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Different Tillage on Crop Productivity Under Rice Cropping System

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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 2017/018, rice contributed 44.66 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. AMTRC, Nawalpur, Sarlahi has been carrying out different research works on use of different machineries and cultivation practices in rice farming. It carried out a study in 2016/017 and 2017/018 on uses of different machineries in three replications with five treatments.
The study was conducted at experimental field of Agricultural Machinery Testing and Research Centre, Nawalpur, Sarlahi, Nepal during 2017-18 under Rice cropping system. Four tillage methods such as Power Tiller Operated Seed Drill (PTOS) T_2, Zero Tillage Seed Drill (ZT) T_3, Rice Transplanter (RT) T_1 and Conventional Tillage (CT) T_4 were evaluated experiment Design with threereplications. 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 (PTOS, ZT, RT, CT). Economic analyses of five tillage methods suggest RT method is more economic than PTOS, ZT and CT tillage methods.
Key words: Rice, mechanization, transplanter, variable costs, gross margin

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 2074/075 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 2075/076 (MoF, 2019). The agricultural sector production during 2074/075 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).

In Nepal rice during the year 2007/2008 was grown in 1549262 ha which produced 4299246 metric ton with an average yield of 2775.00 kg/ha. The area, production and productivity in 2016/2017 reached to 1552469.00 ha, 5230327.00 mt and 3369.00 kg/ha (Table 1). The area increment in 2016/2017 over 2007/2008 has been counted as only 0.21 per cent while in production and productivity the increment is 21.66 and 21.41 per cent, respectively. The trend of increment in area is slow (Figure 1) while in productivity it is not in always positive trend (Figure 2). Since rice is a labor intensive crop, and migration of youth force from rural to urban and urban to gulf and other countries in search of opportunities have created a state of labor scarcity in the country. It has compelled to think over labor substitution technologies in rice farming. Mechanization in rice farming is one of the best solutions to replace labor, reduce drudgery and increase income of the farmer through the reduction of cost of cultivation and increase in the productivity and production.

Table 1 Area, production and yield of rice (2007/2008-2016/2017) in Nepal

Year	Area (Ha)	Production (Mt)	Yield (Kg/ha)	Remarks
2007/2008	1549262.00	4299246.00	2775.00	
2008/2009	1555940.00	4523693.00	2907.00	
2009/2010	1481289.00	4023823.00	2716.00	
2010/2011	1496476.00	4460278.00	2981.00	
2011/2012	1531493.00	5072248.00	3312.00	
2012/2013	1420570.00	4504503.00	3171.00	
2013/2014	1486951.00	5047047.00	3394.00	
2014/2015	1425346.00	4788612.00	3360.00	
2015/2016	1362908.00	4299079.00	3154.00	
2016/2017	1552469.00	5230327.00	3369.00	

Source: GoN/MoALC/MESD/Agriculture Statistics Section, Singhdurbar, Kathmandu, 2018.

Production and productivity is increasing due to increase in adoption of improved rice cultivation practices like improved seed, application of fertilizers, improvement in farmers' knowledge and skill, availability of technical services etc. Chances of expanding land is minimum, therefore the technologies to increase productivity has been imperative. Mechanization also supports to increase production and productivity in rice cultivation.

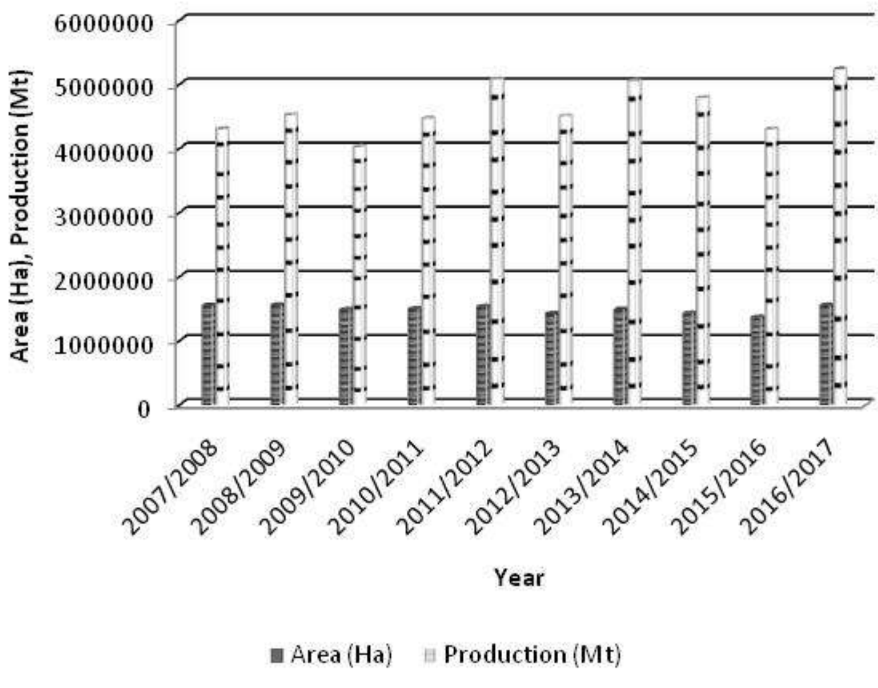

Figure 1 Area and production of rice (2007/2008-2016/2017) in Nepal

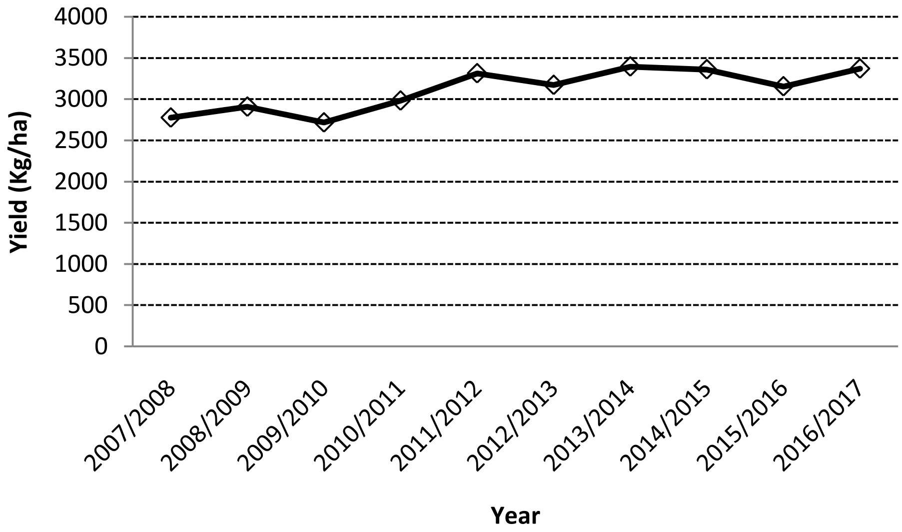

Figure 2 Yield of rice (2007/08-2016/17) in Nepal

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 initiallydeveloped forrice farmingwere alsoadapted and modified by engineers for vegetables and other crops (Hegazy et al., 2013).

Before 1962, theRepublic ofKorea (henceforth-Korea‖) was one ofthe poorest agriculturalcountries 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 AMTRC, Nawalpur, Sarlahi. 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 AMTRC, Nawalpur, Sarlahi

Treatment no.	Treatments	Operations	Remarks
T_1	Rice transplanted by mechanical 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.	
T_2	Rice direct seeded	In Dry Land preparation two-pass primary tillage was performed	

	with zero till drill (ZT)	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.
T_3	Direct seeded rice by power tiller drill (DTOS)	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.
T_4	Conventional Method (Farmer's practices)	The 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 puddlefieldwas 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 last week of Jestha (second week of June) at the rate of 30kg/ha. The crop was harvested in the last week of Ashoj (second week of October).

The fertilizer doses supplied were at the rate of 100:30:30 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.

First irrigation wassupplied after 25 days of sowing and the second irrigation after 75 days. Other intercultural practices were followed as per need and recommendation for this crop. 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.

The data were fed into computer and analyzed using ms-excel and ms-word package. The data recorded were analyzed for individual parameters separately for each year. Similarly, the combined analysis was performed for two years data.

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 2075/076 and in combined analysis was found significant at 5 per cent and 1 per cent level, respectively, while it was non-significant during 2016/017. 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). In combined 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 at AMTRC, Nawalpur, Sarlahi

Tr. no.	Treatments	Plant height (Cm)			Remarks
		2016/2017	2017/2018	Combined	
T_1	Rice transplanted by Rice transplanter (RT)	96.73	99.00	97.86	
T_2	Direct seeded rice by power tiller drill (PTOS)	104.77	105.43	105.10	
T_3	Rice direct seeded with zero till drill (ZT)	100.69	101.10	100.89	
T_4	Conventional Tillage (Farmers' practices	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 both of the years of 2016/017 and 2017/018 and in combined 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 in 2016/017, 2017/018 and in combined analysis.

Table 4 Average length of panicle of rice at AMTRC, Nawalpur, Sarlahi

Tr. no.	Treatments	Panicle length (Cm)			Remarks
		2074/2075	2075/2076	Combined	
T_1	Rice transplanted by Rice transplanter (RT)	24.88	25.44	25.16	
T_2	Direct seeded rice by power tiller drill (PTOS)	25.33	26.22	25.78	
T_3	Rice direct seeded with zero till drill (ZT)	24.65	25.80	25.23	
T_4	Check (Farmers' practices	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 combined analysis (Table 5) of two years. Number of plant per meter square was highest in T_1 in whole experiment which was 281.95, 285.33 and 283.64 in 2016/017, 2017/018 and in combined analysis, respectively. The lowest number was observed in T_3 which recorded 195.11, 199.33 and 197.22 respectively, in the year of 2016/017, 2017/018 and in combined analysis.

Table 5 Average number of plant of rice at AMTRC, Nawalpur, Sarlahi

Tr. no.	Treatments	Plant/m^2 (Number)			Remarks
		2016/2017	2017/2018	Combined	
T_1	Rice transplanted by Rice transplanter (RT)	281.95	285.33	283.64	
T_2	Direct seeded rice by power tiller drill (PTOS)	268.89	270.00	269.44	
T_3	Rice direct seeded with zero till drill (ZT)	195.11	199.33	197.22	
T_4	Conservation Tillage (CT) Farmers' practices	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 combined analysis. However, during 2016/017, it was highest in T_1 (61.66), while in 2017/018, the treatment T_3 recorded highest number of grain (64.66) and in combined analysis it was also highest in T_3 (63.11). In combined analysis, it was lowest in T_2 which was 58.66 (Table 6).

Table 6 Average number of grain/panicle of rice at AMTRC, Nawalpur, Sarlahi

Tr. no.	Treatments	Grain/panicle (Number)			Remarks
		2016/2017	2017/2018	Combined	
T_1	Rice transplanted by Ricetransplanter (RT)	61.66	63.89	62.77	
T_2	Direct seeded rice by power tiller drill (PTOS)	60.78	56.55	58.66	
T_3	Rice direct seeded with zero till drill (ZT)	61.56	64.66	63.11	

T_4	Conservation Tillage (CT) (Farmers' practices	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 both of the years and in pooled analysis (Table 7). The treatment T_1 recorded highest number of tiller in both of the years and in combined analysis as well. It was 32.00, 34.33 and 33.16, respectively in 2016/017, 2017/018 and in combined analysis. The lowest number of tiller per hill was recorded by T_2 as 14.79 in 2016/017, 18.44 in 2017/018 and 16.61 in combined analysis (Table 7).

Table 7 Average number of tiller/hill of rice at AMTRC, Nawalpur, Sarlahi

Tr. no.	Treatments	Tiller/hill (Number)			Remarks
		2016/2017	2017/2018	Combined	
T_1	Rice transplanted by Rice transplanter (RT)	32.00	34.33	33.16	
T_2	Direct seeded rice by power tiller drill (PTOS)	14.79	18.44	16.61	
T_3	Rice direct seeded with zero till drill (ZT)	24.89	26.11	25.50	
T_4	Conventional Tillage (CT) Farmers' practices	14.99	19.22	17.10	

Thousand grain weight

The weight of thousand grains was non-significant in the experiment. The average highest weight in 2016/017 was found in T_3 which was 18.55 gram and lowest of 17.88 gram in T_2. Similarly, in 2017/018, 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 at AMTRC, Nawalpur, Sarlahi

Tr. no.	Treatments	Thousand grain weight (Gram)			Remarks
		2074/2075	2075/2076	Combined	
T_1	Rice transplanted by Rice transplanter (RT)	17.98	17.72	17.85	
T_2	Direct seeded rice by power tiller drill (PTOS)	17.88	17.86	17.87	
T_3	Rice direct seeded with zero till drill (ZT)	18.55	18.17	18.36	
T_4	Conventional Tillage (CT) Farmers' practices	18.07	18.15	18.11	

Grain yield

The mean grain yield in the experiment was found significant at 1 per cent level in 2016/017, 2017/018 and also in combined analysis (Table 9).During 2016/017, the highest mean grain yield was obtained in T_1 which was 3641.67 kg/ha followed by T_4 which recorded 3016.67 kg/ha. Similarly, the lowest mean grain yield was recorded in T_2 which was 2473.67 kg/ha. The highest mean grain yield during 2016/017 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 two years (2016/017 and 2017/018), 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 combined analysis was found in T_2 which was 2576.33 kg/ha (Table 9).

Table 9 Mean grain yield of rice at AMTRC, Nawalpur, Sarlahi

Tr. no.	Treatments	Mean grain yield (Kg/ha)			Remarks
		2016/2017	2017/2018	Combined	
T_1	Rice transplanted by Rice transplanter (RT)	3641.67	3475.00	3558.33	
T_2	Direct seeded rice by power tiller drill (PTOS)	2473.67	2679.00	2576.33	
T_3	Rice direct seeded with zero till drill (ZT)	2514.33	2905.00	2709.67	
T_4	Conventional Tillage Farmers' practices	3016.67	2938.33	2977.50	

Straw yield

The average straw yield was significant at 1 per cent level in 2016/017; it was non-significant in 2017/018 while significant at 1 per cent level in combined analysis (Table 10). The highest straw yield during 2016/017 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 2016/017, the treatment T_3 obtained 4521.67 kg/ha of straw which was highest in the experiment during 2017/018 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 between year 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 at AMTRC, Nawalpur, Sarlahi

Tr. no.	Treatments	Mean straw yield (Kg/ha) 2016/2017	2017/2018	Combined	Remarks
T_1	Rice transplanted by Rice transplanter (RT)	4310.00	4312.67	4311.33	
T_2	Direct seeded rice by power tiller drill (PTOS)	4049.67	3873.33	3961.50	
T_3	Rice direct seeded with zero till drill (ZT)	5436.67	4521.67	4979.17	
T_4	Conventional Tillage Farmers' practices	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 two years (2016/017-2017/018) was found in T_1 where the rice was transplanted by rice tranplanter machine which was Rs. 79786.60/ha followed by the conventional tillage treatment counting the total revenue of Rs. 71709.60/ha (Table 11). The total variable cost was highest in conventional (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. The gross margin for 2016/017 (Annex-1), for the year 2017/018 (Annex-2) and average of two years (Annec-3) are also calculated separately and presented accordingly.

Table 11 Average gross margin of two years data in different cultivation practices of rice at AMRTC, Sarlahi

Item	T_1 (RT)	T_2 PTOS	T_3 ZT	T_4 CT
Land preparation cost (Rs/ha	8385.75	0.00	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 of 2016/017 and 2017/018.

IV. Conclusion

The cultivation of rice through the use of different machines with different practiceshave shown varied results of production quantity and also the costs of production and gross margin in this experiment. The cultivation of rice by the use of rice tranplanter (T_1) yielded highest (3641.66 kg/ha) followed by T_4conventional tillage the farmer's practices (3016.66 kg/ha) in 2016/017. It was 20.72 per cent more production than farmers' practices. The variable cost was 18.64 per cent more in farmer's practices than T_1.The gross margin in 2016/017 was 215.72 per cent more in T_1 than T_4. It was due to more labor costs incurred in farmers' practices

During the year 2017/018, the same treatment T_1 obtained the highest mean grain yield of 3475.00 kg/ha while the check T_4 produced 3330.00 kg/ha. Thus the production by the use of ricetransplanter was only 4.35 per cent more than farmer's practices Conventional tillage (T_4). But the variable costs due to more labor was 20.07 per cent more in farmer's practices than T_1 and thus the gross margin was 84.06 per cent more in T_1 than the gross margin of T_4, conventional tillage the farmer's practices.

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

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.

Annex-1

Gross margin of rice cultivation in different cultural practices with machines, 2016/017

Particulars	T_1 (RT)	T_2 (PTOS)	T_3 (ZT)	T_4 (CT)
Dry land preparation cost (Rs/ha)	5610.00	0.00	3750.00	5610.00
Soil puddling and planking cost (Rs/ha)	**2551.50**	**0.00**	**0.00**	**2551.50**
Land preparation cost (Rs/ha	**8161.50**	**0.00**	**3750.00**	**8161.50**
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**
DAP (60 kg/ha)	3300.00	3300.00	3300.00	3300.00
Urea (150kg/ha)	3000.00	3000.00	3000.00	3000.00
M/P (45 kg/ha)	1800.00	1800.00	1800.00	1800.00
Total fertilizer cost (Rs/ha)	**8100.00**	**8100.00**	**8100.00**	**8100.00**
Herbicide cost (Rs/ha)	**750.00**	**750.00**	**750.00**	**750.00**
Labor for sowing/seedling uprooting/ transplanting cost (Rs/ha)	3750.00	1350.00	1350.00	18297.00
Labor cost for weeding (Rs/ha)	6750.00	13500.00	13500.00	6750.00
Labor cost for fert. application (Rs/ha)	450.00	450.00	450.00	450.00
Labor for irrigation Cost (Rs/ha)	1350.00	675.00	675.00	1350.00
Labor for harvesting Cost (Rs/ha)	9000.00	9000.00	9000.00	9000.00
Labor for threshing and cleaning Cost	4369.99	2968.40	3017.20	3619.99
Total labor cost	**25669.99**	**27943.40**	**27992.20**	**39466.99**
Total variable cost	**49121.49**	**42193.40**	**46892.20**	**58278.49**
Grain yield at 10% m.c. (Kg/ha)	3641.66	2473.67	2514.33	3016.66
Straw yield (kg/ha)	4310.00	4049.67	5430.00	4093.00
Return from Grain (Rs/ha)	72833.20	49473.40	50286.60	60333.20
Return from straw (Rs/ha)	8620.00	8099.34	10860.00	8186.00
Total Revenue	**81453.20**	**57572.74**	**61146.60**	**68519.20**
Gross Margin (Rs/ha)	**32331.71**	**15379.34**	**14254.40**	**10240.71**

Price Rate:

S. No.	Particulars	Rate
1	Farm gate price of rice grain (Rs/kg)	20.00
2	Farm gate price of straw (Rs/kg)	2.00
3	Labor Rate/day	450.00
4	Seed price (Rs/Kg)	60.00

5	DAP price (Rs/Kg)	55.00
6	Urea price (Rs/Kg)	16.00
7	Potash price (Rs/Kg)	40.00
8	Herbicides price (Rs/lr)	600.00
9	Rotavator hire cost (Rs/h)	3750.00
10	Cultivator hire cost (Rs/h)	1860.00
11	MRT Hire Cost (Rs/h)	3750.00
12	Zerotillseed drill Hire Cost(Rs/h)	3750.00

Annex-2

Gross margin of rice cultivation in different cultural practices with machines, 2017/018

Particulars	**T_1 RT**	**T_2 PTOS**	**T_3 ZT**	**T_4 CT**
Dry land preparation cost (Rs/ha)	5610.00	0.00	3750.00	5610.00
Soil puddling and planking cost (Rs/ha)	3000.00	0.00	0.00	3000.00
Land preparation cost (Rs/ha	**8610.00**	**0.00**	**3750.00**	**8610.00**
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**
DAP (60 kg/ha)	3300.00	3300.00	3300.00	3300.00
Urea (150kg/ha)	3000.00	3000.00	3000.00	3000.00
M/P (45 kg/ha)	1800.00	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**
Lob our for sowing/seedling uprooting/ transplanting cost (Rs/ha)	3750.00	1350.00	1350.00	18474.00
Labor cost for weeding (Rs/ha)	6750.00	13500.00	13500.00	6750.00
Labor cost for fert. application (Rs/ha)	450.00	450.00	450.00	450.00
Labor for irrigation Cost (Rs/ha)	1350.00	675.00	675.00	1350.00
Labor for harvesting Cost (Rs/ha)	9000.00	9000.00	9000.00	9000.00
Labor for threshing and cleaning Cost	4170.00	3214.80	3486.00	3996.00
Total labor cost	**25470.00**	**28189.80**	**28461.00**	**40020.00**
Total variable cost	**49370.00**	**42439.80**	**47361.00**	**59280.00**
Grain yield at 10% m.c. (Kg/ha)	3475.00	2679.00	2905.00	3330.00
Straw yield (kg/ha)	4310.00	3870.00	4520.00	4150.00
Return from Grain (Rs/ha)	69500.00	53580.00	58100.00	66600.00
Return from straw (Rs/ha)	8620.00	7740.00	9040.00	8300.00
Total Revenue	**78120.00**	**61320.00**	**67140.00**	**74900.00**
Gross margin	**28750.00**	**18880.20**	**19779.00**	**15620.00**

Price rate

Item	Rate
Farm gate price of rice grain (Rs/kg)	20.00
Farm gate price of straw (Rs/kg)	2.00
LaborRateRs/day	450.00
Seed price (Rs/Kg)	60.00
DAP price (Rs/Kg)	55.00
Urea price (Rs/Kg)	16.00
Potash price (Rs/Kg)	40.00
Herbicides price (Rs/l)	600.00
Rotavator hire cost (Rs/h)	125.00
Cultivator hire cost (Rs/h)	1860.00
MRT Hire Cost (Rs/h)	3750.00

Zero tillseed drill Hire Cost(Rs/h)	3750.00

Annex-3
Average gross margin, revenue and variable costs of rice production at AMTRC, Sarlahi (2016/017-2017/018)

Particulars	T_1 (RT)	T_2 PTOS	T_3 ZT	T_4 CT
Dry land preparation cost (Rs/ha)	5610.00	0.00	3750.00	5610.00
Soil puddling and planking cost (Rs/ha)	2775.75	0.00	0.00	2775.75
Land preparation cost (Rs/ha)	**8385.75**	**0.00**	**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**
DAP (60 kg/ha)	3300.00	3300.00	3300.00	3300.00
Urea (150kg/ha)	3000.00	3000.00	3000.00	3000.00
M/P (45 kg/ha)	1800.00	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**
Lob our for sowing/seedling uprooting/ transplanting cost (Rs/ha)	3750.00	1350.00	1350.00	18385.50
Labor cost for weeding (Rs/ha)	6750.00	13500.00	13500.00	6750.00
Labor cost for fert. application (Rs/ha)	450.00	450.00	450.00	450.00
Labor for irrigation Cost (Rs/ha)	1350.00	675.00	675.00	1350.00
Labor for harvesting Cost (Rs/ha)	9000.00	9000.00	9000.00	9000.00
Labor for threshing and cleaning Cost	4270.00	3091.60	3251.60	3808.00
Total labor cost	**25570.00**	**28066.60**	**28226.60**	**39743.50**
Total variable cost	**49245.75**	**42316.60**	**47126.60**	**58779.25**
Grain yield at 10% m.c. (Kg/ha)	3558.33	2576.34	2709.67	3173.33
Straw yield (kg/ha)	4310.00	3959.84	4975.00	4121.50
Return from Grain (Rs/ha)	71166.60	51526.70	54193.30	63466.60
Return from straw (Rs/ha)	8620.00	7919.67	9950.00	8243.00
Total Revenue (Rs/ha)	**79786.60**	**59446.37**	**64143.30**	**71709.60**
Gross margin (Rs/ha)	**30540.85**	**17129.77**	**17016.70**	**12930.35**

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