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# Effect of Residue Management and Fertilizer Levels on Weeds and Wheat Productivity in Rice-wheat Cropping System

***Preetam Kumar, Sandeep Rawal, A.K. Dhaka, Raj Kumar* and Kavita***
*Department of Agronomy,*
*CCS Haryana Agricultural University, Hisar, (Haryana), India.*

*(Corresponding author: Raj Kumar*)*
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**ABSTRACT: Mechanization in rice-wheat has resulted into generation of large volume of crop residue. Scanty management of this surplus crop residue is a deliberate threat to sustainability of this major cropping system. An experiment was conducted during *rabi* 2019 at Research Farm Area, KVK Damla (Yamunanagar) of CCS Haryana Agricultural University Hisar. The experiment was laid out in split plot design with 3 replications consisting of six residue management practises ($C_0R_1T_3$ = Combine harvesting of paddy without SMS, burning of crop residues and sowing of wheat by conventional tillage method; $C_0R_2T_1$= Combine harvesting of paddy without SMS, residue shredding with mulcher followed by happy seeder sowing of wheat; $C_0R_2T_0$= Combine harvesting of paddy without SMS, direct sowing of wheat with happy seeder; $C_1R_2T_0$= Combine harvesting of paddy with SMS followed by sowing of wheat using happy seeder; $C_0R_2T_2$= Combine harvesting of paddy without SMS, residue shredding with straw chopper followed by happy seeder sowing of wheat and $C_2R_0T_3$= Manual harvesting of paddy, residue removal and sowing of wheat with conventional tillage practice) in main plot and three fertilizer levels (75% RDF= 75 per cent of recommended dose of fertilizer; 100% RDF= 100 per cent of recommended dose of fertilizer and 125% RDF= 125 per cent of recommended dose of fertilizer) in sub-plot. The growth and yield of wheat (plant height, dry matter, spike length, grain yield and straw yield) were maximum with $C_0R_2T_1$ which was statistically at par with treatments having retention of paddy residue on soil surface ($C_0R_2T_0$, $C_1R_2T_0$ and $C_0R_2T_2$) and significantly higher than treatment with either burning ($C_0R_1T_3$) or removal of paddy residue ($C_2R_0T_3$). Lowest weed (density and dry matter) was recorded under $C_0R_2T_1$. The results revealed that application of 125% RDF had significantly higher plant height, dry matter accumulation, spike length and yield (grain as well as straw) of wheat. Lowest weed density and weed dry matter accumulation was achieved under 75% RDF.**

**Keywords:** conservation, Indo-Gangetic plains, mulch, maturity, sustainability.

## INTRODUCTION

Rice (*Oryza sativa* L.) – Wheat (*Triticum aestivum* L.) is the most predominant productive as well as nutrient exhaustive cropping system of India. In the country, rice-wheat cropping system is practised in about 10 m ha in Indo-Gangetic plains (Kumar *et al*., 2019). Rice-wheat is very popular among farmers due to assured procurement, subsidized electricity and other inputs, development of superior photo and thermo-insensitive high-yielding varieties and the mechanised agriculture practises. Combine harvesting of paddy is easy to use, saves time and overcomes the shortage of labour in harvesting season. The combine harvesting pf paddy generates huge amount of loose residue which hinderers the tillage operations. Farmers find burning of these residues as most quick and economical method for preparation of the field for sowing of wheat. Burning of crop residue results in a number of problems like loss of moisture, nutrients, organic matter and degradation of soil (Sidhu *et al*., 2015).

Several mechanization alternatives like reversible MB plough, baler, shrub master, paddy straw chopper, mulcher, zero till seed cum fertilizer drill machine, combine fitted with super straw management (SMS) and happy seeder have now open the way to solve the problem of residue and stubble burning. Conservation agriculture with reduced or zero tillage allows the farmers to decrease energy input, cost of cultivation, labour requirement, conservation of soil and water and addition of organic matter. However, the residue left on soil surface can cause immobilization of nitrogen, which lead to high requirement of fertilizer for meeting the crop needs. Wheat productivity is highly influenced by rice residue and fertilizer management practises adopted. Keeping these points in view, the study was aimed to study the effect of different paddy residue management and wheat sowing method with different fertilizers level by assessing weed dynamics, growth, yield attribute and yield of wheat.

## MATERIAL AND METHODS

The field experiment on wheat crop was conducted during *rabi* 2019 at Research Farm Area, KVK Damla (Yamunanagar) of CCS Haryana Agricultural University Hisar. The experimental site falls under humid subtropical zone in the Indo-Gangetic plains and is located between 30° 08' N latitude and 77° 21' E longitude (270 m above mean sea level) in Haryana state. The soil of experimental site was sandy loam in texture, slightly alkaline in reaction (pH 7.84) with electrical conductivity (0.55 dS $m^{-1}$), low in organic carbon (0.34 %), low in available nitrogen (132 kg $ha^{-1}$), medium in available phosphorus (16 kg $ha^{-1}$) and high in available potassium (366 kg $ha^{-1}$). The experiment was laid out in split plot design with replications having six different mechanization option to manage paddy residue and sowing of wheat in main plot and three fertilizer levels in sub-plot. The main plot treatments were $C_0R_1T_3$= Combine harvesting of paddy without SMS, burning of crop residues and sowing of wheat by conventional tillage method; $C_0R_2T_1$= Combine harvesting of paddy without SMS, residue shredding with mulcher followed by happy seeder sowing of wheat; $C_0R_2T_0$= Combine harvesting of paddy without SMS, direct sowing of wheat with happy seeder; $C_1R_2T_0$= Combine harvesting of paddy with SMS followed by sowing of wheat using happy seeder; $C_0R_2T_2$= Combine harvesting of paddy without SMS, residue shredding with straw chopper followed by happy seeder sowing of wheat and $C_2R_0T_3$= Manual harvesting of paddy, residue removal and sowing of wheat with conventional tillage practice, while sub-plot treatments were 75% RDF= 75 per cent of recommended dose of fertilizer; 100% RDF= 100 per cent of recommended dose of fertilizer and 125% RDF= 125 per cent of recommended dose of fertilizer. The gross plot size was 4.4 m × 4.5 m, while net plot size was 4.0 m × 4.0 m. The experimental site was under rice-wheat cropping system before the establishment of the experiment. Previous direct seeded rice crop was harvested according to the respective treatments followed by pre-sowing irrigation and then sowing of wheat was done according to the treatments. Conventional tillage practice involved two harrowing followed by cultivator and planking to prepare a fine seedbed for sowing of wheat. The wheat variety used was HD 3086 with a recommended seed rate of 100 kg $ha^{-1}$. The sowing was done on 3rd December, 2019. The crop was raised and managed as per the recommended package and practices of CCS HAU, Hisar. Plant height at maturity was calculated by measuring the height of five plant from each plot from ground level to the tip of ear, which then averaged and expressed in cm. Five plants from each plot were cut with the help of sickle from ground level then sun dried followed by oven drying and averaged to calculate dry weight per meter row length. Ten randomly selected spikes from each plot were used to measure spike length. At maturity each plot was harvested manually and bundles were made. Then bundles are sun dried and threshed to calculate grain yield of wheat. The straw yield was obtained after deducting the weight of grains from weight of bundles and expressed as q $ha^{-1}$.

Weed density were counted at two randomly selected spots from each plot by using quadrat of 0.25 $m^2$. The count was taken once before post emergence herbicide application (30 days after sowing) and once after application of herbicide (60 days after sowing). Average was converted into number of weeds $m^{-2}$ and was expressed as weed density.

Weed dry matter accumulation was calculated by collecting weeds from two randomly selected spots using quadrat of 0.25 $m^2$. After sun drying, weeds were dried in the oven at 65 °C till constant weight. Average of two spots was taken and expressed as g $m^{-2}$. The observation of weed dry matter was taken twice; first observation was taken before application of post-emergence herbicide (30 days after sowing) and another after herbicide application (60 days after sowing).

The experimental data recorded were analysed with the help of analysis technique for split plot factorial design as described by Panse and Sukhatme (1985). To judge the significance of differences between means of two treatments, critical difference was worked out, as described by Gomez and Gomez (1983)

## RESULTS AND DISCUSSION

*A. Weed studies*

(i) **Weed density.** Number of weeds (per square meter area) recorded at 30 and 60 days after sowing is presented in Table 1. Highest weed density was observed in $C_0R_1T_3$ treatment at both stages of observations *i.e.* 30 DAS (81.67 $m^{-2}$) and 60 DAS (24.00 $m^{-2}$). The residue retention treatments ($C_0R_2T_1$, $C_0R_2T_0$, $C_1R_2T_0$ and $C_0R_2T_2$) recorded significantly lower weed density compared with $C_2R_0T_3$, $C_0R_1T_3$ treatments at 30 as well as 60 DAS. The lowest weed density was recorded under combine harvesting of paddy without SMS, residue shredding with mulcher followed by happy seeder sowing of wheat ($C_0R_2T_1$) at both 30 DAS (36.44 $m^{-2}$) and 60 DAS (7.22 $m^{-2}$). This might be due to hindrance to weed emergence due to stubble cover on the soil surface thereby leading to decrease in weed density. It has been reported in many studies that mulch in the form of residues (Yadav *et al.*, 2018; Salam *et al*., 2020) reduce weed emergence and hence weed density.

Application of different fertilizer levels posed a significant impact on weed density. Significantly, higher weed density was recorded with 125% RDF (59.67 and 14.83 $m^{-2}$) than 75% RDF (46.22 and 11.50 $m^{-2}$) and 100% RDF (54.50 and 13.39 $m^{-2}$) at 30 and 60 DAS, respectively. The higher weed density with higher fertilizer dose was might be due to higher availability of nutrients. Fazal Munsif *et al.* (2018) also reported increase in weed density with increase in dose of nitrogen fertilizer.

(ii) **Weed dry matter accumulation.** Dry matter of weeds (gram per square meter area) was recorded on 30 and 60 DAS, which shows significant difference among the various residue management practices and fertilizer levels (Table 1). Maximum dry matter accumulation of weeds was observed in $C_0R_1T_3$ at 30 (9.40 g $m^{-2}$) and 60 DAS (12.29 g $m^{-2}$). The treatment $C_0R_2T_1$, $C_0R_2T_0$, $C_1R_2T_0$ and $C_0R_2T_2$ recorded significantly lower weed dry matter accumulation than other treatments ($C_0R_1T_3$ and $C_2R_0T_3$) at both 30 and 60 DAS. Lowest weed dry matter accumulation was recorded with $C_0R_2T_1$ (4.20 and 4.70 g $m^{-2}$) at both 30 and 60 DAS, respectively. This may be attributed to higher number of weeds in the treatments with no residue cover. Chaudhary and Iqbal (2013) also reported lower dry matter of weed with inclusion of residue as surface mulch.

Among the fertilizer levels, significantly higher dry matter of weeds was observed under 125% RDF (6.87 and 8.10 g $m^{-2}$) than 75% RDF (5.32 and 6.40 g $m^{-2}$) and 100% RDF (6.28 and 7.40 g $m^{-2}$) treatments. In comparison to 125% RDF, weed dry matter at 30 DAS was reduced by 9.4 and 22.6 percent in 100% RDF and 75% RDF, respectively. The higher dry matter accumulation with higher fertilizer dose might be due to higher nutrient availability leading to higher vegetative growth of weeds. Similar results were reported by Pandey *et al.* (2007).

**Table 1: Effect of residue management and fertilizer levels on weeds in wheat.**

| Treatments | Weed density (no. $m^{-2}$) | | Weed dry matter (g $m^{-2}$) | |
|---|---|---|---|---|
| | 30 DAS | 60 DAS | 30 DAS | 60 DAS |
| **Residue management practices** | | | | |
| $C_0R_1T_3$ | 81.67 | 24.00 | 9.40 | 12.29 |
| $C_0R_2T_1$ | 36.44 | 7.22 | 4.20 | 4.70 |
| $C_0R_2T_0$ | 44.00 | 10.00 | 5.10 | 5.70 |
| $C_1R_2T_0$ | 41.00 | 9.11 | 4.72 | 5.42 |
| $C_0R_2T_2$ | 38.00 | 8.56 | 4.37 | 5.18 |
| $C_2R_0T_3$ | 79.67 | 20.56 | 9.16 | 10.52 |
| SEm± | 2.51 | 0.85 | 0.28 | 0.41 |
| CD (p=0.05) | 8.02 | 2.70 | 0.90 | 1.30 |
| **Fertilizer levels** | | | | |
| 75% RDF | 46.22 | 11.50 | 5.32 | 6.40 |
| 100% RDF | 54.50 | 13.39 | 6.28 | 7.40 |
| 125% RDF | 59.67 | 14.83 | 6.87 | 8.10 |
| SEm± | 1.11 | 0.41 | 0.13 | 0.20 |
| CD (p=0.05) | 3.26 | 1.19 | 0.37 | 0.59 |

*DAS= days after sowing; $C_0$= Combine harvesting without SMS (Straw management system); $C_1$= Combine harvesting with SMS; $C_2$= Manual harvesting leaving short anchored stubbles; $R_0$= Residue removed; $R_1$= Residue burned; $R_2$= Residue retained; $T_0$= Direct seeding with Happy Seeder in no till conditions; $T_1$= Residue shredding with mulcher followed by sowing with Happy Seeder in no till conditions; $T_2$= Residue shredding with paddy straw chopper followed by sowing with Happy Seeder in no till conditions; $T_3$= Conventional tillage

*B. Crop studies*

(i) **Plant height.** The perusal of data presented in Table 2 indicates that different residue management and fertilizer levels significantly influenced wheat plant height at maturity. Maximum plant height at maturity was recorded with $C_0R_2T_1$ (96.73 cm), which was statistically at par with $C_0R_2T_2$ (96.64 cm), $C_1R_2T_0$ (95.60 cm) and $C_0R_2T_0$ (94.04 cm) but significantly higher than $C_2R_0T_3$ (89.77 cm) and $C_0R_1T_3$ (90.42 cm). This might be ascribed to uniform and longer moisture availability (residue retention shades the soil and serve as vapour barrier against soil moisture loss), enhanced nutrient availability due to decomposition of residues in residue retention treatments which may have favourably influenced the plant height. Ahmed *et al.* (2007) also found higher plant height with residue cover than surface with no residue.

Among the various fertilizer levels, 125 % RDF recorded maximum plant height (95.98 cm) at maturity, which was statistically at par with 100% RDF (94.42 cm) but significantly higher than 75% RDF (91.20 cm). This might be due to split dose of nitrogen applied after first and second irrigation. The higher nitrogen dose favoured more vegetative growth and resulted into significant increase in plant height. Hussain *et al.* (2006) also reported higher plant height with increase in nitrogen dose.

(ii) **Dry matter accumulation.** Data pertaining to dry matter accumulation of wheat at maturity are presented in Table 2. Residue management practices had significant effect on wheat dry matter accumulation at maturity. The treatment $C_0R_2T_1$ (205.28 g/mrl) recorded significantly higher dry matter accumulation at maturity than $C_2R_0T_3$ (191.20 g/mrl) and $C_0R_1T_3$ (193.29 g/mrl), but was statistically at par with $C_0R_2T_0$ (201.32 g/mrl), $C_1R_2T_0$ (202.93 g/mrl) and $C_0R_2T_2$ (203.69 g/mrl) treatments. The abovesaid reasoning and supporting for the plant height is valid for dry matter of wheat too.

Among fertilizer levels, application of 125% RDF (209.35 g/mrl) recorded significantly higher dry matter accumulation of wheat at maturity than 75% RDF (186.75 g/mrl) and 100% RDF (202.76 g/mrl). The higher dry matter with 125% RDF might be due to increase in plant height, because of higher nutrient availability. Yadav and Dhanai (2017) also reported increase in dry matter with increase in nitrogen levels.

(iii) **Spike length.** The data given in Table 2 presents the spike length of wheat as affected by various residue management practices and fertilizer levels. Highest spike length was observed with $C_0R_2T_1$ (9.55 cm) treatment which was statistically at par with $C_0R_2T_0$

(9.33 cm), $C_1R_2T_0$ (9.39 cm) and $C_0R_2T_2$ (9.51 cm) treatment. $C_2R_0T_3$ (9.05 cm) and $C_0R_1T_3$ (9.07 cm) treatment recorded significantly lower spike length as compared to other residue management practices. This might be due to better soil moisture availability, high nutrient availability due to mineralisation of nutrients from paddy residue and higher number of days available for gain filling because of late maturity. Bartaula *et al.* (2020); Khalid *et al.* (2014) also concluded similar results.

Among the fertilizer levels, highest spike length was recorded with 125% RDF (9.75 cm), which was significantly higher over 75% RDF (8.84 cm) and 100% RDF (9.35 cm) treatment. This might be due to better growth with higher availability of plant nutrients. These findings are in line with those of Khalid *et al.* (2014).

**(iv) Grain yield.** Residue management practices and fertilizer levels showed significant effect on grain yield. Perusal of data presented in Table 2 reflect that maximum grain yield was recorded in $C_0R_2T_1$ (52.76 q $ha^{-1}$) treatment which was statistically at par with $C_0R_2T_0$ (51.53 q $ha^{-1}$), $C_1R_2T_0$ (51.77 q $ha^{-1}$) and $C_0R_2T_2$ (52.38 q $ha^{-1}$) treatment which were significantly higher than $C_2R_0T_3$ (48.17 q $ha^{-1}$) and $C_0R_1T_3$ (49.34 q $ha^{-1}$). This might be due to better soil moisture regime, higher availability of nutrients at later crop growth stages because of decomposition of rice residue, late maturity etc. which contributed to increased yield attribute like spike length which in turn resulted in higher grain yield under residue retention treatments. Tripathi *et al.* (2015); Singh *et al*. (2008) also reported higher grain yield in wheat with retention of rice residue as surface mulch cover.

Similarly, significant effect of fertilizer levels was observed in grain yield. Treatment 125% RDF recorded significantly higher grain yield (53.85 q $ha^{-1}$) over the other treatments. Grain yield obtained with 125% RDF was 14% higher over 75% RDF treatment. This might be due to significant increase in yield attributing character with increase in fertilizer level which resulted into higher grain yield. Similar finding of increase in grain yield with increase in fertilizer level were also reported by Hussain *et al.* (2002); Safar-Noori *et al.* 2018.

The interaction of residue management practices and fertilizer level had significant effect on grain yield of wheat. Significantly, more grain yield was observed in residue retention treatments ($C_0R_2T_1$, $C_0R_2T_0$, $C_1R_2T_0$ and $C_0R_2T_2$) at 100% RDF and 125% RDF fertilizer levels as compared to $C_2R_0T_3$ and $C_0R_1T_3$ treatment. Significant increase in grain yield was observed with increase in fertiliser dose from 100% RDF to 125% RDF in residue retention treatments. No significant increase in grain yield was observed with increase in fertilizer dose from 100% RDF to 125% RDF in no-residue retention treatments ($C_2R_0T_3$ and $C_0R_1T_3$).

(v) **Straw yield.** Straw yield was significantly affected by various residue management practices and fertilizer levels (Table 2). Maximum straw yield was recorded in $C_0R_2T_1$ (75.31 q $ha^{-1}$) treatment which was significantly higher than $C_2R_0T_3$ (69.91 q $ha^{-1}$) and $C_0R_1T_3$ (71.37 q $ha^{-1}$) treatment and statistically at par with $C_0R_2T_0$ (73.96 q $ha^{-1}$), $C_1R_2T_0$ (74.14 q $ha^{-1}$) and $C_0R_2T_2$ (74.83 q $ha^{-1}$) treatment. The positive effect of crop residue on soil moisture conservation, soil nutrient availability by mineralisation directly increasing the dry matter accumulation may have contributed to higher straw yield. Plant height may also be an indirect contributor. Singh *et al*. (2013a) also reported higher straw yield in happy seeder sown wheat with residue retained conditions as compared to conventional tillage practices.

**Table 2: Effect of residue management and fertilizer levels on growth, yield attribute and yield of wheat.**

| Treatments | Plant height (cm) at maturity | Dry matter (g/mrl) at maturity | Spike length (cm) | Grain yield (q/ha) | Straw yield (q/ha) |
|---|---|---|---|---|---|
| **Residue Management Practice** | | | | | |
| $C_0R_1T_3$ | 90.42 | 193.29 | 9.07 | 49.34 | 71.37 |
| $C_0R_2T_1$ | 96.73 | 205.28 | 9.55 | 52.76 | 75.31 |
| $C_0R_2T_0$ | 94.04 | 201.32 | 9.33 | 51.53 | 73.96 |
| $C_1R_2T_0$ | 95.60 | 202.93 | 9.39 | 51.77 | 74.14 |
| $C_0R_2T_2$ | 96.64 | 203.69 | 9.51 | 52.38 | 74.83 |
| $C_2R_0T_3$ | 89.77 | 191.20 | 9.05 | 48.17 | 69.91 |
| SEm± | 0.99 | 2.18 | 0.07 | 0.41 | 0.80 |
| CD (p=0.05) | 3.17 | 6.95 | 0.23 | 1.31 | 2.56 |
| **Fertilizer levels** | | | | | |
| 75% RDF | 91.20 | 186.75 | 8.84 | 47.22 | 68.30 |
| 100% RDF | 94.42 | 202.76 | 9.35 | 51.90 | 74.50 |
| 125% RDF | 95.98 | 209.35 | 9.75 | 53.85 | 76.96 |
| SEm± | 0.62 | 1.32 | 0.06 | 0.22 | 0.44 |
| CD (p=0.05) | 1.81 | 3.87 | 0.16 | 0.66 | 1.29 |

*mrl= meter row length; DAS= days after sowing; $C_0$= Combine harvesting without SMS (Straw management system); $C_1$= Combine harvesting with SMS; $C_2$= Manual harvesting leaving short anchored stubbles; $R_0$= Residue removed; $R_1$= Residue burned; $R_2$= Residue retained; $T_0$= Direct seeding with Happy Seeder in no till conditions; $T_1$= Residue shredding with mulcher followed by sowing with Happy Seeder in no till conditions; $T_2$= Residue shredding with paddy straw chopper followed by sowing with Happy Seeder in no till conditions; $T_3$= Conventional tillage

Among the fertilizer levels, significantly higher straw yield was observed in 125% RDF (76.96 q ha$^{-1}$) with an advantage of 12.8 and 3.2 per cent over 75% RDF and 100% RDF, respectively. Higher plant height and dry matter accumulation with 125% RDF resulted into significantly higher straw yield compared to other fertilizer levels. Similar results were also reported by Ullah *et al.* (2018).

## CONCLUSION

Based on one year study it may be concluded that combine harvesting of paddy without SMS, residue shredding with mulcher followed by happy seeder sowing of wheat can reduce the yield losses due to weeds, enhance the growth, yield attribute and yield (grain and straw) of wheat. Application of 125 per cent recommended dose of fertilizer resulted in higher grain and straw yield of wheat under no-till residue retained condition as compared to conventional tillage practices with no-residue retention. However, contribution of nutrients from decomposition of residue may increase with successive inoculation of residue. There is need to fine tune the fertilizer level in long run of residue retention to sustain the crop yield along with improving the soil health.

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