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Evaluation of Different Wheat Establishment Methods at Agricultural Machinery Testing and Research Centre, Nawalpur, Sarlahi, Nepal

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Abstract

The labour scarcity has been the serious problem in Nepalese agriculture due to youth migration in urban areas and in gulf countries in search of better opportunities. Lack of human resources in agriculture has compelled farmers to find out alternate choice. Mechanization in wheat farming is one of the best solutions to overcome scarce labor for better production. In order to address this issue, an experiment on uses of different agricultural machineries and cultivation practices in wheat crop was conducted at AMTRC during 2017-18 and 2018-19. Experiments were carried out in three replications with six treatments in 2800 m^2 plot size. The wheat variety Gautam was sown at the rate of 120 kg ha^{-1} and other cultural practices were followed as per recommendation. The pooled analysis of two years data of grain yield was significant at 1% level. The highest yield of 3659.17 kg ha^{-1} was obtained in treatment where zero-till seed-drill (ZTSD) machine was used for wheat cultivation followed by the treatment where power tiller operated seed-drill (3547.50 kg ha^{-1}) was used. The lowest mean grain yield (3005.00 kg ha^{-1}) was recorded in treatment-3 for which seed sowing rotavator was used in experiment. The average gross margin of two years was obtained highest (Rs. 67767.51 ha^{-1}) by treatment-5, the Zero Till Seed Drill (ZTSD) machine. In this treatment the total variable cost was 18.29% less than farmers' practices. Similarly the gross margin was also 16.66 % and yield was more than 10% higher than farmer's practices (Check) obtained in ZTSD machine used treatment.

Keywords: Mainstay, mechanization, wheat, zero-till, yield, gross margin

1. Introduction

Wheat is the third most important crop after rice and maize both in area and production which is generally sown in November-December and harvested in March-April in Nepal. The area production and productivity of wheat in 2016-17 reached to 0.73 million ha, 1.88 million tone and 2554 kg ha^{-1} from 70648.00 ha, 1.57million tone and 225.00 kg ha^{-1} in 2007-08 (Anonymous, 2018a, 2018b). Food insecurity in Nepal is a major problem with more than two third of the districts facing food deficit every year (Joshi et al., 2012). Wheat contributes about 20% of the total cereal production in Nepal. Over 60% of wheat is produced in the Terai (plain) region, though they are also produced in the mid hills and high hills regions of Nepal (Timsina et al., 2018). Devkota and Phuyal (2015) found significant positive impact of the average and maximum temperature and significant negative impact of the minimum temperature on net revenue

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and wheat yield of terai region.

By 2020, demand for wheat is expected to be 40% greater than its current level of 552 million tons (Rosegrant et al., 1997). Between 1961 and 1994, wheat yields increased at an average annual rate of more than 2 per cent in all developing countries except China and India (Pingali and Heisey 1996).

The United Nation Food and Agriculture Organization (FAO) and the United Nations Industrial Development Organization (UNIDO) concluded that the goal of agricultural mechanization is to reduce labor (Emami et al., 2018).

In Nepal, farm mechanization formally started from 1970s with the advent two and four wheel tractors (Takeshima, 2017b). While Basnyat (2017) reported that the beginning of modern age started after Mr. Krishna BahadurThapa of Biratnagar first time imported single cylinder tractor. The labor shortage in agriculture sector has increased the rural labor wage rates (Wang et al., 2016; Wiggins and Keats, 2014).

In Nepal, just 8 per cent of farmers use tractors, 26 per cent use iron plows (Kaur, 2017). Study carried out by GC et al., (2019) showed that light machinery is an essential part of Nepali farming system.Marahatta et al. (2018) found higher yield of both rice and wheat (4106; 3042 kg ha^{-1}) in conservation agriculture than conventional agriculture (4106; 3022 kg ha^{-1}). Rahaman et al. (2011) reported that the less number of labors per hectare is required to complete the production process by mechanized farm compared to traditional farms. Paudel et al. (2019) showed that farm size, on-farm wage rates, access to credit serviceswere positively associated with willingness to pay for mini-tillers in mid-hills.

Din and Khattak (2018) found the per acre productivity of mechanized farmers a little bit greater than the non-mechanized farmers. In the same district, Aurangzeb et al. (2007) found the labor requirements of the mechanized farms were nearly 20% of that of the traditional farms. The study carried out by Yamin et al. (2011) revealed a good scope of increment in production of wheat by increasing and managing agricultural machines in Punjab-Pakistan. Hossain and Collaghan (1996) found oxen to be the most expensivein Peshawar valley, Pakistan, and power tillers the cheapest in wheat cultivation in Bangladesh. Zero-till that have the capacity to improve labor and farm input efficiencies in wheat cultivation in Nepal (Mcdonald et al., 2018).

Takesima (2017a) reported that less than 8% farms used farm mechanization in the hills, while 46% farms used mechanization in the terai area. More than 51% of holding in terai own and use animal drawn iron plough due to increased field efficiency than traditional plough and easy availability in border towns (Shrestha, 2012). Agriculture machinery is having a positive impact on small holders since they are efficient in accomplishing timely farm operations, reducing cost and improving product quality (Gauchan and Shrestha, 2017).

The shortage of farm labor, expensive available labors are the major reasons to follow mechanization in wheat farming. The appropriate machines and cultivation practices to increase yield, gross margin and reduce drudgeries and farm cost has been imperative to find out and suggest to farmers in Nepal terai region. AMTRC conducted experiments on use of different machines and cultivation practices for wheat crop in Sarlahi, Nepal during 2017-18/2018-19.

2. Materials and Methods

Different machines used for wheat cultivation were identified at AMTRC, Nawalpur, Sarlahi. The cultivation practices for wheat cultivation by using different machineries were evaluated in three replications with six treatments (Table 1).

The trials were carried out in three replications of six treatments in 2800 m^2 plot size for each treatment. The experiment was laid out in randomized complete block design (RCBD). The variety of wheat was Gautam. Seeds were sown in last week of November to first week of December) at the rate of 120 kg ha^{-1}. The crop was harvested in the first week of April. The row to row distance was maintained as 18-20 cm in power tiller operated seed drill (T_1-PTOSD), rotavator zero tiller (T_2-RZ), and zero till seed drill (T_5-ZTSD), respectively. In other treatments, the seeds were broadcasted. The herbicides used for controlling weeds were 2-4-D and Pendimethalin sprayed at the rate of 5 ml l^{-1} of water. No any insecticides were sprayed as incidences of pests were not observed in the crop.

The fertilizer doses supplied were at the rate of 100:60:60 kg NPK ha^{-1}. 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 after 30 and 60 days of sowing, respectively. 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 was given after 20-22 days of sowing and the second irrigation after 80 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 spike of wheat. 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 Mstat package. The data recorded were analyzed for individual parameters separately for each year. Similarly, the combined analysis was performed for two years data.

3. Results and Discussion

3.1. Plant height

Plant height was significant at 1 % level during the year 2017-

Table 1: Treatments followed in wheat experiment at Sarlahi

Treatment no.	Treatments	Operations	Remarks
T_1	Power tiller operated seed drill (PTOSD)	In this treatment, four operations were performed in one pass. First operation was tilling the field, the second was seed sowing, the third operation was fertilizer application and the forth one was planking the field for level maintenance.	
T_2	Rotavator and zero till seed drill (RZ)	The field was first tilled with rotavator and then seeds and fertilizers were applied with zero tiller seed drill machine.	
T_3	Seed sowing and rotavator (SR)	In this treatment, seeds and fertilizers were broadcasted in the field followed by tilling with rotavator	
T_4	Cultivator seed sowing and rotavator (CSR)	In this treatment while preparing the land, first primary tillage was done with the use of cultivator. After the land preparation, seeds of Gautam variety of wheat were broadcasted followed by fertilizer broadcasting. After broadcasting of seeds and fertilizer the field was tilled with rotavator.	
T_5	Zero till seed drill (ZTSD)	In this treatment, both the seeds and fertilizers were sown through the use of machine without any prior tillage in the field. It was done in one pass.	
T_6	Check (Farmer's practices	In this treatment, the prevailing farmers' practices were followed. The field was given first preparation by ploughing with cultivators. After preparing the land with cultivators, the seeds were broadcasted followed by the broadcasting of fertilizers. The land was again tilled by using cultivators and then planked finally.	

18 and in combined analysis. It was non-significant in 2018-19 (Table 2). Highest plant height of 92.22 cm was observed in T_3 followed by T_1 which was 92.11 cm. The lowest height of 80.55 cm was recorded in T_2. Although the result was non-significant in 2018-19, the highest plant height of 96.89 cm was found in T_5 while the treatment T_2 recorded the lowest height of 85.33 cm. In combined analysis the effect of year was non-significant while the interaction between year and plant height was significant at 5% level. The average plant height of two years was recorded in T_5 which was 93.55 cm followed by 91.72 cm in T_1 while the lowest height was 82.94 cm obtained in T_2 (Table 2).

3.2. Spike length

Spike length was significant at 1% level in 2017-18 and was non-significant in 2018-19. In combined analysis it was significant at 5% level (Table 2). The spike length in treatment T_1 and T_5 was at par which recorded 10.89 cm and was also the highest among other treatments. The lowest length 8.11 cm was recorded in T_2. In combined analysis the average highest spike length was recorded by T_5 (12.50 cm) and the lowest by T_2 which was 9.94 cm (Table 2). The effect of year was significant at 1 % level while the interaction between year and treatment was non-significant.

3.3. Plant population

Plant population was recorded as the number of plant per square meter which was found non-significant in both of the years and also in combined analysis (Table 2). When calculated as average of two years data, T_3 recorded 80.67 which were highest among other treatments and T_5 obtained the lowest population of 73.25 in the experiment. The effect of year and the interaction between year and treatment was also found non-significant (Table 2).

3.4. Number of grain spike^{-1}

The number of grain per spike, when analyzed statistically was found non-significant in both of the years (2017-18-2018-19) and was also non-significant in combined analysis (Table 2). In combined analysis, the highest number of grain spike^{-1} was observed in T_5 which was 56.83 followed by T_6 which recorded 56.61 grains spike^{-1}. The effect of year on treatments and the interaction between year and treatment were also non-significant (Table 2).

3.5. Number of tillers hill^{-1}

The number of tillers hill^{-1} in the experiment was non-significant for both of the years (2017-18 and 2018-19). In combined analysis too, it was found non-significant. However, the average of two years showed the highest number of tillers in T_5 which was recorded as 8.33 and the lowest in T_2 which obtained 5.55 tillers hill^{-1} in the experiment (Table 2). Similarly, the effect of year and treatments were also found non-significant in this trial.

3.6. Thousand grain weight

The weight of thousand grains was found significant at 5 % level in 2017-18 and at 1% level in 2018-19. In combined analysis, the treatments were found non-significant (Table

Table 2: Performance of different parameters of wheat at AMTRC, Nawalpur, Sarlahi, Nepal (2017-18/2018-19).

Tr. no.	Treatments	Plant height (cm)		Spike length (cm)		No. of plant m^{-2}		Number of grain $spike^{-1}$		No. of tillers $hill^{-1}$	
		2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1	Power tiller operated seed drill	92.11[a]	91.33	10.89[a]	12.11	76.17	78.50	55.44	52.89	7.33	5.00
T_2	Rotavator zero tiller	80.55[c]	85.33	8.11[b]	11.77	77.17	81.67	49.00	49.44	6.55	4.55
T_3	Seed sowing rotavator	92.22[a]	89.44	10.88[a]	11.00	80.00	81.33	53.44	45.11	7.17	4.33
T_4	Cultivator seed sowing rotavator	86.11[b]	91.88	10.44[a]	12.77	68.17	79.17	50.66	52.11	7.40	4.77
T_5	Zero till seed drill	90.22[ab]	96.89	10.89[a]	14.11	74.00	72.50	61.00	52.66	8.11	8.55
T_6	Check (farmers' practices	94.11[a]	88.44	10.22[a]	12.00	74.50	78.50	55.55	57.66	6.33	5.33
F test		**	Ns	**	Ns	Ns	Ns	Ns	Ns	Ns	Ns
CV (%)		1.93	4.52	7.32	11.21	6.56	7.58	10.41	11.66	15.68	46.71
LSD (1%)		4.46	-	1.94	-	-	-	-	-	-	-
LSD (5%)		-	-	-	-	-	-	-	-	-	-

Pooled analysis (2017-18-2018-19)

T_1	Power tiller operated seed drill	91.72[a]	11.50[ab]	77.33	54.16	6.16
T_2	Rotavator zero tiller	82.94[b]	9.94[c]	79.42	49.22	5.55
T_3	Seed sowing rotavator	90.83[a]	10.94[bc]	80.67	49.27	5.75
T_4	Cultivator seed sowing rotavator	89.00[a]	11.61[ab]	73.67	51.38	6.09
T_5	Zero till seed drill	93.55[a]	12.50[a]	73.25	56.83	8.33
T_6	Check (farmers' practices	91.28[a]	11.11[bc]	76.50	56.61	5.83
Grand mean		89.89	11.26	76.81	52.91	6.28
F Test:						
Year (Y)		Ns	**	Ns	*	Ns
Treatment (T)		**	*	Ns	Ns	Ns
Y×T		*	Ns	Ns	Ns	Ns
CV (%)		3.49	9.85	7.11	11.02	31.16
LSD for T (1%)		5.16	-	-	-	-
LSD for T (5%)		-	1.34	-	-	-
LSD for Y×T (1%)		-	-	-	-	-
LSD for Y×T (5%)		5.35	-	-	-	-

Table 2: Continue...

Tr. no.	Treatments	1000 grain weight (g)		Mean grain yield (t ha^{-1})		Mean straw yield (mt ha^{-1})	
		2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1	Power tiller operated seed drill	49.17^{ab}	46.45ab	3661.67^{a}	3433.33	3930.00^{ab}	4773.33
T_2	Rotavator zero tiller	49.69^{a}	46.82a	3480.00^{a}	3433.33	3960.00^{ab}	4565.33
T_3	Seed sowing rotavator	49.43^{a}	45.95b	2626.67^{c}	3383.33	3323.33^{c}	4666.67
T_4	Cultivator seed sowing rotavator	48.60^{bc}	47.03a	3070.00^{b}	3018.33	3686.67^{bc}	4536.67
T_5	Zero till seed drill	49.36^{a}	46.45ab	3676.67^{a}	3641.67	4446.67^{a}	4725.00
T_6	Check (farmers' practices	48.47^{c}	47.14a	3123.33^{b}	3516.67	3630.00^{bc}	4903.33
	F test	*	**	**	Ns	**	Ns
	CV (%)	0.78	0.66	3.02	11.05	5.70	13.65
	LSD (1%)	0.69	0.79	256.10	-	564.60	-
	LSD (5%)	-	-	-	-		

Pooled analysis (2017-18-2018-19)				
T_1	Power tiller operated seed drill	47.81	3547.50^{a}	4351.67
T_2	Rotavator zero tiller	48.25	3456.67^{ab}	4262.67
T_3	Seed sowing rotavator	47.70	3005.00^{b}	3995.00
T_4	Cultivator seed sowing rotavator	47.82	3044.17^{b}	4111.67
T_5	Zero till seed drill	47.90	3659.17^{a}	4585.83
T_6	Check (farmers' practices	47.80	3320.00^{ab}	4266.67
Grand Mean		47.88	3338.75	4262.25
F Test:				
Year (Y)		**	Ns	*
Treatment (T)		Ns	**	Ns
YxT		**	*	Ns
CV (%)		0.72	8.24	11.23
LSD for T (1%)		-	451.8	-
LSD for T (5%)		-	-	-
LSD for YxT (1%)		0.80	468.40	-
LSD for YxT (5%)		-	-	-

**: Significant at (p=0.01) level, *: Significant at (p=0.05) level, Ns=Non-significant. Any two means having a common letter in superscript are not significantly different at the given level of significance

2). The treatment T_2 recorded 49.69 gram of thousand grains' weight which was highest in 2017-18 among the treatments and the lowest weight of 48.47 g was obtained in T_6 during the same year. While in 2018-19, T_4 recorded the highest mean weight of thousand grains which was 47.03 gram and T_3 obtained the lowest weight of thousand grains which was 45.95 g. In combined analysis, 48.25 g weight of thousand grains was recorded by T_2 followed by T_5 with the weight of 47.90 g in the experiment. In combined analysis, the effect of year and interaction between year and treatments were observed significant at 1% level (Table 2).

3.7. Grain yield

The mean grain yield in 2017-18 was found significant at 1% level while it was non-significant in 2018-19. In combined analysis, the treatments were significant at 1% level (Table 2). The highest mean grain yield was obtained in T_5 followed by T_1 which were 3676.67 and 3661.67 kg ha^{-1}, respectively in year 2017-18. Despite non-significant result in 2018-19, the highest mean grain yield was recorded in T_5 which was 3641.67 kg ha^{-1} and the T_4 obtained lowest mean grain yield of 3018.33 kg ha^{-1}. In combined analysis, the treatment T_5 produced highest mean grain yield of 3659.17 kg ha^{-1} followed by T_1 (3547.50 kg ha^{-1}) and the lowest mean grain yield of 3005.00 kg ha^{-1} was observed in T_3 (Table 2). Similarly, the effect of year was non-significant, while the interaction between year and treatment was significant at 5% level.

3.8. Straw yield

The straw yield in 2017-18 was significant at 1% level in 2017-

18 while non-significant in 2018-19. In combined analysis too, the treatments were found non-significant in straw yield (Table 2). The highest mean straw yield of 4446.67 kg ha^{-1} was obtained in T_5 and lowest in T_3 (3323.33 kg ha^{-1}) in 2017-18. Similarly, in 2018-19 the treatment T_6 obtained highest mean straw yield of 4903.33 kg ha^{-1} and lowest by T_4 (4536.67 kg ha^{-1}) in the experiment. In combined analysis, T_5 recorded the highest mean straw yield of 4585.83 kg ha^{-1} and lowest by T_3 which was 3995.00 kg ha^{-1}. The effect of year in treatments was found significant at 5% level while the interaction between year and treatment was non-significant (Table 2).

3.9. Gross margin

A gross margin is the difference between the gross income and the variable costs of producing a crop. It is a guide to the earning potential of a particular crop in an average situation after the growing costs have been met. Gross margins do not measure farm profits as they do not take into consideration fixed or overhead expenses. A gross margin refers to the total income derived from an enterprise less the variable costs incurred in the enterprise. In other words, a gross margin for an enterprise is its financial output minus its variable costs. One of the major benefits of mechanization is reduction of cost of production and ultimately the increment in farm income.

In this experiment gross margins of each treatment were calculated for individual year of 2017-18 (Table 3) and 2018-19 (Table 4). The average of two years (Table 5) was also calculated which has been taken as concluding remarks for briefing the benefit of mechanization in this experiment.

Table 3: Gross margin of wheat (Rs. ha^{-1}) at AMTRC, Sarlahi, Nepal during 2017-18

Particulars	T_1 PTO SD	T_2 RZ	T_3 SR	T_4 CSR	T_5 ZTSD	T_6 Check
Land preparation cost (Rs ha^{-1})	4000.00	6750.00	7000.00	6500.00	3750.00	10500.00
Seed cost (Rs. 75 kg^{-1})	9000.00	9000.00	9000.00	9000.00	9000.00	9000.00
Total fertilizers cost (Rs ha^{-1})	11819.80	11819.80	11819.80	11819.80	11819.80	11819.80
Herbicide cost (Rs. kg^{-1})	1350.00	1350.00	1350.00	1350.00	1350.00	1350.00
Total labor cost	5400.00	5400.00	6300.00	6300.00	5400.00	6300.00
Total machine hire cost	10500.00	10500.00	10500.00	10500.00	10500.00	10500.00
Total variable cost	42069.80	44819.80	45969.80	45469.80	41819.80	49469.80
Return from grain (Rs. ha^{-1})	91541.50	87000.00	65666.50	76750.00	91916.50	78083.25
Return from straw (Rs. ha^{-1})	9825.00	9900.00	8308.33	9216.65	11116.65	9075.00
Total revenue	101366.50	96900.00	73974.83	85966.65	103033.15	87158.25
Gross margin	59296.70	52080.20	28005.03	40496.85	61213.35	37688.45

1USD=102.47 Nepalese Rupees (April 6, 2018)

Table 4: Gross margin of wheat (Rs. ha^{-1}) at AMTRC, Sarlahi, Nepal during 2018-19

Particulars	T_1 PTO SD	T_2 RZ	T_3 SR	T_4 CSR	T_5 ZTSD	T_6 Check
Land preparation cost (Rs ha^{-1})	4000.00	6750.00	7000.00	6500.00	3750.00	10500.00
Seed cost (Rs. 75 kg^{-1})	9000.00	9000.00	9000.00	9000.00	9000.00	9000.00
Total fertilizers cost (Rs ha^{-1})	11819.80	11819.80	11819.80	11819.80	11819.80	11819.80
Herbicide cost (Rs. kg^{-1})	1350.00	1350.00	1350.00	1350.00	1350.00	1350.00
Total labor cost	5400.00	5400.00	6300.00	6300.00	5400.00	6300.00
Total machine hire cost	10500.00	10500.00	10500.00	10500.00	10500.00	10500.00
Total variable cost	42069.80	44819.80	45969.80	45469.80	41819.80	49469.80
Return from Grain (Rs. ha^{-1})	96133.24	96133.24	94733.24	84513.24	101966.48	98466.48
Return from straw (Rs. ha^{-1})	14319.99	13695.99	14000.01	13609.98	14175.00	14709.99
Total Revenue	110453.23	109829.23	108733.25	98123.22	116141.48	113176.47
Gross margin	68383.43	65009.43	62763.45	52653.42	74321.68	63706.67

Note: 1USD=110.46 Nepalese Rupees (April 6, 2019)

Table 5: Average of two years gross margin of wheat (Rs. ha^{-1}) at AMTRC, Sarlahi, Nepal during 2017-18/2018-19

Particulars	T_1 PTO SD	T_2 RZ	T_3 SR	T_4 CSR	T_5 ZTSD	T_6 Check
Land preparation cost (Rs. ha^{-1})	4000.00	6750.00	7000.00	6500.00	3750.00	10500.00
Seed Cost (Rs. 75 kg^{-1})	9000.00	9000.00	9000.00	9000.00	9000.00	9000.00
Total Fertilizers Cost (Rs. ha^{-1})	11819.80	11819.80	11819.80	11819.80	11819.80	11819.80
Herbicide cost (Rs. kg^{-1})	1350.00	1350.00	1350.00	1350.00	1350.00	1350.00
Total labor cost	5400.00	5400.00	6300.00	6300.00	5400.00	6300.00
Total machine hire cost	10500.00	10500.00	10500.00	10500.00	10500.00	10500.00
Total variable cost	42069.80	44819.80	45969.80	45469.80	41819.80	49469.80
Return from Grain (Rs. ha^{-1})	93837.37	91566.62	80199.87	80631.62	96941.49	88274.87
Return from straw (Rs. ha^{-1})	12072.50	11798.00	11154.17	11413.32	12645.83	11892.50
Total Revenue:	105909.87	103364.62	91354.04	92044.94	109587.32	100167.36
Gross margin	63840.065	58544.815	45384.238	46575.135	67767.515	50697.56

Note: 1USD=110.46 Nepalese Rupees (April 6, 2019)

The total variable costs incurred during 2017-18 were highest in check T_6 which was Rs. 49469.80 ha^{-1} and the lowest was Rs. 41819.80 ha^{-1} in T_5. The total revenue from grain and straw products was obtained highest in T_5 (Rs. 103033.15 ha^{-1}) followed by T_1 (Rs. 101366.50 ha^{-1}). The lowest revenue was recorded in T_3 (Rs. 73974.83 ha^{-1}). Thus, the highest gross margin was obtained in T_5 (Rs. 61213.35 ha^{-1}) followed by T_1 (Rs. 59296.70 ha^{-1}). The T_3 treatment obtained lowest gross margin of Rs. 28005.03 ha^{-1} (Table 3). In this year of experiment, the use of zero till seed drill machine was found comparatively more profitable to farmers than other practices of wheat cultivation.

During the year 2018-19 of the experiment, the variable cost incurred in treatments was found highest in T_6 (Check) which was Rs.49469.80ha^{-1} followed by T_3 of Rs. 45969.80 ha^{-1}. The lowest variable cost was counted in T_5 which was found as Rs. 41819.80 ha^{-1} (Table 4). Similarly, the revenue from grain and straw yield was recorded highest in T_5 which was Rs.116141.48ha^{-1} followed by T_6 which was Rs. 113176.47 ha^{-1}. While calculating the gross margin, it was found highest in T_5 which recorded Rs. 74321.68 ha^{-1} followed by the treatment T_1 which obtained Rs. 68383.43 ha^{-1} and the lowest gross margin was observed in T_4 which was Rs. 52653.42 ha^{-1} (Table 4).

The variable cost when calculated as average of two years was found highest in T_6 which was Rs. 49469.80 ha^{-1} and the lowest cost of Rs. 41819.80 ha^{-1} was recorded in T_5 (Table 5). Similarly, the total revenue of grain and straw yield was obtained highest by T_5 (Rs. 109587.32 ha^{-1}) followed by T_1 which recorded Rs. 105909.87 ha^{-1}. It was lowest in T_3 (Rs. 91354.04 ha^{-1}). The average gross margin of two years (2017-18-2018-19) was highest in T_5 which was Rs. 67767.51 ha^{-1} followed by T_1 where the gross margin was recorded as Rs. 63840.06 ha^{-1}. The treatment T_3 recorded the lowest gross margin of Rs.45384.24 ha^{-1} in the experiment (Table 5). Thus on an average the use of zero till seed drill machine in wheat cultivation was found efficient to fetch better income in wheat farming.

4. Conclusion

Mechanization has supported to increase wheat yield, farm income, reduce drudgeries and cope up the labor scarcity. The use of ZTSD machine reduces the cost and has no any effect on grain yield, either it yields more. In this experiment, use of ZTSD in wheat cultivation resulted better than other treatments followed in the trial. Therefore, the use of Zero-till seed drill machine can be economical for wheat cultivation particularly in terai area of Nepal.

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6. References

Abdi Reza, H.R., Ghasemzadeh, S., Abdollahpour, M., Sabzeparvar, A., Dabbag, Nasab, M., 2010. Modeling and analysis of mechanization projects of wheat production by GERT networks. Agricultural Science in China. Vol. 9, Issue 7, July 2010, 1078–1083.

Anonymous, 2018a. Government of Nepal /Ministry of Agriculture, Land and Cooperatives /Monitoring, Evaluation and Statistics Division /Agriculture Statistics Section, Singhdurbar, Kathmandu, 2018.

Anonymous, 2018b. Statistical information on Nepalese agriculture. 2073/2074 (2016/2017). GoN/Ministry

of Agriculture, Land Management and Cooperatives/ Monitoring, Evaluation and Statistics Division/Agriculture Statistics Section, Singhdurbar, Kathmandu, Nepal, 2018.

Aurangzeb, M., Nigar, S., Khan, M., 2007. Labor requirements model for the wheat crop under mechanized and traditional farming systems in the NWFP; A case study of Peshawar district. Sarhad Journal of Agriculture 23(1).

Devkota, N., Phuyal, R.K., 2015. Climatic impact on wheat production in Terai of Nepal. The journal of development and administrative studies (JODAS), 23 (1-2), 1–22.

Din, R., Khattak, N.R., 2018. Impacts of farm mechanization on wheat and maize crops productivity in Peshawar valley. Sarhad journal of agriculture, 34(3), 516–525.

Emami, M., Almassi, M., Bakhoda, H., Kalantari, I., 2018. Agricultural mechanization, a key to food security in developing countries: strategy formulating for Iran. Agriculture and food security 7, 24.

GC, A., Yeo, J.H., Ghimire, K., 2019. Determinants of farm mechanization in Nepal. Turkish Journal of Agriculture-Food Science and Technology, 7(1), 87–91.

Gauchan, D., Shrestha, S., 2017. Agricultural and rural mechanization in Nepal: status, issues and options for future in Mandal, S.M.A., Biggs, S.D., Justice, S.E. (Eds) 2017. Rural mechanization. A driver in agricultural change and rural development. Institute for inclusive finance and development (In.M), Dhaka, Bangladesh.

Hossain, A.H.M.S., O'Callaghan, J.R., 1996. A case study on the mechanization of wheat cultivation in Bangladesh. Journal of Agricultural Engineering Research 65(3), 175–181.

Joshi, K.D., Conroy, C., Witcombe, J.R., 2012. Agriculture, seed, and innovation in Nepal: industry and policy issues for the future. Project Paper, International Food Policy Research Institute, Washington, DC.

Kaur, A., 2017. Agricultural mechanization in Nepal. IFPRI. South Asia. April 7, 2017.

Muhammad, Y., [LT]Tahir, A.R., Nasir, A.A, Muhammad, Y., 2011. Studying the impact of farm mechanization on wheat production in Punjab-Pakistan. Soil and Environment 30(2), 151–154, 2011.

Marahatta, S., Acharya, J., 2018. Simulation of growth and yield of rice and wheat varieties under varied agronomic management and changing climatic scenario under subtropical condition of Nepal. Journal of Agriculture and Forestry University (2018), 2141–156.

Mcdonald, M., Park, A.G., Devkota, M., Davis, A.S., 2018. Increasing yield stability and input efficiencies with cost effective mechanization in Nepal. Article in Field Crops Research 228. September 2018. DOI:10.1016/j.fcr.2018.08.012.

Paudel, G.K., Koirala, D.K.C., Rahut, D., 2019. Small holder farmers' demand for farm mechanization in the mid-hills of Nepal. Conference paper. Conference: Southern Agricultural Economics Association (SAEA) Annual Meeting, at Birmingham, Alabama, February 2-5, 2019.

Pingali, P., Heisey, P.W., 1996. Cereal crop productivity in developing countries: Past trends and future prospects. In Global Agricultural Science Policy for the Twenty-First Century. Melbourne, Australia: Natural Resources and Environment, 51–94.

Rahman, M.S., Miah,M. A. M., Moniruzzaman, Hossain, S., 2011. Impact of farm mechanization on labor use for wheat cultivation in northern Bangladesh. Journal of Animal and Plant Sciences 21(3), 2011, 589–594.

Rosegrant, M.W., Sombilla, M.A., Gerpacio, R.V., Ringler, C., 1997. Global food markets and US exports in the twenty-first century. Paper presented at the Illinois World Food and Sustainable Agriculture Program Conference, Meeting the Demand for Food in the 21st Century: Challenges and Opportunities, 28 May, University of Illinois, Urbana-Champaign.

Shrestha, S., 2012. Study on performance of conservation tillage equipment for wheat and maize planting in Nepal. https://www.researchgate.net/publication/228534387 Status_of_Agricultural_Mechanization_in_Nepal.

Takeshima, H., 2017a. Custom-hired tractor services and returns to scale in small holder agriculture; a production function approach. Agricultural Economics. 48(3), 363–372.

Takeshima, H., 2017b. Overview of the evolution of agricultural mechanization in Nepal. IFPRI discussion paper 01662, Development Strategy and Governance Division. International Food Policy Research Institute, Washington, DC.

Timsina, K.P., Ghimire, Y.N., Gauchan, D., Suvedi, S., Adhikari, S.P., 2018. Lessons for promotion of new agricultural technology: a case of Vijaya wheat variety in Nepal. Agriculture and Food Security 2018 7, 63.

Wang, X., F. Yamauchi, K. Otsuka, and Huang, J., 2016. Wage growth, landholding, and mechanization in Chinese agriculture. World Dev. 86, 30–45.