**Bangladesh J. Environ. Sci., Vol. 38, 86-91, 2020** **@ BAED ISSN 1561-9206**

# IMPACTS OF INTEGRATED PLANT NUTRIENTS SYSTEM ON T. *AMAN* RICE YIELD AS WELL AS SOIL PROPERTIES (ORGANIC CARBON AND NITROGEN CONTENT) UNDER DIFFERENT TILLAGE MANAGEMENT

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**ABSTRACT**

Depletion of soil fertility is a major constraint to higher production in Bangladesh. Optimum use of fertilizers along with the good management practices such as tillage and residue management are the key to success of achieving higher and sustainable crop yields. The present study was carried out at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during *aman* season of 2018, to study the impact of different tillage system, crop residue retention and Integrated Plant Nutrition System (IPNS) on soil chemical properties and yield of rice. The experiment was laid out in a split-split-plot design with two tillage system 1) single passing of a power tiller at 0-5 cm depth (minimum tillage) and 2) four times ploughing of soil at 0-15 cm depth (conventional tillage) in main plot; two residue treatments (with residue and without residue) in sub plots and three IPNS treatments (recommended fertilizer dose, livestock compost and bio-slurry) on sub-sub plot. Urea, TSP, MOP, Gypsum, and zinc sulphate were used as a source of N, P, K, S and Zn and the recommended rate of fertilizer application followed the Fertilizer Recommendation Guide 2012. Each treatment was replicated three times. BRRI dhan 71 was used as a test crop. Results showed that grain yield and straw yield of rice were significantly influenced with different tillage system ($p > 0.05$). The effect of tillage on soil organic carbon in T. *aman* rice field was significant ($p > 0.05$). Total nitrogen content was significantly influenced by the IPNS ($p > 0.01$). The interactions of tillage x residue x IPNS did not show significant effect on rice yield, soil organic carbon and total nitrogen in soil.

**Key words:** Minimum tillage, crop residue retention, bio-slurry, rice.

## Introduction

IPNS (Integrated Plant Nutrition System) is a holistic approach to plant nutrition by obtaining the nutrients from both inorganic and organic source to maintain and sustain soil fertility and enhance crop productivity in a framework of an ecologically compatible, socially acceptable, technically appropriate and economically viable situation. Concurrently, it encourages, informs, trains and organizes farmers to increase crop production while sustaining soil productivity. Nevertheless, it is true that applying livestock manure to soil can enhance soil fertility and crop growth (Gina *et al.* 2006). Residual effects of manure or compost application on crop production and soil properties can last for several years (Bahman Eghball *et al.* 2005). Integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. The long-term research at BARI revealed that the application of cowdung @ 5 t $ha^{-1}$ $year^{-1}$ improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Poultry manure is another good source of nutrients in soil. Organic manure can supply a good amount of plant nutrients and therefore can contribute to crop yields. Therefore, it is necessary to use fertilizer and manure in an integrated way in order to obtain sustainable crop yield without declining soil fertility. On the other hand, tillage is considered to be the oldest and the most fundamental farm activity of mankind for crop production. It is the practices of working the soil for the purpose of bringing about more favourable condition for plant growth. Tillage operation influences soil physical properties, crop yield, water conservation, root growth, nutrient availability and distribution. No tillage is encouraged by conservation agriculture for crop production. It resists the soil from erosion, conserves moisture and reduces energy but weed, insect and disease infestation are major challenges. So, finding a suitable tillage practice is one of the important considerations in crop production. Due to growing repeated cereal crops, soil fertility and crop productivity are declined over time. This has occurred due to inappropriate management of fertilizers, tillage and crop residues retention (Singh and Singh, 2001).Crop residues are defined as crop or its parts left in field for decomposition after it has been thrashed or harvested(Kumar and Goh, 2000).Crop residue has great potential to return a considerable amount of plant nutrients to the soil. Crop residue retention practice is suggested for the purpose of preserving and enhancing productivity (Wilhelm *et al.* 2004). Based on this background, present study was designed with the objectives of i) to estimate the effects of tillage operation and IPNS on yield of T. *Aman* rice and ii) to determine the impact of tillage and IPNS on the residual Carbon and Nitrogen content in soil.

## Materials and Methods

**Study area:** A study link to the assessing the impacts of IPNS and tillage operation on T. *Aman* rice yield and soil properties (OM and total N) was conducted as a short-term field experiment at the Soil Science field Laboratory of Bangladesh Agricultural University, Mymensingh during kharif season of 2018 (July 2018 to December 2018). The soil of the experimental field belongs to Sonatala series. The land is moderately well drained with a silty loam texture The climatic condition of the experimental area is characterized by scanty rainfall associated with moderately low temperature during Rabi season (16 October to 15 March) and relatively high temperature, high humidity, and heavy rainfall with occasional gusty winds in Kharif season (16 March to 15 October).

**Inputs:** The rice seeds were collected from the Bangladesh Agricultural University Farm. Urea, TSP, MoP, Gypsum and $ZnSO_4$ fertilizers were collected from the local market. Chemicals e.g. $KMnO_4$, $K_2Cr_2O_7$, $FeSO_4$, $H_2SO_4$, NaOH etc. were collected from different chemical suppliers.

**Treatment and design of the study:** The experiment was laid out in a split-split plot design. There were three sets of experimental treatments viz. (i) tillage practices: minimum tillage (MT) and conventional tillage (CT) were arranged in the main plot and (ii) Residue: with residue (R) and without residue (NR) were arranged in the sub-plot and (3) IPNS: Recommended fertilizer doze (RD), Livestock manure compost (LC) and bio-slurry (BS) were arranged in sub–sub plot. Main plots represented two tillage system and sub-plots represented with and without residue retention and sub-sub plots represented three fertilizers rates. The size of the unit plot was 7.5 m x 5.5 m = 41.25 $m^2$. Each plot was separated by the earthen bunds of 25 cm width and 10 cm height. In MT system light ploughing up to 5 cm depth was done and in CT system 15 cm deep ploughing was done. Urea 360g, TSP 850g, MOP 455g, Gypsum 635g, $ZnSO_4$ 88g was used as a recommended doze. Urea 270g, TSP 850g, MOP 380g, Gypsum 400g, $ZnSO_4$ 88g was used as a livestock manure compost. And Urea 270g, TSP 715g, MOP 370g, Gypsum 400g, $ZnSO_4$ 88g was used as a bio-slurry into the sub-sub plot respectively.

**Test crop:** The recommended high yielding variety BRRI dhan71 (BRRI released variety) was used as a test crop. It is short duration variety and medium slender grain. Low pest- disease incidence but cost of irrigation is high. The life cycle is 114-120 days.

**Fertilization:** The land was fertilized by applying of N, P, K, S and Zn fertilizers i.e. Urea 125 kg/ha, TSP 22 kg/ha MoP 67 kg/ha, Gypsum 11 kg/ha and $ZnSO_4$ 6 kg/ha as per recommendation of Fertilizer Recommendation guide (BARC, 2012). Whole amount of TSP, MoP, Gypsum and $ZnSO_4$ were applied during final land preparation but the urea was applied in three splits; one third of urea was added at 12 days after transplanting and one third was applied at maximum vegetative growth stage (32 days after transplanting) and the rest of the urea was applied before panicle initiation stage of the crop (50 DAT).

**Crop cultivation:** Seeds of *Aman* rice were sown on the nursery bed on the experimental field using line sowing method. Proper care was taken to avoid the damage of seeds and emerging seedlings by birds. Thirty days old seedlings of BRRI dhan7l was transplanted on 15 July, 2018 in 20 cm apart rows maintaining 20 cm hill to hill distance and 3 seedlings per hill.

**Harvesting and recording yield of *Aman* rice:** The crop was harvested on 9 November, 2018 at full maturity. For data collection, twenty hills from each plot were sampled randomly. The crop was cut at the ground level. Grain yield, and straw yield were recorded and moisture percentage was calculated after drying in the oven. The grain and straw yields were adjusted with 14% moisture. Grain yield and straw yield were considered for Harvest index (HI). It is the ratio of grain yield to biological yield and was calculated with the following formula: Harvest index (HI) = Grain yield/(grain yield + straw yield) x 100.

**Collection and preparation of soil sample for chemical analysis:** Soil samples were collected from five different spots at 0-15 cm depth and all samples were composited to make a single sample for initial soil analysis from each plot. The collected soil samples were air dried ground and sieved through and kept in polythene bags for laboratory analysis.

**Determination of soil organic carbon:** Organic carbon of the soil sample was determined by wet oxidation method (Walkley and Black, 1934). Then the organic matter content of the soil was calculated multiplying the percent of organic carbon Van Bemmelen factor.

**Determination of total N:** Total N content of soil was estimated following the micro-Kjeldahl method. For the determination of Nitrogen 1.0 g oven dried soil was taken in digestion flask. When the digestion was completed, the flasks were cooled and the digest was transferred into 100 mL volumetric flask and the volume was made up to the mark with distilled water. Reagent blanks were prepared in a similar manner. Later the nitrogen contents in the digests were determined by distillation with 40% NaOH followed by titration of distillate trapped $NH_3$ in 4% $H_3BO_3$ containing 5 drops of mixed indicator of bromocressol green ($C_{10}H_{10}N_3O_3$) solution with O.O1N $H_2SO_4$ until the color changed from green to pink (Bremner and Mulvaney, 1982).

**Statistical Analysis:** Data collected on different parameters under study were statistically analyzed using MSTAT-C to ascertain the significant differences between the treatments. Mean comparisons of the treatments were made by the Duncan's Multiple Range Test (DMRT).

## Results and Discussion

We trialed T. *aman* rice to see the benefits of minimum tillage in combination with crop residue retention and IPNS practice at Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh. The single and interaction effect of the three factors have been presented in this chapter in Table 1 and described under different headings and sub-headings.

**Crop yield:** The tillage practices *viz.* Conventional tillage and Minimum tillage had significant effect on the grain yield of T. *aman* rice. Grain yield in conventional tillage (5.73 t/ha) was found higher than Minimum tillage (4.82 t/ha). The residue amendment did not have significant effect on grain yield of T. *aman* rice. Grain yield in residue amended (R) plots were found higher than no residue amendment (NR). The grain yield with and without residue amendment were 5.31 t/ha and 5.23 t/ha, respectively. Integrated Plant Nutrient System (IPNS) did not show significant effect on grain yield of T. *aman* rice. The highest grain yield (5.44 t/ha) was obtained in the plots treated with livestock Compost and the lowest grain yield (5.14 t/ha) was observed in the bio-slurry treated plots; the Recommended Fertilizer dose gave the grin yield of 5.24 t/ha. There was no significant interaction effect of tillage operations, crop residue retention and IPNS on grain yield of T. *aman* rice. The highest grain yield in T. *aman* rice (6.00 t/ha) was for the plots where plots were prepared by conventional tillage with Livestock compost based IPNS and no crop residue amendment. The plots prepared by minimum tillage with bio-slurry based IPNS combining No residue amendment had the lowest grain yield (4.63 t/ha).

**Straw yield:** The tillage practices *viz.* Conventional tillage and Minimum tillage had significant effect on the straw yield of T. *aman* rice. Straw yield in conventional tillage (6.20 t/ha) was found higher than Minimum tillage (5.17 t/ha). The residue amendment did not have significant effect on straw yield of T. *aman* rice. Straw yield in no residue amended (NR) plots were found higher than residue amendment (R).

The straw yield without and with residue amendment were 5.74 t/ha and 5.63 t/ha, respectively. Integrated Plant Nutrient System (IPNS) did not show significant effect on straw yield of T. *aman* rice. The highest straw yield (5.88 t/ha) was obtained in the plots treated with livestock Compost and the lowest straw yield (5.55 t/ha) was observed in the bio-slurry treated plots; the Recommended Fertilizer dose gave the straw yield of 5.64 t/ha. There was no significant interaction effect of tillage operations, crop residue retention and IPNS on straw yield of T. *aman* rice. The highest straw yield in T. *aman* rice (6.44 t/ha) was for the plots where plots were prepared by conventional tillage with Livestock compost based IPNS and no crop residue amendment. The plots prepared by minimum tillage with Recommended fertilizer dose based IPNS combining Residue amendment had the lowest straw yield (4.91 t/ha).

Table 1: Effect of tillage, residue retention and IPNS on yield of BRRI dhan 71 and soil properties (organic carbon and total nitrogen)

| Treatment | Crop yield | | | Soil properties | |
|---|---|---|---|---|---|
| | Grain yield (t/ha) | Straw yield (t/ha) | Harvest Index (HI) | Organic carbon (%) | Total N (%) |
| Tillage (MT= Minimum Tillage, CT= Conventional Tillage) | | | | | |
| MT | 4.82b | 5.17b | 48.25 | 2.10a | 0.17 |
| CT | 5.73a | 6.20a | 47.97 | 1.82b | 0.16 |
| CV (%) | 7.14 | 6.15 | 10.84 | 11.24 | 8.33 |
| Level of Sig. | * | * | NS | * | NS |
| Residue (R= Residue, NR= No Residue) | | | | | |
| R | 5.31 | 5.63 | 48.55a | 1.99 | 0.166 |
| NR | 5.23 | 5.74 | 47.67b | 1.93 | 0.162 |
| CV (%) | 7.14 | 6.15 | 10.84 | 11.24 | 8.33 |
| Level of Sig. | NS | NS | ** | NS | NS |
| IPNS (RD= Recommended Dose, LC= Livestock Compost, BS= bio-slurry) | | | | | |
| RD | 5.24 | 5.64 | 48.17 | 1.88 | 0.154c |
| LC | 5.44 | 5.88 | 48.03 | 2.04 | 0.174a |
| BS | 5.14 | 5.53 | 48.12 | 1.97 | 0.164b |
| CV (%) | 7.14 | 6.15 | 10.84 | 11.24 | 8.33 |
| Level of Sig. | NS | NS | NS | NS | ** |
| Tillage x residue x IPNS | | | | | |
| MTRRD | 4.69 | 4.91 | 48.84 | 2.04 | 0.166 |
| MTRLC | 4.78 | 5.30 | 47.48 | 2.18 | 0.182 |
| MTRBS | 4.80 | 5.00 | 49.01 | 2.14 | 0.168 |
| MTNRRD | 4.94 | 5.35 | 48.02 | 2.01 | 0.154 |
| MTNRLC | 5.05 | 5.42 | 48.21 | 2.17 | 0.177 |
| MTNRBS | 4.63 | 5.03 | 47.91 | 2.05 | 0.162 |
| CTRRD | 5.77 | 6.07 | 48.69 | 1.74 | 0.150 |
| CTRLC | 5.92 | 6.36 | 48.23 | 1.95 | 0.168 |
| CTRBS | 5.89 | 6.12 | 49.07 | 1.89 | 0.162 |
| CTNRRD | 5.57 | 6.23 | 47.13 | 1.72 | 0.146 |
| CTNRLC | 6.00 | 6.44 | 48.22 | 1.84 | 0.168 |
| CTNRBS | 5.21 | 5.98 | 46.50 | 1.80 | 0.162 |
| CV (%) | 7.14 | 6.15 | 10.84 | 11.24 | 8.33 |
| Level of Sig. | NS | NS | NS | NS | NS |

In a column figures with same letter or without letter do not differ significantly

* = Significant at 5% level of probability; ** = Significant at 1% level of probability; NS = Not significant

**Harvest index:** The tillage practices *viz.* Conventional tillage and Minimum tillage had insignificant effect on the harvest index of T. *aman* rice. Harvest index in minimum tillage (48.25%) was found higher than conventional tillage (47.97%). The residue amendment has a significant effect on harvest index of T. *aman* rice. Harvest index in residue amended (R) plots were found higher than no residue amendment (NR). The harvest index with and without residue amendment were 48.55% and 47.67% respectively. Integrated Plant Nutrient System (IPNS) did not show significant effect on harvest index of T. *aman* rice. The highest harvest index (48.17%) was obtained in the plots treated with recommended fertilizer dose and the lowest harvest index (48.03%) was observed in the livestock compost treated plots; bio-slurry gave the harvest index of 48.12%. There was no significant interaction effect of tillage operations, crop residue retention and IPNS on Harvest index of T. *aman* rice. The highest harvest index in T. *aman* rice (49.07%) was for the plots where plots were prepared by conventional tillage with bio-slurry based IPNS and crop residue amendment. The plots prepared by conventional tillage with bio-slurry based IPNS combining no residue amendment had the lowest Harvest index (46.50%).

**Soil organic carbon:** The tillage practices *viz.* Conventional tillage and Minimum tillage had significant effect on the soil organic carbon of T. *aman* rice. Soil organic carbon in Minimum tillage (2.10%) was found higher than Conventional tillage (1.82%). The residue amendment did not have a significant effect on soil organic carbon of T. *aman* rice. Soil organic carbon in residue amended (R) plots were found higher than no residue amendment (NR). The soil organic carbon with and without residue amendment were 1.99% and 1.93% respectively. Integrated Plant Nutrient System (IPNS) did not show significant effect on Soil organic carbon of T. *aman* rice. The highest Soil organic carbon (2.04%) was obtained in the plots treated with Livestock compost and the lowest Soil organic carbon (1.88%) was observed in the recommended fertilizer dose treated plots; bio-slurry gave the Soil organic carbon of 1.97%. There was no significant interaction effect of tillage operations, crop residue retention and IPNS on Soil organic carbon of T. *aman* rice. The highest Soil organic carbon in T. *aman* rice (2.18%) was for the plots where plots were prepared by Minimum tillage with Livestock compost based IPNS and crop residue amendment. The plots prepared by conventional tillage with recommended fertilizer dose based IPNS combining no residue amendment had the lowest Soil organic carbon (1.72%).

**Total nitrogen:** The tillage practices *viz.* Conventional tillage and Minimum tillage had no significant effect on the soil total nitrogen of T. *aman* rice. Soil total nitrogen in Minimum tillage (0.17%) was found higher than Conventional tillage (0.16%). The residue amendment did not have a significant effect on soil total nitrogen of T. *aman* rice. Soil total nitrogen in residue amended (R) plots were found higher than no residue amendment (NR).The soil total nitrogen with and without residue amendment were 0.166% and 0.162% respectively. Integrated Plant Nutrient System (IPNS) shows significant effect on Soil total nitrogen of T. *aman* rice. The highest Soil total nitrogen content (0.174%) was obtained in the plots treated with Livestock compost and the lowest Soil total nitrogen content (0.154%) was observed in the recommended fertilizer dose treated plots; bio-slurry gave the Soil total nitrogen content of 0.164%. There was no significant interaction effect of tillage operations, crop residue retention and IPNS on Soil total nitrogen of T. *aman* rice. The highest Soil total nitrogen in T. *aman* rice (0.182%) was for the plots where plots were prepared by Minimum tillage with Livestock compost based IPNS and crop residue amendment. The plots prepared by conventional tillage with recommended fertilizer dose based IPNS combining no residue amendment had the lowest Soil total nitrogen content (0.146%).

Tillage is considered to be the oldest and the most fundamental farm activity of mankind for crop production. Many studies have revealed that there is a significant different between minimum tillage and conventional tillage on crop yield and soil health. Here, the impacts of tillage on grain yield, straw yield and soil organic carbon is significantly. Govaert *et al*. (2009) observed significantly higher total nitrogen under both zero tillage and permanent raised beds compared to conventional tillage. Crop residue adds nutrients into the soil which is auspicious for improving soil health as well as microbial population and ameliorates soil physical properties. For better results, it is important to practice crop residue for a long time for improving soil organic matter status as well as soil health.  In the conventionally tilled rice-wheat system in Nepal, Ghimire *et al*. (2012) did not find any significant effect of crop residues incorporation to increase SOC in rice-wheat system; though incorporation of wheat residues in flooded rice could increase C storage and maintain high grain yields (Aulakh *et al*. 2001). Sustainable production of crops cannot be maintained by using only chemical fertilizers; on the other hand it is not possible to obtain higher crop yield by using organic manure alone. So, IPNS has potential for soil health management and better crop production in agriculture sector. We observed that there is a little impacts of use of chemical and organic fertilizer as a combination. Grain yield, straw yield, harvest index and soil organic carbon did not show any significant impact from IPNS. In contrast total nitrogen content in soil shows significant effect with IPNS using Livestock compost. Zaman *et al.* (2004) reported that chemical properties of soil were favorably influenced by the application of organic sources of nitrogen and potassium.

## Conclusion

The yield of rice significantly varied with two tillage systems, conventional tillage performed better than minimum tillage. Higher SOC was recorded in MT than in CT treatment. There was no significant effect of tillage system on harvest index. In case of residue, there was not significant effect on rice yield and chemical properties of soil except harvest index. IPNS did not show significant variations in different yield and soil characters except total nitrogen content at LC. The change of soil properties is not a quick process. It rather requires long–term continuous tillage, residue management and IPNS management to evaluate the have remarkable change in soil properties. However, further investigation is necessary to establish the present findings.

## References

Aulakh, M. S., Khera, T. S., Doran, J. W. and Bronson, K. F. 2001. Managing crop residue with green manure, urea, and tillage in a rice-wheat rotation. *Soil Sci. Soc. America J*., 65, 820–827.

Bhuiyan, N. I. 1994. Crop production trends and need of sustainability in agriculture. The paper presented at the workshop on Integrated Nutrient Management for Sustainable Agriculture, held at SRDI, Dhaka, Bangladesh, June 26-28.

Bremner, J. M. and Mulvaney, C. S. 1982. Nitrogen-Total. In methods of soil Composted bio-solids enhance fertility of a sandy loam soil under dairy pasture. *Bio. Fertility of Soils*, 40:349-358.

Ghimire, R., Adhikari, K. R., Chen, Z. S., Shah, S. C. and Dahal, K. R. 2012. Soil organic carbon sequestration as affected by tillage, crop residue, and nitrogen application in rice-wheat rotation system. *Paddy Water Environ*., 10, 95–102.

Gina *et al*. (2006). Residual effects of composted and fresh solid swine manure on soyabean growth and yield. *Agron. J*., 98:873-882.

Govaerts, B., Sayre, K. D., Goudeseune, B., De Corte, P., Lichter, K., Dendooven, L., and Deckers, J. 2009. Conservation agriculture as a sustainable option for the central Mexican highlands. *Soil Till. Res*., 103, 222-230.

Singh, Y. and Singh, B. 2001. Efficient management of primary nutrition in the rice-wheat system. Pages 23-85. In: Kataki, P.K. (ed). The rice-wheat cropping systems of south Asia: Efficient production management. Food Products Press, New York, USA.

Walkley, A. and Black, A. 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic add titration method. *J. Soil Sci.*, 37 29-38.

Wilhelm, W. W., Johnson, J. M. F., Hatfield, J. L., Voorhees, W. B. and Linden, D. R. 2004. Crop and soil productivity response to corn residue removal: a literature review. *Agron. J.*, 96(1):1 -17.

Zaman, M., Matsushima, M., Chang, S. X., Inubushi, K., Nguyen, L., Goto, S., Kaneko, F. and Yoneyama, T. 2004 Nitrogen mineralization, production and soil microbiological properties as affected by long-term applications of sewage sludge composts. *Bio. Fert. Soils*, 40:101-109.