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Effect of Fly Ash and Farm Yard Manure on Soil Nutrient Dynamics in a Saturated Inceptisol Under Incubated Conditions

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ABSTRACT

An incubation experiment was conducted for 60 days with one kg soil (fine loamy, mixed hyperthermic Typic Haplustept) at saturated moisture conditions. The studies on available N, P, K, S, Fe, Mn, Cu and Zn contents in soil indicated that there was significant increase in nutrient availability due to application of fly ash and FYM and their interaction at all the time intervals studied *viz.,* 7, 15, 30 and 60 DAI. The addition of fly ash @ 10 or 15 t ha^{-1} along with FYM @ 10 t ha^{-1} has recorded the highest available nitrogen (214.6, 222.0, 226.6 and 227.3 kg ha^{-1}), P_2O_5 (18.13, 20.20, 21.83 and 23.03 kg ha^{-1}), K_2O (308.6, 314.6, 318.0 and 320.3 kg ha^{-1}), sulphur (10.20, 11.20, 11.50 and 12.53 mg kg^{-1}), Fe (10.20, 10.50, 12.00 and 12.47 mg kg^{-1}), Mn (5.43, 6.10, 6.30 and 6.47 mg kg^{-1}), Cu (1.76, 1.85, 1.93 and 21.6 mg kg^{-1}) and Zn (1.50, 1.58, 1.50 and 1.51 mg kg^{-1}) at 7, 15, 30 and 60 days after incubation, respectively. The soil available N, Fe and Zn status increased from 7 to 30 days after incubation, which remained more or less the same at 60 DAI. The available P, K, S, Mn and Cu status increased with increasing incubation period from 7 to 60 days.

Key words : FYM, Groundnut, Growth, Phosphate rock, PROM and Yield.

Fly ash is chemically a ferro-alumeno silicate and a major solid waste of the industrial areas. Huge amounts of this fly ash is produced every day at every thermal power station in the country. The disposal of fly ash at thermal power stations demand search for its utilization in different industries. Agriculture is vast industry that may hold promise for its large scale consumption. Fly ash could be used as a source of plant nutrients. It contains appreciable amounts of N, P, K, Ca, Mg and trace quantities of micronutrients required for plant growth (Kene *et al*., 1991). Application of fly ash at high rate improved the chemical properties like available N, P, K, Mg and organic carbon, etc. (Maciak, 1980). Hence, an experiment was conducted to study the effect of integrated use of fly ash and FYM on nutrient dynamics in a saturated Inceptisol under incubated conditions.

MATERIAL AND METHODS

An incubation experiment was conducted for 60 days with one kg soil at saturated moisture conditions. It was treated with 0, 5, 10 and 15 t fly ash ha^{-1} soil with FYM @ 10 t ha^{-1} and without FYM for 60 days. The treatments were replicated thrice. The fly ash was collected from National Thermal Power Corporation (NTPC), Ramagundam, Andhra Pradesh. It contained the nutrients like N (27.5 mg kg^{-1}), P_2O_5 (29.6 mg kg^{-1}), K_2O (110.5 mg kg^{-1}), S (25.4 mg kg^{-1}), Ca (7.25 mg kg^{-1}), Mg (2.20 mg kg^{-1}), Fe (17.50 mg kg^{-1}), Mn (3.34 mg kg^{-1}), Cu (0.98 mg kg^{-1}), Zn (1.83 mg kg^{-1}). The texture of fly ash was silty loam with pH 8.1 and EC 0.37 dS m^{-1}. The experimental soil was sandy clay loam in texture, slightly alkaline in reaction (pH 7.9), non-saline (EC 0.29 dS m^{-1}), low available N (210 kg. ha^{-1}), available phosphorus (8.7 kg P_2O_5 ha^{-1}), medium in available potassium (180 kg K_2O ha^{-1}), low in available sulphur (8.3 mg kg^{-1}) and sufficient in micronutrient status (Fe 8.62 mg kg^{-1}, Mn 5.56 mg kg^{-1}, Cu 1.09 mg kg^{-1} and Zn 1.05 mg kg^{-1}). The samples were drawn periodically on 7^{th}, 15^{th}, 30^{th} and 60^{th} day after incubation (DAI) and were analysed for available soil nutrient status (N, P, K, S, Fe, Mn, Cu and Zn). Soil reaction (1:2 soil : water suspension) was determined by using combined glass electrode pH meter and electrical conductivity (1:2 soil : water suspension) was determined by using EC meter (Jackson, 1967). Available nitrogen was estimated by alkaline potassium permanganate method (Subbaiah and Asija, 1956). Available phosphorus content was extracted by Olsen's reagent and determined by ascorbic acid method (Watanabe and Olsen, 1965). Available potassium was extracted by using neutral normal ammonium acetate (Muhr *et al*., 1965) and determined by flame photometer. The available sulphur was extracted by 0.15% $CaCl_2$ 2 H_2O and determined by turbidometric method. Available micronutrients (DTPA extractable) Fe, Mn, Cu and Zn were analysed by DTPA method using atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

Table 1. Effect of fly ash and FYM on available nitrogen content in soil at different time intervals under incubation studies (kg N ha^{-1})

Fly ash levels (t ha^{-1})	7 DAI			15 DAI			30 DAI			60 DAI		
	FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})		
	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean
FA_0	199.3	205.3	202.3	206.3	208.0	207.1	211.0	216.0	213.5	210.0	217.6	213.8
	(-5.2)	(-2.3)	(-1.1)	(-1.7)	(-0.9)	(-1.4)	(0.5)	(2.8)	(1.6)	(0.0)	(3.6)	(1.8)
FA_5	201.6	209.6	205.6	210.6	215.0	212.7	211.6	219.3	215.5	212.0	221.0	216.5
	(-4.2)	(-0.5)	(-2.7)	(0.3)	(2.7)	(1.5)	(0.7)	(4.2)	(2.6)	(0.95)	(5.2)	(3.1)
FA_{10}	204.3	214.3	209.3	211.3	220.6	216.0	214.3	225.0	219.6	213.3	226.6	220.0
	(-2.7)	(2.0)	(-0.31)	(0.63)	(5.1)	(2.9)	(2.16)	(7.1)	(4.6)	(1.6)	(7.9)	(4.8)
FA_{15}	205.3	214.6	210.0	211.6	222.0	216.8	214.6	226.6	220.6	214.3	227.3	220.8
	(-2.3)	(2.2)	(0.0)	(0.79)	(5.71)	(3.3)	(2.2)	(7.6)	(5.1)	(2.1)	(8.3)	(5.2)
Mean	202.6	211.0	206.8	210.0	216.5	213.2	212.9	221.7	217.3	212.4	223.1	217.7
	(-3.8)	(0.48)	(-1.5)	(0.0)	(3.13)	(1.7)	(1.4)	(5.2)	(3.5)	(1.2)	(6.3)	(3.7)

	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
FA	1.58	3.39	1.44	3.09	1.50	3.22	1.59	3.41
FYM	1.12	2.40	1.02	2.18	1.06	2.28	1.12	2.41
FA x FYM	2.24	4.80	2.03	4.36	2.12	4.56	2.25	4.82

Initial nitrogen status = 2.10 kg N ha^{-1}

Figures in parentheses are the per cent build up or depletion over initial available N status of soil

Table 2. Effect of fly ash and FYM on available phosphorus content in soil at different time intervals under incubation studies (kg P_2O_5 ha^{-1})

Fly ash levels (t ha^{-1})	7 DAI			15 DAI			30 DAI			60 DAI		
	FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})		
	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean
FA_0	10.10	12.67	11.38	11.60	15.73	13.67	12.67	15.67	14.17	12.87	17.17	16.02
	(16.09)	(45.6)	(31.0)	(33.3)	(81.0)	(57.1)	(46.0)	(80.1)	(62.8)	(47.9)	(120.3)	(84.1)
FA_5	11.37	16.27	13.82	14.30	18.03	16.17	15.87	18.47	17.17	16.33	20.67	18.50
	(30.6)	(87.0)	(59.0)	(64.4)	(107.2)	(86.0)	(82.4)	(112.3)	(97.3)	(87.7)	(137.5)	(112.6)
FA_{10}	15.57	18.03	16.80	16.73	20.20	18.47	18.93	20.40	19.67	19.13	22.41	20.77
	(78.9)	(107.2)	(93.1)	(92.3)	(132.2)	(112.2)	(117.0)	(134.5)	(126.0)	(119.8)	(157.5)	(138.7)
FA_{15}	15.47	18.13	16.80	16.77	19.93	18.35	18.97	21.83	20.40	19.93	23.03	21.48
	(77.8)	(108.3)	(93.1)	(93.0)	(129.0)	(111.0)	(118.0)	(151.0)	(134.5)	(129.0)	(167.8)	(146.8)
Mean	13.13	16.28	14.70	14.85	18.48	16.61	16.61	19.09	17.85	17.07	21.32	19.19
	(50.5)	(87.1)	(69.0)	(71.0)	(112.4)	(91.4)	(91.4)	(129.0)	(105.2)	(96.2)	(145.0)	(120.5)

	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
FA	0.28	0.59	0.14	0.31	0.64	1.37	0.49	1.06
FYM	0.20	0.42	0.10	0.22	0.45	0.97	0.35	0.75
FA x FYM	0.39	0.84	0.20	0.44	0.90	1.94	0.70	1.49

Initial phosphorus status =8.7 kg P_2O_5 ha^{-1}

Figures in parentheses are the per cent build up or depletion over initial available P_2O_5 status of soil

Table 3. Effect of fly ash and FYM on available potassium content in soil at different time intervals under incubation studies (kg K_2O ha^{-1})

Fly ash levels (t ha^{-1})	7 DAI			15 DAI			30 DAI			60 DAI		
	FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})		
	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean
FA_0	280.0	283.3	281.6	287.0	297.3	292.1	292.6	299.3	296.0	298.0	301.3	299.6
	(55.5)	(57.4)	(56.4)	(59.4)	(65.1)	(62.5)	(62.5)	(66.2)	(64.4)	(65.5)	(67.4)	(66.4)
FA_5	287.0	299.0	293.0	295.3	305.0	300.1	300.3	308.6	304.5	301.6	313.5	307.5
	(59.4)	(66.1)	(62.7)	(64.0)	(69.4)	(66.7)	(66.8)	(71.4)	(69.1)	(67.5)	(74.0)	(70.8)
FA_{10}	295.3	308.6	302.0	302.6	314.3	308.5	310.6	317.3	314.0	313.6	319.6	316.6
	(64.0)	(71.4)	(67.7)	(68.1)	(74.6)	(71.3)	(72.5)	(76.2)	(74.4)	(74.2)	(77.5)	(75.9)
FA_{15}	300.6	307.3	304.0	305.0	314.6	309.8	309.6	318.0	313.8	314.6	320.3	317.5
	(67.0)	(70.7)	(68.8)	(69.4)	(74.8)	(72.1)	(72.0)	(76.6)	(74.3)	(74.8)	(77.9)	(76.3)
Mean	290.7	299.5	295.1	297.5	307.8	302.6	303.3	310.8	307.0	307.0	313.6	310.3
	(61.5)	(66.4)	(63.9)	(65.2)	(71.0)	(68.1)	(68.5)	(72.6)	(70.6)	(70.5)	(74.2)	(72.4)

	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
FA	1.76	3.77	1.83	3.93	1.37	2.94	1.43	3.07
FYM	1.24	2.67	1.30	278	0.97	2.08	1.01	2.17
FA x FYM	2.49	5.33	2.59	5.56	1.94	4.16	2.02	4.34

Initial available potassium status =180 kg K_2O ha^{-1}

Figures in parentheses are the per cent build up or depletion over initial available K_2O status of soil

Table 4. Effect of fly ash and FYM on available sulphur content in soil at different time intervals under incubation studies (mg SO_4 kg^{-1})

Fly ash levels (t ha^{-1})	7 DAI			15 DAI			30 DAI			60 DAI		
	FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})		
	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean
FA_0	8.23	8.50	8.37	8.33	8.43	8.38	9.10	9.43	9.27	9.87	11.07	10.47
	(-0.84)	(2.40)	(0.84)	(0.36)	(1.5)	(0.9)	(9.6)	(13.6)	(11.6)	(18.9)	(33.3)	(26.1)
FA_5	8.73	9.50	9.12	8.93	9.53	9.23	9.47	10.77	10.12	10.50	11.70	11.10
	(5.1)	(14.4)	(9.8)	(7.5)	(14.8)	(11.2)	(14.0)	(29.7)	(21.9)	(26.5)	(40.9)	(33.7)
FA_{10}	8.77	10.20	9.48	9.80	10.80	10.30	10.03	11.50	10.77	11.73	12.47	12.10
	(5.6)	(22.8)	(14.2)	(18.0)	(30.1)	(24.0)	(20.8)	(38.5)	(29.7)	(41.3)	(50.2)	(45.7)
FA_{15}	9.23	10.13	9.68	9.93	11.20	10.57	10.20	11.40	10.80	12.00	12.53	12.27
	(11.2)	(22.0)	(16.6)	(19.6)	(34.9)	(27.3)	(22.8)	(37.3)	(30.1)	(44.5)	(50.9)	(47.8)
Mean	8.74	9.58	9.16	9.25	9.99	9.62	9.70	10.78	10.24	11.03	11.94	11.48
	(5.3)	(15.4)	(10.3)	(11.4)	(20.3)	(15.9)	(16.8)	(29.8)	(23.3)	(36.1)	(43.8)	(38.3)

	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
FA	0.16	0.34	0.13	0.28	0.27	0.59	0.06	0.13
FYM	0.11	0.24	0.09	0.20	0.19	0.41	0.04	0.09
FA x FYM	0.22	0.48	0.18	0.40	0.39	0.83	0.09	0.19

Initial available sulphur status =8.3 mg kg^{-1}

Figures in parentheses are the per cent build up or depletion over initial available sulphur status of soil

Table 5. Effect of fly ash and FYM on available iron content in soil at different time intervals under incubation studies (mg Fe kg^{-1})

Fly ash levels (t ha^{-1})	7 DAI			15 DAI			30 DAI			60 DAI		
	FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})		
	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean
FA_0	7.06	8.43	7.75	8.07	8.63	8.35	8.73	9.77	9.25	9.57	9.97	9.77
	(-18.0)	(-2.2)	(-10.0)	(-6.3)	(0.11)	(-3.1)	(1.2)	(13.3)	(7.3)	(11.0)	(15.6)	(13.3)
FA_5	7.64	9.30	8.47	8.47	9.37	8.92	9.00	10.77	9.88	9.97	10.43	10.20
	(-11.3)	(7.8)	(-1.7)	(-1.7)	(8.7)	(3.4)	(4.4)	(24.9)	(14.6)	(15.6)	(20.9)	(18.3)
FA_{10}	8.44	9.83	9.14	8.90	10.50	9.70	9.57	11.83	10.70	10.80	12.03	11.42
	(-2.0)	(14.0)	(6.0)	(3.2)	(22.0)	(12.5)	(11.0)	(37.2)	(24.1)	(25.2)	(39.5)	(32.4)
FA_{15}	8.54	10.20	9.37	9.27	10.33	9.80	10.17	12.00	11.08	11.47	12.47	11.97
	(-0.9)	(18.3)	(8.7)	(7.5)	(19.8)	(13.6)	(17.9)	(39.2)	(28.5)	(33.0)	(44.6)	(38.8)
Mean	7.92	9.44	8.68	8.68	9.71	9.19	9.37	11.09	10.23	10.45	11.23	10.87
	(-8.1)	(9.5)	(0.69)	(0.69)	(12.6)	(6.6)	(8.7)	(28.6)	(18.6)	(21.2)	(30.2)	(25.7)
	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
FA	0.34	0.72		0.23	0.50		0.13	0.28		0.24	0.52	
FYM	0.24	0.51		0.16	0.35		0.09	0.20		0.17	0.37	
FA x FYM	0.48	1.02		0.33	0.71		0.18	0.40		0.34	0.74	

Initial available iron status =8.62 mg kg^{-1}

Figures in parentheses are the per cent build up or depletion over initial available iron status of soil

Table 6. Effect of fly ash and FYM on available manganese content in soil at different time intervals under incubation studies (mg Mn kg^{-1})

Fly ash levels (t ha^{-1})	7 DAI			15 DAI			30 DAI			60 DAI		
	FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})		
	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean
FA_0	4.04	4.78	4.41	4.31	5.57	4.94	4.44	5.71	5.07	5.09	5.92	5.51
	(-27.3)	(-14.0)	(-20.6)	(-22.4)	(0.17)	(-11.1)	(-20.1)	(2.6)	(-8.8)	(-8.4)	(6.4)	(-0.89)
FA_5	4.32	5.17	4.75	4.70	5.78	5.24	4.78	5.97	5.38	5.30	6.13	5.72
	(-22.6)	(-7.0)	(-14.5)	(-15.4)	(4.3)	(-5.7)	(-14.0)	(7.3)	(-3.2)	(-4.6)	(10.2)	(2.8)
FA_{10}	4.67	5.40	5.03	5.04	6.09	5.57	5.10	6.30	5.70	5.80	6.47	6.14
	(-19.0)	(-2.8)	(-9.5)	(-9.3)	(9.5)	(0.17)	(-8.2)	(13.3)	(2.5)	(4.3)	(16.3)	(10.4)
FA_{15}	4.77	5.43	5.10	5.08	6.10	5.59	5.16	6.30	5.73	5.90	6.47	6.19
	(-14.2)	(-2.3)	(-8.2)	(-8.6)	(9.7)	(0.53)	(-7.1)	(13.3)	(3.0)	(6.1)	(16.3)	(11.3)
Mean	4.45	5.20	4.78	4.78	5.89	5.33	4.87	6.07	5.47	5.52	6.25	5.89
	(-19.9)	(-6.4)	(-13.3)	(-14.0)	(5.9)	(-5.1)	(-12.4)	(9.1)	(-1.6)	(-0.7)	(12.4)	(5.9)
	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
FA	0.11	0.25		0.04	0.08		0.04	0.08		0.05	0.11	
FYM	0.08	0.17		0.03	0.05		0.03	0.06		0.03	0.07	
FA x FYM	0.16	0.35		0.05	0.11		0.05	0.11		0.07	0.15	

Initial available manganese status =5.56 mg kg^{-1}

Figures in parentheses are the per cent build up or depletion over initial available manganese status of soil

Table 7. Effect of fly ash and FYM on available zinc content in soil at different time intervals under incubation studies (mg Zn kg^{-1})

Fly ash levels (t ha^{-1})	7 DAI			15 DAI			30 DAI			60 DAI		
	FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})		
	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean
FA_0	0.96	1.10	1.10	1.10	1.26	1.18	1.21	1.28	1.25	1.24	1.30	1.27
	(-8.5)	(4.7)	(4.8)	(4.8)	(20.0)	(12.3)	(15.2)	(26.9)	(19.0)	(18.0)	(23.8)	(20.9)
FA_5	1.20	1.35	1.28	1.23	1.35	1.29	1.38	1.44	1.41	1.39	1.38	1.39
	(14.2)	(28.5)	(21.9)	(17.1)	(28.5)	(22.8)	(31.4)	(37.1)	(34.2)	(32.3)	(31.4)	(32.3)
FA_{10}	1.30	1.49	1.40	1.34	1.52	1.43	1.46	1.49	1.47	1.49	1.46	1.48
	(23.8)	(41.9)	(33.3)	(27.6)	(44.7)	(36.1)	(39.0)	(41.9)	(40.0)	(41.9)	(39.0)	(40.9)
FA_{15}	1.35	1.50	1.43	1.39	1.58	1.49	1.46	1.50	1.48	1.45	1.51	1.48
	(28.5)	(42.8)	(25.3)	(32.3)	(50.4)	(41.9)	(39.0)	(42.8)	(40.9)	(38.0)	(43.8)	(40.9)
Mean	1.20	1.36	1.28	1.27	1.43	1.35	1.38	1.43	1.40	1.40	1.41	1.41
	(14.2)	(29.5)	(21.9)	(20.9)	(36.1)	(28.5)	(31.4)	(36.1)	(33.3)	(33.3)	(34.2)	(34.2)
	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
FA	0.02	0.03		0.03	0.06		0.03	0.07		0.03	0.05	
FYM	0.01	0.02		0.02	0.04		0.02	0.05		0.02	0.04	
FA x FYM	0.02	0.05		0.04	0.08		0.04	0.10		0.04	0.08	

Initial available zinc status =1.05 mg kg^{-1}

Figures in parentheses are the per cent build up or depletion over initial available zinc status of soil

Table 8. Effect of fly ash and FYM on available Cu content in soil at different time intervals under incubation studies (mg Cu kg^{-1})

Fly ash levels (t ha^{-1})	7 DAI			15 DAI			30 DAI			60 DAI		
	FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})			FYM levels (t ha^{-1})		
	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean	FYM_0	FYM_{10}	Mean
FA_0	1.70	1.70	1.70	1.81	1.82	1.82	1.81	1.82	1.82	2.11	2.14	2.13
	(55.9)	(55.9)	(55.9)	(66.0)	(66.9)	(66.9)	(71.5)	(74.3)	(73.3)	(93.5)	(96.3)	(95.4)
FA_5	1.71	1.72	1.71	1.82	1.84	1.83	1.82	1.84	1.83	2.10	2.16	2.13
	(56.8)	(57.7)	(56.8)	(66.9)	(68.8)	(67.8)	(73.3)	(76.1)	(75.2)	(92.6)	(98.1)	(95.4)
FA_{10}	1.73	1.73	1.73	1.82	1.85	1.83	1.90	1.93	1.91	2.13	2.16	2.15
	(58.7)	(58.7)	(58.7)	(66.9)	(69.7)	(67.8)	(74.3)	(77.0)	(75.2)	(95.4)	(98.1)	(97.2)
FA_{15}	1.76	1.73	1.75	1.83	1.85	1.84	1.90	1.93	1.91	2.15	2.16	2.15
	(61.40)	(58.7)	(60.5)	(67.8)	(69.7)	(68.8)	(74.3)	(77.0)	(75.2)	(97.2)	(98.1)	(97.2
Mean	1.73	1.72	1.72	1.82	1.84	1.83	1.82	1.84	1.83	2.12	2.15	2.14
	(58.7)	(57.7)	(57.7)	(66.9)	(68.8)	(67.8)	(73.3)	(76.1)	(75.2)	(94.4)	(97.2)	(96.3)
	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
FA	0.01	0.03		0.01	0.02		0.01	0.03		0.01	0.02	
FYM	0.01	NS		0.01	0.03		0.01	0.03		0.01	0.02	
FA x FYM	0.02	0.04		0.01	0.02		0.01	0.03		0.01	0.02	

Initial available copper status =1.09 mg kg^{-1}

Figures in parentheses are the per cent build up or depletion over initial available copper status of soil

RESULTS AND DISCUSSION

The studies on available N, P_2O_5, K_2O, SO_4, Fe, Mn and Zn contents in soil (Table 1 to 8) indicated that, there was significant increase in nutrient availability due to application of fly ash, FYM and their interactions at all the time intervals *viz*., 7, 15, 30 and 60 DAI. However, the Cu content was not significantly influenced by FYM application at 7 DAI.

Among the fly ash levels, FA_{15} and FA_{10} have recorded the highest nutrient status when compared to FA_0 at all the time intervals under incubation conditions. Addition of fly ash @ 15 t ha^{-1} has resulted in build up of N, P_2O_5, K_2O, SO_4, Fe, Cu and Zn compared to the initial status at all the time intervals *viz.,* 7, 15, 30 and 60 DAI. However, Mn content was depleted when compared to the initial soil status at 7 DAI, which however later showed build up compared to the initial soil status. A fly ash contains essential plant nutrients, it might be possible that the availability of these nutrients increased with an increase in amount of fly ash applied. The similar results were reported by Selvakumari *et al*. (2000), Bharti Bhaisare *et al*. (1999), Kene *et al*. (1991) and Arvind Kumar *et al*. (1998) under field conditions.

Application of FYM @ 10 t ha^{-1} has recorded highest available nutrient status when compared to FYM_0 at all the time intervals under incubation conditions. Compared to the initial status, addition of FYM resulted in build up of available nutrient status at all the time interval. In addition to supplying plant nutrients, FYM is a constant source of energy for heterotropic microorganisms, which might have resulted in increasing the availability of nutrients.

Among the interactions, the treatment FA_{15} FYM_{10} and FA_{10} FYM_{10} have recorded the higher available nutrient status at all the time intervals under incubated conditions. When compared to the initial status, all the treatments have resulted build up of available nutrients except nitrogen at 7 DAI and manganese at 7 and 15 DAI. The soil available N, Fe and Zn status increased from 7 to 30 days after incubation, which remained more or less the same at 60 DAI. The available P, K, S, Mn and Cu status increased with increasing incubation period from 7 to 60 days.

Conclusion

Thus based on results of present study, application of fly ash levels, FYM and their interactions had significant effect on available N, P, K, S, Fe, Mn and Zn content of soil at all the time intervals at 7, 15, 30 and 60 DAI under incubation conditions. However, Cu content was not significantly influenced by FYM application at 7 DAI.

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