Performance Evaluation of Rice Transplanters and Weeders in Diverse Soil Conditions

ABSTRACT

The experiment was conducted with the objectives are to assess the performance of current rice transplanter models across various soil types, evaluate the performance of existing power weeder models in different soil conditions, and reduce cultivation costs while improving rice production and profitability. A strip plot design was used, with major three soil types as the main plot treatments, existing rice transplanter five models as the sub-plot treatments, and current power weeder three models as the sub-sub-plot treatments. Among the growth and yield parameters, the 6-row walking type transplanter combined with a cono weeder showed superior performance, recording higher tillers and productive tillers (16.28 & 20.65 per hill), filled grains (113 & 145 per panicle), and seed yields (5922 & 5733 kg/ha) in sandy clay loam and sandy loam soils, respectively. This combination also achieved higher net returns (Rs. 70,195/ha & Rs. 55,343/ha) and benefit-cost ratios (BCRs) of 2.62 and 2.28. Additionally, it resulted in an extra grain yield of 1769 kg/ha and 1873 kg/ha, with an additional net profit of Rs. 37,027/ha and Rs. 34,813/ha for sandy clay loam and sandy loam soils, respectively. In clay loam soil, the riding type 8-row transplanter combined with a single-row power weeder produced higher productive tillers (15.25 per hill), filled grains (122 per panicle), and seed yields (5506 kg/ha), along with a higher net return of Rs. 58,175/ha and a BCR of 2.32. This combination also resulted in an additional grain yield of 1121 kg/ha, leading to an extra net profit of Rs. 24,618/ha and a corresponding net income increase compared to traditional farming practices. In conclusion, using the 6-row riding type transplanter and cono weeder, along with appropriate agronomic practices, is the key to achieving higher yields, net returns, and BCR in sandy clay loam and sandy loam soils. Similarly, the 8-rowriding transplanter combined with a single-row power weeder is essential for higher yield performance and profitability in clay loam soil

Key words: Economics; Partial budgeting; Productivity; Riding type transplanters; Walking type Transplanters and Weeders

1. INTRODUCTION

Rice is cultivated either by transplanting in wetland conditions or by direct sowing, depending on the availability of labour. Transplanting is favoured by farmers because it typically produces higher yields and reduces weed growth compared to direct seeding. However, it is energy-intensive and requires a significant amount of labour [1]. Paddy transplanting is a highly labor-intensive process that is still largely done by hand. A practical solution to address this challenge is the adoption of mechanical transplanting. There is an urgent need for a more affordable, labuor-saving method of transplanting rice that doesn't compromise yield. Mechanical rice transplanters are both cost-effective and easy to operate. Their performance has been found satisfactory, reducing labour requirements to just 3 man-days per hectare, compared to 33 man-days per hectare for manual transplanting[2]. The field capacity of six- row manually operated paddy transplanter was 0.38 ha per day, six row riding type paddy transplanter was 0.54 ha per day, eight row riding type paddy transplanter was 0.62 ha per day, while for hand transplanting it was 0.04 ha per day [3]. Mechanization plays a vital role in addressing the labour shortage in food production by acting as a force multiplier, helping to offset the reduced availability of human labour [4]. A comparable reduction in labor requirements and timely completion of crop establishment operations has

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التعليق [M4]: [1,2] Merza NAR, Atab HA, Al-Fatlawi ZH, Alsharifi SKA (2023). Effect of irrigation systems on rice productivity. *SABRAO. J. Breed. Genet*. 55(2): 587-597. http://doi.org/10.54910/sabrao2023.55.2.30.

التعليق [M5]: [3,4] Alwan, S. K., A. Arabhosseini, M. H. Kianmehr, and A. M. Kermani.
2016. Effect of husking and whitening machines on rice
Daillman cultivar. *CIGR Journal*, 18(4): 232–242.

التعليق [M6]: Citing modern sources

التعليق [M7]: Alsharifi, S. K. A., A. Arabhosseini, M. H. Kianmeher, and A. M. Kermani. 2017. Effect of moisture content, clearance, and
machine type on some qualitative characterstics of rice on (TarmHashemi) cultivar. Bulgarian Journal of Agricultural
Science, 23(2): 348–355.

been observed [5]. Most beneficiaries (95 percent) stated that machine transplanting enables timely planting and address the issue of labour shortages[6]. All beneficiaries acknowledged that machine planting demands specific technical skills in nursery management. In India, mechanical transplanters have been developed and are now widely adopted by farmers. However, two major drawbacks of mechanical transplanting are the skills needed for nursery preparation and the increased care required after transplanting in the main field[7]. Suitability of transplanters pertaining to the soil type and nursery management is important to exploit the full benefit of transplanters.

Weed problems are more prevalent in direct-seeded rice compared to transplanting. Weeding constitutes approximately 25% of the total labour requirement of 900–1200 man-hours per hectare [8]. The most common methods adopted in weed control are mechanical and chemical methods at farmers holding. Among these, mechanical weeding, whether using hand tools or weeders, is the most effective [9]. Hand weeding is a common practice; it requires more labor and is costly. Delayed weeding can also lead to significant yield loss. Adopting alternative weeding methods is crucial for reducing rice cultivation costs and ensuring timely management for manual hand weeding. The introduction of mechanical rice transplanters in Indian agriculture has encouraged farmers to use inter-row weeding tools like rotary weeders and conoweeders. These tools have become popular among farmers, offering a more efficient and less labour-intensive alternative to traditional hand weeding [10]. Alternative methods of weed control are crucial to reduce the cost of rice cultivation and ensure timely weed management for higher productivity. With this background, experiments were conducted at six locations representing three soil types (sandy clay loam, sandy loam, and clay loam) of delta zone of Tamil Nadu during *Samba* season.

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2. MATERIALS AND METHODS

2.1 Experimental site

The experiments was laid out in Strip plot design with the objective to evaluate the performance of existing three models of rice transplanters in three major soil types, to evaluate the performance of existing models of power weeder in three major soil types and to reduce the cost of cultivation and enhance the rice production.

2.2. Experimental design

The treatment details consists of different soil types (3) viz., Sandy Clay loam(S_1), Sandy loam(S_2) and Clay loam(S_3) as main plot treatment, Five models of transplanter consists of Four row Walking type transplanters of India model(T_1), Four row Walking type transplanters of Japan model(T_2), Six row riding type of Japan model(T_3), Eight row riding type of Japan model(T_4) and Eight row riding type of china model(T_4) was used as sub plot treatments. Three types of weeder includes; cono weeder, single row power weeder and two row power weeder were used as sub-sup plot treatments.

2.3. Crop husbandry

Nursery was prepared by using medium duration variety in mat type nursery by following recommended agronomic practices. The experiment executed by using Eighteen days old seedling and it was transferred from the plastic tray and placed in transplanters as per the size of the seedling rack (22 cm to 25cm) by cutting mat and size specification of transplanters. Between rows, distance between the hills within the row, and the number of seedlings per hill were maintained as 100 square meter. Depth of transplanting was maintained @ 2.5cm. Main field was puddled and leveled, the recommended dose of fertilizer was applied as per the recommendation for medium duration variety. Field water level was maintained up to the

height of 2.5 cm and transplanted as per the treatments. Pre emergence herbicide of Butachlor was applied @ 1.kg ai ha on the third day after transplanting. Weeders were used asper the treatments on 25 DAT. Irrigation and pests and disease were managed as per the crop production guide.

2.4. Machine Parameters

The field efficiency of transplanter, plant population (number of seedlings/m^2) and establishment percentage, number of weeds at 15 DAT & 30 DAT were observed and calculated Field efficiency by using actual field capacity and theoretical field capacity of the machine by using the following formula recommend by[11].

التعليق **[M10]:** Aljibouri, M. A., Alsharifi.S.K, and Alaamer.A. (2022). A test of the threshing machine (LMS type) at different feed rates and speeds on some corn properties. In IOP Conf. Series: Earth and Environmental Science, 1060 ; 012133.

Actual Field Capacity (AFC) = Total area planted (sq.m) /Total time required (hr).

Theoretical Field capacity (TFC) is the rate of field capacity that would be obtained if the machine were performing its function 100 % of the time at the rated forward speed and always covered 100 % of its rated width.

TFC= Rated speed x Rated width. Field Efficiency(%)= (AFC/TFC) x 100

2.5. Weed parameters

Number of weeds per unit area was monitored and weed control efficiency was calculated by the formula recommended [12].

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Weed number was observed per unit area and recorded weed count on 15 and 30 DAT and different weeders was used as per the treatments and weed control efficiency was calculated by using the formula as depicted below.

WCE (%)= (Weed count in un-weeded plots- Weed count in treated plots)/ (Weed count in un-weeded plots) x 100.

2.6. Crop growth and yield parameters and Economics

The growth parameters of plant height, total number of tillers and yield parameters of total number of productive tillers per unit area at specified intervals, filled grains per panicle, test weight (g), grain(kg/ha) and straw yield (kg/ha) at harvest were observed and calculated economics by using gross income(Rs./ha), cost of cultivation(Rs./ha), net income(Rs./ha) and benefit cost ratio involved in the cultivation of paddy.

2.7. Partial budgeting

Using additional return, reduction in cost, additional costs incurred, and reduction return by net income changes were calculated by partial budgeting [13] when compared to farmers practice.

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2.8. Data analysis

The collected data were analyzed by using AGRES software. The use of transplanter and weeders on reduction in labour requirement and reduction in cost of cultivation, yield improvement and changes in the income compared to farmers' practice was analyzed by using partial budgeting and indicated through additional return, reduced cost, additional cost, reduced return and net change when compared to the farmers practice.

3. RESULTS AND DISCUSSION

3.1 Efficiency of Transplanter and weeder

The 8-row riding type transplanter (30x12 cm) achieved higher field efficiencies (74.46%, 79.08%, and 77.71%) in sandy clay loam, sandy loam, and clay loam soils, respectively. This could be the result of wider width and higher speed. Field capacity and efficiency of weeders varied depending on the soil type, the single-row power weeder demonstrating higher field efficiency compared to the double-row power weeder and manual cono-weeder across all soil types(Fig 1).

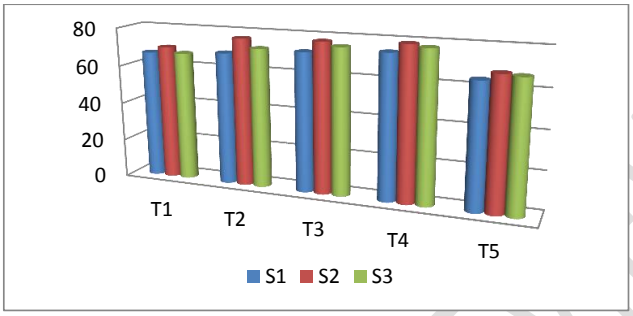

Fig 1: Field efficiency of Transplanters and weeders under different soil types

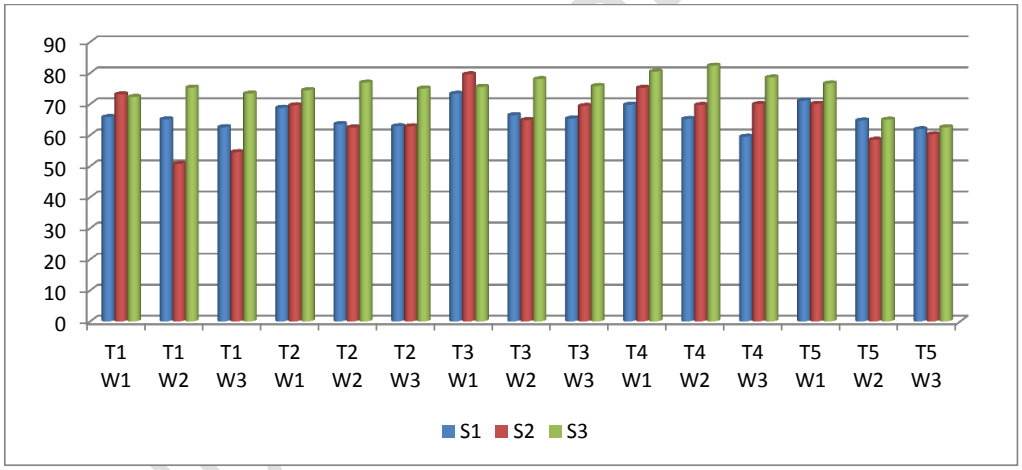

Fig 2: Weed control efficiency at 30 DAT

Cono weeder recorded low weed count and higher weed control efficiency (73.01) when compared to single and double row power weeders(Fig 2). This may be due to the push-pull mechanism in the cono weeder and the wider 30 cm spacing in the transplanter, allowing easier movement of the weeder. A similar trend was observed with the combination of cono weeder and transplanter in sandy clay loam and sandy loam soils. However, in clay loam soil, the single-row power weeder paired with the transplanter resulted in a lower weed count and higher weed control efficiency compared to the cono weeder and double-row power weeder. Clay soils require more energy for operation, which might be better supported by the single-row power weeder and the spacing in the single row of the rice crop. The field efficiency of 86.5% for the cono weeder, recommending its use in the early stages of weed growth due to its better weeding efficiency, soil turning, and weed uprooting, despite the higher operational cost [15]. The cono weeder demonstrated higher field capacity and a better performance index during early weed infestation stages.

3.2 Growth and yield parameters

The righting type 8-row transplanter recorded a higher plant population (98 and 123) and establishment percentage (96% and 95%) in sandy clay loam and clay loam soils. In contrast, the 4-row walking transplanter achieved a higher number of seedlings (102/m²), and the walking type 6-row transplanter showed a higher establishment percentage in sandy loam soil. The improved establishment rates could be attributed to the automatic levelling control mechanism available in the transplanter. Lower establishment percentages were observed under traditional farmer practices in sandy clay loam and sandy loam soils. The self-propelled rice transplanter (Kubota model) achieved a field efficiency of 62.96% and a field capacity of 0.54 ha/h under various puddling conditions [14].

Among the growth and yield parameters, the combination of the 6-row transplanter and cono-weeding resulted in higher tiller and productive tiller counts (16.28 and 20.65 per hill), as well as a greater number of filled grains (113 and 145 per panicle) and seed yields (5922 and 5733 kg/ha) in sandy clay loam and sandy loam soils, respectively. In clay loam soil, the 8-row riding type transplanter (30x12 cm) combined with a single-row power weeder recorded a higher number of productive tillers (15.25 per hill), filled grains (122 per panicle), and a seed yield of 5506 kg/ha. Mechanical control not only removes weeds between rows but also loosens the topsoil and improves soil aeration. Using a weeder alone increased plant height and boosted grain yield by 10.9% compared to manual hand weeding. Among the transplanters, the Yanmar 6-row transplanter showed superior performance, promoting better growth and yield parameters. For weeders, conoweeding also performed well, resulting in higher growth and yield outcomes [16].Mechanical transplanting significantly boosted grain yield by 23%, 37%, and 63%, straw yield by 17%, 14%, and 22%, and biological yield by 20%, 24%, and 39%, compared to manual transplanting, dry direct seeding, and direct seeding of sprouted seeds in puddled conditions, respectively[17].

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Table 1 : Effects of treatment on yield parameters of rice

Treatments	Number of productive tillers/hill				Number of filled grains/ panicle				Seed Yield (kg/ha)			
	S_1	S_2	S_3	MEAN	S_1	S_2	S_3	MEAN	S_1	S_2	S_3	MEAN
$T_1 W_1$	16.12	16.84	15.05	16.00	113	127	106	115.33	5025	4843	4392	4753.33
$T_1 W_2$	15.06	14.85	15.35	15.08	109	116	107	110.66	4055	4367	4616	4346.00
$T_1 W_3$	13.98	14.48	14.25	14.23	108	109	104	107.00	4153	4071	4392	4205.33
$T_2 W_1$	12.99	18.35	13.40	14.91	114	136	109	119.66	5253	5016	4702	4990.33
$T_2 W_2$	12.15	16.62	11.95	13.57	108	122	108	112.66	4157	4548	5064	4589.66
$T_2 W_3$	11.47	15.67	11.10	12.74	107	114	106	109.00	3952	4212	4798	4320.66
$T_3 W_1$	16.28	20.65	12.50	16.47	113	145	113	123.66	5922	5733	5145	5600.00
$T_3 W_2$	13.85	17.95	13.00	14.93	109	132	114	118.33	5166	4965	5260	5130.33
$T_3 W_3$	12.79	17.03	12.50	14.10	107	120	109	112.00	4659	4486	5064	4736.33
$T_4 W_1$	12.95	16.49	14.55	14.66	108	121	119	116.00	5106	4599	5391	5032.00
$T_4 W_2$	13.04	15.67	15.25	14.65	109	116	122	115.66	4681	4275	5506	4820.66
$T_4 W_3$	13.35	15.17	14.25	14.25	108	107	116	110.33	4664	4068	5281	4671.00
$T_5 W_1$	12.60	17.53	12.40	14.17	109	129	112	116.66	5368	4763	5099	5076.66
$T_5 W_2$	11.09	16.08	12.15	13.10	109	117	114	113.33	4616	4305	5165	4695.33
$T_5 W_3$	11.41	15.46	10.95	12.60	107	112	107	108.66	4246	4071	5049	4455.33
Farmers practice	12.54	13.95	10.85	12.44	103	103	99	101.66	3728	3860	4385	3991.00
LSD (P=0.05)				2.20				10.55				568.15

3.3 Labour requirement

Farmers practice of conventional transplanting and machine transplanting were compared and resulted on higher number of labour reduction(49) supported by machine transplanting(Table 2).Mechanical transplanting will be the best alternative for the future of agriculture especially high labour requirement crops.

Table 2 Comparison of labour requirement in Conventional transplanting and machine transplanting

Sl.No	Activities	Conventional transplanting	Machine transplanting
1	Nursery preparation		
a	Trimming &plastering	1	-
b	Levelling, Sowing and irrigation management	3	
	Filling of soil medium and maintenance		3
c	Pulling out of seedlings	7	-
d	Transporting of seedlings to main field	3	3
2	Transplanting	20	3
3	Weeding		
a	First weeding	20	3
b	Second weeding	10	3
	Total labour required	64	15

3.4 Economics

Among the various transplanters and weeders, the 6-row riding type transplanter combined with cono-weeding provided the highest net return (Rs. 70,195/ha) and BCR (2.62) in sandy clay loam soil. Similarly, in sandy loam soil, it achieved a higher net return (Rs. 55,343/ha) and BCR (2.28). In contrast, the 8-row riding type transplanter (30x12 cm) combined with a single-row power weeder resulted in a higher net return (Rs. 58,175/ha) and BCR (2.32) in clay loam soil. The 6-row riding type transplanter with cono-weeding also led to additional returns and cost reductions, yielding a net income change of Rs. 37,027/ha and Rs. 38,899/ha in sandy clay loam and sandy loam soils, respectively. Similarly, the 8-row riding type transplanter (30x12 cm) with a single-row power weeder achieved a net income change of Rs. 24,618/ha compared to traditional farming practices. Clay loam soil, four row walking type transplanter with conoweeder resulted in negative result in change in the net income.

Mechanical transplanting in farmers field condition reported yields that were 200-240 kg per acre higher than those from manually transplanted fields, even with the same input levels. The study highlights that widespread adoption of mechanical transplanting could lead to a substantial increase in paddy production [18] Soil specific transplanter and weeders resulted on higher growth, yield parameters and yield and net return in addition to the higher change in the net income and supports for higher level of adoption at farmers holding[19].

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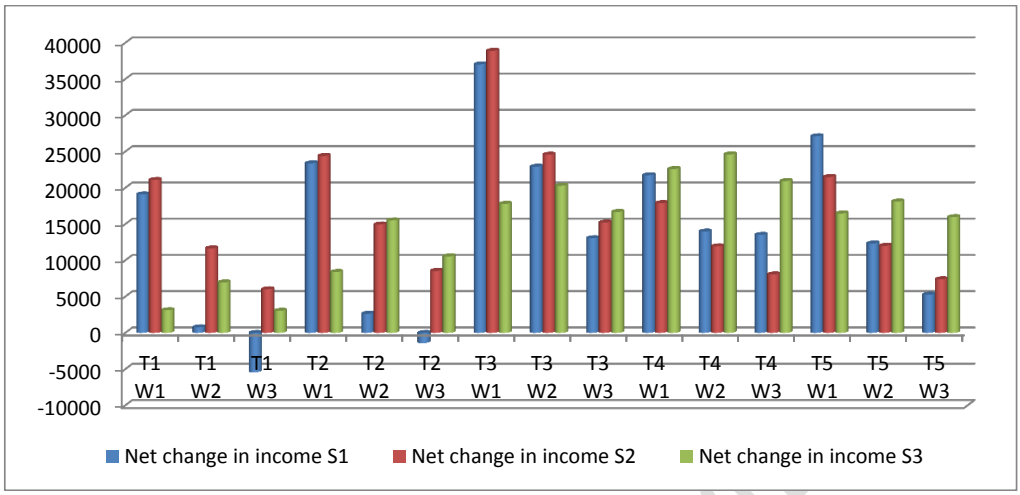

Fig 3: Effect of treatment combination on partial budgeting

4. CONCLUSION

Rice cultivation using eighteen day-old seedlings grown in a mat-type nursery, along with a 6-row riding type transplanter and cono-weeder for weeding, combined with other recommended agronomic practices, is crucial for achieving higher yield performance, net return, and BCR in sandy clay loam and sandy loam soils. Similarly, using an 8-row riding type transplanter (30x12 cm) for transplanting and a single-row power weeder for weeding, along with the recommended agronomic practices, is essential for maximizing yield, net return, and BCR in clay loam soil. Use of right type of transplanter specific to the soil results in positive change in the net income and better alternative to the issue of wet land seeder and to overcome the problem of labour scarcity and efficiency.

REFERENCES

1. Verma A. Modelling for mechanization strategies of rice cultivation in Chhattisgarh, India. Agril. Mech. in Asia, Africa and Latin America. 2010.41(1): 20-26.
2. Manjunatha, MV, BG Masthana Reddy, SD Shashidhar and VR Joshi. 2009. Studies on the performance of self-propelled rice transplanter and its effect on crop yield. Karnataka Journal of Agricutural Sciences.2009. 22(2):385-387.
3. Yadav R, Patel M, Shukla SP and Pund S. Ergonomic evaluation of manually operated six-row paddy transplanter. Int. Agril. Engg. J. 2007.16(3-4): 147-157.
4. Harisudan, C. Partial mechanization of rice cultivation for enhancing productivity and energetics. In Proc. of International symposium on "100 years of Rice science and looking beyond" to be held during 9th –12th January, 2012 at TNAU, Coimbatore.
5. Mohammad Shahid, A.K. Nayak, R.Tripathi, Sangita Mohanty, B.B. Panda, S. Saha, Vijayakumar S, S.D.Mohapatra, S.Priyadarsini, P.K. Guru, S. Munda, D.R. Sarangi, Udaya Sekhar Nagothu and H. Pathak. Machanical Transplanting of rice. 2019. Resilience. Technology Brief no. 3, ICAR, Cuttack.
6. Nirmala Devi. M. C. Harisudan and Arunachalam. R. Impact Study of Machine Transplantation in Rice and its Socio Economic Comparison with Conventional Method in Cauvery Delta Region of Tamil Nadu, India. Int.J.Curr.Microbiol.App.Sci. 9(06): 977-983. doi: https://doi.org/10.20546/ijcmas.2020.906.122.
7. RAVI KUMAR THEODORE and VENKATESA PALANICHAMY, N. Use of mechanical transplanter for rice cultivation in Cauvery delta districts of Tamil Nadu : Impact and feedback assessment. Crop Research (0970-4884) . Sep-Nov2018, Vol. 53, Issue 5/6, p257-264. 8p.

8. Yadav, R. and Pund, S. Development and ergonomic evaluation of manual weeder. Agricultural Engineering International: the CIGR Ejournal. Manuscript 2007. PM 07 022. Vol IX, October, 2007.
9. Manjunatha K, Shirwal S, Sushilendra and Vijayakumar P. Development and Evaluation of manually operated sprocket weeder. International Journal of Agricultural Engineering.2014. 7(1) 156 -159.
10. Remesan, R, M S Roopesh, N Remya and P S Preman. Wet land weeding-A comprehensive comparative study from south India. The CIGR E-journal. Manuscript.2007. PM 07011, 9:1-21.
11. Hunt, D. Farm Power and Machinery Management cost determination,95h edition, IOWA State University, Press,USA.1995.
12. Mani,V S.,Malla, ML., Gautam, KC and Bhagwndas. Weed killing chemicals in Potatocultivation. Indian Farm.1973;22:17-18.
13. Horton, D. Partial Budget Analysis for On-Farm Potato Research. Technical Information Bulletin 16. International Potato center. Lima, Peru. 1982. 1-17.
14. Murali, M., M. Anantachar, K. V. Prakash, Sunil Shirwaland U. Satishkumar., Performance and Evaluation of Six Row Self-propelled Paddy Transplanter under Different Puddling Methods. 2016. Indian Journal of Science and Technology, Vol 9(47).
15. Karhale SS, Lambe SP and Neharkar PS. Mechanical weed control by conoweeder in SRI method of paddy cultivation. International Journal of Advance Research in Science and Engineering.2015. 4.
16. Bhagwan Singh Narwariya1, K.B. Tiwari and Prateek Shrivastava. Performance evaluation of different manual operated weeding equipment for Paddy crop in vertisols. Eco. Env. & Cons. 22 (June Suppl.) : 2016; pp. (S357-S363).
17. Singh KK, Lohan SK, Jat AS and Rani T (2006). New technologies for planting rice for higher production. Research on crops 7(2): 369-371.
18. UMAR FAROOQ, A.D. SHEIKH, MUHAMMAD IQBAL, ARSHED BASHIR AND ZUBAIR ANWAR. Diffusion Possibilities of Mechanical Rice Transplanters. INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY.2001. 1560–8530/2001/03–1–17–20.
19. Vallal Kannan S, Veeramani A, Hemalatha M, Elamathi S, Umamageswari C, Satheesh Kumar N and Shri Rangasami, S R(2021). Suitability of Transplanters and weeders in different soil types. Journal of experimental agriculture international. 43(4): 103-113.

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