International Scholars Journals

International Journal of Agricultural Extension and Rural Development ISSN 2756-3642 Vol. 10 (1), pp. 001-009, Aug, 2023. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

SUSTAINABLE WHEAT PRODUCTION IN WESTERN INDO GANGETIC PLAINS: IMPACT OF TILLAGE AND RESIDUE MANAGEMENT

DR. ADISHESHA .K

Faculty, Dept of Crop physiology,

Bharatiya Engineering Science & Technology Innovation University, Andhra Pradesh, India.

Accepted 15 August, 2023

ABSTRACT

Crop residue management has emerged as a major challenge in recent years. No-till wheat sowing, aims to either incorporate paddy residue or retain it in the field, is one of the best technological measures to address this challenge. Therefore, a farmer participatory on-farm trial was conducted during 2020–21 and 2021–22 at five loca- tions in Rohtak to validate no-till wheat sowing for resource conservation, paddy residue management and its im- pact on wheat yield and profitability. The trial consisted of four different wheat establishment methods: conven- tional sowing, zero till drill sowing, happy seeder sowing and super seeder sowing. The no-till sowing resulted in 75–80% reduction in fuel consumption and 10–25% savings in water during first irrigation. Zero tillage and happy seeder methods showed 40–45% less weed flora incidence, especially of *Phalaris minor*. The grain yield was 5.3% higher under the super seeder than the conventional method, while zero till drill and happy seeder sowing were comparable to conventional sowing. However, the B: C ratio (3.5) was significantly higher under zero till drill sow- ing. Thus, the participatory on-farm trials demonstrates the potential benefits of no-till wheat sowing for sustainable crop production and better economics in western Indo-Gangetic plains.

Key words: Happy seeder, No-till, Residue incorporation, Residue retention, Super seeder and Zero drill

The rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) cropping system occupies 13.5 million hectares in the Indo-Gangetic Plains (IGP), predominantly in India (9.2 million hectares), contributing significantly to food security (Jat *et al.*, 2020). However, the sustainability of this system is threatened by soil, water, nutrient, and environmental is- sues, as both crops are exhaustive cereal crops (Singh *et al.*, 2020). The problem is further intensified when farm- ers burn the rice crop residue left in their fields after mechanized harvesting. Crop–residue is the biomass which is retained either below or on the soil surface after an eco- nomic product of a crop has been harvested (Reddy *et al.*, 2021). Rice straw constitutes 60% of burned crop residues, with an estimated 50 million tonnes burned in fields annu- ally (Bhattacharya *et al.*, 2021). In northwest India, about 23 million tonnes of rice residue are burned by approxi- mately 2 million farmers during (NAAS, 2017). In Haryana, the total paddy straw gener- ated was 7.6 million tonnes in 2020 and 6.8 million tonnes in 2021 (PIB, 2021). Due to the lack of economical alter- natives, around two-third to three-fourth of the residue is burned in the field. Moreover, the removal of paddy straw from the field is labor-intensive, and there is a very short window between the harvesting of paddy and the sowing of wheat, making burning the easiest method to dispose-off the residue for timely wheat sowing. The leftover rice resi- due also interferes with tillage and sowing operations for the successive wheat crop. In Haryana, a total of 4202 ac- tive burning events were recorded in 2020, which in- creased to 6987 in 2021, marking a 66.3% increase. How- ever, in 2022, the number of active burning events reduced to 3661, a 47.6% decrease compared to 2021 (CREAMS-IARI, 2022).

Effectively managing paddy straw has the potential to safeguard agricultural sustainability and enhance the eco- nomic security of those dependent on rice farming (Sharma *et al.*, 2021). A common perception among farmers is that sowing wheat in leftover paddy stubble results in poor crop germination. Thus, finding alternative methods for manag- ing rice straw with minimal environmental, soil and health impacts is a significant challenge. Potential solutions include sowing wheat in leftover paddy residue using no- till sowing machines like zero till drill, happy seeder and super seeder, either to incorporate or retain the residue on the soil surface. Zero-tillage wheat reduces the infestation of *Phalaris minor*, a significant challenge to maintaining sustainable wheat production in the rice-wheat cropping system. Weed count was significantly reduced by 13.1- times with happy seeder technology (Gupta *et al.*, 2021). Singh *et al.* (2024) also reported that CRM (Crop residue management) practices significantly reduce the usage of or- ganic and inorganic fertilizer. Thus, no-till wheat sowing presents a promising approach to sustainable crop produc- tion by managing crop residues effectively. Considering these points, a farmers' participatory on-farm trial was con- ducted to assess no-till wheat sowing with different ma- chineries at farmers' fields during 2020–2022.

MATERIALS AND METHODS

Farmers' participatory on-farm trials (OFTs) on wheat sowing with different machineries were conducted for two consecutive years during the *Rabi* seasons of 2020-21 and 2021-22 at farmers' fields in Rohtak district under CCS Haryana Agricultural University Krishi Vigyan Kendra, Rohtak (Haryana).

The district received an average annual rainfall of 432.8 mm and 844.2 mm during 2020-21 and 2021-22, respec- tively, with about 80% of this rainfall occurring during the monsoon season (June to September). The mean tempera- tures ranged from a minimum of 12.8°C to a maximum of

27.2ºC during the wheat season (November to April). There was a significant increase (2 to 4°C) in minimum and maximum temperatures in March and April during 2021-22 (Table 1). The soil of the experimental fields was sandy loam in texture with low organic carbon (0.3-0.6%) and available nitrogen (250-280 kg/ha), medium in avail- able phosphorous (9-13 kg/ha) and available potassium (180-220 kg/ha) with pH 7.8-8.4. The OFTs comprising four crop establishment methods: conventional wheat sow- ing (T1), zero till drill sowing in anchored stubble (T2), happy seeder machine sowing with residue retention (T3) and super seeder machine sowing with residue incorpora- tion (T4) were conducted at five farmers' fields, consider- ing each field as a separate replication.

Rice was harvested manually at 10–15 cm above ground in the zero till drill sowing treatments, while a combine harvester fitted with a straw management system (SMS) was used in happy seeder and super seeder sown wheat treatments. After harvesting the paddy, wheat variety 'HD 2967' was sown at the farmers' fields during the first fort- night of November using a seed rate of 100 kg/ha and a row-to-row spacing of 20 cm with different wheat estab- lishment methods. All crop production and protection prac- tices were adopted as per recommendations of CCS Haryana Agricultural University. In the conventional sow- ing method, field preparation involved two harrowings, followed by cultivation and leveling with a planker, and sowing was carried out using a seed-cum-fertilizer drill. Conversely, in the no-tillage system, wheat was directly sown using zero-till drill, happy seeder and super seeder. Fertilizer application across all establishment methods in- cluded nitrogen (150 kg/ha), phosphorus (60 kg/ha), potas- sium (30 kg/ha), and zinc (25 kg/ha), with 50% of nitrogen and the entire dose of phosphorus, potassium, and zinc applied at sowing, while the remaining nitrogen was top- dressed at the first irrigation. The crop received three irri- gations: pre-sowing, at 22 days after sowing (DAS), and at 85 DAS. Supplemental rainfall occurred during the later growth stages at all experimental sites. Weed management was uniformly implemented across all treatments through

Table 2. Details of experimental site

Village	GPS Location	Soil type
Bainsi	29.024223N	Sandy loam 76.411613E
Bainsi	29.024054N	Sandy loam 76.411655E
Bainsi	29.024194N	Sandy loam 76.412365E
Sanghi	29.065277N 76.625833E	Sandy loam
Sanghi	29.033333N	Sandy loam

76.616666E

Table 1. Monthly meteorological observation during 2020–2022

(mean monthly temperatures and total monthly rainfall) the application of pendimethalin at 5.0 L/ha as a pre-emer- gence herbicide, followed by the post-emergence applica- tion of ACM-9 at 600 g/ha. Germination (%), saving of irrigation water (%) and visual weed incidence (%) obser- vation at 30 DAS was reported on scale of 0 to100. Plant height (cm) at harvest and yield attributes were measured from five randomly selected plants. The number of effective tillers/meter row length was counted from five randomly selected one-meter rows. The crop was harvested at physiological maturity when the grains had approxi- mately 12% moisture content, and grain yield was con- verted to q/ha.

All experimental data for various parameters were ana- lyzed using SPSS software (version 26). The significante difference among treatments was tested using one-way ANOVA (F-test) and comparison of treatment means was tested using critical difference at 5% level of significance. The economics of different treatments was worked out in terms of net returns (₹/ha) and B:C, on the base of prevail- ing market prices for inputs and outputs.

RESULTS AND DISCUSSION

Germination and resource conservation

The no-till wheat sowing method has been identified as the most time and energy-efficient compared to conven- tional sowing methods. It allows for the wheat crop to be sown 10 to 15 days earlier, which results in timely sowing and an increase in yield. Among all the treatments, the highest germination percentage (95%) was observed with conventional and super seeder sowing methods, followed by zero drill sowing (Fig 1). However, the number of plants per meter row length was statistically lower with happy seeder sown wheat (Table 3). This might be due to both conventional and super seeder sowing methods ensure bet- ter seed placement, uniform seed-to-soil contact, and opti- mal seed depth, all of which contribute to a higher germi- nation percentage. In contrast, happy seeder sowing leaves a significant amount of loose straw on the soil surface,

Max. Temp (℃)	34.4	32.9	33	32.6	27.7	22.3	19.5	26.2	30.9	36.9	36.8	38.7
Min. Temp (℃)	27	26.1	24.1	19.3	14.1	9	6.6	11.1	16.4	18.9	22.5	25.9
Rainfall (mm)	82	60	8	4	16	25	36.4	33.8	0	6	92	69.6
					2021-22							
Max. Temp (℃)	36	34.6	32.4	32.1	27.5	22.4	16.8	23.4	31.8	40.7	41.4	41.1
Min. Temp (℃)	26.8	26.3	24.9	19.3	11.7	8.3	8.4	10.6	17.1	21.7	25.6	26.9
Rainfall (mm)	262.4	127.0	251.5	7.6	0.0	7.4	83.4	32.4	0.0	2.0	41.3	29.2

which can create a barrier, reducing seed-to-soil contact and hindering seedling emergence.

The zero till, happy seeder and super seeder sowing methods demonstrated a significant reduction in fuel con- sumption, being 75-80% lower compared to conventional methods. The lower fuel consumption in no-till sowing is due to less soil disruption and fewer machinery operations, resulting in more efficient field operations. Additionally, both the zero till drill and happy seeder methods led to sub- stantial water savings. The first irrigation required about 25% less water with the zero till and happy seeder meth- ods, while the super seeder method achieved a 10% water saving compared to the conventional method. This reduc- tion in water usage is likely attributed to the presence of residue or stubbles in the fields, which help reduce evapo- ration and maintain soil moisture. These residues act as mulch, limiting water loss. Additionally, minimal soil dis- turbance helps preserve soil structure, enhancing its mois- ture retention capacity. As a result, the soil retains water more effectively, decreasing the need for extra irrigation.

Weed management

Tillage affects various factors, such as the vertical dis- tribution of weed seeds in the soil, soil moisture, inter-day temperature fluctuations and light availability. These fac- tors influence weed seed dormancy, emergence and mortal- ity, thereby affecting weed density in the field. The major weed flora in wheat crops at farmers' fields includes *Phalaris minor*, *Polypogon monspeliensis*, *Rumex dentatus*, *Convolvulus arvensis*, *Chenopodium album*, *Medicago denticulata*, *Coronopus didymus* and *Melilotus alba*. After harvesting paddy, no tillage facilitates the timely sowing of wheat, creating more favourable ecologi- cal conditions for crop growth rather than for weeds. At 30 DAS, no-till wheat establishment methods showed a 15 to 45% reduction in weed flora incidence, especially *Phalaris minor*, compared to conventional sowing (Fig 1). This re- duction is likely due to minimal soil disturbances, causing

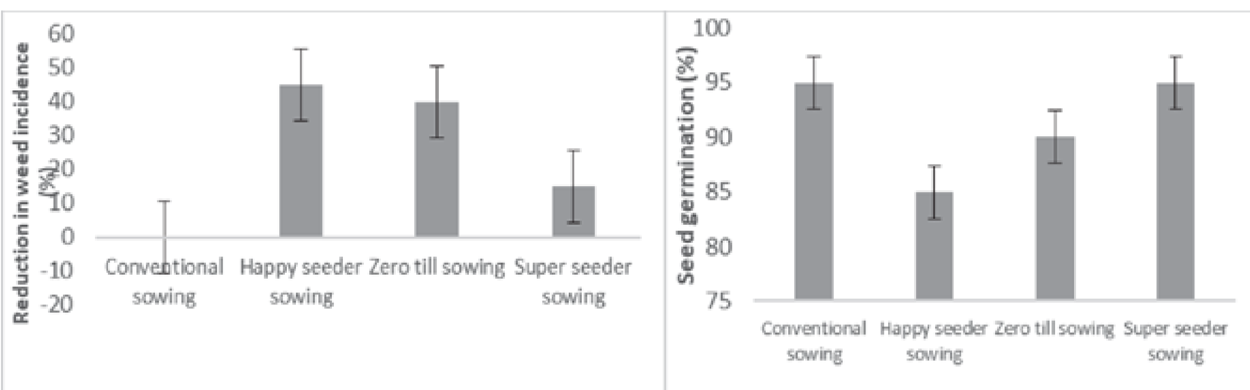

Fig. 1. Germination percentage and weed reduction (%) under different machineries

weed seeds present in the lower soil layer to fail to germi- nate due to mechanical impedance. Similarly, Kumar *et al.* (2013) reported that when rice residues are kept on the soil surface as mulch, the emergence of *P. minor*, *C. album* and

R. dentatus was inhibited by 45%, 83% and 88%, respec- tively, at a 6 t/ha rice residue load compared to fields with- out residue mulch. Raj *et al.* (2022) also observed that CA- based zero-till rice-wheat-mungbean system with residue retention reduces weeds, boosting wheat yield and profit- ability in the NW Indo-Gangetic Plains.

Yield parameters and yield

In the current farmer field experiment, the super seeder sown wheat exhibited statistically greater plant height, a higher number of effective tillers, more spikelets per panicle, longer panicle length and a greater number of grains per panicle in both years (Table 3). The grain yield using the super seeder machine was reported to be 5.43 t/ ha, which is 5.3% higher than the conventional sowing method and statistically higher than all other treatments. The zero till and happy seeder sowing methods yielded

5.16 and 5.20 t/ha, respectively, and were statistically simi- lar to each other and to the conventional sowing method (Table 3).

An overall yield reduction was observed during 2021- 22 *rabi* season, likely due to a significant increase in tem- perature during the grain filling and crop maturing period (Fig 2). The mean weekly temperature during 2021-22 was relatively 1 to 4°C higher (Table 1) than the previous year during crop maturity. This rise in temperature adversely affected grain size and number, leading to a reduction in wheat crop yield. The results are consistent with Song *et al.* (2015) who stated that significant reduction in the rate of grain filling in wheat cultivars at day/night tempera- ture of 32/22°C when compared with that of 25/15°C. Singh *et al.* (2011) also reported that even a rise of 1°C in the mean temperature in month of March–April leads to reduction in the duration of wheat crop by seven days and yield by about 400 kg/ha. In present experiment, wheat sown with the happy seeder had a slightly higher yield than

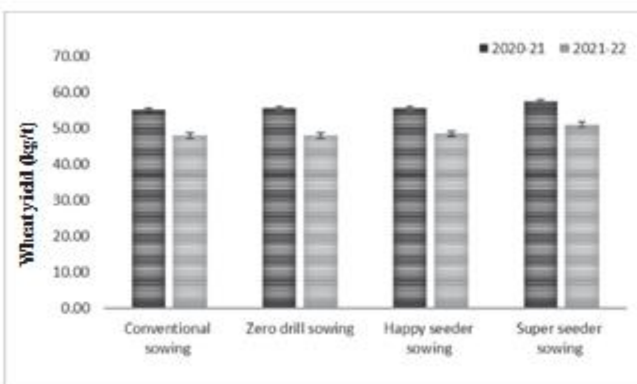

Fig. 2. Wheat yield under different sowing machineries during 2020–21 and 2021–22

zero till drill sowing and convention sowing method during 2021-22, likely because the crop residue used as mulch helped lessen the effects of terminal heat stress on grain number and size during the grain filling and maturation stages (Fig 2). However, this yield was statistically similar to both zero till drill and conventional sowing methods.

Super seeder sown wheat recorded the highest net re- turn, while the highest benefit-cost (B: C) ratio was ob- served with zero till drill sown wheat due to its lower cost of cultivation (Table 3). The cost of cultivation for no-till sown wheat was significantly reduced, as the expenditure for field preparation was only one-fourth of that for the conventional sowing method. The results of the effect of sowing method on net returns are in line with the findings of Singh *et al.* (2024) who stated that adoption of CRM practices in wheat crop has reduced the cost of cultivation by 4 per cent and increased gross and net returns by 26.8 and 44.3 per cent, respectively.

Pest incidence

The increased stem borer infestation was observed in wheat might be due to the surface retention of paddy resi- dues from the happy seeder sowing method which provides a favorable habitat for stem borers. These results are in line with Jasrotia *et al.* (2021) who reported that pink ste

Table 3. Crop growth and yield parameters of wheat sown with different machineries at harvest stage (pooled data)

Treatments	Plants/ m.r.l	Plant height (cm)	Effective tillers (No./m^2)	Spikelets/ panicle	Panicle length (cm)	Grains/ panicle	Grain yield (t/ha)	Benefit: cost ratio
Conventional sowing (T)	42.6^{c}	108.8^{b}	510^{a}	18.0^{a}	9.4^{a}	59.6^{a}	5.16^{a}	2.8
Zero drill sowing (T)	39.2^{b}	106.2^{a}	502^{a}	19.0^{a}	9.5^{a}	60.9^{a}	5.18^{a}	3.5
Happy seeder sowing (T)	34.6^{a}	106.2^{a}	504^{a}	18.0^{a}	9.5^{a}	60.0^{a}	5.20^{a}	3.2
Super seeder sowing (T)	42.8^{c}	110.2^{b}	531^{b}	21.0^{b}	10.14^{b}	64.6^{b}	5.43^{b}	3.3
SEm±	0.83	0.53	2.68	0.46	0.76	0.48	0.04	

m.r.l- meter row length

borer damage was significantly higher in the no tillage sys- tem. Similarly, the retention of straw on the surface, com- bined with heavy rain and high moisture, caused chlorosis (yellowing) in wheat during the early stages of growth un- der happy seeder sowing.

The study indicates that no-till wheat sowing is an effec- tive way to manage crop residue and improve wheat prof- itability. Super seeder sowing showed better germination and higher yield than other methods. However, the benefit- cost ratio (3.5) was higher with zero till machine, making it the preferred choice for most farmers when manually harvesting. Conversely, for combine harvesting, farmers favored the super seeder over the happy seeder due to lower incidences of stem borer and reduced risk of yellow- ness in the wheat crop after heavy rain or high moisture, which were more common with the happy seeder due to surface straw retention. Therefore, no-till wheat sowing can be recommended to farmers for better crop residue management and sustainable wheat production.

However, further research on the efficiency of the super seeder machine and its long-term impact on soil health is recommended from a sustainability perspective.

REFERENCES

- Bhattacharya, P., Bisen, J., Bhaduri, D., Priyadarsini, S., Munda, S., Chakraborti, M., Adak, T., Panneerselva, P., Mukherjee, A.K., Swain, S.L., Dash, P.K., Padhy, S. R., Nayak, A.K., Pathak, H., Kumar, S. and Nimbrayan, P. 2021. Turn the wheel from waste to wealth: economic and environmental gain of sustainable rice straw management practices over field burning in reference to India. *Science of the Total En- vironment* **775**: 145,896. creams.iari.res.in
- Gupta, A., Singh, P., Singh, G., Sekhon, B.S. and Sodhi, G.P.S. 2021. On-farm testing of rice residue management techniques for wheat establishment in Punjab. *Indian Journal of Extension Education* **57**(4): 85–88. https://pib.gov.in/PressRelease Page.aspx?PRID=1762056
- Jasrotia, P., Bhardwaj, A. K., Katare, S., Yadav, J., Kashyap, P.L., Kumar, S. and Singh, G.P. 2021. Tillage intensity influences insect-pest and predator dynamics of wheat crop grown un- der different conservation agriculture practices in rice-wheat cropping system of Indo-Gangetic plain. *Agronomy* **11**: 1087. https://doi.org/10.3390/agronomy11061087
- Jat, M.L., Jat, H., Agarwal, T., Bijarniya, D., Kakraliya, S.K. and Choudhary, K.M. 2020. A Compendium of Key Climate

- Smart Agriculture Practices in Intensive Cereal Based Sys- tems of South Asia. *International Maize and Wheat Improve- ment Center (CIMMYT)*, New Delhi, India, 42.
- Kumar, V., Singh, S., Chhokar, R.S., Malik, R.K., Brainard, D.C. and Ladha, J.K. 2013. Weed management strategies to re- duce herbicide use in zero-till rice–wheat cropping systems of the Indo-Gangetic Plains. *Weed Technology* **27**: 241–254.
- NAAS. 2017. Innovative viable solution to rice residue burning in rice–wheat cropping system through concurrent use of super straw management system-fitted combines and turbo Happy Seeder. Policy Brief No. 2. National Academy of Agricultural Sciences. Retrieved September 10, 2020, from https:// naasindia.org/ documents/CropBurning.pdf.
- Raj, R., Das, T.K., Ghosh, A., Govindasamy, P., Kumar, V., Babu, S., Saha, P., Sen, S., Roy, A., Sharma, T. and Tiwari, G. 2022. Crop-establishment methods and weed management effects on weeds, wheat (*Triticum aestivum*) yield and economics under a conservation agriculture-based rice (Oryza sativa)– wheat system. *Indian Journal of Agronomy* **67**(4): 354– 362.
- Reddy, M.M., Ramanjaneyulu, A.V., Bindu, G.S.M., Reddy, T.P., Rajaiah, P., Ramya, V., Rajitha, G. and Jagadeeshwar, R. Crop–residue management for augmenting carbon sequestra- tion and agricultural/ sustainability. *Indian Journal of Agronomy* **66**(5th IAC Special issue): S111–S127.
- Sharma, S., Singh, P., Choudhary, O.P. and Neemisha. 2021. Nitro- gen and rice straw incorporation impact nitrogen use effi- ciency, soil nitrogen pools and enzyme activity in rice-wheat system in north-western India. *Field Crops Research* **266**: 108,131.
- Singh, B.P., Singh, M., Kumar, V., Reddy, M.B., Chander, M., Shruti, Suma, R.S. and Yadav, V. 2024. Crop residue man- agement initiatives in changing the farmers behaviour and farm production in Bareilly district. *Indian Journal of Exten- sion Education* **60(**1): 73–79.
- Singh, K., Sharma, S. N. and Sharma, Y. 2011. Effect of high tem- perature on yield attributing traits in bread wheat. *Bangladesh Journal of Agricultural Research* **363**: 415–426.
- Singh, P., Singh, G. and Sodhi, G.P.S. 2020. Energy and carbon foot- prints of wheat establishment following different rice residue management strategies vis-à-vis conventional tillage coupled with rice residue burning in north-western India. *Energy* **200**: 117,554.
- Song, W.F., Zhao, L.J., Zhang, X.M., Zhang, Y.M., Li, J.L., Zhang,