USING COMBINED NUTRIENT MANAGEMENT PRACTICES TO MAXIMIZE YIELDS, NUTRIENT UPTAKE, AND BALANCE FOR RICE-RICE CROPPING SYSTEMS

ABSTRACT

An on-site experiment was carried out at the Bangladesh Rice Research Institute (BRRI). The objective was to assess the most appropriate blend of organic and inorganic fertilizers for the Boro-Fallow-T. Aman rice cropping pattern. An experiment was carried out at the BRRI Farm in Gazipur, Bangladesh to assess rice yields, nutrient absorption, and balance. The nutrient management practices included absolute nutrient control (T1), the recommended chemical fertilizer dose by BRRI (T2), a combination of kitchen waste (3 t/ ha) and 50% of the recommended BRRI fertilizer dose (T3), a combination of cow dung bio-slurry (3 t ha-1) and 50% of the recommended BRRI fertilizer dose (T4), and a combination of poultry litter (3 t/ ha) and 50% of the recommended BRRI fertilizer dose (T5). The practices were evaluated using a randomized complete block design with three replications conducted over two consecutive years. The performance of Poultry litter with 50% BRRI-recommended fertilizer (T5) and BRRI-recommended fertilizer dosage (T2) has been superior in all parameters. The same approaches (T5) and (T2) demonstrated the highest absorption of nutrients by rice crops. The observed N and K balance exhibited a negative trend but with a lesser degree of negativity. Additionally, a lower level of deficit was seen in the T5 treatments. The T5 treatment exhibited a surplus of P, while other treatments showed a deficit of P. This research shows that poultry litter (3 t/ ha) combined with 50% of the fertilizer suggested by BRRI is enough and acceptable for a sustainable rice yield.

*** Correct way of writing is **t/ ha** not t ha-1*

Keywords: Chemical fertilizer, organic materials, rice-rice cropping pattern.

INTRODUCTION

Rice is the staple food for nearly half the world's population, and its continued increased production to meet the enhanced demand due to the ever-increasing population faces many challenges (Chauhan, 2017). Rice–Fallow–Rice, the dominant cropping system in Bangladesh, has received little attention regarding soil organic carbon (SOC) changes through organic amendments (Fahmida, 2016). In Bangladesh, loss of soil fertility is a major impediment to increased crop output. Increased land use intensity, along with the use of chemical fertilizers and little or no organic manure, has resulted in serious soil fertility loss, resulting in crop productivity stagnation or even decline. Bangladeshi farmers utilize an average of 172 kg of nutrients per hectare per year (132 kg N + 27 kg P + 17 kg K + 4 kg S, and 2 kg Zn), while crop removal is around 250 kg/ha (Islam, 2002). At least 2.5 percent

organic matter is required in optimal soil. However, most soils in Bangladesh have less than 1% organic matter, (BARC, 2012) which is increasing day by day, generating a nutritional imbalance in the soil. Soil organic matter (SOM) promotes soil fertility and productivity through improving physical, chemical, and biological qualities. SOM can help improve soil quality and crop output in a variety of ways, including nutrient cycling and provisioning during decomposition, aggregate stability and soil porosity, water-holding capacity, particularly accessible water, and cation exchange capacity (Johnston and Poulton, 2009, Murphy, 2015). The purpose of this experiment is to see how different organic manures and chemical fertilizers affect rice yield and soil qualities using kitchen waste, cowdung bio-slurry, and poultry manure.

*** In the Introduction section it's mandatory to specify the total area, production and productivity of rice the World, Bangladesh and State.*

MATERIALS AND METHODS

Study location and soil

The experiment was conducted from T. Aman (wet season) 2017 to Boro (dry season) 2019 at the experimental field of Bangladesh Rice Research Institute, Gazipur, located at 23.58°N latitude and 90.25°E longitude at an elevation of about 8.5 m above the sea level. The average annual rainfall is 2200 mm, of which 70% occurs between mid-June and to end of September. The lowest mean temperature (12°C) prevails in January and the highest (34°C) in May. The soil of the experimental site belongs to inceptions according to the USDA soil classification system.

Experimental design and treatments

The experiment consisted of five treatments in a Randomized Complete Block Design with three replications. The treatments were different sources of soil nutrients such as absolute nutrient control (T_1); BRRI recommended fertilizer dose (T_2); Kitchen waste (3 t/ ha) + 50% BRRI recommended fertilizer dose (T_3); Cow dung bio-slurry (3 t ha^{-1}) + 50% BRRI recommended fertilizer dose (T_4) and Poultry litter (3 t ha^{-1}) + 50% BRRI recommended fertilizer dose (T_5). Organic materials with chemical fertilizers were applied to Boro and T. Aman rice separately.All organic materials were applied on a dry weight basis after calculating their moisture contents. The BRRI recommended dose of NPKS in the T. Aman season was 100-10-85-5 kg ha^{-1} and in the Boro season, it was 138-10-80-5 kg ha^{-1}. Organic manures and all the fertilizers, except urea, were applied at the time of final land preparation and incorporated into the surface soil. Urea was applied in three equal splits; the first split was applied at final land preparation, the second split at maximum tillering, and the third split at the panicle initiation stage. The unit plot size was 4m x 5m. Rice crops were grown twice (T. Aman and Boro) in a year and between these two rice crops, there was a fallow period. In the T. Aman season, 30- to 35-day-old seedlings of BRRI dhan49 were transplanted at 20-cm×20-cm spacing in the last

week of July; paddy was harvested in the last week of November. In the Boro season, 40- to 42-day-old seedlings of BRRI dhan58 were transplanted at the same spacing in the second week of January; paddy was harvested in the first week of May.

Soil and Plant Samples Analysis

Soil samples at 0-15 cm were collected after the completion of two cycles of the cropping system from each treatment plot. Plant samples (straw and grain) against each treatment plot were oven-dried at 70 °C for 48 h and finely ground.

The initial and final soil samples were analyzed for soil pH and organic matter by the Nelson and Sommers (1982) method; total N by the Microkjeldahl method (Bremner & Mulvaney, 1982); exchangeable K by 1N NH_4OAc method (Jackson, 1973); available P by Olsen and Sommers (1982) method; available S by turbidity method using $BaCl_2$ (Fox et al., 1964).

Ground plant samples were digested with di-acid mixture (HNO_3-$HClO_4$) (5:1) as described by Piper (1966) for the determination- concentration of N (Micro-Kjeldahl method), P (spectrophotometer method), and K (atomic absorption spectrophotometer method).

Nutrient Uptake and Apparent Balance Calculation

Crop nutrient uptake was calculated from the nutrient (N, P, and K) concentration and the straw and grain yields (Quayyum et al., 2002). Apparent nutrient balance for the Boro-Fallow-T. Aman rice cropping system (average of two years) was computed as the difference between nutrient input and output (Paul et al., 2014). The inputs were supplied from fertilizer and the outputs were estimated from crop uptake in a cycle.

Organic Fertilizer collection and Nutrient content

Organic Fertilizers were collected from the Bangladesh Rice Research Institute (BRRI) residential area and nearby BRRI. The nutrient status of different sources of Organic fertilizer is in the Table.1

Table 1 Nutrient status of different organic fertilizers.

Organic Fertilizer	Nutrient content status (%)		
	N	P	K
Kitchen waste	0.65	0.18	0.45
Cow dung bio-slurry	0.67	0.29	0.60
Poultry litter	1.84	1.20	2.08

Statistical analysis

The data on yield and yield contributing characters were subjected to analysis of variance (ANOVA) to determine the effects of organic fertilizer treatments. The least significant difference (LSD) at a 5% level of probably was used to separate the means for organic treatments. All the analysis was carried out using a standard statistical procedure (R-software 1).

RESULTS AND DISCUSSION

Rice yield and agronomic performance:

The plant height, tiller production, panicle number, grain number, grain yield, and straw yields of T. Aman and Boro rice were significantly impacted by various nutrient management practices in both the first and second years (Tables 2 and 3). Treatment T_5 produced the tallest plant, maximum number of tillers, panicle, and grains/ panicle, as well as the highest grain and straw yields of T. Aman and Boro rice. These were significantly higher than that of other treatments, except T_2 treatment in both years which were statistically identical with T_5 for every parameter. The treatment T_2 exhibited the second highest values for plant height, number of tillers, panicle, grain per panicle, grain yield, and straw yield of T. Aman rice. These values were substantially higher compared to those seen in treatments T_3 and T_4. For every rice crop in both years, T_4's performance was again noticeably better than T_1's (Table 2 & 3). The average plant height, tiller production, panicle number, grain number, grain yields, and straw yields in T. Aman rice varied between 90.5 and 101.8 cm, 189 and 250.5 no. m^{-2}, 182 and 240.5 no. m^{-2}, 98.5 and 117 no. $panicle^{-1}$, 2.36 and 5.28 t ha^{-1}, and 2.74 and 5.80 t ha^{-1}, respectively, as a result of different nutrient management practices. However, in Boro rice, the treatments exhibited statistically significant differences from each other. The T_5 treatment had the greatest value, while the T_1 treatment had the lowest value in both years. The average plant height, tiller production, panicle number, grain number, grain yields, and straw yields in Boro rice varied between 77.57 and 91.85 cm, 182.5 and 260 no. m^{-2}, 160 and 239.5 no. m^{-2}, 94.5 and 143 no. $panicle^{-1}$, 2.46 and 6.29 t ha^{-1}, and 2.71 and 6.35 t ha^{-1}, respectively, due to different nutrient management practices (Table 2 & 3).

Table 2. Agronomic features and yield of different nutrient management approaches during T. Aman in the rice-rice cropping system.

Treatments	Plant height (cm)			Number of Tiller m^{-2}			Number of Panicle m^{-2}			Number of Grain/ panicle			Grain yield (t/ ha)			Straw yield (t/ ha)		
	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean
T_1	95.23	85.77	90.5	194	184	189	187	177	182	98	99	98.5	2.6	2.11	2.36	2.95	2.53	2.74
T_2	102.85	99.81	101.33	245	236	240.5	238	226	232	112	114	113	5.54	4.86	5.2	6.18	4.98	5.58
T_3	101.53	93.67	97.6	219	217	218	209	208	208.5	107	108	107.5	4.71	4.2	4.46	5.16	4.43	4.80
T_4	101.6	92.94	97.27	227	216	221.5	216	201	208.5	105	115	110	4.45	4.13	4.29	5.2	4.33	4.77
T_5	103.35	100.25	101.8	251	250	250.5	244	237	240.5	115	119	117	5.65	4.9	5.28	6.48	5.12	5.8
$LSD_{0.05}$	1.23	1.68	-	18.55	18.55	-	12.09	17.71	-	6.52	6.48	-	0.39	0.35	-	0.53	0.43	-
CV (%)	2.10	1.25	-	4.18	4.18	-	5.70	4.28	-	6.1	5.22	-	6.4	4.32	-	6.85	4.62	-

***CD (5%) value is missing, CD (5%) value must add of the analyzed data.*

Table 3. Agronomic features and yield of different nutrient management approaches during Boro in the rice-rice cropping system.

Treatments	Plant height (cm)			Tiller m^{-2} (no.)			Panicle m^{-2} (no.)			Grain $panicle^{-1}$ (no.)			Grain yield (t ha-1)			Straw yield (t ha-1)		
	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean
T_1	80.87	74.27	77.57	159	206	182.5	136	184	160	95	94	94.5	2.4	2.53	2.465	2.75	2.68	2.71
T_2	85.1	96.83	90.965	228	270	249	203	256	229.5	144	135	139.5	6.2	5.95	6.075	6.17	5.83	6.00
T_3	83.83	90.5	87.165	207	253	230	176	223	199.5	140	113	126.5	5.07	5.2	5.135	4.93	5.11	5.02
T_4	82.94	91.61	87.275	190	245	217.5	162	218	190	142	107	124.5	4.9	5.33	5.115	4.73	5.27	5.00
T_5	86.36	97.35	91.855	244	276	260	219	260	239.5	145	141	143	6.49	6.1	6.295	6.51	6.2	6.35
$LSD_{0.05}$	1.35	1.41	-	17.11	14.11	-	18.09	17.77	-	5.36	7.43	-	0.43	0.41	-	0.55	0.51	-
CV (%)	2.3	2.35	-	6.3	7.21	-	6.45	6.48	-	5.92	6.42	-	3.6	5.05	-	5.98	8.76	-

***CD (5%) value is missing, CD (5%) value must add of the analyzed data.*

Nutrient concentration of rice grain and straw:

The contents of grain N, P, and K were significantly higher in the T_5 treatment where 3 tha^{-1} Poultry litter with 50% BRRI recommended chemical fertilizer was applied and which is statistically identical with T_2 treatment where BRRI recommended 100 % chemical fertilizer was applied. The straw N, P, and K contents were also higher with the T_5 treatment. On the other hand, the T_1 (absolute control) resulted in the lowest N, P, and K contents in the grain and straw of both rice varieties. The treatment combinations indicated that the increased N, P, and K contents in grain and straw were the effect of poultry litter application, and the decreased N, P, and K contents in grain and straw were the effect of no nutrient application (Table 4).

Table 4: Effect of different nutrient management on N, P, and K concentrations in BRRI dhan49 and BRRI dhan58.

Treatment	Grain			Straw		
BRRI dhan49	N%	P%	K%	N%	P%	K%
T_1	0.99	0.23	0.24	0.51	0.10	1.78
T_2	1.13	0.26	0.28	0.60	0.12	1.96
T_3	1.07	0.24	0.28	0.54	0.09	1.87
T_4	1.00	0.25	0.27	0.55	0.11	1.90
T_5	1.17	0.28	0.30	0.65	0.13	2.05
BRRI dhan58	N%	P%	K%	N%	P%	K%
T_1	1.12	0.25	0.23	0.62	0.10	1.75
T_2	1.32	0.28	0.27	0.70	0.14	2.10
T_3	1.21	0.27	0.25	0.63	0.12	1.81
T_4	1.13	0.26	0.26	0.62	0.12	1.85
T_5	1.38	0.30	0.28	0.79	0.15	2.14
CV (%)	5.17	7.95	9.68	8.15	11.25	9.10

***CD (5%) value is missing, CD (5%) value must add of the analyzed data.*

Nutrient uptake by rice:

Different nutrient management practices demonstrated significant uptake of N, P, and K by the Boro Fallow-T. Aman rice cropping system in both first and second years (Table 5). The greatest uptakes of all nutrients were estimated from T_5 treatment by all the rice crops which were significantly different from the other treatments. The nutrient uptake followed the order: K > N > P. The control (T_1) treatment showed significantly inferior nutrient uptake to the other treatment (Table 5). The total nutrient uptake by crops (BRRI dhan49+BRRI dhan58) varied from 68.18-215.97 kg N ha^{-1}, 13.78-45.94 kg P ha^{-1} and 82.30-252.59 kg K ha^{-1}. Among the treatments, maximum total nutrient uptakes were recorded from 3 tha^{-1} Poultry litter with 50% BRRI recommended chemical fertilizer treatments plot (T_5) followed by BRRI recommended dose treatment (T_2), and the minimum was in control plot (T_1) (Table 5).

Table 5. Effect of different nutrient managements on nutrient uptake by BRRI dhan49 and BRRI dhan58.

Treatment	N		P		K	
BRRI dhan49	1st year	2nd year	1st year	2nd year	1st year	2nd year
T_1	36.77	30.51	7.50	6.20	46.67	39.78
T_2	88.45	75.12	19.31	16.44	117.16	95.37
T_3	69.35	60.98	14.68	12.92	86.06	74.26
T_4	64.06	56.99	14.56	13.04	87.29	73.67
T_5	97.80	81.66	21.38	17.94	125.51	100.30
$LSD_{0.05}$	13.10	13.25	5.02	5.15	6.46	6.50
BRRI dhan58	1st year	2nd year	1st year	2nd year	1st year	2nd year
T_1	36.76	37.66	7.36	7.58	43.25	42.52
T_2	104.93	100.19	21.84	20.86	118.05	111.76
T_3	77.61	79.87	16.51	16.98	82.29	85.17
T_4	71.08	77.94	15.50	16.98	80.96	89.91

T_5	118.17	111.58	24.56	23.18	127.08	120.83
$LSD_{0.05}$	5.65	5.50	4.98	4.85	6.98	7.48
BRRI dhan49+BRRI dhan58	1st year	2nd year	1st year	2nd year	1st year	2nd year
T_1	73.53	68.18	14.86	13.78	89.91	82.30
T_2	193.38	175.31	41.15	37.30	235.22	207.13
T_3	146.95	140.84	31.18	29.90	168.35	159.43
T_4	135.14	134.93	30.06	30.01	168.25	163.59
T_5	215.97	193.24	45.94	41.12	252.59	221.13

Total Input and Output of Nutrients

40% N from urea was effectively considered in the input estimation. Annual input of N varied from 0.00 to 158 kg ha^{-1} yr^{-1}, P input ranged from 0.00 to 82 kg ha^{-1} yr^{-1} and K input was from 0.00 to 207 kg ha^{-1} yr^{-1}. The great amounts of nutrients were measured in the T_5 treatment and the tine amount in the T_1 treatment (Table 6). The output of nutrients (mean of two years) ranged from 70.85 to 204.61 kg N ha^{-1}, 14.32 to 43.53 kg P ha^{-1} and 86.11 to 236.86 kg K ha^{-1}. The highest outputs of all nutrients were found in T_5 and the lowest were in the control (T_1) treatment (Table 6).

Table 6. Effect of different nutrient management practices on nutrients input (added from fertilizer and manure) and output (crops uptake) of rice- rice cropping system.

Treatment	N	P	K
Input		kg $ha^{-1}yr^{-1}$	
T_1	0	0	0
T_2	95.2	20	165
T_3	86.6	20.8	109.5
T_4	87.8	27.4	118.5
T_5	158	82	207.3

Output		kg $ha^{-1}yr^{-1}$	
T_1	70.85	14.32	86.11
T_2	184.35	39.23	221.17
T_3	143.90	30.54	163.89
T_4	135.04	30.04	165.92
T_5	204.61	43.53	236.86

Apparent Nutrient Balance

The nutrient balance did not account for the addition of N from rainfall, irrigation water, or gaseous losses, or BNF. The apparent balance of N, P, and K are shown in Figure 1.

Results revealed that N balance was negative in all the treatments and the depletion ranged from -46.60 to -89.14 kg N ha^{-1} yr^{-1}. In the case of P balance, the value was negative in all treatments (ranging from -2.63 to -19.22 kg P ha^{-1} yr^{-1}) except treatment T_5 where the P magnitude was greater in soil receiving from poultry manure. The soils of all treatments showed negative K balance where the K mining ranged from -29.56 to -86.10 kg K ha^{-1} yr^{-1}. The greatest K mining was measured from control (T_1) followed by BRRI recommended dose (T_2) and the lowest K mining was calculated in Poultry litter use treatment (T_5).

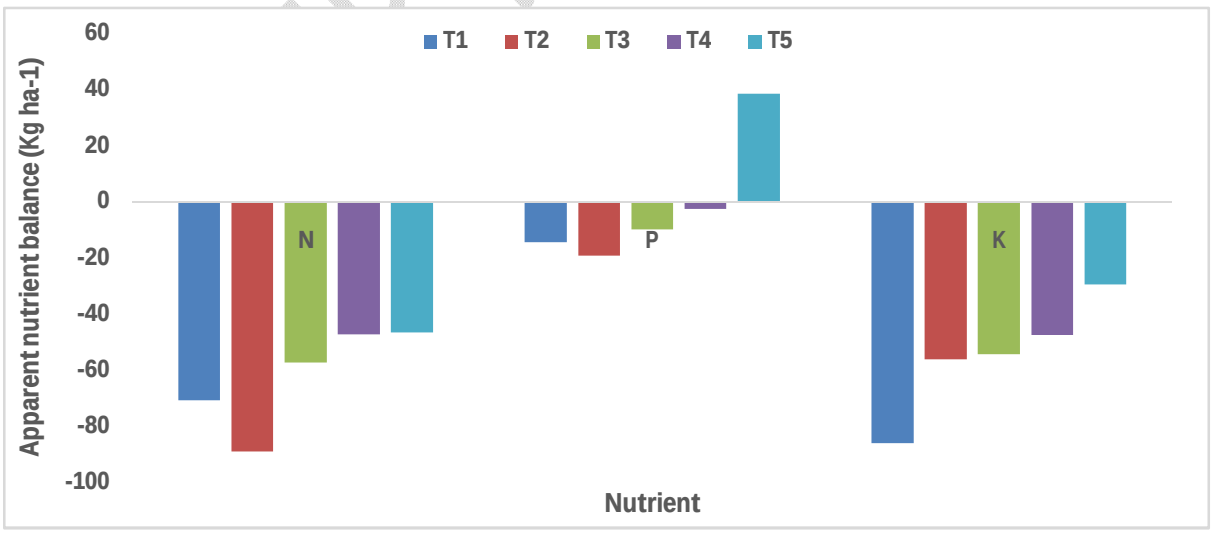

Figure 1: Effect of nutrient management practices on apparent nutrient balance of rice-rice cropping system

Soil properties after two years

After two years of experiment, soil pH in the tested treatments varied from 6.10 to 7.25 and organic matter varied from 1.33 to 1.41, respectively (Table 7). The differences in pH, OM, P, and K among the treatments were not significant. Yadvinder Singh *et al*. (2000) found only a little improvement in soil organic matter, P and K due to green manuring, while application of crop residues raised their levels significantly. Farmyard manure application increased P and K in their long-term experiment. Chettri *et al*. (2003) found an increase in organic carbon from 1.4 to 1.6% for eight years due to the application of seven tones of farm yard manure in rice and wheat cropping. Mandal *et al*. (2003) also reported that the organic matter and total N concentration in the soil were found to be higher in green manuring treated plots.

Table: 7. Characteristics of soil of the experimental plots after two years.

Treatments	pH	OM (%)	Total N (%)	P (ppm)	K (meq/100g soil)	S (ppm)
T_1	6.90	1.35	0.16	9.50	0.17	20
T_2	7.05	1.33	0.18	10.0	0.18	21
T_3	7.14	1.40	0.18	10.7	0.20	22
T_4	7.25	1.40	0.18	10.7	0.21	22
T_5	7.18	1.41	0.19	10.9	0.22	23
Initial Soil	7.10	1.38	0.19	9.70	0.24	21

CONCLUSION

In this experiment, we concluded that the combined application of organic and inorganic fertilizers increased the rice yield and yield contributing characters over native soil in both seasons. Among the treatments, the application of poultry manure at the rate of 3 t ha^{-1} with 50% BRRI recommended fertilizer dose has performed higher and statistically similar with 100% chemical fertilizer like BRRI dose. There was a slightly increasing trend in soil organic matter, pH, total N (%), available P, S, and exchangeable K after two years of continuous rice

cultivation. Long-term use of organic materials like poultry manure would improve the organic matter and other nutrient content of soil for better productivity.

Revised Conclusion: *It is concluded from the two years of experiment, that the combined application of organic and inorganic fertilizers increased the rice yield and yield contributing characters over native soil in both seasons. The application of poultry manure (3/ t ha) with 50% BRRI recommended fertilizer dose (treatment 5) has performed significantly higher and statistically similar with 100% chemical fertilizer like BRRI dose. There was a slightly increasing trend in soil chemical properties after two years of continuous rice cultivation. Long-term use of organic materials like poultry manure would improve the organic matter and other nutrient content of soil for better productivity.*

REFERENCES

BARC (Bangladesh Agricultural Research Council). (2012). Fertilizer Recommendation Guide. BARC, Bangladesh Agril. Res. Council, Farmgate, Dhaka.

Bijay-Singh, Singh, V.K. (2017). Fertilizer Management in Rice. In: Chauhan, B., Jabran, K., Mahajan, G. (eds) Rice Production Worldwide. Springer, Cham. https://doi.org/10.1007/978-3-319-47516-5_10

Bremner, J. M., and Mulvaney, C. S. (1982). Total nitrogen. In A. L. Page, R. H. Miller, D. R. Keeney (Eds.), Methods of Soil Analysis (Part 2, 2nd ed., pp. 599-622). Am. Soc. Agron., Madison, USA.

Chauhan BS, Jabran K, Mahajan G. Rice production worldwide: Springer; 2017.

Chettri, G. B., Ghimiray, M., and Floyd, N. C. (2003). Effects of farmyard manure, fertilizers and green manuring in rice-wheat systems. Bhutan. Exp. Agri. 39:129-144.

Ebaid, R A and EL-REFAEEI S. (2007). Utilization of rice husk as an organic fertilizer to improve productivity and water use efficiency in rice fields, African Crop Science Conference Proceedings. 8: 1923-1928.

Fahmida Rahman, Md Mizanur Rahman, G.K.M Mustafizur Rahman, M.A. Saleque, A.T.M Sakhawat Hossain & Md Giashuddin Miah (2016). Effect of organic and inorganic fertilizers and rice straw on carbon sequestration and soil fertility under a rice–rice

cropping pattern, Carbon Management, 7:1-2, 41-53, DOI: 10.1080/17583004.2016.1166425

Fox, R. L., Olsen, R. A., & Rhoades, H. F. (1964). Evaluating the sulphur status of soil by plant and soil test. Soil Science Society of America Proc, 28, 243-246. https://doi.org/10.2136/sssaj1964.03615995002800020034x

Islam, M S. (2002). Soil fertility history, present status and future scenario in Bangladesh. Paper presented at the Training Course on Soil Fertility and Fertilizer Management held at CERDI, Gazipur, 9 Sept. 2002.

Jackson, M. L. (1973). Soil Chemical Analysis (p. 498). Prentice Hall of India Private Limited, New Delhi.

Johnston, A E and P R Poulton. (2009). Coleman, K. Soil organic matter: Its importance in sustainable agriculture and carbon dioxide fluxes. Adv. Agron. 101: 1–57.

Lidong, Bi, Zhang Bin, Guangrong Liu, Zuzhang Li, Yiren Liu, Chuan Ye, Xichu Yu, Tao Lai, Jiguang Zhang, Jianmin Yin and Liang Yin (2009) Long-term effects of organic amendments on the rice yields for double rice cropping systems in subtropical China. Agriculture, Ecosystems and Environment. 129: 534-541.

Mandal, U K, G Singh, U S Victor and K L Sharma. (2003). Green manuring: its effect on soil properties and crop growth under rice-wheat cropping system. Europ. J. Agronomy 19: 225-237.

Miller, H B. (2007). Poultry litter induces tillering in rice. J. Sustain. Agric. 31:1-12.

Mirza Hasanuzzaman, K U Ahamed, N M Rahmatullah, N Akhter, and M L Rahman. (2010). Plant growth characters and productivity of wetland rice (Oryza sativa L.) as affected by application of different manures, Emir. J. Food Agric. 22 (1): 46-58.

Muhammad Ibrahim. (2008). Response of wheat growth and yield to various levels of compost and organic manure. Pak. J. Bot. 40(5): 2135-2141.

Murphy, B W. (2015). Impact of soil organic matter on soil properties-a review with emphasis on Australian soils. Soil Res. 53: 605–635.

Nelson, D. W., & Sommers, L.E. (1982). Total carbon, organic carbon and organic matter. In A. L. Page, R. H. Miller, & D. R. Keeney (Eds.), Methods of Soil Analysis (Part 2, 2nd ed., pp. 539-580). Am. Soc. of Agron., Madison, USA.

Olsen, S., & Sommer, L. E. (1982). Phosphorus. In A. L. Page, R. H. Miller, & D. R. Keeney (Eds.), Methods of Soil Analysis (Part 2, 2nd ed., pp. 403-427). Am. Soc. of Agron., Madison, USA.

Paul, F., Brentrup, F., BruuIsema, T., Garcia, F., Norton, R., &Zingore, S. (2014). Nutrient/fertilizer use efficiency: Measurement, current situation and trends. IFA, IWMI, IPNI and IPI.

Piper, C. S. (1966). Soil and Plant Analysis. Adelaide University Press, Australia.

Quayyum, M. A., Timsina, J., Jahan, M. A. H. S., Ara, R., & Connor, D. J. (2002). Grain Yield and System Productivity for Rice-Wheat-Mungbean and Rice-Wheat-Maize Sequences in Northern Bangladesh. Thai J Agric Sci, 35(1), 51-62.

Rakshit, A, N C Sarkar, and S Debashish. (2008). Influence of organic manures on productivity of two varieties of rice. J. Cent. Eur. Agric., 9(4): 629-634.

Salem, A K M. (2006). Effect of nitrogen levels, plant spacing and time of farmyard manure application on the productivity of rice. Journal of applied sciences research. 2(11):980-987.

Saleque, M A, M S Abedin, N I Bhuiyan, S K Zaman, and G M Panaullah. (2004). Longterm effect of inorganic and organic fertilizer sources on yield and nutrient accumulation of lowland rice. Field Crops Res.86:53-65.

***References need to refresh... Start from Surname and then name.*