



On-Farm Economic Evaluation of Mechanized In-Situ Paddy Residue Management in Paddy-wheat Cropping System of Yamunanagar, Haryana, India

Kapil Singla ^{a++}, Sandeep Rawal ^{a#}, Vishal Goel ^{a†},
Anil Kumar ^{a‡}, Aradhana Bali ^{a^} and Ashma Khan ^{a##*}

^a CCS Haryana Agricultural University, Hisar- Krishi Vigyan Kendra, Yamunanagar-135001, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author KS contributed to the conceptualization, methodology, software development, and preparation of the original draft. Author SR was involved in the methodology, validation, and in reviewing and editing the manuscript. Author VG contributed to the review and editing of the manuscript. Author Anil Kumar also contributed to the review and editing of the manuscript. Author AB participated in the review and editing process as well. Author Ashma Khan contributed to validation, formal analysis, and the review and editing of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: <https://doi.org/10.9734/air/2025/v26i31331>

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://pr.sdiarticle5.com/review-history/135463>

Original Research Article

Received: 01/03/2025
Accepted: 03/05/2025
Published: 06/05/2025

⁺⁺ District Extension Specialist (Agricultural Engineering);

[#] Coordinator;

[†] District Extension Specialist (Soil Science);

[‡] District Extension Specialist (Agroforestry);

[^] District Extension Specialist (Agronomy);

^{##} District Extension Specialist (Home Science);

*Corresponding author: E-mail: a.khan@hau.ac.in;

Cite as: Singla, Kapil, Sandeep Rawal, Vishal Goel, Anil Kumar, Aradhana Bali, and Ashma Khan. 2025. "On-Farm Economic Evaluation of Mechanized In-Situ Paddy Residue Management in Paddy-Wheat Cropping System of Yamunanagar, Haryana, India". *Advances in Research* 26 (3):136-43. <https://doi.org/10.9734/air/2025/v26i31331>.

ABSTRACT

The economics of super seeder machine sown wheat (paddy residue incorporated into the soil and side by side machine sowing) over conventionally sown wheat (manual broadcasting of wheat after burning paddy residue followed by tillage) was evaluated at farmers' field. The study was conducted in paddy-wheat cropping system of Yamunanagar, Haryana. The study was carried out by CCS Haryana Agricultural University- Krishi Vigyan Kendra, Yamunanagar at farmers' fields during Rabi 2022-23. The demonstrations were funded under the project "Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi." This project was sponsored by Indian Council of Agricultural Research, New Delhi through Agricultural Technology Application Research Institute, Jodhpur". The study was conducted in selected villages of Yamunanagar district i.e. Bahadarpur, Khajuri and Laxibas. There were a total 250 demonstrations. These villages had predominant Paddy- wheat cropping system and considerable area under hybrid varieties with higher potential of residue generation. The maximum area under paddy was harvested through combine harvesters. The burning of paddy residue was a major challenge in the region. The super seeder sown wheat was found to be more economical and profitable. The average grain yield was found to be significantly higher ($p < 0.0001$) under super seeder (59.0 q/ha) compared to the conventional method (54.8 q/ha). To find the significant difference in the yield of both treatments, T-test was applied. Super seeded wheat produced a higher net return (Rs. 45960/ha) compared to conventional technique (Rs. 32084/ha). The Benefit cost ratio of super seeded wheat and conventional technique was 1.43 and 1.29 respectively. Apart from profitability to the farmers, the super seeder had an added environmental benefit of saving one irrigation along with avoiding of crop residue burning.

Keywords: Economics; super seeder; burning; in-situ crop residue management.

1. INTRODUCTION

A sharp rise in the production and productivity of paddy has exacerbated the problem of surplus crop residue within the two northwestern states, Punjab and Haryana, generating more than 27 million tonnes of paddy straw in a year (Chandra *et al.*, 2016). In Haryana, the total cereal crop residue generated was about 25.73 million tonnes/year out of which 9.18 million tonnes was burnt (Kumar *et al.*, 2015). Burning of crop residue causes severe atmospheric pollution and huge nutritional loss and physical health deterioration to the soil. Paddy-wheat cropping system is predominant in North Eastern region of Haryana (Statistical abstract of Haryana, 2022-23). The rice straw burning causes environmental pollution through the discharge of many gases such as CO₂ (70%), CH₄ (0.66%), CO (7%), N₂O (2.09%), and ash (Pathak *et al.*, 2021). These gases affect human and animal health due to degradation in air quality. The burning of crop residue also destroys the precious nutrients contained in the straw. One ton of paddy residue contains approximately 5.5 kg N, 2.3 kg P₂O₅, 25 kg K₂O, 1.2 kg S, 50-70% of micro-nutrients absorbed by paddy crop and about 400 kg of carbon, which are lost due to burning of paddy residue (Bhuvaneshwari *et al.*, 2019; Khan *et al.*, 2023). Apart from loss of

nutrients, the soil properties like soil temperature, pH, moisture, available phosphorus and soil organic content are also adversely affected owing to burning of paddy residue (Anonymous, 2022). Some of the important reasons of burning of surplus paddy residue is the smaller sowing window (20-30 days) available between paddy harvesting and wheat sowing, lack of suitable mechanized options for residue management, farmers' inclination to clear the fields for wheat sowing etc. Soil organic content (SOC) is the major component of Soil Organic Matter (SOM). SOC is derived from biological, chemical and physical decay of various living and non-living organic materials above and below the soil surface (Mehra *et al.*, 2018). SOC plays a crucial role in regulating nutrient mobilization, availability, cycling, sequestration, and global carbon dynamics (Yang *et al.*, 2022). Incorporation of paddy straw increases the Soil Organic Carbon content (Singh *et al.*, 2005; Bi *et al.*, 2009). Gangwar *et al.*, (2006) also reported significantly higher carbon content upon addition of crop residue @ 5 tonne/ha. The organic carbon content in the soils of Yamunanagar is in low to medium range of 0.20 to 0.66% with an average value of 0.34 % as per Mondal and Ramkala, 2016. Therefore, the soil of Yamunanagar has the scope to get benefitted from incorporation of paddy residues. In nut

shell, the in-situ paddy residue management provides an opportunity of getting rid of ill effects of residue burning as well as improving the soil health by increasing the organic carbon content. Thus, the selection of proper machine becomes paramount important considering the narrow time window and effectiveness in incorporating the residues into the soil. Lastly, the profitability of the machine for farmers cannot be ignored even after availing the above-mentioned opportunities. Therefore, in the pursuit of such a machine, the present study was carried out to evaluate on farm economic and practical suitability of in-situ paddy residue management using super seeder machine for sowing of wheat in Yamunanagar district of Haryana.

2. MATERIALS AND METHODS

In order to achieve a zero-residue burning target a Scheme on 'Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi' was launched in 2018-19 by Ministry of Agriculture & Farmers Welfare, Government of India. Under this project demonstrations were planned at farmer's field by CCS Haryana Agricultural University- Krishi Vigyan Kendra Yamunanagar to evaluate the efficacy of super seeder machine to manage paddy residue and timely sowing of wheat. It was compared with farmers practice of removing stubbles either through burning or bailing and then sowing with conventional method of broadcasting of wheat seed and fertilizer. The study was conducted in three randomly selected villages of Yamunanagar district i.e. Bahadarpur, Khajuri and Laxibas. These villages had predominant Paddy- wheat cropping system and considerable area under hybrid varieties with higher potential of residue generation. The maximum area under paddy is harvested through combine harvesters. The burning of paddy residue is a major challenge in the region. The Super seeder machine was used to incorporate the paddy residue into the soil and simultaneous sowing of wheat under the demonstration plots. Super Seeder is an innovative machine with combined operation of tillage, incorporation of straw/residues, line sowing of wheat and fertilizer placement followed by seed covering leading to timely sowing of wheat (Fig. 1). The machine has a shaft which holds the rotavator like blades onto it. The tynes are attached to the frame just behind these blades for the purpose of wheat sowing. The specifications of super seeder machine are given in Table 1. Total 250

demonstrations were laid out by random selection of the fields in all the three villages. The field for conventional wheat sowing was selected from the nearby of the demonstration field. The plot size of each demonstration as well as control treatment was 0.4 ha. Thus, the study involved 250 super seeded wheat fields and 250 conventionally sown wheat fields. The study comprised of two treatments.

- i. Wheat sowing by residue incorporation using super seeder machine - 250 fields.
- ii. Conventionally sown wheat/Farmers' practice (manual broadcasting of wheat after burning/removing the paddy residue followed by tillage)-250 fields.

Table 1. The specifications of super seeder machine

Description of machine	Technical specifications
Make	Landforce
Cost of the machine	Rs 230000
Power source	Tractor (more than 55 hp)
Number of tynes	11
Hitch type	3-point linkage
Type of tynes	Disc
Speed of rotor	180-220 RPM
Type of blades	L J F type

The recommended dose (Package and Practices of Rabi crops, CCSHAU, 2020) of fertilizers was applied in the control as well as super seeder fields. 150 Kg N, 60 Kg P₂O₅, 30 Kg K₂O and 25 Kg ZnSO₄ (21%) per hectare was applied. The seed rate was in both the treatments was 100 kg/ha as per recommendation. In order to calculate the economic evaluation parameters, the cost of different inputs was recorded as per market price. The cost of various machine operations was recorded as per the rate of custom hiring center charges. The harvesting was done with the help of combine harvester. The grain yield was measured for full acre field by subtracting the weight of empty tractor trolley from the weight of grain filled tractor trolley. Then the grain yield obtained from per acre area was converted into q ha⁻¹. After the wheat harvesting, straw reaper was used to prepare the straw from the stalks. The straw yield was observed in one-acre plot, on the basis of experience of the farmer and the straw reaper operator. They could easily estimate the weight of straw by observing the volume of the straw contained in the tractor trolley. The straw yield was then converted into q



Fig. 1. Wheat sowing by Super Seeder machine

ha⁻¹. The Minimum Support Price (Rs 2125 per quintal) was used as grain selling price for the purpose of calculation. While the market rate (Rs 600 per quintal) was used as the price of straw. The evaluated economic parameters were as follows (Bishnoi et al 2023):

1. Grand Total Cost (Rs ha⁻¹) = Total Variable Cost (Rs ha⁻¹) + Total Fixed Cost (Rs ha⁻¹)
2. Gross Return (Rs ha⁻¹) = Main product value (Rs ha⁻¹) + byproduct value (Rs ha⁻¹)
3. Net Return (Rs ha⁻¹) = Gross return (Rs ha⁻¹) – Grand Total Cost (Rs ha⁻¹)
4. Benefit-Cost ratio over Grand Total Cost (B:C) = Gross returns/ Grand Total Cost

t- test was applied at a 5% level of the significance to assess any significant difference between yield of the treatments using the MS Excel for two-sample unequal variance (heteroscedastic) (Singh & Masuku, 2012).

3. RESULTS AND DISCUSSION

3.1 Cost of Cultivation

The cost of wheat cultivation under the conventional sowing and wheat sowing by residue incorporation using super seeder technology of wheat is given in Table 2. The total cost of cultivation in the conventional sowing of wheat (Rs.109760/ha) was estimated to be

higher than the super seeder technology (Rs.106865/ha). The difference between total cost in both methods was mainly due to the cost involved in preparatory tillage operation and pre-sowing irrigation. These operations are required in the conventional technique, while in super seeder technology these are not required. However, cost of fertilizers was higher under super seeder (Rs 11020/ha) than conventional sowing (Rs 10688/ha). Farmers applied higher dose (mean value 57 kg/ha) of Urea in super seeder technology to overcome the nitrogen immobilization effect caused by the decomposition process of the paddy residue (Longshang et al., 2024). This additional urea was applied based upon the general observation and experience of the farmers. The share of the variable cost and fixed cost under the conventional sowing of wheat was found to be 38 % (Rs. 41827/ha) and 62 % (Rs. 67933/ha) respectively. The share of the variable cost and fixed cost under the super seeder technique of wheat was found to be 36.7 % (Rs. 39195/ha) and 63.3 % (Rs. 67670/ha), respectively. Bishnoi et al., (2023) also reported that the variable cost accounted for 38% (Rs. 41,220/ha) while fixed cost was 62% (Rs. 67,270/ha) under the conventional wheat technique. Whereas the share of the variable cost and fixed cost under the super seeder technique of wheat was found to be 34 % (Rs. 34988/ha) and 66 % (Rs. 66616/ha), respectively.

Table 2. Cost of wheat cultivation (Rs. /ha) (n=500)

S. No	Input/Cost item	Conventional Wheat n=250		Super Seeded Wheat n=250	
		Cost, Rs/ha	% of Grand total cost	Cost, Rs/ha	% of Grand total cost
1	Field preparation cost	7500	6.8	0	0.0
2	Sowing cost	250	0.2	5500	5.1
3	Seed cost	2600	2.4	2600	2.4
4	Seed treatment cost	250	0.2	250	0.2
5	Fertilizer cost	10688	9.7	11020	10.3
6	Fertilizer application cost	563	0.5	500	0.5
7	Irrigation cost with labour	2688	2.4	2125	2.0
8	Chemical cost	5250	4.8	5250	4.9
9	Chemical application cost	625	0.6	625	0.6
10	Harvesting cost	5250	4.8	5250	4.9
11	Straw making cost	4750	4.3	4750	4.4
12	Working capital	40413	-	37870	-
13	Interest on working capital @3.5%	1414	1.3	1325	1.2
14	Total variable cost (A)	41827	38.0	39195	36.7
15	Management charges @ 10% of variable cost	4183	3.8	3920	3.7
16	Transportation	1250	1.1	1250	1.2
17	Rental value of land	62500	56.9	62500	58.5
18	Total fixed cost (B)	67933	62.0	67670	63.3
19	Grand total cost C =A+B	109760	100	106865	100.0

3.2 Yield

The average grain yield was found to be significantly higher ($p < 0.00001$) under super seeder (59.0 q/ha) than the conventional method (54.8 q/ha). Thus, the average yield of super seeded wheat was 7.76 % higher than the conventional practice. Zhao *et al.* (2019) also reported higher yield (58%) of wheat after paddy straw incorporation compared to straw removal in

paddy -wheat rotation in China. Ali *et al.* (2019) investigated different residue management options. They also reported higher yield of wheat under residue incorporation treatment compared to residue burning. The value of standard deviation in yield was found to be 2.30 q/ha and 1.38 q/ha under conventional and super seeder technology respectively. The standard error value was found to be 0.042 and 0.023 under conventional wheat and super seeder technology

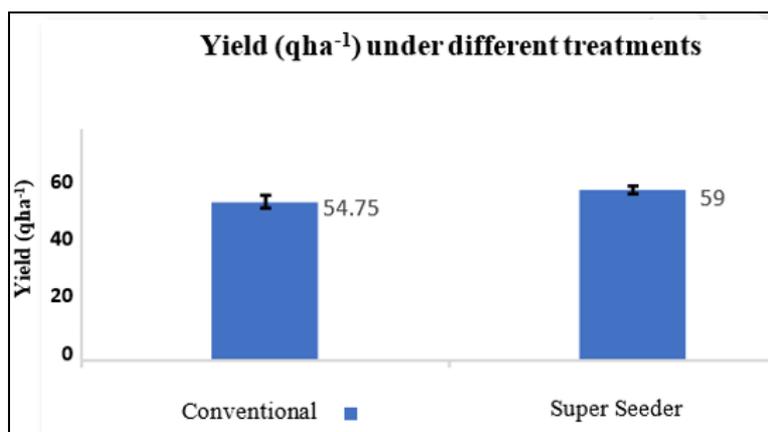


Fig. 2. Average yield of different treatments along with respective standard deviation

Table 3. Returns from wheat cultivation (Rs. /ha) (n=500)

S No.	Output/Parameter	Conventional Wheat n=250		Super Seeded Wheat n=250	
		Quantity, q/ha	Value, Rs/ha	Quantity, q/ha	Value, Rs/ha
1	Production				
	(a) Grain	54.8	116344	59.0	125375
	(b) Straw	42.5	25500	45.0	27000
2	Gross Returns		141844		152375
3	Net Returns		32044		45960
4	B:C		1.29		1.43

respectively. The lower standard deviation values indicated that the yield of the plots was clustered tightly around the mean. The average yield under both the treatment and the standard deviation among the different fields is shown in Fig. 2. One of the possible reasons for higher yield under super seeder technology was the comparatively early sowing (at optimum time) under super seeder technology.

The farmers were able to sow the wheat under super seeder eight days earlier than conventional on an average. It could happen because there was no need of pre-sowing irrigation under super seeder due to the available soil moisture which was retained in the soil because of paddy residue as a mulch. While under conventional technique, the soil moisture was lost due to burning and /or bare soil conditions. Hence, it was necessary to irrigate the land before sowing of wheat to obtain proper vattar condition (soil at workable moisture content) under conventional sowing of wheat. This saving of one irrigation amounted to about 60 mm/ha. The waiting period of obtaining the vattar condition was the reason for delayed sowing of wheat under conventional system. The same reason was reported by Bishnoi et al 2023. Another possible reason for higher yield under super seeder technology may be the enhanced availability of nutrients due to decomposition of paddy residue and their uptake by the wheat crop. Dotaniya (2013) observed maximum N, P and K uptake by wheat in the residue incorporation treatment as compared to residue burning or removal.

3.3 Returns

The returns from wheat cultivation is given in Table 3. The Gross returns under super seeder technology (Rs. 152375/ha) were found to be higher compared to conventional technique (Rs. 141844/ha). Similarly, the net returns were also found to be higher under super seeder

technology (Rs. 45510/ha) compared to the conventional technique (Rs. 32084/ha). The benefit- cost ratio under super seeder technology (1.43) was observed to be more profitable compared to conventional technique (1.29). Similar results were obtained by Grover *et al.* (2011). The higher gross returns under super seeder treatment were due to the higher yield obtained in the treatment. While the higher net returns under super seeder treatment were due to amalgamated effect of higher yield and lower cost of cultivation (especially tillage cost and irrigation cost).

4. CONCLUSIONS

The super seeder technology for wheat sowing proved to be more profitable in terms of higher yield (7.76 %), higher B:C (1.43 compared to 1.29), higher net returns (Rs 13426/ha), lower cost of cultivation (Rs 2895/ha) and time-saving compared to the conventional wheat sowing. The burning of paddy residue can be successfully avoided with the use of super seeder machine. The saving of one irrigation may also be proved helpful in halting the depleting ground water table in the region. The interest of farmers is growing towards super seeder. More number of machines in the district would be helpful in increasing the acreage under this technology. However, there is need for further studies on its effect on soil physical structure, environment and its sustainability.

DATA AVAILABILITY STATEMENT

Data will be made available on request (a.khan@hau.ac.in).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

ACKNOWLEDGEMENTS

Authors wish to acknowledge the support provided by ICAR, New Delhi and Chaudhary Charan Singh Haryana Agricultural University, Hisar.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Ali, I., Nabi, G., Gill, S.M., Mahmood-ul-Hassan, M. & Hussain, I. (2019). Crop residue management in rice-wheat system of Pakistan and its impact on yield and nutrient uptake. *Int. J. Biosci*, 14(3), 221-236.
- Anonymous (2022). Operational Guidelines: Central Sector Scheme on Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi. Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare (Mechanization & Technology Division), Government of India.
- Bhuvaneshwari, S., Hettiarachchi, H. & Meegoda, J.N. (2019). Crop residue burning in India: policy challenges and potential solutions. *International journal of environmental research and public health*, 16, 832.
- Bi, L., Zhang, B., Liu, G., Li, Z., Liu, Y., Ye, C., Yu, X., Lai, T., Zhang, J., Yin, J. & Liang, Y., (2009). Long-term effects of organic amendments on the rice yields for double rice cropping systems in subtropical China. *Agriculture Ecosystem Environment*, 129, 534–541.
- Bishnoi, R., Kumar, V., Bishnoi D.K. & Meena M.S. (2023). Economics of Super Seeder Technique of Wheat Cultivation in Haryana. *International Journal of Environment and Climate Change* 13, 574-582.
- Chandra, B.P, Sinha, V., Hakkim, H., Kumar, A., Pawar, H., Mishra, A.K., Sharma, G., Pallavi, Garg, S., Ghude S.D., Chate, D.M., Pithani, P., Kulkarni, R., Jenamani, R.K. & Rajeevan, M. (2018). Odd-even traffic rule implementation during winter 2016 in Delhi did not reduce traffic emissions of VOCs, carbon dioxide, methane and carbon monoxide. *Current Science*, 114, 1318-1325.
- Dotaniya, M. L. (2013). Impact of crop residue management practices on yield and nutrient uptake in rice-wheat system. *Current Advances in Agricultural Science* 5(2), 269-271.
- Gangwar, K.S., Singh, K.K., Sharma, S.K. & Tomar, O.K. (2006). Alternative tillage and crop residue management in wheat after rice in sandy loam soils of Indo-Gangetic plains. *Soil Till. Res*, 88, 242–252.
- Grover, D.K. & Sharma, T. (2011). Alternative resources conservative technology in agriculture: Impact analysis of zero tillage technology in Punjab. *Indian Journal of Agriculture Research*, 45, 283 290.
- Khan, A. & Dahiya, M. (2023). Crop Residue Burning: Consequences and Management in North India. *International Journal of Education and Management Studies*. 13, 153- 159.
- Kumar, R., Barth, M.C., Pfister, G.G., Nair, V.S., Ghude, S.D. & Ojha, N. (2015). What controls the seasonal cycle of black carbon aerosols in India?. *J. Geophys. Res*, 120, 7788-7812.
- Longshang, P.R., Singh, V.P., Chandra, S., Shukla, A., Singh, V.K., Pareek, N., Zhiipao, R.R., Reddy, K.S., Duo, H., Dorjee, L. and Rayapati, K. (2024). Optimization of nitrogen management reduce nitrogen stress and enhance productivity of super-seeder sown wheat under rice residue incorporation. *Discover Applied Sciences*, 6(4), 211.
- Mehra, P., Baker, J., Sojka, R.E., Bolan, N., Desbiolles, J., Kirkham, M.B., Ross, C. & Gupta, R. (2018). A review of tillage practices and their potential to impact the soil carbon dynamics. *Advances in Agronomy*, 150, 185-230.
- Mondal, K., & Ramkala, R. (2016). Fertility map and horizontal soil potassium status of north-eastern region of Haryana, 2077–2080.
- Package and Practices of Rabi crops, (2020). CCSHAU, Hisar, ISBN: 978-81-7035-723-0, 13.
- Pathak, H., Kumar, M., Molla, K. A. & Chakraborty, K. (2021). Abiotic stresses in rice production: impacts and management, 103-125.
- Singh, A.S. & Masuku, M.B. (2012). An insight in statistical techniques and design in agricultural and applied research. *World*

- Journal of Agricultural Sciences, 8(6), pp.568-584.
- Singh, Y., Singh, B., Timsina, J. (2005). Crop Residue Management for Nutrient Cycling and Improving Soil Productivity in Rice-Based Cropping Systems in the Tropics. *Advances in Agronomy*. 85: 269-407.
- Statistical abstract of Haryana (2022-23). Department of economic and statistical affairs, Haryana, Government of Haryana.
- Yang, Y., Waterhouse, G.I., Chen, Y., Sun-Waterhouse, D. & Li, D. (2022). Microbial-enabled green biosynthesis of nanomaterials: Current status and future prospects. *Biotechnol Adv*, 55, 107914.
- Zhao, X., Yuan, G., Wang, H., Lu, D., Chen, X., Zhou, J. (2019). Effects of full straw incorporation on soil fertility and crop yield in rice-wheat rotation for silty clay loamy cropland. *Agronomy*, 9(3),133.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

© Copyright (2025): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:

<https://pr.sdiarticle5.com/review-history/135463>