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**Full Research Article**

# Effect of Different Residue Management Practices of Rice on Growth and Yield of Wheat and Soil Health in Rice-Wheat System

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**Abstract**

The present experiment was conducted in rice-wheat sequence during 2007−08 and 2008−09 in Birsa Agricultural University Farm, Kanke, Ranchi to assess the effect of rice residue management on growth, yield attributes and yield of grain and straw of wheat and soil health. The trial was laid out in randomized block design with three replications having nine treatment combinations. The various rice residue and nitrogen management systems significantly affect the plant height and number effective spike $m^{-2}$, number of grain ear $head^{-1}$ were maximum with rice residue incorporation or rice residue retention 25% additional N+recommended NPK over sowing of wheat without incorporation of rice residue and recommended NPK and rice residue incorporation+recommended NPK at wheat sowing during both the years. Among the yield attributes and yield viz. number of effective tillers $m^{-2}$, length of ear head, and number of grains ear $head^{-1}$, grain and straw yield were also recorded maximum with the same treatment. Nitrogen uptake by grain and straw influenced significantly by rice residue and nutrient management practices during both the years. Highest nitrogen uptake by grain and straw was recorded under the treatment when rice residue incorporated with 25% additional N+recommended NPK against sowing of wheat without incorporation of rice residue+recommended NPK and rice residue incorporation+recommended NPK.

## 1. Introduction

Rice and wheat are currently grown in rotation on almost 26 mha of South and East Asia under diverse climatic and soil condition (Timsina and Connor, 2001), contributing 72, 85, 92, 100 and 71% of the total cereal pool of China, India, Pakistan, Bangladesh and Nepal, respectively (Singh and Paroda, 1994). Rice-wheat is the dominant cropping system of Indo-Gangetic plains of India. With the development of high yielding, photo-insensitive cultivars of rice and increased irrigation facilities, the rice cultivation has extended to non-traditional areas of North India where wheat was dominant crop in winter. Similarly, cultivation of wheat extended to some of the traditional rice areas like Bihar, West Bengal, Assam and Jharkhand due to development of high yielding, semi-dwarf wheat varieties responsive to nutrient and water. Recently it has been observed that the system is showing sign of fatigue and the crop yield is either stagnating or the factor productivity has fallen down thereby suggesting the requirement of more input to produce the same grain yield. Declining soil fertility resulting from depletion of nutrients, their imbalance application and reduced recycling of organic matter, water-induced degradation of soil and water resources leading to spread of salinity and water balance aberrations, increase in the incidence of pest and disease and loss in biodiversity are some of the factors that adversely affect the sustainability of the production system. There are substantial areas under rice which are combined harvested and also increasing tendency among the farmers to harvest the crop just near the ear-head, leaves behind enormous quantity of the crop residue amounting a million of tonnes is disposed off by burning. The primary reason for burning rather than incorporation for enriching the soil is absence of any suitable residue management practice. The total nutrient value of residues are half of the total contents because it is known that only about 50% of the nutrients are mineralized in the soil on decomposition of crop residues. Their conservative estimates reveal that about 1.6 mt of nutrients from crop residues in rice-wheat system are available for recycling. Besides NPK, estimated to be about 4.8 mt, which can replace about 30% of the total fertilizer consumption in the country with the intensification of agriculture especially in rice-wheat growing regions of the country. The significance of recycling the organic resources for replacement of plant nutrients and the residues also contain appreciable amount of secondary and micronutrients. Based on the above assumptions, it is estimated that about 43 and 37 mt of straw is in utilization from rice and wheat crop, respectively. The total nutrient value of these crop residues in maintenance of soil health has already been established. However, the limited availability of organic manures and almost nil possibility of in-situ green manuring for wheat after the harvest of rice, the only alternative left is the direct incorporation as rice crop residue to maintain soil fertility.

## 2. Materials and Methods

The experiment was conducted at the BAU farm N-E section Kanke, Ranchi, Jharkhand during the winter (*Rabi*) season of 2007–08 and 2008–09. The soil of experimental field was red laterite (A category of red soil) with slightly acidic in reaction (pH 5.6) which was low in available nitrogen (218 N kg $ha^{-1}$), medium in available phosphorus (19.2 $P_2O_5$ kg $ha^{-1}$) and medium in available potassium (218.6 $K_2O$ kg $ha^{-1}$) and 0.39% organic carbon content. The trial was laid out in randomized block design with three replications having nine treatment combinations within recommended dose ($T_1$- Sowing wheat without incorporation of rice residue and recommended NPK ), $T_2$-Rice residue incorporation+recommended NPK in wheat sowing, $T_3$- 25% of more N and rice residue incorporation+recommended NPK in wheat sowing, $T_4$- Rice residue burning+recommended NPK in wheat sowing, $T_5$-Surface retention of rice residue+25% more N+recommended NPK in wheat sowing, $T_6$- Surface retention of rice residue+Sesbania-recommended NPK in wheat sowing , $T_7$-Surface retention of rice residue+Wheat without fertilizers $T_8$-Removal of rice residues-wheat sowing without fertilizer) and $T_9$- Transplanted rice (removal of rice residue+recommended NPK in wheat sowing). In rice crop application of half N as basal dressing and rest half top dressed at 25 and 45 days after sowing in two equal installment while full PK as basal dose. The field was prepared and direct seeding of rice was done at 20 cm row spacing in $T_1$ to $T_8$ and transplanted the rice seedling in $T_9$ for commercial rice cultivation along with recommended package of practices. In rice crop, a pre-harvest irrigation was applied. Rice residue were incorporated as per the treatment (residue removed from plots) wheat was sown in lines at 22.5 cm apart using a seed rate of 100 kg $ha^{-1}$. In rice residue removed and incorporated field conventional tillage practices were used, for the rice residue removed plot ($T_1$), the field was ploughed with tractor drawn plough and left of 7 days, thereafter, one pre–sowing irrigation was applied to the field. At the right tilth, 2 cross ploughing were done with tractor drawn plough. The planking was done invariably after each cross ploughing in order to get fine seed bed. Field preparation worked out for residue incorporated plot, the residue incorporated with the help of disc harrow and then all practices were same as residue removed treatment. On the basis of plot size and treatment, ½ doses of nitrogen, full dose of phosphorus and potassium through Urea, Single Super Phosphate and Muriate of Potash respectively were applied as basal and rest ½ dose of Nitrogen was top dressed at 21 and 45 days after sowing in two equal doses. In $T_6$, *Sesbania acuelata* was broad cast after 60 days sowing of rice crop and incorporated before sowing of wheat crop. Others practices viz. interculture, weeding and plant protection measures were applied as need based. The grain and straw samples collected at the time of harvest were dried in the oven and ground by sample grinder. After grinding, the samples were analysed chemically for nitrogen content by micro Kjeldahl's method, as given by (Jackson, 1973).

## 3. Results and Discussion

Different rice residue and nitrogen management systems significantly affect the plant height with the age of wheat crop (Table 1). Rice residue incorporation with 30% additional+ recommended NPK or rice residue retention with 30% additional N+recommended NPK or rice residue surface retention+Sesbania-recommended NPK in wheat produced significantly taller plants over sowing of wheat without incorporation of rice residue+recommended NPK, rice residue incorporation+recommended NPK, rice residue (Burning)–recommended NPK, removal of rice residue in direct seeded rice or transplanted rice+wheat with no fertilizers sowing during both the years. The increased plant height might be due to cumulative effect of narrow C:N ratio, nutrients availability, soil health and good plant establishment, residue management treatment had the little effect on plant height as reported by Griffin et al. (1982). Meelu et al. (1994) also reported that incorporation of residue had beneficial effects on plant height. Significant variation in plant height might be also due higher levels of nitrogen resulted in more nitrogen uptake, which caused better metabolization of synthesized carbohydrates into amino acids and protein which in turn stimulated the cell division and cell elongation and thus allowed the plant to grow faster, which expressed morphologically an increase in various metabolic processes in presence of abundant supply of nutrients which resulted in to increased tillering and, thus, more number of shoots per running meter (Table 2). These findings are in support to those of Malik (1981) who noted positive effect of nitrogen up to 240 kg ha the number of tillers in wheat. Yield attributes viz. number of effective tillers running $m^{-1}$, length

Table 1: Effect of different rice residue management practices on plant height (cm) at various growth stages of wheat

| Treatments | Plant height (cm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 60 DAS | | | 90 DAS | | | At maturity | | |
| | 2007–08 | 2008–09 | Pooled | 2007–08 | 2008–09 | Pooled | 2007–08 | 2008–09 | Pooled | 2007–08 | 2008–09 | Pooled |
| DSR (Remval) -Wheat | 16.81 | 19.10 | 17.96 | 43.78 | 42.53 | 43.16 | 69.98 | 69.85 | 69.92 | 102.20 | 106.35 | 104.28 |
| DSR (Incorpora-tion)-Wheat | 17.20 | 19.45 | 18.33 | 46.05 | 47.55 | 46.80 | 68.63 | 70.53 | 69.58 | 102.95 | 105.70 | 104.33 |
| DSR (Incorpora -tion+25% more N)-Wheat | 20.30 | 21.90 | 21.10 | 48.95 | 49.20 | 49.08 | 80.40 | 81.50 | 80.95 | 111.35 | 112.55 | 111.95 |
| DSR (Burning) -Wheat | 17.50 | 19.95 | 18.73 | 42.52 | 44.78 | 43.65 | 69.75 | 71.30 | 70.53 | 103.10 | 107.98 | 105.54 |
| DSR (Surface retention 25% more N-wheat | 19.55 | 21.50 | 20.53 | 48.15 | 50.65 | 49.40 | 81.70 | 78.15 | 79.93 | 109.70 | 111.20 | 110.45 |
| DSR (Surface retention)+ Sesbania-Wheat | 17.55 | 19.90 | 18.73 | 46.58 | 45.58 | 46.08 | 73.10 | 74.90 | 74.00 | 106.90 | 106.95 | 106.93 |
| DSR (Surface retention)-Wheat (No fertilizer) | 16.10 | 15.63 | 15.87 | 38.28 | 38.04 | 38.16 | 59.70 | 57.25 | 58.48 | 84.70 | 86.15 | 85.43 |
| DSR (Removal) -wheat | 16.10 | 16.00 | 16.05 | 40.04 | 40.66 | 40.35 | 60.65 | 58.15 | 59.40 | 79.15 | 78.63 | 78.89 |
| Transplanted (Removal)-wheat | 18.38 | 19.95 | 19.17 | 43.09 | 44.87 | 43.98 | 71.08 | 73.95 | 72.52 | 104.50 | 105.00 | 104.75 |
| SEm± | 0.780 | 0.960 | 0.870 | 1.930 | 1.650 | 1.790 | 2.230 | 2.530 | 2.380 | 2.337 | 2.000 | 2.169 |
| CD ($p$=0.05) | 2.070 | 2.810 | 2.440 | 5.630 | 4.810 | 5.220 | 6.510 | 7.370 | 6.940 | 6.822 | 5.830 | 6.326 |

of ear head, number of spikelet's spike and 1000-grain weight is the resultant of good crop growth, photosynthesis and nutrient uptake, the highest values of these parameters were recorded with rice residue incorporation with 25% additional N application+recommended NPK or whereas the lowest values were found in application only recommended NPK having without any incorporation of rice residue. Additional fertilization pushed up the removal of nutrient and water from soil by the crop, which might have enhanced the photosynthesis and translocation of assimilate from source (leaves and stem) to sink *vis-a-vis* grain yield. Grain and straw yields affected significantly due to rice residue and nutrient management practices during both the years. The higher grain and straw yields were recorded when rice residue incorporation was coupled with application of 25% additional N+recommended NPK which was recorded more than other treatments during both the years. It might be due to the addition of crop residue and additional fertilization which might have improved the soil health and consequently higher uptake of available nutrients from the soil and increased the number of running effective tillers $m^{-1}$, length of ear-head number of spikelet's $spike^{-1}$ and 1000 grain weight (g) which ultimately attributed to increase in grain yield (Table 3 and 4). Crop residue on decomposition released nutrients slowly throughout the growth period, which resulted better plant growth and higher straw yield. Incorporation of wheat straw and burning both had higher grain and straw yield of rice over the straw removed (Maskina et al., 1987). Under the clay loam soil incorporation of rice straw increased the wheat yield over sandy loam soil as reported by Singh et al. (1992); Bakht et al. (2009). Nitrogen uptake by grain and straw influenced significantly by rice residue and nutrient management practices during both the years (Table 4). Highest nitrogen uptake by grain and straw was recorded under the treatment when rice residue incorporated with 30% additional NPK+recommended NPK against sowing of wheat without incorporation of rice residue

Table 2: Effect of different rice residue management practices on number of tillers per running meter at various growth stages of wheat

| Treatments | No. of tillers per running meter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 60 DAS | | | 90 DAS | | | At maturity | | |
| | 2007–08 | 2008–09 | Pooled | 2007–08 | 2008–09 | Pooled | 2007–08 | 2008–09 | Pooled | 2007–08 | 2008–09 | Pooled |
| DSR (Remval) -Wheat | 23.95 | 24.90 | 24.43 | 49.33 | 52.98 | 51.16 | 57.70 | 59.05 | 58.38 | 52.95 | 54.18 | 53.57 |
| DSR (Incorpora-tion)-Wheat | 24.40 | 25.40 | 24.90 | 47.23 | 50.03 | 48.63 | 54.10 | 55.20 | 54.65 | 51.78 | 52.95 | 52.37 |
| DSR (Incorpora-tion +25% more N)-Wheat | 31.85* | 32.33* | 32.09 | 74.95* | 76.18* | 75.57 | 79.23* | 80.90* | 80.07 | 75.05* | 76.63* | 75.84 |
| DSR (Burning) -Wheat | 25.15 | 25.75 | 25.45 | 67.68* | 68.58* | 68.13 | 71.55 | 72.25 | 71.90 | 66.35 | 67.2 | 66.78 |
| DSR ( Surface retention 25% more N-wheat | 30.98* | 31.00* | 30.95 | 70.98 | 74.03* | 72.51 | 78.18* | 79.78* | 78.98 | 75.03* | 76.08* | 75.56 |
| DSR (Surface retention)+ Sesbania-Wheat | 24.55 | 25.18 | 24.87 | 53.53 | 54.95 | 54.24 | 64.45 | 65.10 | 64.78 | 61.48 | 61.98 | 61.73 |
| DSR (Surface retention)- Wheat (No fer-tilizer) | 22.48 | 23.13 | 22.81 | 46.00 | 46.25 | 46.13 | 50.08 | 49.00 | 49.54 | 38.80 | 40.25 | 39.53 |
| DSR (Removal) -wheat | 23.05 | 23.60 | 23.33 | 46.85 | 47.95 | 47.40 | 48.85 | 47.68 | 48.27 | 44.98 | 42.05 | 43.52 |
| Transplanted (Removal)- wheat | 24.90 | 26.70* | 25.80 | 59.85 | 62.35 | 61.10 | 66.00 | 67.20 | 66.60 | 57.55 | 57.68 | 57.62 |
| SEm± | 1.880 | 2.007 | 1.944 | 2.967 | 2.770 | 2.869 | 2.368 | 2.305 | 2.337 | 2.981 | 2.673 | 2.827 |
| CD ($p$=0.05) | 5.455 | 5.858 | 5.657 | 8.661 | 8.086 | 8.374 | 6.368 | 6.728 | 6.548 | 8.701 | 7.802 | 8.252 |

*significant at ($p$=0.05)

application+recommended NPK and rice residue incorporation+ recommended NPK. Increase in nitrogen uptake by grain and straw may be due to better root establishment which resulted in better translocation of absorb nutrients from soil and its translocation to plant and seed which may cause higher plant growth, grain and straw yields and ultimately increased the uptake of nitrogen (Table 5). Adequate supply of nutrient in the root zone increased number of tillers per running meter was affected significantly due to various rice residue and nutrient management systems at all the stages of the crop growth during both the years. It increased progressively up to 90$^{th}$ day stage and thereafter decreased. Significantly higher number of tillers per running meter was obtained with rice residue incorporated as compared to rice residue removed during both the years. This might be due to good LAI and root growth and development in the upper layer of soil surface where these got the good opportunity for nutrient uptake. This made possible with rice residue incorporation due to higher organic matter content in soil. Good pulverization of soil may be achieved as field was ploughed for residue incorporation. It increased the availability of nutrients, which resulted into increased tillering and thus, number of tillers per running meter. In relation to these findings, Meelu et al. (1994) also reported the higher number of tillers with incorporation of residue treatment in the soil. The higher number of tillers associated with increasing levels of nutrient might be due to less tiller mortality, enhanced photosynthetic area, proper nourishment, enhanced cell expansion and various metabolic processes in

Table 3: Effect of different rice residue management practices on number of effective tillers m$^{-2}$, length of ear head and number of spikelets spike$^{-1}$ in wheat

| Treatments | Number of effective tillers metre$^{-2}$ | | | length of ear head (cm) | | | Number of spikelets spike$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2007–08 | 2008–09 | Pooled | 2007–08 | 2008–09 | Pooled | 2007–08 | 2008–09 | Pooled |
| DSR (Remval-Wheat | 291.50 | 284.00 | 287.75 | 7.00 | 6.98 | 6.99 | 15.50 | 17.25 | 16.38 |
| DSR (Incorporation)-Wheat | 305.00 | 310.00 | 307.50 | 7.68 | 7.75* | 7.72 | 17.25* | 19.00* | 18.13 |
| DSR (Incorporation+25% more N)-Wheat | 380.25* | 387.75* | 384.00 | 8.93* | 9.05* | 8.99 | 20.75* | 22.00* | 21.38 |
| DSR (Burning)-Wheat | 307.50 | 312.50 | 310.00 | 7.08 | 7.00 | 7.04 | 16.50 | 17.25 | 16.88 |
| DSR ( Surface retention 25% more N-wheat | 355.75* | 360.75* | 358.25 | 8.80* | 8.80* | 8.80 | 19.50* | 20.50* | 20.00 |
| DSR (Surface retention)+Sesbania-Wheat | 316.00* | 322.50 | 319.25 | 8.40* | 8.50* | 8.45 | 19.25* | 19.25* | 19.25 |
| DSR(Surface retention)-Wheat (No fertilizer) | 204.50 | 194.50 | 199.50 | 6.10 | 6.10 | 6.10 | 11.50 | 11.25 | 11.38 |
| DSR(Removal)-wheat | 200.25 | 188.75 | 194.50 | 6.03 | 6.03 | 6.03 | 10.50* | 11.00 | 10.75 |
| Transplanted (Removal)-wheat | 312.00 | 304.50 | 308.25 | 8.28* | 8.28 | 8.28 | 18.50* | 20.25* | 19.38 |
| SEm± | 22.84 | 19.44 | 21.140 | 0.44 | 0.46 | 0.450 | 1.29 | 1.39 | 1.340 |
| CD (*p*=0.05) | 66.7 | 56.74 | 61.720 | 1.23 | 1.36 | 1.295 | 3.77 | 4.06 | 3.915 |

*significant at (*p*=0.05)

Table 4: Effect of different rice residue management practices on test weight, grain yield and Straw yield in wheat

| Treatments | Test weight (g) | | | Grain yield (q ha$^{-1}$) | | | Straw yield (q ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2007–08 | 2008–09 | Pooled | 2007–08 | 2008–09 | Pooled | 2007–08 | 2008–09 | Pooled |
| DSR (Straw Removal)-Wheat | 40.43* | 40.90* | 40.67 | 25.65 | 25.60 | 25.63 | 35.10 | 35.45 | 35.28 |
| DSR (Straw Incorporation)-Wheat | 40.63* | 40.95* | 40.79 | 26.50 | 27.35 | 26.93 | 37.23 | 37.90 | 37.57 |
| DSR (Straw incorpora-tion+25% more N)-Wheat | 41.60* | 41.73* | 41.67 | 30.38* | 31.50* | 30.94 | 41.50* | 42.03* | 41.77 |
| DSR (Burning)-Wheat | 40.15* | 40.00* | 40.08 | 25.45 | 25.98 | 25.72 | 35.95 | 35.50 | 35.73 |
| DSR (Straw Surface retention 25% more N-wheat | 41.00* | 41.33* | 41.17 | 28.30* | 28.10 | 28.20 | 37.95 | 38.85 | 38.40 |
| DSR (Straw Surface retention)+Sesbania-Wheat | 40.20* | 40.45* | 40.33 | 25.95 | 26.18 | 26.07 | 36.20 | 37.10 | 36.65 |
| DSR (Straw Surface retention)-Wheat (No fertil-izer) | 38.28 | 37.83 | 38.06 | 12.45 | 13.08 | 12.77 | 21.80 | 20.88 | 21.34 |
| DSR (Straw Removal)-wheat (No fertilizer) | 38.75 | 37.88 | 38.32 | 11.13 | 11.28 | 11.21 | 19.25 | 17.93 | 18.59 |
| Transplanted (Straw Removal)-wheat | 40.53* | 40.88* | 40.71 | 26.50 | 26.90 | 26.70 | 37.23 | 37.38 | 37.31 |
| SEm± | 0.583 | 0.717 | 0.650 | 0.807 | 0.899 | 0.853 | 0.921 | 0.961 | 0.941 |
| CD (*p*=0.05) | 1.70 | 2.093 | 1.897 | 2.345 | 2.625 | 2.485 | 2.687 | 2.805 | 2.746 |

*significant at (*p*=0.05)

Table 5: Effect of varying rice residue management practices on nitrogen uptake, organic carbonin grain and straw of wheat

| Treatments | Nitrogen uptake (kg ha$^{-1}$) | | | | | | O.C. (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Grain | | | Straw | | | | | |
| | 2007−08 | 2008−09 | Pooled | 2007−08 | 2008−09 | Pooled | 2007−08 | 2008−09 | Pooled |
| DSR (Straw Removal)-Wheat | 41.05 | 39.75 | 40.40 | 17.20 | 17.30 | 17.25 | 0.34 | 0.35 | 0.35 |
| DSR (Straw Incorporation)-Wheat | 42.28 | 42.68 | 42.48 | 17.78 | 17.90 | 17.84 | 0.34 | 0.38 | 0.36 |
| DSR (StrawIncorporation+25% more N)-Wheat | 48.60 | 48.75 | 48.68 | 20.35 | 20.38 | 20.37 | 0.38 | 0.39 | 0.39 |
| DSR (Burning)-Wheat | 40.53 | 40.25 | 40.39 | 17.50 | 18.38 | 17.94 | 0.33 | 0.32 | 0.33 |
| DSR (Straw Surface retention 25% more N-wheat | 44.88 | 44.52 | 44.70 | 18.35 | 18.70 | 18.53 | 0.36 | 0.36 | 0.36 |
| DSR (Straw Surface retention)+Sesbania-Wheat | 41.50 | 42.63 | 42.07 | 17.45 | 18.68 | 18.07 | 0.36 | 0.36 | 0.36 |
| DSR (Straw Surface retention)-Wheat(No fertilizer) | 19.95 | 20.23 | 20.09 | 10.48 | 8.90 | 9.69 | 0.33 | 0.34 | 0.34 |
| DSR(Straw Removal)-wheat (No fertilizer) | 17.65 | 17.08 | 17.37 | 9.15 | 8.98 | 9.07 | 0.33 | 0.33 | 0.33 |
| Transplanted (Straw Removal)-wheat | 42.40 | 42.18 | 42.29 | 17.90 | 17.80 | 17.85 | 0.34 | 0.34 | 0.34 |
| SEm± | 1.298 | 1.491 | 1.390 | 0.694 | 0.777 | 0.740 | 0.010 | 0.011 | 0.010 |
| CD ($p$=0.05) | 3.789 | 4.351 | 4.070 | 2.026 | 2.268 | 2.147 | 0.030 | 0.032 | 0.031 |

presence of abundant supply of nutrients which resulted into increased tillering and, thus, more number of shoots per running meter. These findings are in support to those of Malik (1981) who noted positive effect of nitrogen up to 240 kg ha$^{-1}$ the number of tillers in wheat. Yield attributes viz. number of effective tillers running per meter, length of ear-head number of spikelet's spike$^{-1}$ and 1000-grain weight is the resultant of good crop growth, photosynthesis and nutrient uptake, the highest values of these parameters were recorded with rice residue incorporation including 25% additional N application+ recommended NPK, whereas the lowest values were found in treatment, rice straw removal followed by wheat sowing without NPK. Additional fertilization pushed up the removal of nutrient and water from soil by the crop, which might have enhanced the photosynthesis and translocation of assimilate from source (leaves and stem) to sink *vis-a-vis* grain yield. Grain and straw yields affected significantly due to rice residue and nutrient management practices during both the years. The grain and straw yields recorded when rice incorporation was coupled with the application of 25% additional NPK+ recommended NPK which was recorded more than other treatments during both the years. It might be due to the addition of crop residue and additional fertilization which might have improved the soil health and consequently higher uptake of available nutrients from the soil and increased the number of effective tillers running per meter, length of earhead number of spikelet's spike$^{-1}$ and 1000-grain weight (g), which ultimately attributed to increase in grain yield. Crop residue on decomposition released nutrients slowly throughout the growth period, which resulted better plant growth and higher straw yield. Incorporation of wheat straw and burning both had higher grain and straw yield of rice over the straw removed (Maskina et al., 1987). Under the clay loam soil incorporation of rice straw increased the wheat yield over sandy loam soil as reported by Singh et al. (1992); Bakht et al. (2009). Nitrogen uptake by grain and straw influenced significantly by rice residue and nutrient management practices during both the years (Table 5). Highest nitrogen uptake by grain and straw was recorded under the treatment when rice residue incorporated with 25% additional N+recommended NPK against sowing of wheat without removal of rice residue+without NPK and rice residue incorporation+without NPK. Increase in nitrogen uptake by grain and straw may be due to better root establishment which resulted in better translocation and the movement of nutrient in soil solution and ultimately their greater absorption and utilization by the growing plants. It has been reported that each increment of nitrogen level from 60 to 180 kg $ha^{-1}$ increased the grain and straw yields as well as N uptake under loamy soil condition at Karnal (Kumar et al. (1995). Further Kumar et al. (2000) also reported that nitrogen uptake increased with increasing level of nitrogen up to 120 kg $ha^{-1}$ under sandy loam soils of Bihar. Increased nitrogen uptake in residue incorporated treatment was mainly due to cumulative effect of better soil health, increased the availability of nutrients and better root and plant growth and development, which enhanced the crop yield. Similar findings were also reported by Dwivedi and Thakur (2000) under silt-clay loam soil that incorporation of rice straw increased the nitrogen uptake. Further Das et al. (2000) were also reported in rice. Rice residue and nutrient management significantly influenced the organic carbon content during both the years (Table 5). Significantly higher organic carbon content was recorded with rice residue incorporation with application of 25% additional N recommended NPK, rice residue retention with application of 25% additional N+recommended NPK, Surface retention+ Sesbania-Wheat recommended NPK, against sowing of wheat without incorporation of rice residue+recommended NPK during 2007–2008. Where as in 2008–2009 slight variation was observed and the treatment incorporation of rice residue+wheat sowing with recommended NPK also gave statistically similar results as compared to rice residue incorporation with application of 25% additional N recommended NPK , rice residue retention with application of 25% additional N+recommended NPK and surface residue retention+Sesbania-wheat with recommended NPK, as compared to sowing of wheat without incorporation of rice residue+recommended NPK, burning of rice residue+wheat with recommended NPK or removal of rice residue in transplanted+wheat with recommended NPK or incorporation of rice residue+wheat sowing without NPK. It is probably due to the fact that addition of carbonaceous substances in soil which on decomposition added organic matter. Verma and Bhagat (1992) have also recorded the maximum soil build-up of organic carbon under the rice straw chopped and incorporated with animal manure, followed by animal manure and straw mulch, while minimum organic carbon under rice straw burnt and rice straw removed.

## 4. Conclusion

Farmers of being practiced in rice-wheat system region may, therefore, be advised to adopt rice residue incorporation practice with 25% additional N or rice residue retention with 25% additional N+recommended NPK or surface rice residue retention+Sesbania-wheat with recommended NPK fertilizer under rice-wheat cropping system to get higher yield and benefits from wheat on sustainable basis.

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