and pooled data however, T_{14} recorded higher content of P in 2012. It was at par with treatment, T_{14}, T_{15} and T_{13} in 2011, and Treatment, T_{16}, $T_{15,}$ T_{13} and T_{12} in 2012 and T_{14}, T_{15} and T_{13} and T_{12} in pooled data. The lowest phosphorous content was recorded in treatment T_1.The interaction between crop × soil × treatment was non-significant.

The higher phosphorous content in straw was recorded in rice under *Alfisol* during 2011, 2012 and pooled data (Table 1). However, higher phosphorous content was recorded in wheat straw in *Vertisol* during 2011-12, 2012-13 and pooled data. Interaction between crop × soil × treatments reveals (Table 6) that, rice × *Vertisol* × treatment, T_{16} and T_{15} recorded significantly highest phosphorous content in straw among all the treatments and rice × *Alfisol* × treatment, T_{12} recorded highest phosphorous content in straw. It was at par with treatment, $T_{11,}$ T_{16}, T_{14}, T_9, T_{13} and T_{15} in rice × *Alfisol* × treatment. In case of wheat × *Vertisol* × treatment, T_{15} recorded significantly highest phosphorous content in straw among all the treatments, and it was at par with T_{16}, T_{14}, T_{10}, T_{13}, and T_{11}. However, highest phosphorous content in straw was recorded in T_{16} and it was at par with treatment, T_{14}, T_{12} and T_{10} in wheat × *Alfisol* × treatment. The lowest straw yield was recorded in treatment $T_{1.}$ This might be due to the supply of these nutrients by fly ash and P fertilizer. This could also be due to fly ash addition which might have further helped in creating soil favorable physical condition for root prolification and also solubilization of phosphorus due to spurt in biotic activity in soil. Similar findings were also reported by Selvakumari *et al* (2000) [5] and Warambhe *et al.* (1993) [7].

Table 1: Effect of fly ash alone or in combination with organic manure and fertilizers on nitrogen content in grain and straw in rice-wheat cropping system in *Alfisol* and *Vertisol* at harvest.

Particulars	Nitrogen content in grain (%)						Nitrogen content in straw (%)					
	2011-12		2012-13		Pooled		2011-12		2012-13		Pooled	
	Vertisol	*Alfisol*	*Vertisol*	*Alfisol*	*Vertisol*	*Alfisol*	*Vertisol*	*Alfisol*	*Vertisol*	*Alfisol*	*Vertisol*	*Alfisol*
Rice	1.11	1.10	1.10	1.09	1.11	1.10	0.55	0.57	0.55	0.57	0.55	0.57
Wheat	1.55	1.53	1.55	1.54	1.55	1.54	0.55	0.54	0.55	0.54	0.55	0.54
	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
A	0.002	0.005	0.006	0.021	0.003	0.012	0.002	0.006	0.003	0.011	0.002	0.007
B	0.002	0.005	0.006	N/A	0.003	0.012	0.002	N/A	0.003	N/A	0.002	N/A
A×B	0.002	N/A	0009	N/A	0.005	N/A	0.003	0.009	0.005	0.016	0.003	0.010

Table 2: Effect of fly ash alone or in combination with organic manure and fertilizers on phosphorous content in grain and straw in rice-wheat cropping system in *Alfisol* and *Vertisol* at harvest.

Particulars	Phosphorous content in grain (%)						Phosphorous content in straw (%)					
	2011		2012		Pooled		2011		2012		Pooled	
	Vertisol	*Alfisol*	*Vertisol*	*Alfisol*	*Vertisol*	*Alfisol*	*Vertisol*	*Alfisol*	*Vertisol*	*Alfisol*	*Vertisol*	*Alfisol*
Rice	0.24	0.23	0.24	.023	0.24	0.23	0.064	0.066	0.062	0.068	0.063	0.067
Wheat	0.31	0.30	0.32	0.30	0.31	0.30	0.067	0.060	0.070	0.064	0.069	0.062
	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at5%	SEm±	CD at 5%	SEm±	CD at 5%
A	0.003	0.009	0.001	0.004	0.001	0.004	0.001	N/A	0.001	N/A	0.001	N/A
B	0.003	N/A	0.001	0.004	0.001	0.004	0.001	N/A	0.001	N/A	0.001	N/A
A×B	0.004	N/A	0.002	N/A	0.002	N/A	0.002	N/A	0.001	0.004	0.001	0.003

Table 3: Effect of fly ash alone or in combination with organic manure and fertilizers on nitrogen content in grain in rice-wheat cropping system in *Alfisol* and *Vertisol* at harvest.

Treatments			Nitrogen content in grain (%)					
			2011		2012		Pooled	
T_1	-	Control	1.24		1.25^{f}		1.24^{i}	
T_2	-	10 t FA ha^{-1}	1.25		1.26^{e}		1.26^{h}	
T_3	-	20 t FA ha^{-1}	1.26		1.27^{e}		1.27^{g}	
T_4	-	STCR	1.30^{d}		1.31^{c}		1.30^{e}	
T_5	-	75%NPK ha^{-1}	1.30^{d}		1.29^{d}		1.29^{f}	
T_6	-	100% NPK ha^{-1}	1.32^{c}		1.32^{c}		1.32^{d}	
T_7	-	75%NPK ha^{-1}+10 t FA ha^{-1}	1.29^{e}		1.29^{d}		1.29^{f}	
T_8	-	75%NPK ha^{-1}+20 t FA ha^{-1}	1.30^{d}		1.30^{d}		1.30^{e}	
T_9	-	100%NPK ha^{-1}+10 t FA ha^{-1}	1.34^{b}		1.33^{c}		1.33^{d}	
T_{10}	-	100%NPK ha^{-1}+20 t FA ha^{-1}	1.34^{b}		1.34^{b}		1.34^{c}	
T_{11}	-	75% NPK ha^{-1}+5 t FYM ha^{-1}	1.34^{b}		1.32^{c}		1.33^{d}	
T_{12}	-	100%NPK ha^{-1}+5 t FYM ha^{-1}	1.36^{a}		1.36^{b}		1.36^{b}	
T_{13}	-	75%NPK ha^{-1}+5 t FYM+10 t FA ha^{-1}	1.38^{a}		1.37^{a}		1.37^{b}	
T_{14}	-	75%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	1.38^{a}		1.38^{a}		1.38^{a}	
T_{15}	-	100%NPKha^{-1}+5 t FYM+10 t FA ha^{-1}	1.39^{a}		1.39^{a}		1.39^{a}	
T_{16}	-	100%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	1.39^{a}		1.40^{a}		1.40^{a}	
			SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
C			0.007	0.020	0.011	0.031	0.007	0.018
A×C			0.010	0.028	0.016	N/A	0.009	0.026
B×C			0.010	N/A	0.016	N/A	0.009	N/A

Table 4: Effect of fly ash alone or in combination with organic manure and fertilizers on nitrogen content in straw in rice-wheat cropping system in *Alfisol* and *Vertisol* at harvest

Treatments			Nitrogen content in straw (%)					
			2011		2012		Pooled	
T_1	-	Control	0.49		0.48		0.48	
T_2	-	10 t FA ha^{-1}	0.50		0.50		0.50	
T_3	-	20 t FA ha^{-1}	0.50		0.50		0.50	
T_4	-	STCR	0.55^{b}		0.55^{c}		0.55^{e}	
T_5	-	75%NPK ha^{-1}	0.53^{c}		0.53^{d}		0.53^{g}	
T_6	-	100% NPK ha^{-1}	0.55^{b}		0.55^{c}		0.55^{e}	
T_7	-	75%NPK ha^{-1}+10 t FA ha^{-1}	0.53^{c}		0.54^{c}		0.54^{f}	
T_8	-	75%NPK ha^{-1}+20 t FA ha^{-1}	0.54^{c}		0.54^{c}		0.54^{f}	
T_9	-	100%NPK ha^{-1}+10 t FA ha^{-1}	0.56^{b}		0.56^{b}		0.56^{d}	
T_{10}	-	100%NPK ha^{-1}+20 t FA ha^{-1}	0.57^{a}		0.58^{a}		0.57^{c}	
T_{11}	-	75% NPK ha^{-1}+5 t FYM ha^{-1}	0.55^{b}		0.55^{c}		0.55^{e}	
T_{12}	-	100%NPK ha^{-1}+5 t FYM ha^{-1}	0.58^{a}		0.58^{a}		0.58^{b}	
T_{13}	-	75%NPK ha^{-1}+5 t FYM+10 t FA ha^{-1}	0.58^{a}		0.58^{a}		0.58^{b}	
T_{14}	-	75%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	0.59^{a}		0.59^{a}		0.59^{a}	
T_{15}	-	100%NPKha^{-1}+5 t FYM+10 t FA ha^{-1}	0.60^{a}		0.59^{a}		0.59^{a}	
T_{16}	-	100%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	0.60^{a}		0.59^{a}		0.60^{a}	
			SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
C			0.009	0.024	0.007	0.021	0.005	0.015
A×C			0.012	N/A	0.010	N/A	0.008	N/A
B×C			0.012	N/A	0.010	N/A	0.008	N/A

Table 5: Effect of fly ash alone or in combination with organic manure and fertilizers on phosphorous content in grain in rice-wheat cropping system in *Alfisol* and *Vertisol* at harvest.

Treatments			Phosphorous content in grain (%)		
			2011	2012	Pooled
T_1	-	Control	0.233	0.236^{d}	0.235
T_2	-	10 t FA ha^{-1}	0.247	0.246^{d}	0.246
T_3	-	20 t FA ha^{-1}	0.249	0.251^{c}	0.250
T_4	-	STCR	0.289^{b}	0.288^{b}	0.289
T_5	-	75%NPK ha^{-1}	0.255	0.257^{c}	0.256
T_6	-	100% NPK ha^{-1}	0.276^{d}	0.278^{b}	0.277
T_7	-	75%NPK ha^{-1}+10 t FA ha^{-1}	0.259	0.264^{b}	0.262
T_8	-	75%NPK ha^{-1}+20 t FA ha^{-1}	0.272^{d}	0.273^{b}	0.272
T_9	-	100%NPK ha^{-1}+10 t FA ha^{-1}	0.286^{c}	0.283^{b}	0.285
T_{10}	-	100%NPK ha^{-1}+20 t FA ha^{-1}	0.287^{c}	0.286^{b}	0.286
T_{11}	-	75% NPK ha^{-1}+5 t FYM ha^{-1}	0.280^{c}	0.282^{b}	0.281
T_{12}	-	100%NPK ha^{-1}+5 t FYM ha^{-1}	0.295^{b}	0.297^{a}	0.296^{a}
T_{13}	-	75%NPK ha^{-1}+5 t FYM+10 t FA ha^{-1}	0.300^{a}	0.297^{a}	0.299^{a}

T_{14}	-	75%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	0.306^{a}		0.309^{a}		0.307^{a}
T_{15}	-	100%NPKha^{-1}+5 t FYM+10 t FA ha^{-1}	0.304^{a}		0.306^{a}		0.305^{a}
T_{16}	-	100%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	0.308^{a}		0.308^{a}		0.308^{a}
			SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
C			0.004	0.012	0.005	0.015	0.003	0.009
A×C			0.006	N/A	0.008	N/A	0.005	N/A
B×C			0.006	N/A	0.008	N/A	0.005	N/A

Table 6: Effect of fly ash alone or in combination with organic manure and fertilizers on phosphorous content in straw in rice-wheat cropping system in *Alfisol* and *Vertisol* at harvest.

Treatments			Phosphorous content in straw (%)			
			Rice		Wheat	
			Vertisol	***Alfisol***	***Vertisol***	***Alfisol***
T_1	-	Control	0.050	0.033	0.037	0.037^{e}
T_2	-	10 t FA ha^{-1}	0.053	0.053^{c}	0.043	0.037^{e}
T_3	-	20 t FA ha^{-1}	0.060	0.050c	0.047	0.047^{d}
T_4	-	STCR	0.057	0.060^{b}	0.057^{c}	0.050^{d}
T_5	-	75%NPK ha^{-1}	0.057	0.050^{c}	0.067^{b}	0.057^{d}
T_6	-	100% NPK ha^{-1}	0.053	0.060^{b}	0.067^{b}	0.060^{c}
T_7	-	75%NPK ha^{-1}+10 t FA ha^{-1}	0.050	0.063^{b}	0.060	0.053^{d}
T_8	-	75%NPK ha^{-1}+20 t FA ha^{-1}	0.057	0.063^{b}	0.073^{b}	0.050^{d}
T_9	-	100%NPK ha^{-1}+10 t FA ha^{-1}	0.053	0.073^{a}	0.080^{a}	0.073^{b}
T_{10}	-	100%NPK ha^{-1}+20 t FA ha^{-1}	0.063	0.067^{b}	0.083^{a}	0.077^{a}
T_{11}	-	75% NPK ha^{-1}+5 t FYM ha^{-1}	0.063	0.087^{a}	0.077^{a}	0.060^{c}
T_{12}	-	100%NPK ha^{-1}+5 t FYM ha^{-1}	0.070	0.097^{a}	0.073^{b}	0.077^{a}
T_{13}	-	75%NPK ha^{-1}+5 t FYM+10 t FA ha^{-1}	0.073	0.070^{a}	0.080^{a}	0.070^{b}
T_{14}	-	75%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	0.073	0.077^{a}	0.083^{a}	0.077^{a}
T_{15}	-	100%NPKha^{-1}+5 t FYM+10 t FA ha^{-1}	0.087^{a}	0.070^{a}	0.087^{a}	0.073^{b}
T_{16}	-	100%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	0.087^{a}	0.083^{a}	0.083^{a}	0.087^{a}
SEm±			0.005			
CD at 5% level			0.013			

Table 7: Effect of fly ash alone or in combination with organic manure and fertilizers on potassium content in grain and straw in rice-wheat cropping system in *Vertisol* and *Alfisol* at harvest.

Particulars	Potassium content in grain (%)						Potassium content in straw (%)					
	2011		2012		Pooled		2011		2012		Pooled	
	Vertisol	***Alfisol***	***Vertisol***	***Alfisol***	***Vertisol***	***Alfisol***	***Vertisol***	***Alfisol***	***Vertisol***	***Alfisol***	***Vertisol***	***Alfisol***
Rice	0.53	0.52	0.52	0.52	0.53	0.52	1.44	1.44	1.44	1.44	1.44	1.44
Wheat	0.41	0.40	0.42	0.40	0.41	0.40	1.48	1.47	1.48	1.47	1.48	1.47
	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
A	0.002	0.007	0.002	0.006	0.001	0.004	0.002	0.008	0.003	0.009	0.002	0.002
B	0.002	0.007	0.002	0.006	0.001	0.004	0.002	0.008	0.003	N/A	0.002	0.002
A×B	0.003	N/A	0.003	N/A	0.002	0.005	0.003	0.011	0.004	N/A	0.003	0.003

Table 8: Effect of fly ash alone or in combination with organic manure and fertilizers on potassium content in grain in rice-wheat cropping system in *Alfisol* and *Vertisol* at harvest.

Treatments			Potassium content in grain (%)					
			2011		2012		Pooled	
T_1	-	Control	0.420^{d}		0.420^{e}		0.420	
T_2	-	10 t FA ha^{-1}	0.433^{d}		0.431^{e}		0.432	
T_3	-	20 t FA ha^{-1}	0.433^{d}		0.437^{d}		0.435	
T_4	-	STCR	0.482^{a}		0.484^{b}		0.483^{c}	
T_5	-	75%NPK ha^{-1}	0.452^{c}		0.456^{c}		0.455^{d}	
T_6	-	100% NPK ha^{-1}	0.475^{b}		0.469^{b}		0.470^{c}	
T_7	-	75%NPK ha^{-1}+10 t FA ha^{-1}	0.461^{b}		0.458^{c}		0.460^{d}	
T_8	-	75%NPK ha^{-1}+20 t FA ha^{-1}	0.463^{b}		0.468^{c}		0.468^{c}	
T_9	-	100%NPK ha^{-1}+10 t FA ha^{-1}	0.468^{b}		0.464^{c}		0.465^{c}	
T_{10}	-	100%NPK ha^{-1}+20 t FA ha^{-1}	0.486^{a}		0.480^{b}		0.481^{b}	
T_{11}	-	75% NPK ha^{-1}+5 t FYM ha^{-1}	0.463^{b}		0.463^{c}		0.462^{d}	
T_{12}	-	100%NPK ha^{-1}+5 t FYM ha^{-1}	0.490a		0.491^{a}		0.491^{a}	
T_{13}	-	75%NPK ha^{-1}+5 t FYM+10 t FA ha^{-1}	0.491^{a}		0.488^{a}		0.489^{a}	
T_{14}	-	75%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	0.497^{a}		0.498^{a}		0.497^{a}	
T_{15}	-	100%NPKha^{-1}+5 t FYM+10 t FA ha^{-1}	0.500^{a}		0.500^{a}		0.500^{a}	
T_{16}	-	100%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	0.505^{a}		0.505^{a}		0.505^{a}	
			SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
C			0.007	0.018	0.005	0.014	0.004	0.012

A×C	0.009	0.026	0.007	0.019	0.006	0.017
B×C	0.009	N/A	0.007	N/A	0.006	N/A

Table 9: Effect of fly ash, alone or in combination with organic manure and fertilizers on potassium content in straw in rice-wheat cropping system in *Alfisol* and *Vertisol* at harvest.

Treatments			Potassium content in straw (%)					
			2011		2012		Pooled	
T_1	-	Control	1.334		1.338		1.336	
T_2	-	10 t FA ha^{-1}	1.343		1.342		1.342	
T_3	-	20 t FA ha^{-1}	1.353		1.355		1.354	
T_4	-	STCR	1.504[a]		1.500[a]		1.502[b]	
T_5	-	75%NPK ha^{-1}	1.439[d]		1.449[e]		1.444[f]	
T_6	-	100% NPK ha^{-1}	1.483[b]		1.481[b]		1.482[c]	
T_7	-	75%NPK ha^{-1}+10 t FA ha^{-1}	1.440[d]		1.441[e]		1.440[f]	
T_8	-	75%NPK ha^{-1}+20 t FA ha^{-1}	1.453[d]		1.453[d]		1.453[e]	
T_9	-	100%NPK ha^{-1}+10 t FA ha^{-1}	1.503[a]		1.498[a]		1.500[b]	
T_{10}	-	100%NPK ha^{-1}+20 t FA ha^{-1}	1.505[a]		1.509[a]		1.507[a]	
T_{11}	-	75% NPK ha^{-1}+5 t FYM ha^{-1}	1.464[c]		1.471[c]		1.468[d]	
T_{12}	-	100%NPK ha^{-1}+5 t FYM ha^{-1}	1.523[a]		1.523[a]		1.523[a]	
T_{13}	-	75%NPK ha^{-1}+5 t FYM+10 t FA ha^{-1}	1.504[a]		1.502[a]		1.503[b]	
T_{14}	-	75%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	1.493[b]		1.496[a]		1.494[b]	
T_{15}	-	100%NPKha^{-1}+5 t FYM+10 t FA ha^{-1}	1.508[a]		1.512[a]		1.510[a]	
T_{16}	-	100%NPK ha^{-1}+5 t FYM+20 t FA ha^{-1}	1.514[a]		1.511[a]		1.513[a]	
			SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
C			0.007	0.019	0.005	0.014	0.004	0.012
A×C			0.010	0.027	0.007	0.020	0.006	0.018
B×C			0.010	N/A	0.007	N/A	0.006	N/A

Potassium content in grain and straw

The potassium content in grain was significantly influenced due to application of fly ash alone or in combination with organic manure and fertilizers (Table 7). The higher potassium content in grain was recorded in rice under *Vertisol* during 2011, and pooled data. However, higher potassium content was recorded in wheat grain under *Vertisol* during 2011-12, 2012-13 and pooled data. The potassium content in rice grain was higher than wheat.

The potassium content in grain was significantly increased due to application of fly ash alone or in combination with organic manure and fertilizers (Table 8). The treatment, T_{16} recorded significantly highest potassium content in grain during 2011, 2012 and pooled data. It was at par with treatment, T_{15}, $T_{14,}$ T_{13}, $T_{12,}$ T_{10} and T_4 in 2011, treatment T_{15}, $T_{14,}$ T_{12} and T_{13} in 2012 and pooled data. The lowest potassium content was recorded in treatment $T_{1.}$ The interaction between crop × soil × treatments was non-significant. The higher potassium content in straw was recorded in wheat under *Vertisol* during 2011-12, 12-13 and pooled data (Table 7). The potassium content in wheat straw was higher than rice. The treatment, T_{12} recorded significantly highest potassium content in straw during 2011, 2012 and pooled data. It was at par with treatment, T_{16}, T_{15}, $T_{10,}$ T_4, T_{13} and T_9 in 2011, treatment T_{15}, and $T_{16,}$ T_{10}, T_4, T_{13}, T_9 and T_{14} in 2012, and T_{16}, T_{15} and T_{10} in pooled data (Table 9). The lowest potassium content was recorded in treatment $T_{1.}$ The higher potassium content in grain and straw in rice under *Alfisol* responsible for supply of sufficient amount of nutrients.

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