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Rice Transplanter for Establishment of Rice and Comparison of Its Performance with Conventional Method

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Abstract
Nepal is an agricultural country and agriculture is the mainstay of national economy. Rice is a major staple crop of the country. During the year 2015/2016, rice contributed 44.75 per cent to the total edible cereal grain production in the country. Rice is a labor intensive crop and youth migration has created a situation of labor scarcity. Introduction of mechanization in rice cultivation is one of the best solutions to get rid of labor scarcity and increase production of rice. NRRP, Herdinath, Dhanusa has been carrying out different research works on use of different machineries and cultivation practices in rice farming. It carried out a study in 2015/016, 2016/2017 and 2017/018 on uses of different machineries in three replications with five treatments.
The study was conducted at experimental field of Nation Rice Research Programme, Herdinath, Dhanusa, Nepal during 2017-18 under Rice cropping system. Four tillage methods such as Power Tiller Operated Seed Drill (PT) T_2, Zero Tillage Seed Drill (ZT) T_3, Rice Transplanter (RT) T_1 and Conventional Method (CM) T_4 were evaluated experiment Design with three replications. The objective of present study was to be evaluating four tillage methods on rice crop productivity under rice cropping system. There is significant among the treatment in rice crop but trend was towards Conservation Agriculture (CA) based tillage methods (PT, ZT, RT, CM). Economic analysis of five tillage methods suggest RT method is more economic than PT, ZT and CM tillage methods.
Key words: *Rice, mechanization, transplanter, variable costs, gross margin*

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I. INTRODUCTION

Nepal is small, land-locked mountainous country with diverse agro ecologies. Agriculture is the mainstay of Nepalese economy which contributes almost one third of the national economy (NPC, 2017). Agricultural crop productivity in Nepal is lowest among South Asian countries (FAO, 2018). During the year 2015/016 the contribution of agriculture, forestry and fishery to gross domestic product was 27.59 per cent which has been expected as 26.98 during the fiscal year of 2016/2017 (MoF, 2019). The agricultural sector production during 2015/2016 was increased by 2.7 per cent which has been estimated as 5.1 per cent in 2075/076 (MoF, 2019).

Rice is the seed of the grass species *Oryza sativa* (Asian rice) or *Oryzaglaberrima*(African rice). As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia. It is the agricultural commodity with the third highest worldwide production (Rice, 741.5 million tones, in 2014), after sugarcane (1.9 billion tones) and maize 1.0 billion tones (FAO Stat, 2017).the rice in Nepal is transplanted by human labor and animal traction (Upadhyaya, 1996). During the year 2016/2017, rice contributed 44.66 per cent to total edible cereal grain production in the country (ASS, 2018).

Rice land preparation using traditional bullocks and laborers takes 64 hrs per hectare, while the scale appropriate farm mechanization can prepare the same land in approximately 20 hrsper hectare (Paudel et al., 2019). Adoption and spread of agricultural and rural mechanization technologies are increasing recently in Nepal with liberal import policies, increased connectivity and acute labor scarcity resulting from youth migration (Gauchan and Shrestha, 2017).Rice is a labor intensive crop.

Mechanization of rice farming can increase rice production in hill area of Nepal. Paudel et al. (2019) reported that rising on-farm rural wage rates and an emerging decline in draft animal availability are driving adoption of the mini-tiller. Among users, the mini-tiller increased rice productivity by 1110 kg/ha (27%). Further regression results suggested that mini-tiller non-adopters would be able to increase their rice productivity by 1250 kg/ha (26%) if they adopt. In recent years, Nepalese agriculture has experienced an accelerating trend of labor out-migration, particularly to middle-east countries in search of better job opportunities (Maharjan et al., 2013a). This has created acute labor shortages in the agriculture sector that have affected timely crop establishment and other crop cultivation practices (ILO, 2017; Maharjan et al., 2013b, 2013a). The labor scarcity and rising labor wages have forced farmers to think alternatives and many studies have also shown that the rising labor scarcity and/or increased labor wages as the major driver for adopting farm mechanization (Reddy et al. 2014; Wang et al., 2016; Win and Thinzar, 2016; Yang et al., 2013 and Zhang et al., 2014).

Agricultural mechanization can more simply be defined as the use of any machine to accomplish a task or an operation involved in agricultural production. Such tasks or operations include reduction in human drudgery, improvement in the timeliness and efficiency of various agricultural operations, bringing more land under cultivation, preserving the quality of agricultural products, providing better rural living conditions, and markedly advancing economic growth (Odigboh 2000, Azogu 2009).Alam (2006) describes mechanization as the interjection of machinery between people and the materials handled by them. Based on the source of power, the technological levels of mechanization have been broadly classified as hand tool technology, draught animal technology, and mechanical power technology. Mechanization also includes irrigation systems, food processing and related technologies and equipment (Hegazy et al., 2013). Rising rural wages in Nepal have increasingly put pressures on smallholder farmers, who tend to operate labor-intensive farming. Agricultural mechanization through custom hiring of tractors services has recently been considered as an option to mitigate the impact of rising labor costs for smallholders (Takesima et al., 2016).

An agricultural mechanization strategy is part of any agricultural development strategy. Pellizzi (1992) describes The primary objectives and benefits of agricultural mechanization include minimization of production costs; optimization of product quality; protection of the environment; reduction of farm drudgery; timely provision of suitable conditions for plant and animal growth; better control of such production functions as seedbed preparation, drainage, cultivation, fertilizer application, planting, and weed and pest control; reduction of harvest losses; and postharvest quality preservation, storage, processing, distribution, and marketing, which in turn contribute to enhanced food security, employment opportunities, better rural living and working conditions, and thus reduced poverty.

Japan has been the strongest innovator and technology provider in terms of farm mechanization and farm machinery used in Southeast Asia. Many machinery designs found in Southeast Asian countries for transplanting, harvesting, and milling were first developed in Japan and later adapted in other countries. Also, the machines initially developed for rice farming were also adapted and modified by engineers for vegetables and other crops (Hegazy et al., 2013).

Before 1962, the Republic of Korea (henceforth-Korea‖) was one of the poorest agricultural countries in the world. Korean agriculture was poor, small scale, and powered by animal and human labor. Agricultural mechanization was initially intended to overcome natural disasters due to drought, disease, and insects, and to free farmers from drudgery. Agricultural mechanization became a foundation stone not only for the development of rural areas but also for the economic development of the country as a whole.

People's Republic of China has made significant contributions to the transformation of the country's traditional farming in modern agriculture by both of the development of agriculture mechanization and the manufacturing of farm machinery.

Agriculture mechanization in India is continuously increasing. In 2007, India had 3.2 million agricultural tractors and 0.48 million combine harvesters and threshers. The density of tractors per 1000 ha of cropped area was about 16 compared with the world average of 19, and 27 in the US (Directorate of Economics and Statistics, 2013). Most of the earlier innovations in the rice mechanization sector in India were on tractors, drillers, mechanical transplanters, different type of irrigation machinery, and mechanical weed control as pre - harvest machines

The zero-tillage drilling of wheat after rice in North India is becoming popular, mainly due to savings both in cost and time. The use of laser land levelers on a custom-hire basis is growing, as it saves up to 30 per cent of irrigation water and helps increase productivity. Combine harvesters operating in custom-hire business models gained popularity (Mani et al., 2008).

Rice is the largest and economically most important crop and serves as the staple food for the Thai people. Presently agricultural machinery is widely used among Thai farmers. Rice is major crop in Vietnam and highest level of mechanization is in rice production achieving 72 per cent in land preparation, 86 per cent in irrigation, 20 per cent in crop establishment, and 100 per cent in threshing (APCAEM, 2009). In Taiwan, the development of rice machinery started in the 1950s and reached a peak in the 1980s. A key milestone was the establishment of the Rice Seedling Nursery Center, which contributed indirectly to the Taiwanese custom of hiring out rice machinery and to the full mechanization of rice cultivation (Hegazy et al., 2013).

In a study carried out in Bangladesh, Kamruzzaman et al. (2009) reported that the maximum cost in rice cultivation was incurred in transplanting, weeding, harvesting and threshing but only transplanter, weeder, reaper and thresher can reduce the big amount of production cost.

II. MATERIALS AND METHODS

Different practices and machines used for rice cultivation were identified at NRRP, Herdinath, Dhanusa. The cultivation practices for rice cultivation by using different machineries were evaluated in four treatments (Table 2).

Table 2 Treatments followed in rice experiment at NRRP, Herdinath, Dhanusa

Rice transplanter (RT) in Dry Land preparation, two-pass primary tillage was done with cultivators, and secondary tillage was done by the disc harrow to break down the clods. The wet land puddling and planking was done by rotavator. Half dose of fertilizers was applied before puddling the field. The prepared land was left overnight before the rice transplantation. In this treatment, the seedlings (seedlings Mat) nursery was prepared in tray. The rice seeds of Hardinath-1 variety which was soaked in water for 24 hours was taken out from water and kept in shade in gunny bag for 8to 12 hours. After that the germinated seeds were placed in tray with half-filled soil in tray. The seed mat was ready in 15-20 days for transplantation. For the Weed management herbicide pretilacholor at the rate 1lt/ha was used during puddling.

Rice direct seeded with zero till drill (ZT) in Dry Land preparation two-pass primary tillage was performed by cultivators, and then secondary tillage was done by the disc harrow to break down the clods. Before land preparation basal dose of nitrogen and potassium fertilizers was applied in the field. After that rice seed of Hardinath-1 variety with phosphorous (DAP) was sown by the zero till seed cum fertilizer seed drill machine followed by the planking of the field. For the weed management, the herbicide pendimethylene 5ml/ltr of water was sprayed within 24 hours of seed sowing.

Power tiller drill (PT) in this treatment no pre land preparation was required. Before land preparation basal dose nitrogen and potassium fertilizer was applied in the field while DAP and Hardinath-1 variety of rice seed was sown by machine. The primary and secondary tillage was done in single action along with seed sowing fertigation. The field was leveled by planking in single move with power tiller operated seed drill machine. Within 24 hours of sowing, the herbicide pendimethylene @5ml/lt of water was sprayed for weed management.

Conventional Method (Farmer's practices) in dry Land was prepared with two-pass primary tillage with cultivators followed by the secondary tillage by the disc harrow to break down the clods in the field. The wet land puddling and planking was operated by Cultivator. The basal dose of fertilizers was applied before puddling of the field. The puddle field was left overnight before the transplantation of Hardinath-1 variety of rice. The seed-bed nursery was prepared 20 days before transplantation of seedlings. The seedlings were uprooted from nursery field and transplanted manually by labors. For the Weed management herbicide pretilacholor at the rate 1lt/ha was supplied during the puddling of the field

The trials were carried out in three replications of five treatments in 1400 m^2 plot size for each treatment. The experiment was laid out in randomized complete block design (RCBD). The variety of rice was Hardinath-1.Seeds were sown in the month of Jestha at the rate of 30kg/ha. The crop was harvested in the month of Ashoj.

The fertilizer doses supplied were at the rate of 100:60:60 kg NPK/ha. The full dose of phosphorous, potash and half dose of nitrogen were applied as basal dose during the time of land preparation while remaining half dose of nitrogen was top dressed. The source of phosphorous was Dia-ammonium phosphate (DAP) and that of potassium was muriate of potash and of nitrogen was DAP and urea.

The data were recorded on date of sowing, date of harvesting, plant height, spike length, number of plant per square meter area and average number of grain per panicle. Similarly, average number of tiller per hill, thousand grains weight, grain yield and straw yield per hectare were also recorded.

III. RESULTS ANDDUSCUSSIONS

The data of experiment were analyzed statistically. The results of different parameters were found interesting.

Plant height

The plant height of rice during 2015/2016 and in average analysis was found significant at 5 per cent and 1 per cent level, respectively, while it was non-significant during 2015/2016. The highest plant height of 105.10 cm was found in T_2 where the rice seed was directly seeded with power tiller drill. The lowest height was 95 cm was recorded in T_4 conventional tillage and 2016/2017 the highest plant height of 104.77 cm was found in T_2 where the rice seed was directly seeded with power tiller drill. The lowest height was 94.44 cm was recorded in T_4 conventional tillage. Despite non-significant result in 2017/018, the highest plant height of 105.43 cm was recorded in the same treatment T_2 and lowest in T_4 98.20 cm. Average analysis. The same treatment T_2, obtained highest height of plant 105.10 cm and lowest of 96.32 cm in conventional tillage T_4 (Table 3).

Table 3 Average plant height of rice in cm

S. No.	Treatments	Plant height (cm)			
		2015/2016	2016/2017	2017/2018	Average
1	Rice transplanted by Rice transplanter (RT)	96.6	96.73	99.00	97.45
2	Direct seeded rice by power tiller drill (PT)	105.10	104.77	105.43	105.10
3	Rice direct seeded with zero till drill (ZT)	100.8	100.69	101.10	100.89
4	Conventional Method (CM) (Farmers' practices	96.32	94.44	98.20	96.32

Panicle length

The length of panicle did not show any significant result in whole experiment. It was non-significant in three of the years of 2015/2016, 2016/017 and 2017/018 and in average analysis too (Table 4). However, the average length of panicle was recorded in T_3 treatment which was 25.33, 26.22 and 25.78 cm, respectively.

Table 4 Average length of panicle of rice in cm

S. No.	Treatments	Panicle length (cm)			
		2015/2016	2016/2017	2017/2018	Average
1	Rice transplanted by Rice transplanter (RT)	25.16	24.88	25.44	25.16
2	Direct seeded rice by power tiller drill (PTOS)	25.78	25.33	26.22	25.78
3	Rice direct seeded with zero till drill (ZT)	25.23	24.65	25.80	25.23
4	Conventional Method (CM) (Farmers' practices	24.77	24.77	24.78	24.77

Plant population

The number of plant when counted for one square meter was found significant at one per cent level in whole experiment including Average analysis (Table 5) of three years. Number of plant per meter square was highest in T_1 in whole experiment which was 283.64, 281.95, 285.33 and 283.64 plant population in average analysis, respectively. The lowest number was observed in T_3 which recorded 197.22,195.11, 199.33 and 197.22 respectively.

Table 5 Average number of plant population of rice in number

S. No.	Treatments	Plant/m^2 (Number)			
		2015/2016	2016/2017	2017/2018	Average
1	Rice transplanted by Rice transplanter (RT)	283.64	281.95	285.33	283.64
2	Direct seeded rice by power tiller drill (PTOS)	269.44	268.89	270.00	269.44
3	Rice direct seeded with zero till drill (ZT)	197.22	195.11	199.33	197.22
4	Conventional Method (CM) Farmers' practices	247.11	222.77	271.44	247.11

Number of grain per panicle

The number of grain per panicle was found non-significant in all the years and also in average analysis. However, during three years, it was highest in T_1 92.77, 61.66, the treatment T_3 recorded highest number of grain 64.66 and in average analysis it was also highest in T_3 63.11. In average analysis, it was lowest in T_2 which was 58.66 number of grain (Table 6).

Table 6 Average number of grain/panicle of rice in number grain

S. No.	Treatments	Grain/panicle (Number)			
		2016/2017	2016/2017	2017/2018	Average
1	Rice transplanted by Rrice transplanter (RT)	62.77	61.66	63.89	62.77
2	Direct seeded rice by power tiller drill (PTOS)	58.66	60.78	56.55	58.66
3	Rice direct seeded with zero till drill (ZT)	63.11	61.56	64.66	63.11
3	Conventional method (CT) (Farmers' practices	62.66	61.55	63.78	62.66

Number of tiller/hill

The number of tiller per hill was found significant at 1 per cent level in three of the years and in pooled analysis (Table 7). The treatment T1 recorded highest number of tiller in three of the years and in average analysis as well. The average number of tiller/ hill T1 33.11, T2 16.61 T3 25.5 and T4 17.1 respectively. (Table 7).

Table 7 Average number of tiller/hill of rice in number

S. No	Treatments	Tiller/hill (Number)			
		2015/2016	2016/2017	2017/2018	Average
1	Rice transplanted by Rice transplanter (RT)	33.16	32.00	34.33	33.16
2	Direct seeded rice by power tiller drill (PTOS)	16.61	14.79	18.44	16.61
3	Rice direct seeded with zero till drill (ZT)	25.50	24.89	26.11	25.50
4	Conventional Method (CM) Farmers' practices	17.10	14.99	19.22	17.10

Thousand grain weight

The weight of thousand grains was non-significant in the experiment. The average highest weight in2015/2016 was found T3 18.36 gram. 2016/2017 was found in T_3 which was 18.55 gram and lowest of 17.88 gram in T_2. Similarly, in 2017/2018, it attained highest weight of 18.17 gram in T_2 while lowest in T_1 17.72 gram. In pooled analysis T_3 recorded highest mean weight of thousand grains as 18.36 gram and lowest in T_1 which was 17.85 gram (Table 8).

Table 8 Thousand grain weight of rice in gram

S. No.	Treatments	Thousand grain weight (Gram)			
		2015/2016	2016/2017	2017/2018	Average
1	Rice transplanted by Rice transplanter (RT)	17.85	17.98	17.72	17.85
2	Direct seeded rice by power tiller drill (PT)	17.87	17.88	17.86	17.87
3	Rice direct seeded with zero till drill (ZT)	18.36	18.55	18.17	18.36
4	Conventional method (CM) Farmers' practices	18.11	18.07	18.15	18.11

Grain yield

The mean grain yield in the experiment was found significant at 1 per cent level in three years in average analysis (Table 9). During 2015/2016 the highest mean grain yield was obtained in T1 3558.33 kg/ha followed by T4 2977.5 kg/ha. 2016/2017 the highest mean grain yield was obtained in T1 3641.67.33 kg/ha followed by T4 3016.67 kg/ha. 2017/2018, the highest mean grain yield was obtained in T_1 which was 3475.00 kg/ha followed by T_4 which recorded 32938.33 kg/ha. Similarly, during 2015/2016 the lowest mean grain yield was recorded in T2 2576.33 kg/ha. and the lowest mean grain yield was recorded in T_2 which was 2473.67 kg/ha. The highest mean grain yield during 2016/2017 was produced by the same treatment T_1 which was 3475.00 kg/ha followed by T_4 which recorded a mean grain yield of 2938.33 kg/ha. The lowest mean grain yield 2679.00 kg/ha was found in T_2 in the same year.

In combined analysis of three years, the highest mean grain yield was found in T_1 which produced 3558.33 kg/ha followed by T_4 in which 2977.50 kg/ha yield was recorded. Similarly, the lowest mean grain yield in average analysis was found in T_2 which was 2576.33 kg/ha (Table 9).

Table 9 Mean grain yield of rice in Kg/ha

S. No.	Treatments	Mean grain yield (Kg/ha)			
		2015/2016	2016/2017	2017/018	Average
1	Rice transplanted by Rice transplanter (RT)	3558.33	3641.67	3475.00	3558.33
2	Direct seeded rice by power tiller drill (PT)	2576.33	2473.67	2679.00	2576.33
3	Rice direct seeded with zero till drill (ZT)	2709.67	2514.33	2905.00	2709.67
4	Conventional Method(CM) Farmers' practices	2977.50	3016.67	2938.33	2977.50

Straw yield

The average straw yield was significant at 1 per cent level in 2015/2016 and 2016/2017; it was non-significant in 2017/2018 while significant at 1 per cent level in average analysis (Table 10). The highest straw yield during 2015/2016 was obtained T3 was 4979.17 kg/ha followed by T1 which recorded an average 4126 kg/ha. And in 2016/2017 was obtained in T_3 which was 5436.67 kg/ha followed by T_1 which recorded an average straw yield of 4310.00 kg/ha. The lowest straw yield 4049.67 kg/ha was found in T_2. Despite of non-significant result in 2016/2017, the treatment T_3 obtained 4521.67 kg/ha of straw which was highest in the experiment during 2017/2018 and the lowest yield of 3873.33 kg/ha was recorded in T_3.

In pooled analysis, the effect of year was found non-significant and the interaction three years and treatment was also non-significant. However, the yield in experiment was found significant. The treatment T_3 obtained highest mean straw yield of 4979.17 kg /ha followed by T_1 4311.33 kg/ha. The T_2 obtained lowest mean straw yield of 3961.50 kg/ha (Table 10).

Table 10 Mean straw yield of rice in Kg/ha

S. No.	Treatments	Mean straw yield (Kg/ha)			
		2015/2016	2016/2017	2017/2018	Average
1	Rice transplanted by Rice transplanter (RT)	4311.33	4310.00	4312.67	4311.33
2	Direct seeded rice by power tiller drill (PT)	3961.50	4049.67	3873.33	3961.50
3	Rice direct seeded with zero till drill (ZT)	4979.17	5436.67	4521.67	4979.17

4	Conventional Method (CM) Farmers' practices	4126.00	4093.33	4158.67	4126.00

Gross margin

Gross margin is the difference between revenue and variable costs incurred in input expenditures. The gross margin is also be calculated in percentage terms by dividing the gross margin amount by revenue. Gross margin = (Total revenue – Variable costs)/Total revenue. Thus it can be expressed in percentage too. Gross margin supports to measure the production costs related to the revenue of the farm. If gross margin is low, it may look for the processes that allow the farm to cut in use of the variable cost which seem less productive.

In this experiment, the gross margin was calculated based on the expenses incurred in different inputs and farm works related to the farm operations. The different methods of cultivation practices obtained varying quantity of production and thus gross margin was also different for different treatments.

The highest amount of revenueas an average of three years was found in T_1 where the rice was transplanted by rice tranplanter machine which was Rs. 79786.60/ha followed by the conventional method treatment counting the total revenue of Rs. 71709.60/ha (Table 11). The total variable cost was highest in conventional method (Farmer's practices) which was Rs. 58779.25 followed by T_1 Rs. 49245.75/ha. A gross margin of Rs. 30540.85/ha was found highest in T_1 followed by T_2 17129.77. The lowest gross margin of Rs. 12930.35 was calculated in farmer's practices.

Table 11 Average gross margin of three years' data in different cultivation practices of rice.

Item	T_1 RT	T_2 PT	T_3 ZT	T_4 CM
Land preparation cost (Rs/ha	8385.75	3550.00	3750.00	8385.75
Sowing/transplanting machine hire cost(Rs/ha)	5000.00	3600.00	4500.00	0.00
Seed Cost (Rs/ha)	1440.00	1800.00	1800.00	1800.00
Total fertilizer cost (Rs/ha)	8100.00	8100.00	8100.00	8100.00
Herbicide cost (Rs/kg)	750.00	750.00	750.00	750.00
Total labor cost	25570.00	28066.60	28226.60	39743.50
Total variable cost	49245.75	42316.60	47126.60	58779.25
Total Revenue	79786.60	59446.37	64143.30	71709.60
Gross margin	30540.85	17129.77	17016.70	12930.35

Source: Rice experiment data

IV. CONCLUSION

The cultivation of rice through the use of different machines with different practices have shown varied results of production quantity and also the costs of production and gross margin in this experiment.

The average of three years' data on yield, variable cost and gross margin was also found in favor of T_1 (Rice transplanter). The highest mean grain yield of rice 3558.33 kg/ha was obtained in rice transplanter while in T_4 (conventional) method it was 3173.33 kg/ha. The rice transplanter produced 12.13 per cent more than conventional method. The variable cost was 19.36 per cent more in farmer's practices than rice transplanter, while the gross margin was 136.19 per cent more in rice transplanter than farmer's practices conventional method.

The mechanization in rice cultivation is one of the best solutions to scope up with labor scarcity. Although there are many machines and tools used in rice cultivation, the costs are also incurred according to their efficiency. The labor cost is very high due to scarcity of manpower and thus farmers' have to pay more for labor causing comparatively high variable costs in rice farming. It has ultimately affected the gross margin of the farmers with less return than cultivating rice with different machines. In this experiment, the use of rice transplanter has been found efficient in production, fewer costs incurred and resulting better gross margin than other practices followed in the trial.

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