Residual Effects Of Organic Manures With Different Levels Of Chemical Fertilizers On Rice

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Abstract: A field experiment was conducted to evaluate the residual effects of organic manures and different level of recommended fertilizer dose (RFD) on the yield and nutrient uptake of BBRI dhan29 at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh, Bangladesh. The experiment containing seven treatments were laid out in a randomized complete block design with three replications. The treatments were T_0 (Control), T_1 (100% RFD), T_2 (75% RFD + residual effect of CD 5 t ha^{-1}), T_3 (75% RFD + residual effect of PM 3 t ha^{-1}), T_4 (75% RFD + residual effect of residual effect of Com. 5 t ha^{-1}), T_5 (75% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha$^{-1,}$ and Com 2.5 t ha^{-1}) and T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}). The manures viz. cowdung (CD), poultry manure (PD) and compost (Com.) was applied to the previous crop (T. Aman rice). The recommended doses of fertilizers were used to supply N, P, K and S @ 140, 15, 60 and 15 kg ha^{-1}, respectively to the present crop. Residual effects of organic manure with inorganic fertilizers significantly increased the yield attributes as well as grain and straw yields of rice. Treatment T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}) produced the highest grain yield (6.87 t ha^{-1}) and straw yield (7.24 t ha^{-1}). The lowest grain yield (3.22 t ha^{-1}) and straw yield (4.55 t ha^{-1}) were found in T_0 (Control) treatment. Further, it was observed that T_2 (75% RFD + CD 5 t ha^{-1}) performed better compared to T_3 (75% RFD + PM 3 t ha^{-1}) and T_4 (75% RFD + Com 5 t ha^{-1}) in exerting residual effects. The NPKS contents and uptake were markedly influenced by residual effects of manures and fertilizers. Therefore, treatment T_6 receiving 50% RFD along with the residual effect of 2.5 t ha^{-1} cowdung, 1.5 t ha^{-1} poultry manure and 2.5 t ha^{-1} compost was found to be the best combination of organic and inorganic fertilizers for obtaining the maximum yield of BRRI dhan29.
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Key words: Cowdung, Poultry manure, Compost, Recommended fertilizer dose, Residual effect, Rice yield, Nutrient uptake, and Marginal benefit cost ratio.

1. Introduction

Cropping intensity is increasing in Bangladesh without adequate and balanced use of chemical fertilizers and with little or no use of organic fertilizers. As a result soil fertility is causing deterioration and crop productivity is declining. Soil organic matter supplies a substantial quantity of some macro and micronutrients for the growing plants and it improves soil health. Sarkar (2004) showed that residual effect of cow dung and chemical fertilizers was significantly positive on the availability of nitrogen, phosphorus, potassium, sulphur, copper, zinc, manganese and nutrient content of soil. It also contributes to soil fertility and productivity through its positive effect on the chemical, physical and biological properties of the soil. But, the organic matter content in most of the soils of Bangladesh is below 1.5% and in many cases it is less than 1%. In spite of that the farmers are using lesser quantities of animal manures and crop residues because most of these materials are being used for cooking, for building houses and as feed for cattle. Hence, management of soil organic matter has now become a major issue in dealing with the problem of soil fertility and crop productivity in Bangladesh. Combined use of organic and inorganic fertilizers helps to maintain soil fertility and crop productivity for a long-term basis. Residual effects of manure or compost application on crop production and soil properties can last for several years (Eghball et al. 2005). By applying integrated use of organic and inorganic fertilizers, farmers may cultivate rice crops without any harmful impact on soil environment. Using of various organic and inorganic fertilizers for the production of rice can reduce the application of chemical fertilizers ultimately reducing cost of production. Badruzzaman et al.(2002) showed that organic manures had direct and residual effects on

both rice and wheat yields and the effect of PM was dominant Therefore, the goal of the present study was to evaluate the residual effects of organic manures and different level of RFD on the yield and nutrient uptake of BRRI dhan29 and the suitability of different sources of organic materials for using as manures for rice cultivation.

2. Material and Methods

Experimental site, soil and climate

The experiment was carried out at the Soil Science Field Laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh. The experimental area is located at $24^0 75^/$ N latitude and $90^0 50^/$ E longitudes at the elevation of 18 m above the sea level. The land of experimental field was medium high, belonging to the Sonatala soil series of Non-calcareous dark grey floodplain soils under the Agro ecological zone (AEZ) of Old Brahmaputra Floodplain and soil order Inceptisol.

Table -1. Physical-chemical properties of soil of the experimental plots

Soil properties	Analytical data
Sand	18%
Silt	78%
Clay	4%
Textural class	Silt loam
Soil pH	6.71
CEC(me/100g soil)	15.00
Organic carbon (%)	1.678
Total nitrogen (%)	0.17
Available P (ppm)	10.55
Exchangeable K (me/100g soil)	0.14
Available S (ppm)	14.25

Table-2. Nutrient contents in cow dung, poultry manure and compost

Manure	Nutrient contents			
	%N	%P	%K	%S
Cowdung	0.57	0.47	0.69	0.23
Poultry manure	1.18	1.13	0.81	0.35
Compost	0.89	0.30	0.45	0.46

Treatments and crop culture

The rice variety BIRI dhan29 was used as the planting materials in the experiment. The experiment consists of seven treatments including T_0 (control), T_1 (100% RFD), T_2 (75% RFD + residual effect of CD 5 tha^{-1}), T_3 (75% RFD + residual effect of PM 3 t ha^{-1}), T_4 (75% RFD + residual effect of Com 5 t ha^{-1}), T_5 (75% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com 2.5 t ha^{-1}) and T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com 2.5 t ha^{-1}). The RFD indicates Recommended Fertilizer Dose as per BARC Fertilizer Recommendation Guide (BARC, 2005). Manures like cowdung, poultry manure and compost were applied in the previous crop (T. Aman rice). Only recommeded fertilizers including urea, TSP, MoP and Gypsum @ 140 kg ha^{-1}, 15 kg ha^{-1}, 60 kg ha^{-1} and 15 kg ha^{-1} were applied during the present study. The P, K, S and Zn fertilizers were applied at the rate of 50, 75, 45 and 2.6 kg ha^{-1}, respectively as a basal dose during the final land preparation. Prilled urea was applied in two equal splits. The first dose of urea (PU was applied at 12 days after transplanting (DAT), the second dose of prilled urea was added as top dressing 36 days after transplanting (active tillering stage). Thirty five-days-old rice seedlings were carefully uprooted from a seedbed nursery bed. The seedlings per hill were placed at a spacing of 20 cm × 20 cm. Several irrigations were provided to maintain the water level 6 cm for water sample collection and as per necessity of the crop. The experimental plots were infested with some common weeds, which were removed from the field by uprooting during entire the period of the experiment.

Chemical analysis of soils

Initial soil samples were collected at a depth of 0-15 cm from the surface. After removing weeds, plant roots, stubbles, stones, etc, the samples were air dried and ground to pass through a 2 mm (10 meshes) sieve. The samples were then stored in clean plastic bags for chemical and mechanical analyses. Initial soil samples were analyzed for physical and chemical properties following standard methods. Particle size analysis of soil was done by hydrometer method (Black, 1965) and the textural class was determined by plotting of the values for % sand, % silt and % clay to the Marshall's Triangular Coordinate following the USDA system. Organic matter was determined by Walkley and Black method (Walkley and Black,1934), soil pH (1:2.5 soil-water) by glass electrode pH meter method (Michael, 1965), total N by Semi-micro Kjeldahl method (Bremner and Mulvaney, 1982), available P by Olsen method (Olsen *et al.*, 1954), exchangeable K by Flame Photometer after extraction with 1N NH_4OA_c at pH 7.0 (Knudsen *et al.*, 1982), available S by extracting soil samples with $CaCl_2$, solution (0.15%) and by measuring turbidity by Spectrophotometer (Williams and Steinbergs,1959) method and CEC by Sodium saturation method (Chapman, 1965).

Data collection on rice

From each plot ten hills were randomly selected to keep records on yield and yield contributing characters. The selected hills were collected before the crop was harvested and the data on plant height, effective tillers per hill, panicle length, and filled grains per panicle and 1000-grain weight were

recorded. Grain yield was recorded at 14% moisture basis and straw yield at sun dry basis.

Chemical analyses of plant samples

The representative grain and straw samples were dried in an oven at 65°C for about 24 hours before they were ground by a grinding machine. Then the ground samples were passed through a 20-mesh sieve and stored in paper bags and finally they were kept in desiccators. The grain and straw samples were analyzed for determination of N, P, K and S. Total N, P, K, and S contents of plant were determined after H_2SO_4-H_2O_2 digestion method described by Lu *et al*. (1999).

Calculation of nutrient (NPKS) uptake

Nutrient uptake (kg ha^{-1}) = (Gy × N_{Gr})/ 100 + (Sy × N_{st})/100; where, Gy = Grain yield (kg ha^{-1}), Sy = Straw yield (kg ha^{-1}), N_{Gr} = N content in grain (%), N_{St} = N content in straw (%).

Economic analysis

A partial budget was estimated. Marginal benefit cost ratio (MBCR) was used as a tool of partial budget analysis. Added cost and added benefit were calculated. Besides, the gross return was calculated on the basis of farm prices of rice grain and straw prevailed during the harvesting period. Marginal benefit cost ratio (MBCR) is the ratio of marginal or added benefit and cost. To compare different fertilizer treatments with one control the following equation was used as outlined by Rahah *et al*. (2007).

$$MBCR = \frac{Gross\ income\ of\ treatment - Gross\ income\ of\ control}{Gross\ cost\ of\ production(treatment) - Gross\ cost\ of\ production(control)}$$

Statistical Analysis

The analysis of variance for different crop characters as well as for different nutrient concentrations of the treatments was made and the mean differences were judged by Duncan's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

3. Results and Discussion

Plant height, effective tillers $hill^{-1}$, panicle length, number of grains panicle, and1000-grain weight of BRRI dhan29 responded significantly to the residual effects of organic manures and and different levels of RFD (Table-3.). All the treatments gave significantly higher plant height over the control (T_0). The tallest plant of 88.47 cm was found in T_1 (100% RFD) which is identical to T_4 (75% RFD + residual effect of Com. 5 t ha^{-1}) and T_5 (75% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t $ha^{-1,}$ and Com 2.5 t ha^{-1}) with the value of 85.47 cm and 84.63 cm respectively. The shortest plant of 69.167 cm was observed in control treatment. The highest number of effective tillers $hill^{-1}$ of 13.1 was found in T_1 (100% RFD) and the lowest value of 9.73 was observed in T_0. The maximum panicle length (25.63 cm) was found in T_4 which was at par with T_5, T_1, T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}) with the value of 25.37 cm, 24.93 cm and 24.80 cm, respectively. The minimum panicle length (20.10 cm) was found in T_0. The number of grains $panicle^{-1}$ varied from 59.93 to 161.2 with the highest value in T_5 treatment. The lowest number of grains $panicle^{-1}$ (59.93) was found in control (T_0). The 1000-grain weight of BRRI dhan29 responded significantly to residual effects of manures and fertilizers (Table-3.). Gana (2009) earlier showed that combined application of cattle manure with inorganic fertilizers gave better performance of growth parameters and yield than separate application of cattle manure and inorganic fertilizer. Bodruzzaman (1996) observed that application of cowdung and Zn had a residual effect on following T. aman rice.

Grain and straw yield

Residual effects of cowdung, poultry manure, compost with NPKS fertilizers showed a positive effect on grain and straw yield of BRRI dhan29 (Table-3.). The grain yield ranged from 3.22 to 6.87 t ha^{-1}. The highest grain yield (6.87 tha^{-1}) was observed in T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1})) and the lowest value (3.22 tha^{-1}) was recorded in T_0 (control). This might be due to the slow releasing nature of cowdung. The increase in grain yield over control ranged from 56.54 to 113.13% where the highest increase was obtained in T_6 and the lowest one was obtained with T_3 (75% RFD + residual effect of PM 3 t ha-1). The grain yield produced by T_3 is statistically similar with T_4 (75%RFD + residual effect of Com. 5 t ha^{-1}) and that by T_1 (100% RFD) is identical with T_5 (75% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t $ha^{-1,}$ and Com 2.5 t ha^{-1}), although there is a numerical variation in grain yield among the treatments. Based on grain yield the treatments may be ranked in order of T_6> T_2> T_5> T_1> T_4> T_3> T_0. These results are also in agreement with the findings of Khan *et al*. (2007) who reported that grain yield was significantly increased due to application of organic and inorganic fertilizers. The yields of straw ranged from 4.55 to 7.24 tha^{-1}. The maximum straw yield of 7.24 tha^{-1} was found in T_6 and the minimum value of 2.55 kg ha^{-1} was noted in T_0 treatment. The treatment may be ranked in the order of T_6 >T_2>T_5 >T_1 >T_3 >T_4 > T_0 in terms of straw yield. Singh *et al*. (2001) studied on the direct and residual effects of nutrient management practices on transplanted rice and reported that integrated use of FYM and NPK gave significantly maximum average rice yield of

3.34 t ha^{-1}. Badruzzaman *et al.* (2010) observed that organic manures had direct and residual effects on rice and wheat yields and the effect of poultry manure was dominant.

Table-3. Residual effects of manures and fertilizers on the yield attributes and yield of BRRI dhan29

Treatments	Plant height	Effective tillers hill^{-1}	Panicle length	Grains panicle^{-1}	1000-grain weight	Grain yield	Straw yield
T_0	69.17d	7.2b	20.10d	59.93d	22.26b	3.22e	4.55c
T_1	88.47a	13.1a	24.93ab	152.2ab	22.99a	5.80c	6.87a
T_2	81.77bc	11.66a	24.5bc	141.5bc	22.96ab	6.38b	7.24a
T_3	79.77c	11.11a	23.7c	136.3c	23.26a	5.04d	5.47b
T_4	85.47ab	12.02a	25.63a	160.6a	23.08a	5.10d	5.27b
T_5	84.63abc	12.1a	25.37ab	161.2a	22.94ab	5.80c	6.99a
T_6	82.80bc	11.87a	24.8ab	145.6bc	22.76ab	6.87a	7.24a
CV (%)	3.57	11.82	2.01	5.08	1.65	1.69	3.38

T_0 (Control), T_1 (100% RFD), T_2 (75% RFD + residual effect of CD 5 t ha^{-1}), T_3 (75% RFD + residual effect of PM 3 t ha^{-1}), T_4 (75% RFD + residual effect of residual effect of Com. 5 t ha^{-1}), T_5 (75% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha$^{-1,}$ and Com 2.5 t ha^{-1}) and T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}). Figures in a column having common letters do not differ significantly at 5% level of significance. CV (%) = Coefficient of variation.

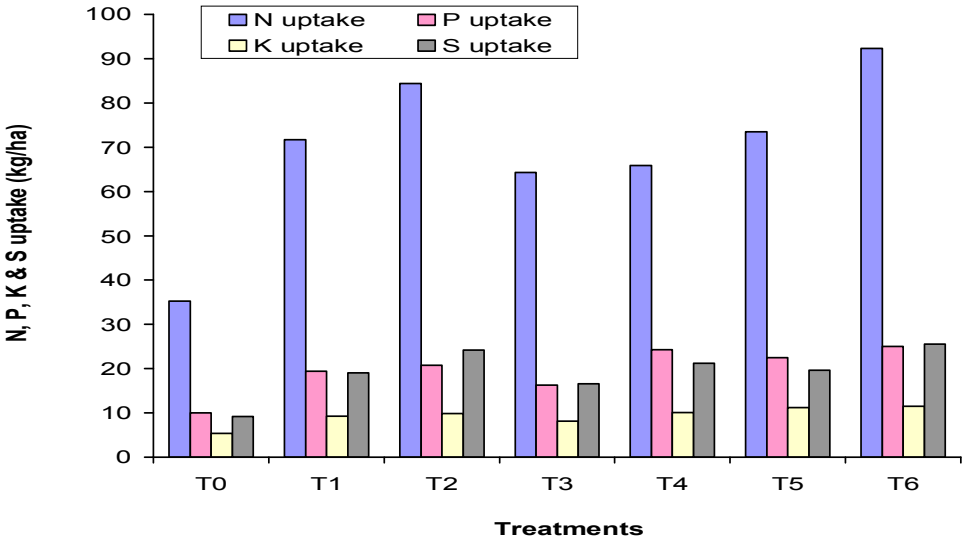

Figure-1. Pattern of N, P, K and S uptake by grain

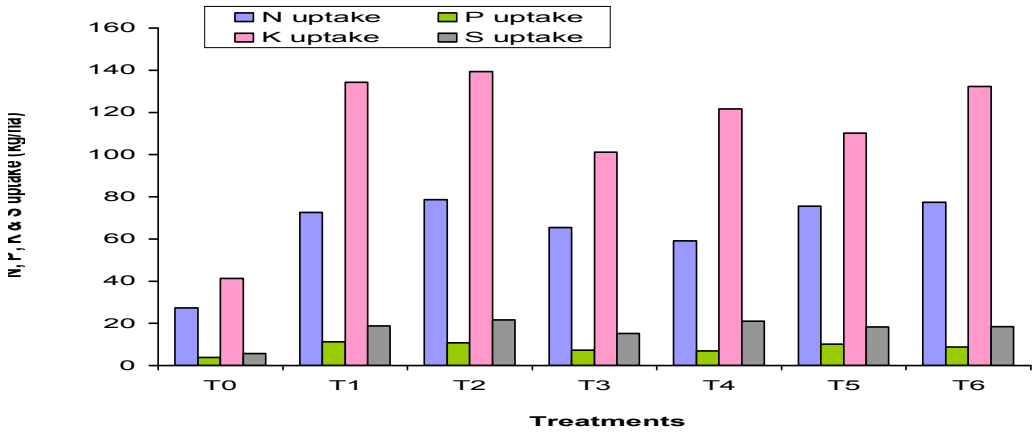

Figure- 2. Pattern of N, P, K and S uptake by straw

T_0 (Control), T_1 (100% RFD), T_2 (75% RFD + residual effect of CD 5 t ha^{-1}), T_3 (75% RFD + residual effect of PM 3 t ha^{-1}), T_4 (75% RFD + residual effect of residual effect of Com. 5 t ha^{-1}), T_5 (75% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha$^{-1,}$ and Com 2.5 t ha^{-1}) and T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}).

Table-4. Residual effects of organic and inorganic fertilizers on total uptake of N, P, K and S by BRRI dhan29

Treatment	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	S uptake (kg ha^{-1})
T_0	49.51f	7.87e	37.7e	8.904d
T_1	109.7c	16.69c	127.5a	31.84b
T_2	131.4b	21.52bc	131.3a	40.76a
T_3	101.2d	13.58d	95.32d	25.76c
T_4	95.73e	21.27bc	108.7b	36.25ab
T_5	121.2c	21.65ab	101.4c	29.02b
T_6	139.5a	23.87a	130.81a	37.90a
CV (%)	2.64	3.10	2.61	7.91

T_0 (Control), T_1 (100% RFD), T_2 (75% RFD + residual effect of CD 5 t ha^{-1}), T_3 (75% RFD + residual effect of PM 3 t ha^{-1}), T_4 (75% RFD + residual effect of residual effect of Com. 5 t ha^{-1}), T_5 (75% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha$^{-1,}$ and Com 2.5 t ha^{-1}) and T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}).Figures in a column having common letters do not differ significantly at 5% level of significance. CV (%) = Coefficient of variation.

Table-5. Economic analysis of BRRI dhan29 as influenced by the residual effects of organic and inorganic fertilizers

Treatment	Yield (tha^{-1})		Gross return (Tk.)	Added cost over control (Tk/ha)	Added benefit over control (Tk/ha)	Gross margin over control (Tk/ha)	MBCR (over control)
	Grain	Straw					
T_0	3.22	2.55	63,102	-	-	-	-
T_1	5.80	6.87	1,18,194	2,713	55,092	52,379	19.31
T_2	6.38	7.24	1,29,382	2,713	66,280	63,567	23.43
T_3	5.04	5.47	1,01,736	2,713	38,634	35,921	13.24
T_4	5.10	5.27	1,02,404	2,713	39,302	36,589	13.49
T_5	5.80	6.99	1,18,438	2,713	55,336	52,623	19.40
T_6	6.87	7.24	1,38,094	2,713	74,992	72,279	26.64

T_0 (Control), T_1 (100% RFD), T_2 (75% RFD + residual effect of CD 5 t ha^{-1}), T_3 (75% RFD + residual effect of PM 3 t ha^{-1}), T_4 (75% RFD + residual effect of residual effect of Com. 5 t ha^{-1}), T_5 (75% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha$^{-1,}$ and Com 2.5 t ha^{-1}) and T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}).

Nutrient Uptake

Results in Figure-1 and Figure -2 indicate that the N uptake both by grain and straw of BRRI dhan29 varied significantly due to residual effects of organic and inorganic fertilizers. The highest N uptake by grain (77.13 kg ha^{-1}) was recorded in T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}) and by straw (62.39 kg ha^{-1}) was recorded in T_2 (75% RFD + residual effect of CD 5 t ha^{-1}) and the lowest N uptake by grain (27.83 kg ha^{-1}) and by straw (21.68 kg ha^{-1}) was found in T_0 (control). The total N uptake by BRRI dhan29 was also influenced significantly by different treatments (Table-4). The highest total N uptake (139.5 Kg ha^{-1}) was observed in T_6 and the lowest value (49.5 Kg ha^{-1}) was found in T_0. Similar to above findings, the N uptake by rice grain and straw increased significantly with the combined application of organic and inorganic fertilizers has been investigated by Malika, (2011). Yang *et al.* (2007) showed that application of N in combination with P and/or K fertilizers in both manured and unmanured treatments usually increased the N recovery in the crop as much as 66%. The maximum P uptake by grain (19.05 kg ha^{-1}) was found in T_6 and straw (6.25 kg ha^{-1}) was observed in T_1 (100% RFD) and the minimum P uptake by grain (6.03 kg ha^{-1}) and straw (1.841 kg ha^{-1}) was found in T_0 (control) as shown in Figure-1 and Figure-2. The residual effects of organic and inorganic fertilizers showed significant effect on the uptake of total P by BRRI dhan29 (Table-4). The highest total P uptake (23.87 kg ha^{-1}) was obtained in T_6 which was identical with T_5 (75% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha$^{-1,}$ and Com 2.5 t ha^{-1}) and the lowest total P uptake (7.87 kg ha^{-1}) was observed in T_0 (control). Khatik *et al.* (2001) reported that the availability of N, P and K increased in the soil with the addition of organic amendments, either alone or

inorganic fertilizers.

The highest total K uptake (131.3 Kg ha^{-1}) was obtained in T_2 and the lowest value (37.7 Kg ha^{-1}) was observed in T_0. It was found that the K uptake by grain was much less than that by straw. Combined use of organic fertilizers exerted better performance in increasing the K uptake both by grain and straw. The results are in agreement with Meena *et al*. (2003) who reported that application of organic and inorganic fertilizers significantly increased the K uptake by rice. The highest S uptake by grain (21.51 kg ha^{-1}) was found in T_6 and by straw (16.39 kg ha^{-1}) was found in T_2 treatment. The lowest S uptake by grain (5.162 kg ha^{-1}) and straw (3.742 kg ha^{-1}) was found in T_0 (control). The highest total S uptake (40.76 kg ha^{-1}) was found in T_2 which was at par with T_6 and the lowest value (8.904 kg ha^{-1}) was observed in T_0. Residual effect of cowdung, poultry manure and compost with different levels of chemical fertilizers showed better effects than other treatments in increasing S uptake by BRRI dhan29. These results are in agreement with Akter (2011) and Malika (2011) who observed positive effects on S uptake by rice with application of manures and fertilizers.

Economic analysis

The cost and return analysis of BRRI dhan29 shows that the highest marginal benefit-cost ratio of 26.64 was obtained from T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}) which was followed by T_2 (75% RFD + residual effect of CD 5 t ha^{-1}) with the value of 23.43 (Table-5). The gross margin was also the maximum in T_6 followed by T_2, T_5 and T_1 treatments. Considering the above facts, the T_6 might be the best suited combination of organic and inorganic fertilizers for BRRI dhan29 and it could be considered as economically profitable as well.

4. Conclusion

The overall results indicate that the highest marginal benefit-cost ratio of 26.64 was obtained from the treatment T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}) which was followed by T_2 (75% RFD + residual effect of CD 5 t ha^{-1}) with the value of 23.43. The gross margin was also prominent in T_6. Thus it appears that 50% of the recommended dose of fertilizer along with the residual effect of 1.5 t ha^{-1} cow dung, 1.5 t ha^{-1} poultry manure and 1.5 t ha^{-1} compost is the best suited combination of organic and inorganic fertilizers for BRRI dhan29. Therefore, it could be considered for economically profitable rice production.

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