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DIRECT AND RESIDUAL EFFECT OF FERTILIZATION SOURCES AND TIME OF APPLICATION ON EQUIVALENT YIELD OF RICE-POTATO CROPPING SEQUENCE AND SOIL PROPERTIES

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ABSTRACT

A study was conducted at Kharagpur during 1996-98 on direct effect of item of application of different organic materials under integrated nutrient management with fly ash as supplement on yield of rice and residual effect on yield of potato and soil properties. Incorporation organic materials in between 30 days before planting of rice was equally beneficial on equivalent rice grain yield or rice-potato cropping sequence. Integrated nutrient management involving organic material and chemical fertilizers with fly ash @ 10 t/ha as supplement applied to rice crop followed by recommended chemical fertilizer to potato crop was superior to continuous use of chemical fertilizers on equivalent nutrient basis. Maximum equivalent rice grain yield of 12.6 t ha^{-1} was realized under integrated use of paddy straw 5 t, complimentary chemical fertilizer (57.5 kg N and 18.5 Kg P) and fly ash 10 t for rice followed by 125 : 46 : 104 kg N:P:K through chemical fertilizers for potato.

In high rainfall regions of Eastern India, cultivation of rice during wet season (Kharif) is indispensable under excess water stress. After harvest of rice, potato is popular due to high productivity and economic return. However, both the crops are nutrients exhaustive and require intensive nutrient management, Integrated use of organic materials and chemical fertilizers (CF) is superior to application of only CF (Hegde, 1998). However, organic materials are in short supply. Therefore, recycling of fly ash is being tried as supplementary source of mineral nutrition for soils and plants (Adriano et al., 1980, Mittra et al. 2000). Availability of this ash is not a problem because it is produced in huge quantities (About 60 m tons per annum in India) as west product in thermal power plants. These materials with different C:N ratios and biochemical compositions release nutrients at different pace (Azmal et al, 1996). Further, in presence of fly ash and CF, the rate of decomposition may vary and hence, the nutrient availability to rice and subsequent potato crop. Therefore, direct and residual effect of fertilization sources on the performance of rice-potato cropping sequence was studied.

MATERIALS AND METHODS

A field experiment was conducted during 1996 to 1998 with rice variety IR36 during wet season (June-October) at the experimental farm of Indian Institute of Technology, Kharagpur, West-Bengal. The test soil was sandy loam in texture and acid lateritic (pH 6.21) with low organic carbon (3.0 g/kg), action exchange capacity (3.37 c.mol/kg), alkaline $KmnO_4N$ (180 kg/ha) and NH4Oac extractable

K (99kg/ha) but, medium in Bray's P (18 kg/ha). Coal ash in the form of pond ash was obtained from Kolaghat. Thermal Power Plant, West Bengal produced through combustion of bituminous coal. The ash was dominant in silt size fraction (47.3%) and low in clay (10.2%) with high water holding capacity (59.3%) and low bulk density (0.93 Mg M^{-3}). It was alkaline (pH 8.28) and low in organic carbon (2.9g/kg) and action exchange capacity (2.31 c.mol/kg). Nutritionally, the ash was very low in total N (0.01%) but rich in total P (0.30%) and total K (0.21%). The available N, P and K were 15.4, 57.0 and 61.0 ppm respectively. Paddy straw (PS), FYM, Water hyacinth compost (WH), Green manure, Sesbania rostrata (GM), and Azolla (AZ) were the organic materials used. The rate of application of these materials and quantity of N, P and K supplied and their C:N ratios are presented in Table 1. The variation in N, P and K content and C:N ratio was narrow and hence the average value for two years is shown in Table 1.

Equivalent nutrient level of 90:26:33 kg N:P:K /ha was supplied to rice crop through organic material and CF. However, in case of treatments involving PS, equivalent K level of 33 kg/ha could not be maintained because a higher dose (66.5 kg/ha) was added through 5 t PS (Table 1). The addition of nutrients through PA was not taken in to account while calculating the equivalent nutrients through PA was not taken in to account while calculating the equivalent nutrient level. The five organic materials in combination with complimentary chemical fertilizer dose and PA uniformly @ 10 t ha^{-1} (PA10) as supplement formed five different integrated nutrient treatments. Organic materials and PA were incorporated in to soil at 15 cm depth in three times of application viz., 30 days before planting (DBP), 15 DBP and at planting. However, CF (Urea, SSP and MOP) was applied as per the recommended practice (Half N and full P and K as basal at planting and remaining N in two equal splits at tillering and panicle initiation stages. The experiment was laid out in split plot design with time of application in the main plot and integrated nutrient treatments in the sub-plot, Besides, one additional treatment with CF alone at equivalent nutrient level was included outside the design. All the treatments were replicated thrice.

After harvest of rice, potato variety Kufri Chandramukhi was grown in the same layout. Potato crop received a standard fertilize dose of 100:26:83 and 150:65:125 kg N:P:K kg/ha through CF during first and second year, respectively. Because of low inherent fertility in acid lateritic soil, it was not possible to grow a successful potato crop in absence of direct application of CF. Hence, all the ;lots received uniformly direct application of CF and the variation in residual effect was studied in presence of CF. Potato crop received 33% of N, full dose of P and K at planting and the remaining quantity of N in two equal splits at 30 and 45 days after planting (DAP)

RESULTS AND DISCUSSION

Direct effect of time of application on grain yield of rice (pooled mean for two years) revealed that incorporation of organic materials at 15 DBP resulted in highest yield while application at planting resulted in lowest grain yield (Table 2). One month old rice seedlings at planting were in active vegetative stage requiring readily available nutrients. Availability of nutrients determines the nutritional condition of mother culm, which in turn influences tillering behaviour (Matsushima, 1967) and finally grain yield. Application of organic materials at planting might have delayed the release of nutrients due to initial competition of crop plants with soil microbes for readily available nutrients. However, when the organic materials were applied at 15 DBP, microbial immobilization might be over in absence or rice plant facilitating ready availability or nutrients from the beginning of crop growth. Direct effect of fertilization sources on grain and straw yield of rice revealed that standard split application of CF resulted in maximum grain yield during first year. This was possible because at similar soil fertility, standard split application of nitrogen could match to the active stages of crop growth viz. tillering and panicle initiation. However, superiority of CF over integrated nutrients was not observed during second year. This was due to better residual fertility under integrated nutrients (Table 3). In general, grain yield was increased under all the integrated nutrient treatments in the second year as compared to first year. However, the trend was reverse for the treatment CF.

Residual effect of fertilization sources revealed that application of organic materials at rice planting resulted in more tuber yield than at 30 DBP or 15 DBP. Rice crop was less benefited when organic materials were applied at planting and thus higher residual fertility was accrued under this time of application as compared to 30 DBP or 15 DBP. Residual effect of fertilization sources on tuber yield of potato revealed that it was lowest under CF. This was due to build up of residual fertility (Table 3) under integrated nutrient treatments involving coal ash and organic materials. Among the different integrated nutrient treatments, highest tuber yield (24.1 t/ha) was realized under PA_{10} + PS_5 + CF and minimum under PA_{10}+$GM_{2.5}$+CF. Paddy straw with wide C:N ratio (71.1) might be slower in decomposition resulting in higher residual fertility. On the contrary, GM with narrow C:N ratio might be in very much active mineralization stage (Singh, 1984) resulting in faster decomposition and hence, low residual fertility and lower tuber yield. Singh et al. (1999) also reported higher yield of potato tuber under the residual effect of paddy straw based treatments (applied to rice) than under treatments with sesbania.

Yield of potato tuber was converted to rice equivalent rice yield (REY) of grain for comparing the effect of treatments in rice-potato cropping sequence. It is apparent from the Table 2 that REY was not influenced under different times of application indicating incorporation of organic materials any time in between 30 DBP was equally beneficial for rice-potato cropping sequence. All the integrated nutrients were superior to continuous use of CF in producing higher rice equivalent yield in rice potato cropping sequence. This benefit was to the extent of 15 percent for the treatment PA_{10} + PS_5 +CF. Higher equivalent yield under this treatment can be ascribed to higher tuber yield as the effect of fertilization sources was not significant on mean yield, study on the fate of soil fertility is important from sustainability point of view. The data on available N, P and K (Table 3) at the end of two crop rotations revealed that there was appreciable increase in available P and K status of soil over seasons. This increase was marginal in case of available N. All the sources were effective in increasing available nutrient status of soil. However, it was minimum under continuous use of CF and all the integrated nutrients were superior to it. Higher residual fertility under integrated nutrients might be due to addition of N, P and K through pond ash (Pond ash 10 t provided 1 kg N, 30 kg P and 21 kg K) as additional source and slow release nature of organic materials. Among the integrated sources, PA_{10} + PS_5 + CF was most effective in increasing the initial available N status from 82 to 97 mg/kg. The corresponding increase in available P and K was from 8 and 39 mg/kg-1 to 20 and 61 mg/kg respectively. Higher residual fertility under PS based treatments can be ascribed to slower rate of decomposition.

REFERENCES

Adriano, D.D., Page, A.L. Elseewi, A.A. Chang A.C. and Straughan I (1980). Utilization of fly ash and other coal residues interrestrial ecosystems: a review. *J. Environ. Qual.* **9**:333-344.

Azmal, A.K.M., Marumoto, T. Shindo, H. and Nishiyama, M. (1996). Mineralization and microbial biomass formation in upland soil amended with some tropical plant residues at different temperatures. *Soil Sci. Plant Nutr.* **42:** 463-473.

Hegde, D.M. (1998). Effect of integrated nutrient supply on crop productivity ad soil fertility in rice (Oryza sativa) wheat (Triticum aestivum) system in semi-arid and humid ecosystems. *Indian. J. Agron* **43** : 7-12.

Matsushima, S. (1967). Theory of yield determination and its application. Crop Science in Rice. Fuji Publ. Co. Ltd., Tokyo.

Mittra B.N., Ghosh B.C., Karmakar S., George J., Rautaray S.K. and Basu. S. (2000) Utilization of industrial solid wastes in augmenting crop production and soil productivity. In: Waste recycling and resource management in the developing world. B.B. Jana, R.D. Banerjee, B.Guterstam and J.Heeb (Eds.) pp. 185-195.

Singh, A.P., Mittra B.N. and Tripathy R.S. (1999). Influence of soil enrichment with organic and chemical sources of nutrients on rice (*Oryza sativa*) potato (*Solanum tubersum*) cropping system. *Indian J. Agric. Sci.* **69** : 376-8.

Singh, N.T. (1984). Green manures as source of nutrients in rice. In: Organic matter and rice. IRRI, Los Banos, Philippines. P. 217-228.

Table 1. Application rate, quantity of N, P and K supplied and C:N ratio or organic materials

Organic materials	Application Rate (t ha^{-1})	N	P	K
FYM	5.0	45.0	15.5	33.0
PS	5.0	32.5	7.5	66.5
GM	2.5	54.5	4.0	15.8
WH	2.5	31.3	9.5	52.5
AZ	0.75	33.0	5.3	22.1

FYM = Farmyard manure, PS = Paddy straw, GM = Green manure (*Sesbania rostrata*)
WH = Water hyacinth compost, AZ = Azolla.

Table 2. Yield of rice grain and potato tuber and equivalent rice grain yield of the cropping system as influenced by sources of fertilization and their time of application under rice-potato cropping sequence

Treatments	Yield (t / ha^{-1})						
	Rice grain			Potato tuber			equivalent
	1996	1997	Mean	1996-97	1997-98	Mean	rice grain
Time of application							
D_1	4.19	4.89	4.54	16.6	25.4	21.0	11.5.04
D_2	4.50	5.18	4.84	17.2	27.0	22.1	12.1
D_3	4.08	4.76	4.42	18.5	29.3	23.9	12.3
Sem±	**0.076**	**0.021**	**0.034**	**0.12**	**0.52**	**0.15**	**0.121**
LSD (0.05)	**NS**	**0.083**	**0.133**	**0.47**	**2.04**	**0.60**	**NS**
Sources of fertilization							
$PA_{10}+PS_5+CF$	4.28	5.01	4.65	19.4	28.7	24.1	12.6
$PA_{10}+WH_{2}.5+CF$	4.25	4.94	4.59	17.4	27.9	22.7	12.1
$PA_{10}+FYM_5+CF$	4.24	4.96	4.60	17.1	27.0	22.1	11.9
$PA_{10}+AZ_{0.75}+CF$	4.06	4.88	4.47	17.2	27.2	22.2	11.8
$PA_{10}+GM_{2.5}+CF$	4.49	4.92	4.71	16.0	25.3	20.7	11.5
CF	4.86	4.74	4.80	13.8	23.9	18.8	11.0
Sem±	**0.109**	**0.100**	**0.089**	**0.16**	**0.75**	**0.41**	**0.131**
LSD (0.05)	**0.55**	**NS**	**NS**	**0.47**	**2.19**	**1.20**	**0.382**

Equivalent rice grain yield is calculated based on the price Rs. 1.30 and 3.95 per kg of potato tuber and rice grain respectively (Fertilizer statistics 1997)
D_1 = 30 days before planting (DBP), D_2 = 15 DBP, D_3 = at planting
PS = Paddy straw, WH = Water hyacinth compost, FYM = Farmyard manure.
AZ = Azolla, GM = Green manure (Sesbania rostrata)

Table 3. Available nutrients (mg/kg-1) of soil after harvest or fice and potato in sequence as influenced by sources of fertilization and their time of application

Treatments	1996-97						1997-98					
	Rice			Potato			Rice			Potato		
	N	P	K	N	P	K	N	P	K	N	P	K
Time of application												
D_1	87.6	10.4	32.2	92.1	15.0	44.5	88.6	16.4	42.0	9.8	17.4	54.0
D_2	89.0	11.3	33.4	93.2	15.3	44.1	89.2	17.6	40.0	93.4	18.0	55.3
D_3	90.0	12.6	34.4	96.0	15.7	46.0	89.8	18.6	48.0	96.8	19.5	57.3
Sources of fertilization												
$PA_{10}+PS_5+CF$	91.3	11.8	41.3	96.4	15.9	49.2	91.6	17.7	48.3	97.3	20.0	60.8
$PA_{10}+WH_{2.5}+CF$	89.3	11.6	39.7	95.1	15.5	46.7	89.3	17.6	47.0	94.0	18.9	89.8
$PA_{10}+FYM_5+CF$	90.0	12.2	37.3	95.3	15.6	45.2	89.6	18.1	41.7	95.7	19.5	54.6
$PA_{10}+FYM_5+CF$	88.0	11.3	36.7	92.0	14.7	40.8	88.7	17.2	38.3	93.0	17.1	52.1
$PA_{10}+GM_{2.5}+CF$	85.6	10.8	37.6	92.1	14.8	42.5	87.0	16.8	38.3	91.7	15.9	51.3
CF	83.2	10.3	36.0	86.8	11.2	39.2	84.1	11.4	36.5	85.1	13.3	41.7

D_1 = 30 days before planting (DBP), D_2 = 15 DBP, D_3 = At planting
PS = Paddy straw, WH = Water hyacinth compost, FYM = Farmyard manure, AZ = Azolla,
GM = Green manure (Sesbania rostrata)