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Yield And Economic Analysis Of Direct Seeded Spring Rice Using Mechanized And Conventional Method In Farmers Field

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ABSTRACT
Labor scarcity during peak planting and harvesting seasons in rice farming poses a significant challenge, leading to increased production costs and potential yield losses. The research was conducted at Ramdhuni Municipality, Sunsari on comparative study of spring rice planted by drum seeder and manually. The research is based on two treatment , T_1 (Drum seeder) and T_2 (TPR). 13 sample of 1 m^2 was collected data and 10 plant from each sample from both treatments to determine plant number m^{-2} , number of tiller per plant , plant height, Panicle length, moisture percent, sterility percent, grain yield, TGW, B:C ratio etc. for comparison. This collected data was analyzed using R-studio. The major findings from the research conducted for comparison of productivity, profitability and yield attributing characters between drum seeded rice and manual transplanting method shows that drum seeded rice was superior in terms of phenological parameters like drum seeded method floweing occurred at 71 DAS and was harvested at 106 DAS while the manual transplanting flowering occured at 62 DAT were harvested at 120 DAT. The drum seeded rice flowered, matured and harvested earlier i.e drum seeded rice have short period. For biometrical character like number of plant per meter square, plant height and number of hill per meter square show significant differences ($p<0.001$). For the yield attributing characters like effective tiller per m^2, grain per panicle and thousand grain weight show significant difference but for panicle length and sterility was analyzed as non -significant. The average grain yield was found to 6.60 t ha^{-1} and 5 t ha^{-1} for drum seeder rice and manual transplanting method respectively. Likewise, the B:C ratio was 2.53 for drum seeded rice while 1.73 for manually transplanted rice. All the economic parameter show significant difference between the treatment. Therefore, I would like to recommend the farmer to adopt the drum seeder for the rice sowing to minimize the cost of cultovation.

Keywords: *Growth, Planting method, Grain yield, Direct seeded rice, Benefit-cost ratio.*

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I. INTRODUCTION

Nepal is a country where rice is staple food. Production of rice is followed by maize and wheat. The area and production of rice in Nepal is 1.47 million ha and 5.1 million t respectively (AICC, 2022) with an average productivity of 3.47 t ha^{-1}. Rice contributes about 20% of the Agricultural GDP and one-third of the total calorie intake in Nepal. Rice alone contributes 53% to the total cereal food production. The share of rice area and production, and the level of rice yield vary by these ecological regions with the largest production share (73%) in flat land of Terai, hill(24%) and (4%) in mountain (Joshi, 2020). China is a largest producer of rice in world followed by India. Nepal falls under 17 th position on production and 64th in productivity in world (Choudhary, 2022). In Nepal total 140 varieties of rice is been registered including spring and seasonal varieties out which 23 is in denotified list. Jumla is the unique place in Nepal where rice is cultivated at high altitude (3000 masl) in the world favoring the agro-tourism (Paudel M. N., 2011).

The scientific name of rice is *oryza sativa* falling under gramineae family. According to N. Vavilov the center of origin for rice is India and Myanmar. Rice is first cultivated crop in Asia and china being the largest producer of it in the world. Rice is a sunloving and high water requiring crop which is cultivated in wide in eastern terai of Nepal where its climatic requirements are met. Rice can be cultivated from lower terai to high hill i.e from tropical, sub-tropical to warm temperate. The optimal temperature required for rice cultivation is $(27\text{-}32)^0$ C. clayey loam soil is an ideal soil type for rice cultivation as the such soil being highly porous with good water holding capacity. Terai is considered as basket of granary because of good production of rice in flat plain of Terai.

In Nepal monsoon rice contributes 93% whereas spring rice 7% with an cultivation area of 1371706 ha and 120000 ha respectively (Ajay, 2020).

Hardinath-1 is one of the spring rice variety of Nepal released on 2060 B.S. It recommended productivity is 4.03 t ha^{-1} with maturity period of 120 days. Its recommended area is terai, Inner terai and river basin upto 800 m (AICC, 2022).

Drum seeder is manually hand operated machine which is being popular among farmer for DSR. The drum□seeder is made of fiber material and hence requires low pulling force to operate. It allows one person to sow one hectare in 5□6 hours. Drum seeder requires three person at a time to operate one for pulling, one for lifting at end of sowing and one for filling the box. The seeder consists of a seed drum, main shaft, ground wheel, floats, and handle and joining smaller ends of frustum of cones makes the seed to drop from the seed drum. Nine numbers of seed metering holes of two different size; 1 cm and 1.1cm diameter are provided along the circumference of the drum at the both ends for a row-to row spacing of 20 cm. Two floats are provided on either side to prevent restrict the sinkage and to facilitate easy pulling of the seeder. In a single pulling of drum seeder eight row of rice is sowed.

Wet DSR is gaining popularity for research purpose as well various result demonstrations in farmer field regarding the wet DSR using in farmer field for their direct observation for quick acceptance where the facilitation is done by drum seeder. In drum seeder, the pre germinated seed is placed to 2/3 part of the box and is dragged over the field for sowing maintaining (20cm*20cm)spacing which also facilitates the inter-cultural operation as well running conoweeders between the spacing.

DSR is a resource conserving practice of cultivation mostly the labour and water. Since there is no requirement of nursery bed preparation, nurse raising and pulling and transplanting in main field as conventional farmer practice. Irrigated rice accounts for 56% of the total rice production area in Nepal as well as lack of irrigation facilities is consider as constraints for rice production so requires to search for water conserving cultivation practices to overcome high water demand in rice field where wet DSR is consider to be best another alternative without hampering the yield of rice field as well promoting the soil physical and overall biological properties of soil sustaining the soil health and quality. In comparison to wet DSR over dry DSR, the wet DSR in more popularity because of low weed infestation than in dry DSR which saves out the weed management cost and as well increase productivity per hectare .Thus, Wet DSR is an emerging new technology to cultivate the rice in Nepal due to low input cost.

In Nepal, the farmer are usually of poor economic background with low capital to invest in field to cultivate in large area so, the wet DSR could be the best plant establishing method than to dry DSR and conventional method as well as it is easily acceptable by emerging farmer and quick the transfer of technology among large group of farmer in short period of time consequently which increase the yield and area under production securing the food security in Nepal upto some limit.

Statement of problem During the peak period of rice cultivation using conventional method labour requirement is high as well as labour scars. During this peak period, labour wages is also increases resulting to maximum expenses in labor for uprooting and transplanting. Timely unavailability of labour delay the planting which makes the seedling to suffer the stress resulting to yield loss. Additional to this, traditional farmer practices planting method requires high water per kilogram of rice production and unavailability of irrigation become constraints for rice production and also harms the soil health and soil properties . In conventional method, seedling are subjected to standing water right from beginning in main field which results out to high methane production polluting the environment and also the high infestation of aquatic weed to main rice field . Thus, to solve out all this drawbacks of conventional farmer method DSR using drum seeder is now highly emerging and new technology to be transfer and adapted by farmer for their welfare as well for promoting soil health and food security in nation. The performance of drum-seeded rice and manually transplanted rice in comparison to manually planted spring rice is not well-understood, and there is a need to assess the yield variations among these practices. The economic profitability of drum-seeded rice and manually transplanted rice is uncertain, and an investigation is necessary to evaluate the economic viability, considering factors such as input costs, labor requirements, and overall returns in comparison to the conventional manual planting method for spring rice.

II. METHODOLOGY

2.1 Experimental

The research was carried out from March 2023 to September 2023 at farmer field in Ramdhuni Manicipality, Ward No-8, Sunsari, Nepal. The experimental site is positioned at 26° 40’ 719” N latitude and 87° 11’ 255” E longitude. Methodological data throughout the study period.

2.2 Seed Variety

Research is in spring rice; variety (Hardinath-1) collected from directorate of agricultural research, Tarahara Sunsari. Hardinath -1 is an spring variety of rice with maturity period of 120 days.

2.3 Planting method for wet DSR
Drum seeder having four drum was used for sowing wet DSR which sow 8 rows of seeds at single time.
2.4 Plot size and sampling technique
The total number of sample is 13 of plot size (1*1) m^2 and sampling was taken randomly from field in such way that sample taken will represent whole field of that treatment minimizing the border effect creating homogeneity. 10 sample plants will be taken from each replication randomly for further analysis.
Replication number : 13
Sample size : (1*1)m^2
Total area of field : (60m*30m) = 1800m^2

2.5 Treatments
T1: Conventional farmer practice
T2: Drum seeded rice
2.6 Field preparation
Field preparation was carried using power tiller with 3 times ploughing followed by planking for preparing well puddled field to facilitate the sowing, water conservation as well weed control.

2.7 Sowing of pre -germinated seed using drum seeder
In 2023, 19 March, the rice was soaked in water and left for overnight. At the morning the seed was removed from water and was covered with jute sac for facilitate sprouting. At 21 March, the seed was filled in each box of drum seeder leaving the 1/3 rd for proper seed circulation inside the box to assist even & easy dropping and was dragged in the field to be sown. Simuiltaneously, the time to sown plots was also recorded to get average time to sow a single plot. On an regular basis field was visited till the full germination for cheaking the water condition in field. After the full germination, irrigation was done.

2.8 Nursery raising for TPR
In 21 March 2023, on the same day of sowing the rice using the drum seeder, the seed bed was raised by broadcasting the pre-germinated seed at the evening time in fully saturated field with no stagnant water to prevent seed decaying. Three kattha of field was under manually transplanted method for which 2 kg $kattha^{-1}$ seed rate was used for nursery raising. After 30 days, on Baisakh 5 the rice seedling was transplanted to main field.

2.9 Uprooting of 30 days old seedling for transplantation
In 17 April 2023, transplanting was carried out in well puddled field with 3 ploughing followed by planking. All the basal application dose was supplied following R.D.F 120:40:40 NPK Kg ha^{-1}. The full dose of phosphorous & potassium and half dose (50%) of nitrogen was supplied as basal dose whereas the remaining 50% nitrogen was applied in two equal split dose i.e 25% in active tillering phase and 25% in panicle initation stage. The data like labour, time required for planting single plot was also recorded.

2.10 Weed management
For weed management pre-emergence pretilachlor @1-1.25 kg a.i ha^{-1} was sprayed on 3 days of transplanting. For the post- emergence, manual hand weeding method was done on 35 days to facilitates the aeration, sunlight & deducing crop-weed competition. For manually weed uprooting , required number of labour was also recored for later economic analysis between the treatment.

2.11 Nutrient management
It was carried on basis of recommended R.D.F given by krishi dairy i.e 120: 40:40 NPK kg ha^{-1}. Full dose of phosphorous , potassium and half dose of urea was given as basal application and remaining 25% of urea at tillering and 25% at panicle initation stage was splitted uniformally on rice field ensuring levelled water in all plot.

2.12 Water management
Field was under regular supervision to avoid water stress in its critical time period. Proper irrigation scheduling was followed. Water application was stopped ten days before from the time of harvesting.

2.13 Harvesting & Threshing
As the lower leaf started senesense and 80% grain change its colour from green to straw color, the sample was manually harvested using 1 m^2 frame and sample bundle was kept separately after harvesting for obtaining various data. The collected sample was threshed manually avoding mixing of sample taken from different area followed winnowing for obtaining data like sterility%, thousand grain weight, grain yield etc.

2.14 Sampling and data collection

Thirteen sample area was randomly selected from both treatment and sample was collected from one meter square using frame of one meter square. Thirteen bundle of sample from the drum seeded field and manually transplanted field was kept separately. Later, the collected sample was weighed & threshed followed by winnowing to obtain the data.

2.14 Observations and measurement

Ten plants was selected randomly from each thirteen replication to calculate various yield parameters.

Parameters	Description of parameters
Number of plants per sample area	Total no. of plant was counted from each replication area($m^{2)}$.
Number of tillers per hill	Total no. of plants per m^2 was divided by total hill m^{-2} from the plot to obtain number of tillers per hill.
Plant height	Height was measured using measuring scale for selected plant.
Panicle length	It was measured by using scale for each 10 selected plant from sample area.
Number of grain per panicle	It was calculated by counting total grain per panicle from ten selected plant for each sample area.
Sterility percentage	It was calculated by dividing no. of unfilled grain by total grain number.
Moisture content	It was calculated using digital moisture meter.
Thousand grain weight	1000 grain was counted and weighed in digital balance for each replication to obtain TGW.
Bundle /(sample)weight	It was calculated using digital balance.

2.15 Economic analysis (Cost of Cultivation)

The cost of cultivation was calculated based on local charges for different agro-inputs viz., labour, fertilizer, herbicides, machines and other necessary materials.

2.17 Gross return

Economic yield was converted into gross return (Rs/ha) based on local market prices of different commodities.

2.18 Net return

It was calculated by deducting the cost of cultivation from gross return .

2.19 Benefit Cost ratio

It will be calculated by the following formula:

B:C ratio= Gross return/ Cost of cultivation

2.20 Data entry and management

Data entry and management was carried out using software like Ms excel for further analysis.

2.21 Data Analysis

Data analysis was carried using software R- studio version 4.3.1 for testing and comparing the data. The analysis was based on two mean comparison using two sample t-test. Based on two sample t-test analysis was carried out applying recommended command for R-studio & interpretation was made based on p-value to know significance or non-significance .

III. RESULTS AND DISCUSSION

Phenological parameters of rice

3.1 Days to flowering (50% flowering)

In case of drum seeded rice , flowering occurred at 71 DAS which is earlier than manual method while for manually transplanted rice flowering occurred at 92 DAS i.e (30 days old seedling + 62 DAT). Thus it was concluded that flowering occurred earlier in drum seeded rice followed by manual transplanted rice.

3.2 Days to harvesting

From the research it was found that the rice which was sown by using drum seeder was harvested at 106 DAS while the manually transplanted rice was harvested at 120 DAT. Thus, the drum seeded rice was harvested earlier than the manual transplantion method.

3.3 Biometrical observation

Table 1. Plant number, plant height and number of hills of spring rice affected by establishment method at Ramdhuni Municipality, Sunsari, 2023.

Statistics and mean	No. of plants per sq.m	Plant height (cm)	No. of hills per square meter
Drum seeded rice	457.47	96.57	48.46
Manual transplanting	632.62	93.06	27.76
t-value	-9.98	2.54	8.14

P-value	<0.001	0.019	<0.001
df	24	20	16

3.4 Plant Number per meter square

The p-value obtained from the mean comparison between treatment was <0.001. The plant number per meter square was found to be statistically highly significant at the time of harvest with 0.1% level of significance. The mean value of plant number for drum seeded rice was 457.47 and for manually planted rice was analyzed to be 632.62 i.e manually transplanted rice have higher plant number per meter square area in table-1.

3.5 Plant height

The p-value obtained from the mean comparison between treatment for plant height was 0.019 i.e <0.05, thus the plant height at time of harvesting was found statistically significant; accepting the alternative hypothesis with 5% level of significance. The mean of plant height was 96.57 cm and 93.06 cm at the harvesting time for respective treatments i.e 106 DAS &120 DAT respectively (Table 1). Thus, the drum seeded rice posses higher plant height than manually transplanted rice.

3.6 Number of hill per meter square

The p-value obtained from the mean comparison between treatment for number of hill per meter square was < 0.001, thus the hill number per meter square was found statistically significant accepting the alternative hypothesis with 0.1% level of significance. The mean of number of hill per meter square was 48.46 and 27.76 for respective treatments showing higher number of hill m-2 in drum seeded field of research (Table 1).

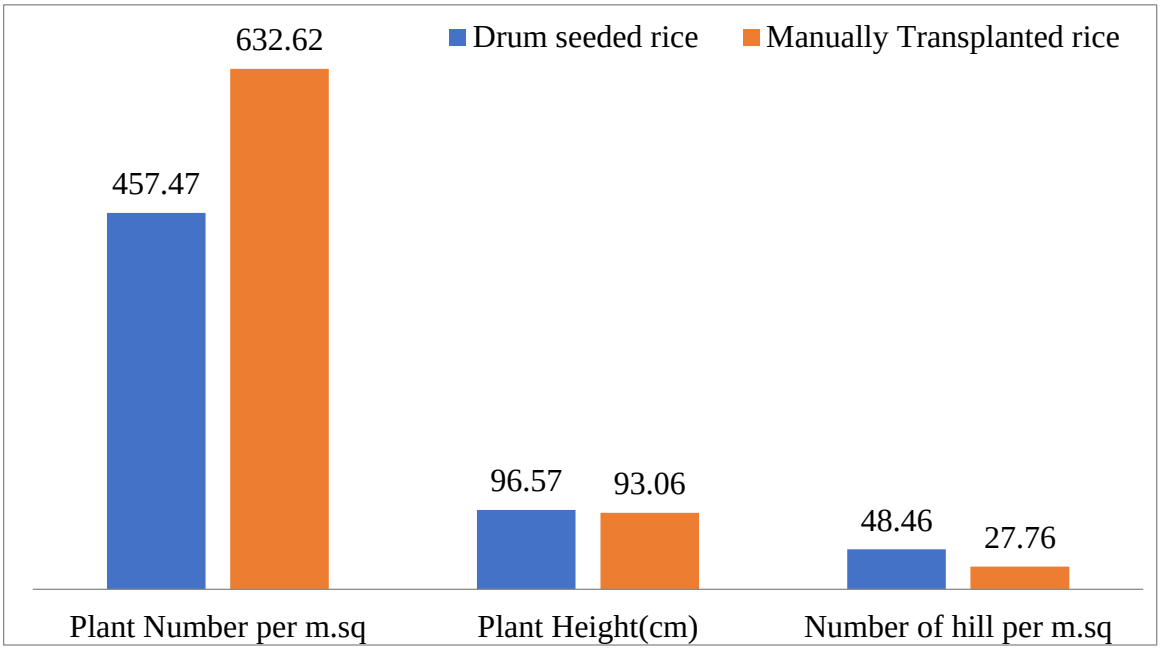

Figure 1: Mean comparison of plant population, plant height & number of hill per m.sq between the treatments.

Yield and yield attributing characters of rice

3.7 Number of tillers per hill

The p-value obtained from the mean comparison between treatment for number of effective tillers per hill was $4.179e^{-}11$(<0.001), thus the number of tillers per hill was found statistically highly significant; accepting the alternative hypothesis with 0.1 % level of significance. The mean of number of tillers per hill was 9.23 & 22.92 for respective treatments during analysis (Table 2).

3.8 Panicle length (cm)

From the result of analysis, the panicle length parameter was found non-significant at 5% level of significance. The p-value obtained from the mean comparison between treatment for panicle length was 0.34. The mean of panicle length was 23.692cm & 24.046cm for respective treatments (Table 2). Thus, the highest panicle length at the time of harvest was found in transplanted rice .

Table 2. Number of tillers hill^{-}, Panicle length, number of grain panicle^{-1}, Sterility%, Thousand grain weight & grain yield of spring rice affected by establishment method at Ramdhuni Municipality, Sunsari, 2023.

Mean and statistics	Number of tillers/ hill	Panicle length (cm)	No of grains per panicle	Sterility percentage	Thousand grain weight (g)	Grain yield (t ha^{-1})
Drum seeded rice	9.23	23.69	100.46	23.06	14.17	6.6
Manual transplanting	22.92	24.05	69.54	25.26	12.26	5
t-value	-14.1	-0.98	6.38	-1.24	4.13	4.18
P-value	<0.001	0.34	<0.001	0.23	<0.001	<0.001
df	18	24	22	24	20	

3.9 Grains per Panicle

From the result of analysis, the grain per panicle was found significant at 0.1% level of significance. The p-value obtained from the mean comparison between treatment for grain per panicle was $2.41e^{-06}$ showing statistically significance rejecting null hypothesis. The mean of panicle length was 100.4615 & 69.5384 for drum seeded rice and manually translanted rice respectively representing higher number of grain per panicle in drum seeded rice (Table 2).

3.10 Sterility %

From the analysis result for sterility % between the treatment was found statistically non-significant. The p-value from the mean comparison between treatment for sterility % was 0.23 showing no high difference in sterility % between the treatments at 5% level of significance. The mean of sterility % was 23.061 & 25.261 for drum seeded rice and manually translanted rice respectively (Table 2). Though the result is non-significant sterility is more in manually transplanted rice.

3.11 Thousand grain weight

Analysis result shows statistically high significance in thousand grain weight from mean comparison between the treatments accepting the alternative hypothesis. The p-value obtained was 0.00054 representing significant at 0.1% level of significance. The mean of thousand grain weight was 14.166 g and 12.263 g for drum seeded rice and manually translanted rice respectively revealing the higher thousand grain weight for drum seeded rice with 0.1 % significance level (Table 2).

3.12 Yield of rice

The grain yield is one of the essential quantifying parameter to revealed the profitability and perfomance of rice under different establishment method. Grain yield is a quantity of rice harvested from per unit area. The result of analysis shows the significant difference in yield of rice for the drum seeded rice and manually transplanted rice. Thus, the yield between the treatments varies. The p-value obtained from analysis of comparison for yield between the treatments was 0.0004 (<0.001) showing significance at 0.1% level of significance.The mean yield of rice for drum seeded rice was 6.609 ton/ha and 5.004 ton/ha for manually transplanted rice (Table 2).

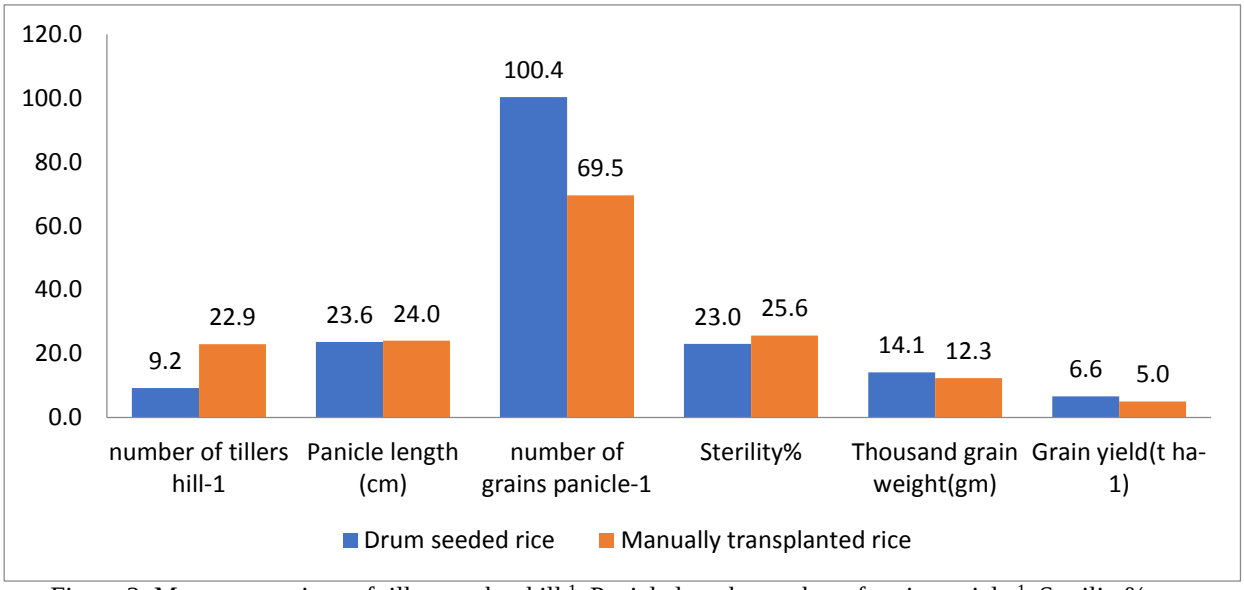

Figure 2: Mean comparison of tiller number hill^{-1}, Panicle length, number of grain panicle^{-1}, Sterility%, thousand grain weight & grain yield between the treatments.

3.13 Economic analysis

Table 3. Economic parameters of spring rice affected by establishment method at Ramdhuni, Municipality, Sunsari: 2023.

Mean and statistics	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
Drum seeded rice	85,795	2,17,500	1,31,705	2.53
Manual transplanting	94,970	1,65,000	70,030	1.73
t-value	-1.81	3.50	15.73	5.59
P-value	0.04	<0.001	<0.001	<0.001
df	24	24	24	24

The cost of cultivation, gross return, net return and B:C ratio was calculated for both the treatments to assess the economic profitability and viability between the treatments. Here, it was found that drum seeded rice and manually transplanted rice for the parameters gross return (Rs/ha), net return (Rs/ha) and B:C ratio shows statistically highly significant differences rejecting the null hypothesis at 0.1% level of significance as a strong evedient while the cost of cultivation also shows the significance from the mean comparison between the treatment at 5% level of significance as an acceptance of alternative hypothesis. The net return, gross return and B:C ratio was analyzed higher for drum seeded rice while cost of cultivation was higher for manually transplanted rice (Table 3).

IV. CONCLUSION

The research conducted for comparison of productivity & profitability between drum seeded rice and manually transplanted rice with only difference in establishment method i.e sown by drum seeder and other manually transplanted of 30 days old seedling concluded that drum seeded rice was superior in terms of phenological parameters. The drum seeded rice flowered , matured and harvested earlier than manually transplanted method i.e drum seeded rice have short period. For the yield attributing characters like effective tiller per m^2, grain per panicle and thousand grain weight show significant difference . The average grain yield was found to 6.60 t ha^{-1} which is higher than manually transplanted rice. Additionally, drum-seeded rice demonstrated greater economic viability with higher net return and benefit-cost ratio.

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