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Effect of paddy residue management techniques on yield of wheat crop and its attributes

Vikramaditya Sangwan*, Surinder Deswal

National Institute of Technology, Department of Civil Engineering, Kurukshetra, India
*Corresponding e-mail address: vikramaditya_6180078@nitkkr.ac.in

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Abstract. The research study deals with the results of the yield and yield attributing characters of the wheat crop corresponding to the nine different treatments (T-1 to T-9) of paddy residue management. The wheat yield accounts for the grain yield and straw yield while the wheat yield attributing characters include the spike length, grains per spike, grain test weight, etc. The results of these pertains to the data collected and analysed from the two consecutive years of field experimentation employing various treatments and replications of paddy stubble management. The resultant data of different parameters (yield and its attributing characters) from various treatments carried out through the two years of field experiments is tabulated in the Table 1 and Table 2 for effective discussion of results. The results suggested that the combined use of SMS (straw management system) mounted combine harvester, happy seeder and decomposer provides the best way to manage paddy residue, thereby yielding good yields of succeeding wheat crop to the farmers.

Key words: Paddy, Stubble, Happy Seeder, Sowing, Grain, Environment, Treatments.

1. Introduction

Paddy residue refers to that residue which is generated upon the cultivation of paddy crops and that includes many things like straw, husks, cut down stems or leaves which are usually considered undesirable and are left behind post-harvest. The residue of the field crops after harvest especially the paddy residue has overtime become a major concern to manage. The farmers resort to paddy residue burning which causes severe air pollution thereby endangering the environment and ecological activities. However, if effectively managed the residue of the field crops can be of enormous utility as well as beneficial for the farmers. Out of the paddy residue management ways of stubble retention and incorporation, the retention of paddy stubble is considered better as a huge amount of energy is needed for the paddy residue incorporation. Worldwide, the crop stubble retention and least disturbance of the field or soil, are considered to be the main aspects of conservation agriculture (CA) that are popular among the farmers because of their sustainable nature (FAO, 2018). Zero tillage (ZT) method not only decreases the tillage cost but also aids in enhancing the intensity of the crops and this is attributed to the reason that time between crop rotation gets reduced (Kayombo & Lal, 1994). The retaining of paddy stubble on the surface of field or soil not only enhances the carbon content of the soil but also has myriad other advantages such as; moisture conservation, temperature moderation, microbial activity enhancement and weed suppression (Blevins et al., 1983; Eguchi & Hirano, 1971; Sharma et al., 2008; Chhokar et al., 2018). Moreover, sowing of wheat into the standing paddy residue provides protective blanket against the low temperature caused due to the frost (Fowler & Gusta, 1978) and in times when crops are damaged due to severe low temperature, zero tillage yields are better as compared to the CT (conventional tillage) yields but in times when there is no case of damage due to severe low temperature then both the methods produce similar wheat yields. For the effective paddy stubble management, the main vital aspect is the availability of required machinery for the purpose. Happy seeder (HS), straw management system (SMS) are two significant machines for sowing wheat in paddy stubble and harvesting paddy crop (Sharma et al., 2008; Sidhu et al., 2007; Sidhu et al., 2008). The residue retention increased the wheat grain yield by 4.6–9.3% and maximum yield was recorded by Happy seeder ZT (3030 and 3920 kg/ha) compared to the conventional method (2836 and 3478 kg/ha) by Zamir et al. (2010). Ali et al. (2016) recorded better grain and straw yields when paddy stubble incorporation was combined with the input of extra nitrogen fertilizer which was superior to other treatments during both years. The incorporation of paddy residue enhanced the yield of wheat crop when cultivated in clay loam soil in place of the sandy loam soil as quoted by Bakht et al. (2009). Samra and Kumar (2003) showed that the paddy residue incorporation into the field enhances the properties of soil in the paddy-wheat crop rotation system. In comparison to the coarse-textured soils, the fine-textured soils yield better results for crop stubble management. The wheat crop stubble incorporation, enhanced the paddy yield and thereby had a favourable residual impact on the following yield of the wheat crop. Nevertheless, in the present research study incorporation of residue did not yield good results in terms of wheat yield and its attributes.

Keeping the above facts and discussion in view, the present study was conducted to study the various paddy residue management techniques. In this study, the paddy residue management techniques entailed nine different treatments to manage paddy residue. The two-year experimental study, was aimed at identifying the most effective treatment to manage the paddy stubble. The effectiveness of the paddy residue management treatments was judged on

the basis of their impact on the corresponding yield and yield attributes of the wheat crop. The study may prove to be beneficial in the reduction of harmful environmental burden caused by improper management of paddy residue on the field.

2. Materials and Methods

The field experimentation study for paddy stubble management techniques was conducted at the research farm of RRS (Regional Research Station) CCS (Chaudhary Charan Singh) Haryana Agricultural University in Samargopalpur village of Rohtak district (Haryana state, India). The area of the field experimentation study was located at the latitude and longitude of 28°57'22" N and 76°32'13" E respectively. This study was conducted on the same location or field for the consecutive two years. The location of study area is depicted in Figure 1.

In the study, the paddy residue management techniques entailed a total of nine treatments to manage paddy stubble. The experiment was conducted in Randomized Block Design (RBD) with three replications each of the nine different treatments of paddy residue management as shown in Figure 2. The total plot size area harvested and cultivated for the experiment was 60 m x 81.75 m (4905 m^2 or 1.21 acres) while the net plot size area harvested and cultivated for each treatment was 60 m x 2.25 m (135 m^2). A path of 0.75 m was left alongside each of the treatments. A tube-well sourced irrigation channel was there for irrigating the different plots. The nine different treatments of paddy residue management to sow wheat are stated as follows:

- T-1: *Sowing wheat by zero tillage with happy seeder in full paddy residue coupled with application of decomposer.
- T-2: *Sowing wheat by zero tillage with happy seeder in full paddy residue.
- T-3: *Sowing wheat by zero tillage with happy seeder in partial paddy residue.
- T-4: Sowing wheat by zero tillage with zero till machine after paddy residue burning.
- T-5: Sowing wheat by conventional tillage (rotavator or harrow) with seed drill after paddy residue burning.
- T-6: Sowing wheat by conventional tillage with seed drill after paddy residue incorporation.
- T-7: Sowing wheat by conventional tillage with seed drill after manual harvesting of paddy using sickle.
- T-8: Sowing wheat by zero tillage with happy seeder in full paddy residue (paddy harvested without SMS mounted combine harvester).
- T-9: Sowing wheat by conventional tillage with seed drill after paddy residue incorporation (paddy harvested without SMS mounted combine harvester).

[Note: *Paddy harvested with straw management system (SMS) mounted combine harvester].

Super fine basmati rice variety PUSA 1509 was transplanted in the first week of July during both the years of experimentation in the experimental plot (Fig. 2). This paddy crop was harvested in the end of October during both the years with and without super SMS mounted combine harvester in mechanical harvesting treatments, and manually with sickle. In conventional tillage method the land was prepared with rotavator, disc harrow or cultivator for wheat sowing. The sowing of wheat variety HD 3086 was done with happy seeder machine, zero till machine and seed cum fertilizer drill across different treatments using 110 kg seed/ha in the month of November during both the years.

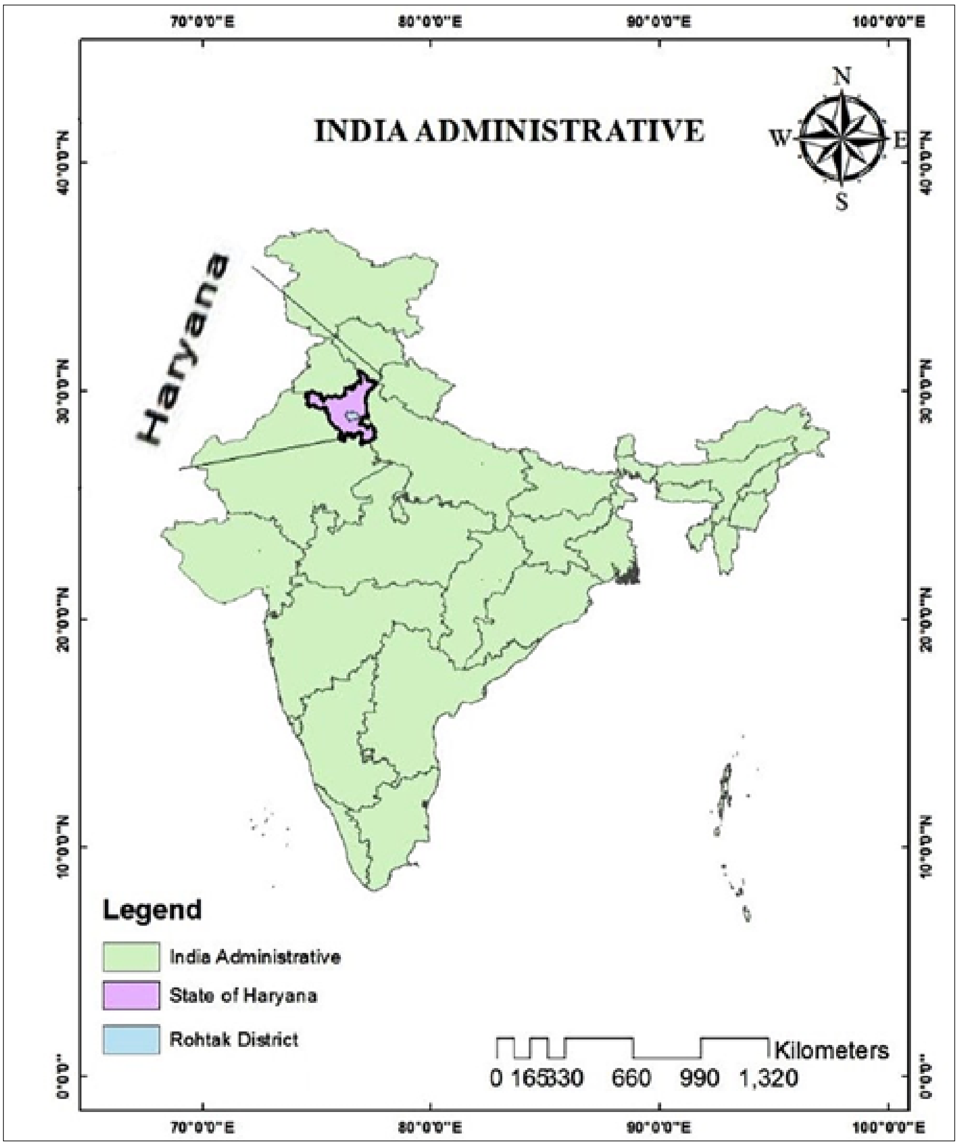

Figure 1. Location of the study area

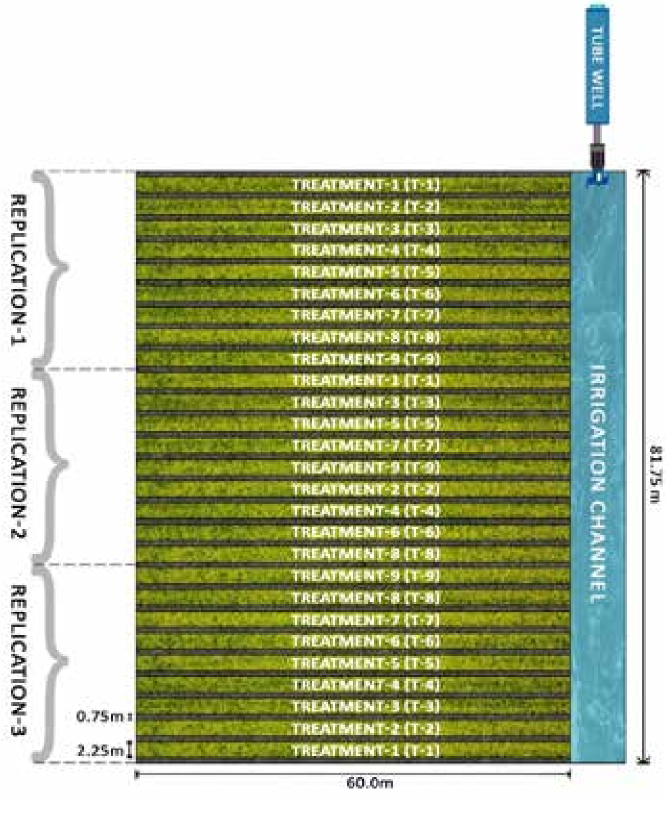

Figure 2. Experimental plot for various treatments of paddy residue management

In treatment T-6 and T-9 paddy residue was incorporated and field was prepared with disc- harrow and rotavator and sowing was done with seed drill. The NPK (nitrogen-phosphorus-potassium) fertilizer mixture (187.5 Kg/ha) was drilled alongside the seeds at the time of sowing across all the treatments. Furthermore, the nitrogen fertilizer i.e., neem coated urea was applied as top dressing in two equal splits (55 Kg/acre in each split) after first and second rounds of irrigation at 20 and 40 DAS (days after sowing), respectively. For the control of weeds, the tank mixture of sulfosulfuron and metsulfuron (25+4 g/ha) was applied at 35 DAS across all the treatments. In total four and three irrigations were applied to the wheat crop during first and second year, respectively. The wheat crop was harvested in the month of April during the first and second year of experiments, respectively.

Decomposer preparation: Five kg of jaggery was dissolved in 500 litres of water in a container and thereafter 50 g of decomposer (recommended by IFFCO- Indian Farmers Fertilizer Cooperative, Government of India) was mixed in it. Finally, the container was covered with jute bags. The mixture was stirred twice a day for two days. A white cotton like fungus appeared on the surface of mixture after 4–5 days and furthermore after 2–3 days the color of fungus turned into blue-green brown. It verified that the solution was ready for use. This decomposer solution was sufficient for application on paddy residue in one hectare of land. The prepared decomposer solution was applied on treatment T-1 with first irrigation at 20 days after sowing (DAS) of wheat crop. The decomposer used is environment friendly and has the ability to convert the agricultural waste to the advantage of soil fertility.

3. Results and Discussion

3.1. Grain Yield and Straw Yield

Encompassing both the years of field experimentation, the highest grain yield of wheat was obtained when the wheat crop was sown using happy seeder in full paddy residue coupled with application of decomposer (T-1) as depicted in Figure 3. As described in the Table 1 and Table 2; the grain yield of T-1 treatment was found to be statistically similar to all the treatments except T-6, T-9 and T-8 treatments i.e., sowing of wheat crop with conventional tillage after residue incorporation (paddy harvested with and without SMS mounted combine harvester) and sowing of wheat using happy seeder in full residue (paddy harvested without SMS mounted combine harvester) respectively. Similar trends were observed in case of straw yield results as is shown in the Figure 4.

The main reason for lower grain and straw yields under the treatments (T-6 and T-9) employing conventional tillage after residue incorporation as compared to the treatments involving the removal or burning of paddy residue was that it takes longer time to decompose the incorporated residue, and so it adversely affects the wheat growth since early stage thereby resulting in lower number of tillers and finally lower yields. Also, the complete incorporation was not achieved by harrow or rotavator during the process of conventional tillage. Moreover, the decomposition of paddy residue requires extra nitrogen which was not added in these treatments and this temporarily created lower nitrogen availability in the soil and thereby less uptake of nutrients by the plants. It should be noted that the cost of extra nitrogen is more than the decomposer. Due to hindrance of paddy residue, seed drill did not place the seed properly and hence resulting in patchy germination of wheat after residue incorporation. Early canopy cover by wheat is important not only for optimum tillering but also for suppression of weeds. The lowest grain and straw yields in the treatment (T-9) using happy seeder sowing (paddy harvested without SMS mounted combine harvester) were due to uneven load of paddy residue on the soil. The proper sowing could not take place wherever the residue load was higher hence it hampered the germination process and ultimately the yields of grain and straw.

As evident from the Figure 3 and Figure 4, the grain and straw yields were found to be better in the treatment T-5 where conventional tillage was done for wheat sowing after the burning of the paddy residue; as compared to the treatment T-4 in which the wheat was sown by employing zero till machine after the burning of the paddy stubble. The underlying reason behind this was that the unburnt paddy stubble and the unwanted growth of weeds caused a slight hindrance to the germination and tillering of the sown wheat. Additionally, the conventional tillage provided the thorough field preparation thereby enhancing the required aeration of the soil. Also, it was observed that the treatment T-7 in which the paddy was harvested manually using the sickle and the wheat was sown after conventional tillage, there was not a significant difference in the grain and straw yields in comparison to the treatment T-1, the treatment with the highest yields (Fig. 3 and Fig. 4). This is attributed to the thorough preparation of field by conventional tillage using harrow or rotavator and proper manual clearance of the field from the paddy stubble.

3.2. Effective Tillers per Square Meter

The effective tillers are the wheat tillers at the time of harvest that potentially bear the wheat grain. As shown in the Figure 5, in both the years of field experimentation the highest number of effective tillers per square meter of wheat crop

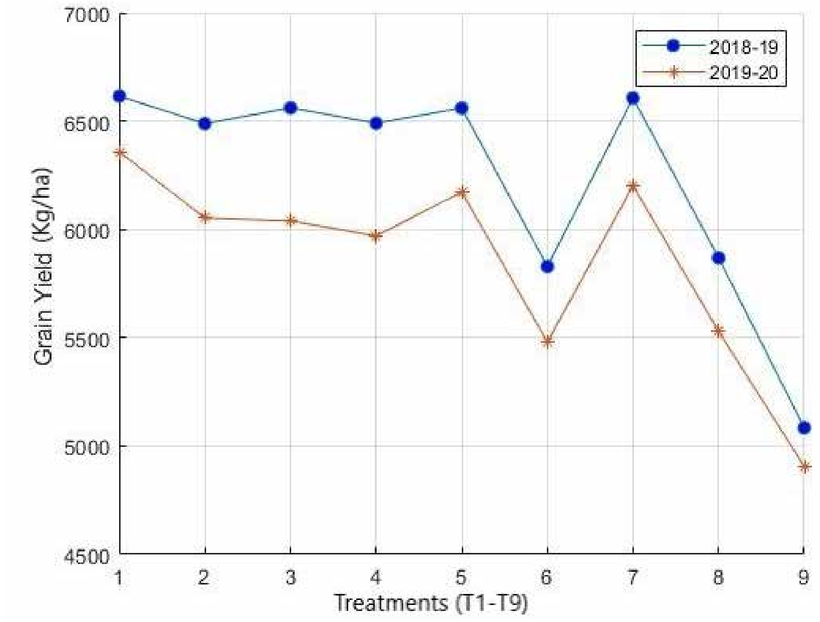

Figure 3. Effect of different treatments on Grain Yield (Kg/ha)

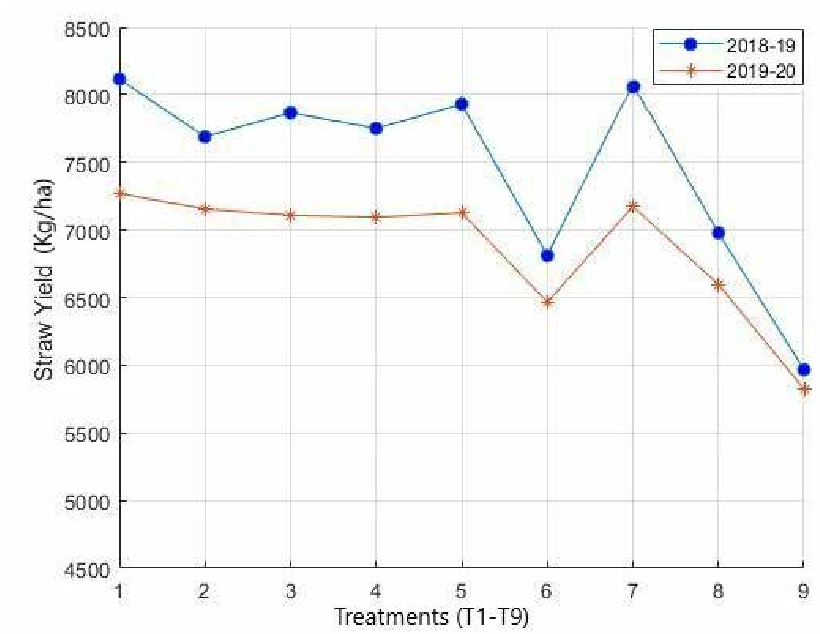

Figure 4. Effect of different treatments on Straw Yield (Kg/ha)

were recorded when wheat was sown using happy seeder in full residue coupled with application of decomposer (T-1). This result was significantly different from T-6, T-9 and T-8 treatments i.e., sowing of wheat crop by employing conventional tillage after residue incorporation (paddy harvested with and without SMS mounted combine harvester) and sowing of wheat using happy seeder in full residue (paddy harvested without SMS mounted combine harvester) respectively. In all the other treatments (T-2, T-3, T-4, T-5, T-7), the results of effective tillers/m^2 were not significantly different from the results of T-1 treatment (Table 1 and Table 2). Also, it is evident from Figure 2, Figure 3 and Figure 4 that there were similar trends of grain yield, straw yield and effective tillers/m^2 of wheat crop across various treatments in the two years of experiments.

The reasons for significantly lower number of tillers in the treatments T-6, T-8 and T-9 include the lack of extra soil-nitrogen required for the purpose of decomposition and also, the paddy residue load led to patchy germination of wheat seeds.

3.3. Spike Length

The comparative trends of the spike length (cm) of wheat crop across various treatments of paddy stubble management are plotted in the Figure 6. From the plot in Figure 5 it is very well evident that during both the years of field experimentation the trends of wheat crop spike length followed a similar path except in case of treatment T-4. The deviation in treatment T-4 from treatment T-3 in the first and second year of experimentation respectively was negligible. The spike length did not vary significantly under all the treatments in both the years (Table 1 and Table 2). Nevertheless, during both the years the maximum spike length was observed in treatment T-1 when the wheat crop was sown using happy seeder in full residue coupled with application of decomposer, while the minimum spike length was observed in treatment T-9 when the wheat crop was sown employing conventional tillage after residue incorporation (paddy harvested without SMS mounted combine harvester).

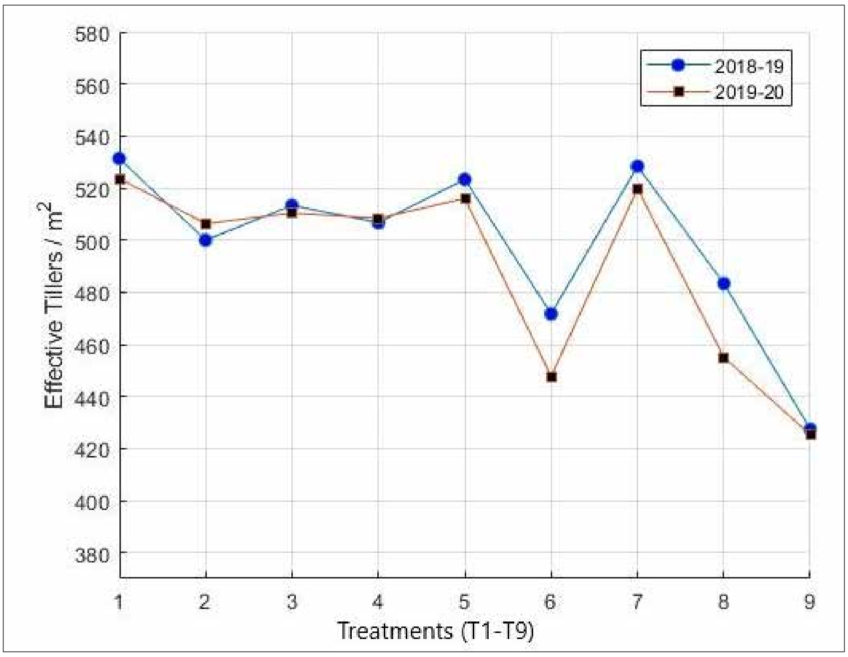

Figure 5. Effect of different treatments on Effective Tillers/m^2

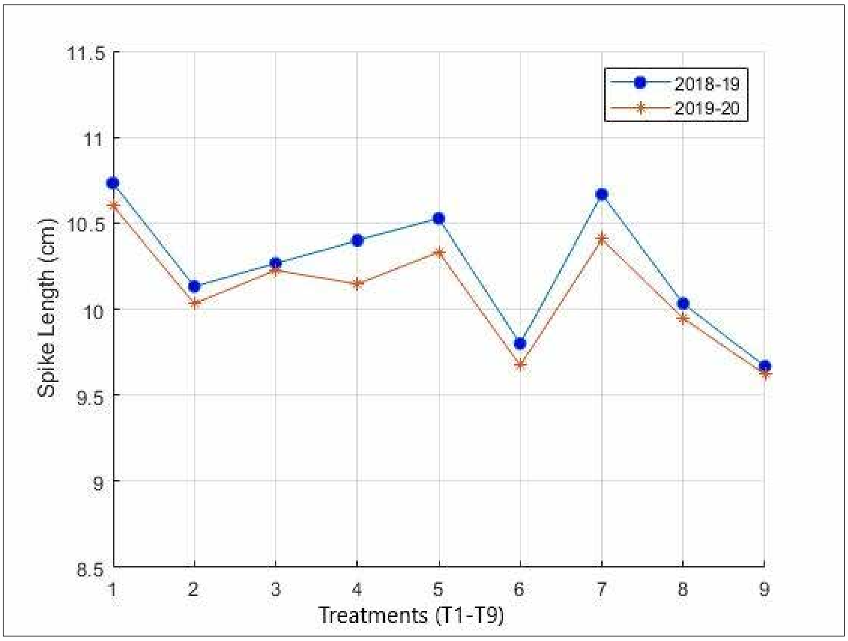

Figure 6. Effect of different treatments on Spike Length (cm)

3.4. Grains per Spike

The trends of the number of grains per spike of wheat crop under different paddy stubble management treatments during the two years of field experiments are depicted in the Figure 7. Encompassing both the years, the number of grains per spike were highest in treatment T-1 when wheat was sown using happy seeder in full residue coupled with application of decomposer while they were lowest in treatment T-9 when wheat crop sown with conventional tillage after residue incorporation (paddy harvested without SMS mounted combine harvester) (Table 1 and Table 2).

3.5. Grain Test Weight

In the presented study the grain test weight signified the thousand (1000) grains weight of wheat in grams. The thousand grains weight of wheat crop did not vary significantly across the different treatments of paddy stubble management during the two phases of experimentation (Table 1 and Table 2). As in case of the other yield attributing

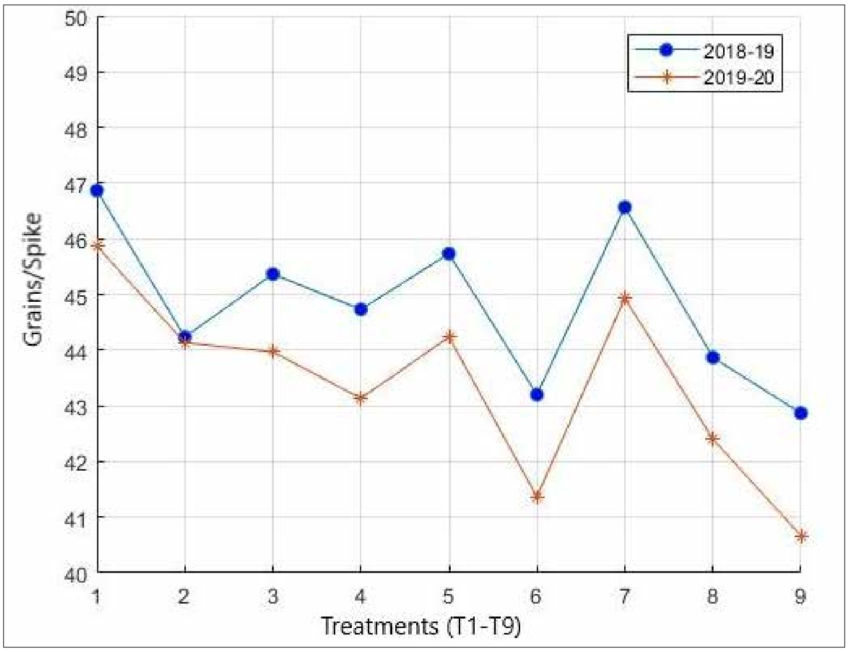

Figure 7. Effect of different treatments on Grains per Spike

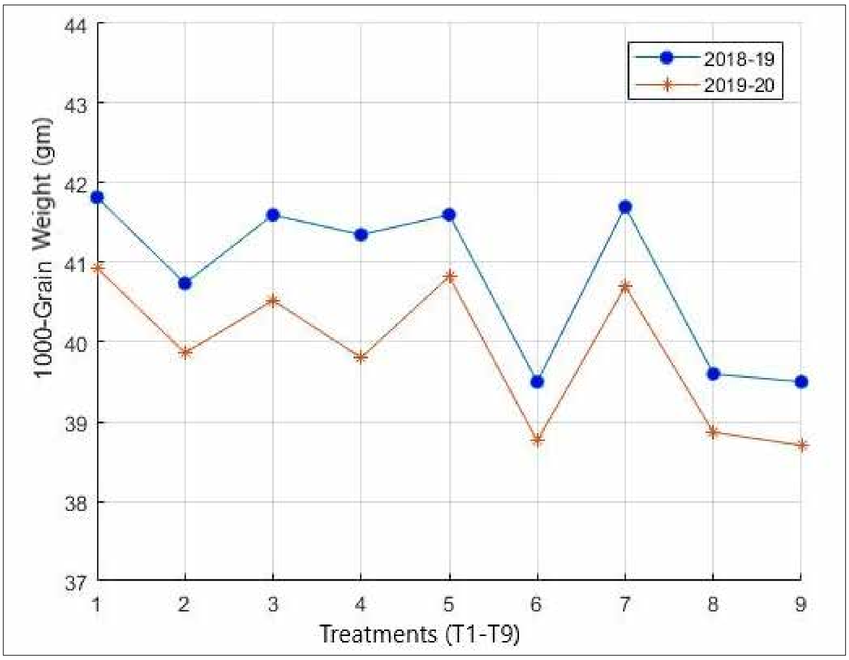

Figure 8. Effect of different treatments on Grain Test Weight (gm)

Table 1. Effect of different treatments on yield and yield attributes of wheat (First Year)

Experiment- 01 (First Year)							
No.	**Treatments**	**Tillers/m²**	**Grains/Spike**	**Test Weight (gm)**	**Spike Length (cm)**	**Grain Yield (Kg/ha)**	**Straw Yield (Kg/ha)**
T-1	*ZT with HS in full residue + Decomposer (SMS)	531	46.9	41.8	10.7	6615	8115
T-2	*ZT with HS in full residue (SMS)	500	44.2	40.7	10.1	6488	7689
T-3	*ZT with HS in partial residue (SMS)	513	45.4	41.6	10.3	6561	7867
T-4	ZT with Zero till machine after residue burning	507	44.7	41.3	10.4	6490	7751
T-5	CT after residue burning	523	45.7	41.6	10.5	6560	7930
T-6	*CT after residue incorporation (SMS)	472	43.2	39.5	9.8	5829	6812
T-7	CT after manual harvesting (sickle)	528	46.6	41.7	10.7	6606	8084
T-8	ZT with HS in full residue	483	43.9	39.6	10.0	5868	6977
T-9	CT after residue incorporation	427	42.9	39.5	9.7	5084	5967
	CD	34	NS	NS	NS	485	533

*Paddy harvested using straw management system (SMS) mounted combine harvester.

Table 2. Effect of different treatments on yield and yield attributes of wheat (Second Year)

Experiment- 02 (Second Year)							
No.	**Treatments**	**Tillers/m²**	**Grains / Spike**	**Test Weight (gm)**	**Spike Length (cm)**	**Grain Yield (Kg/ha)**	**Straw Yield (Kg/ha)**
T-1	*ZT with HS in full residue + Decomposer (SMS)	524	45.9	40.9	10.6	6358	7269
T-2	*ZT with HS in full residue (SMS)	506	44.1	39.9	10.0	6053	7154
T-3	*ZT with HS in partial residue (SMS)	510	44.0	40.5	10.2	6039	7109
T-4	ZT with Zero till machine after residue burning	508	43.1	39.8	10.1	5970	7093
T-5	CT after residue burning	516	44.2	40.8	10.3	6173	7127
T-6	*CT after residue incorporation (SMS)	448	41.4	38.8	9.7	5480	6466
T-7	CT after manual harvesting (sickle)	520	44.9	40.7	10.4	6202	7172
T-8	ZT with HS in full residue	455	42.4	38.9	9.9	5529	6598
T-9	CT after residue incorporation	425	40.7	38.7	9.6	4906	5823
	CD	31	NS	NS	NS	456	572

*Paddy harvested using straw management system (SMS) mounted combine harvester.

characters discussed previously in this chapter, numerically in both the years the maximum thousand grains weight of wheat was observed under treatment T-1 when wheat was sown using happy seeder in full residue coupled with application of decomposer while the minimum thousand grains weight was observed under treatment T-9 when wheat crop was sown with conventional tillage after residue incorporation (paddy harvested without SMS mounted combine harvester). Figure 8 exhibits the trends of thousand grain weight of wheat under different treatments of paddy stubble during both the years.

4. Conclusion

In the presented study, it was observed that some of the parameters related to the wheat yield and its attributing characteristics (grain yield, straw yield, effective tillers/m²) witnessed a significant dip in their respective values during the second phase of field experimentation in comparison to the first phase of field experimentation. This was due to the impact of the unfavourable variance in the weather conditions during second year of field experiment. In the second year, there was slightly more temperature stress

(2–2.5°C) on the wheat crop during 50 to 60 days of wheat growth. And this resulted in negative impact on tillering of the wheat crop, henceforth lowering the grain yield and straw yield too.

It can be clearly concluded that the treatment T-1 in which the wheat crop was sown using happy seeder in full paddy residue load (SMS) coupled with application of decomposer; yielded the best results in case of all the parameters related to the wheat yield and its attributes. In this study it was noted that the treatment (T-7) involving conventional method of manual paddy harvesting (using sickle) and conventional tillage produced excellent results related to wheat yield and its attributes. These results followed the results of treatment T-1.

From the study it was found that in the treatments (T-6 and T-9) where paddy residue was incorporated and afterwards conventional tillage was done, the yields (grain and straw) were the lowest. Also, the treatment (T-8) where the method of zero tillage using happy seeder in full paddy residue (paddy harvested without SMS) was adopted; resulted to the lower yields (grain and straw). Thus, these treatments (T-6, T-8 and T-9) of paddy stubble management were economically challenging as well.

The use of SMS (straw management system) mounted combine harvesters for paddy harvesting and thereafter employing zero till method of wheat sowing using happy seeder machine (T-1, T-2, T-3) produced favorable results in totality. In case of paddy stubble burning treatments (T-4 and T-5), the conventional tillage afterwards for wheat sowing yielded better results in comparison to the employment of zero tillage method. Overall, this study suggested that the problem of paddy stubble can be effectively managed by the extensive use of environment friendly decomposers, happy seeders and SMS mounted combine harvesters.

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