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Modification and Evaluation of 8 Row Self Propelled Paddy Transplanter (Yanji) to Suit SRI Cultivation

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ABSTRACT

In India Rice (*OryzaSativa*) occupies 150 million ha area, producing 573 million tonnes with an average productivity of 3.83 t ha^{-1}.Yanji transplanter used to avoid very cumbersome transplanting process for saving time, labour requirement and to maintain uniformity of planting through tray seedling or the mat nursery but will also help in getting desired plant population. In Yanji transplanter, the spacing was 23.8 × 12 cm, the row to row spacing was constant at 23.8 cm and plant to plant spacing was 10 to 20 cm. The modification to the gear box was initiated to accomplish System of Rice Intensification (SRI) planting spacing of 25X25 cm so as to reap the benefits of SRI .The gear box of Yanji transplanter had been modified in existing transplanter, from small gear teeth (16, 24) to (16, 41) and also big gear teeth was (27, 36) to (17, 41). The field capacities of modified over existing transplanter was 0.1575 ha h^{-1} and 0.1218 ha h^{-1} and field efficiencies were 74.28 per cent and 85.5 per cent at the average operating speed of the modified and existing transplanters were 0.810 km h^{-1} and 0.643 kmh^{-1} respectively. Yield of rice using modified Yanji transplanter 7.1 t $ha^{-1}$is higher than compared to existing transplanter 6.4 t ha^{-1}.

Key words : Rice yield, SMSRI,Yanji transplanter.

Rice (*Oryza Sativa*) is one of the three most important food crops in the world which forms the staple diet for 2.7 billion people. On an average, rice accounts for 27 per cent of all cereal grains production in worldwide. Paddy occupies 150 million ha area, producing 573 million tonnes with an average productivity of 3.83 t ha^{-1} (Anonymous, 2002).

The cultivation area has been increased to produce more than 800 million tonnes of paddy to meet an additional demand in the next three decades. Asia accounts for about 90 per cent and 91 per cent of world's rice area and production respectively. In India, rice accounts for more than 40 per cent of the food grain production. Annually, rice is grown on 44.6 million ha of land producing about 93.86 million tonnes (Chaudhary and Varshney 2003). Rice transplanter gives better performance with proper mat density (110 g of seed per mat) in terms of less missing hills during transplanting. It saves time, labour and provides good uniformity of seedling on the mat but will also help in getting desired plant population (Behera*etal*, 2007).

Improved technologies help the farmers to produce more rice by using improved land and natural resources, followed by modifications in the Yanji transplanter. The need of the hour is to develop new and suitable technologies in Yanji transplanter to the rice growing fields to increase production per hectare. In Yanji transplanter, the spacing was 23.8 × 12 cm, the row to row spacing was constant at 23.8 cm and plant to plant spacing was 10 to 20 cm. In SRI cultivation, the spacing was 25× 25 cm, but any transplanter does not have 25 × 25 cm spacing. So, there is a need to modify the gear box to get desired spacing i.e. 23 × 23 cm. This method of modifying Yanji transplanter to suit SRI cultivation is called Slightly Modified System of Rice Intensification (SMSRI) (Uphoff *etal.,* 2011).

In the context of the above knowledge, there is a strong need for assessing the performance characteristics, economics of operation for mechanical rice transplanter and also to change the gear box of Yanji transplanter to suit the SRI cultivation. This study was therefore, undertaken with the following objectives:

1. To modify the Chinese (Yanji) 8 row paddy transplanter picking mechanism (finger) to pick 1 to 2 seedlings.
2. To modify the spacing (row to row and plant to plant) suitable for SRI.

3. To compare the cost economics over conventional method of manual transplanting.

MATERIAL AND METHODS

The gear box of Yanji transplanter had been modified to suit System of Rice Intensification (SRI). The Yanji 8 row transplanter consists of two gear boxes. One gear box is provided to give drive to the ground wheel and other gear box is provided at the tray, which gives drive to finger mechanism and tray oscillating. The power transfers from engine to gear box through universal cross shaft and finally to transplanting mechanism. The row to row spacing maintained by existing transplanter is 23.8 cm and plant to plant spacing is 12 cm. The plant to plant spacing can be varied from 10 cm to 20 cm by changing suitable gear. The gears were changed in the gear box which is connected to the ground wheel. Since the present study is to modify the transplanter to plant at the spacing of 23 x 23 cm. The spacing maintained in the modified transplanter nearing to the spacing of 25X25cm maintained in SRI cultivation.

To obtain plant to plant spacing of 23 x 23 cm, the gear box which is connected to the ground wheel was modified. The forward speed of the transplanter was altered by replacing set of gears with more number of gear teeth so as to obtain required plant to plant spacing nearly 23.8cm. which is two times greater than the existing machine spacing.

Yanji 8 row transplanter consists of five sets of compound gears. Each set of gear consists of one gear wheel and pinion. Out of these third and forth concequitive compound gears were replaced. Third set of compound gear consists of 31 teeth on gear wheel and 16 teeth on pinion and forth compound gear consists of 24 teeth on gear wheel and 16 teeth on pinion for existing machine. The third and forth compound gears of existing machine were replaced with other two compound gears, which are having 41 teeth on gear wheel and 17 teeth on pinion. The forth compound gear of existing machine was replaced with 36 teeth on gear wheel and 27 teeth on pinion. The change in the gear teeth number causes speed difference in the respective power train to result reduced speed in the ground wheel. For example: 100 rpm is input speed of 31 and 16 gear combination will result in 193rpm, whereas same speed of 100rpm in 41 and 27 teeth will result in 151rpm which is reduced due to the modified /changed combination in compound gear power train.

The third compound gear wheel of 41 teeth is in mesh with 27 teeth of pinion of forth compound gear, in the same fashion 17 teeth of third pinion is in mesh with 36 teeth of gear wheel of forth compound gear.

By replacing a new set of gears which are having large number of teeth with the existing less number of teeth. The speed ratio changed from 0.7741 for existing to 1.394 for modified arrangement of gears. The speed ratio was increased by 0.62.it is shown in fig.

RESULTS AND DISCUSSION

The 8 row Yanji transplanter power train was analysed and hanging arm gear box to support drive ground wheel with compound gear assembly casing was dismantled and studied the components and computed various reductions accomplished in the different stages of its power train. Since the external component design to reduce forward speed may affect the buoyancy parameters of the transplanter with single wheel drive. Hence the existing hanging gearbox was chosen for modifications to get desirable outcome of reduction in forward speed. The modifications in the proposed gear set reduced the speed from 0.810 km h^{-1} and 0.643 kmh^{-1} and the another set of gear in the modified paired gear altered the finger arm movement.

Table 1 shows the planting performance particulars of transplanter before and after needful modifications with the selected transplanter. From the data, it can be observed that the actual field capacities with modified and without modifications of transplanter were 0.1169 hah^{-1} and 0.1030 ha h^{-1}. The field efficiencies of modified and existing transplanter were 74.28 per cent and 85.5 per cent respectively. The transplanting time of modified transplanter (72.2 per cent) is less than existing transplanter (80.1 per cent) and the turning time losses 1.65 per cent and 3.18 per cent were estimated in both the cases respectively. Machine index of modified transplanter (97.76 per cent) is higher than existing transplanter (96.18 per cent).

Table 1. Field evaluation of Yanji 8 row paddy transplanter.

Sl. No.	Particulars	Modified transplanter	Existing transplanter
1	Average operating speed, km/h	0.810	0.643
2	Average turning time, min/turn	0.260	0.406
3	Row to row spacing, cm	23.8	23.8
4	Plant to plant spacing, cm	23	12
5	Width of operation, cm	190.4	190.4
	a.Field capacity, ha h^{-1}	0.1575	0.1218
	b.Actual field capacity, ha h^{-1}	0.1169	0.1030
	c. Field efficiency, %	74.28	85.50
6	Percentage distribution of time		
	a.Transplanting time, %	72.2	80.1
	b.Total time losses during operation		
	i.Turning losses	1.65	3.18
	ii. Mat feeding & adjustment	26.06	16.2
	iii. Others (cleaning of clogged fingers & engine shut down)	0	0.43
7	Machine index	0.977	0.961
8	Fuel consumption, l ha^{-1}	5.0	5.0

Table 2. Transplanting parameters.

Sl. No.	Particulars	Modified Yanji transplanter	Existing Yanji transplanter
1	Hill spacing, cm	23	12
2	No. of seedlings per hill	3	4
3	Depth of transplanting, cm	2.2	2.2
4	Missing hills, %	6	6
5	Floating hills, %	6	12
6	Damaged hills, %	0	0
7	Standing angle of planted seedling, °C	87	85

Table 3. Plant height as influenced by modified & existing, manual SRI method and farmers method.

Plant height	Modified Yanji transplanter	Existing Yanji transplanter	Manual SRI method	Farmers method
30 days	32 cm	30 cm	32 cm	26 cm
60 days	59 cm	57 cm	61 cm	53 cm
90 days	75 cm	72 cm	79 cm	71 cm
120 days	81 cm	78 cm	80.5 cm	75 cm

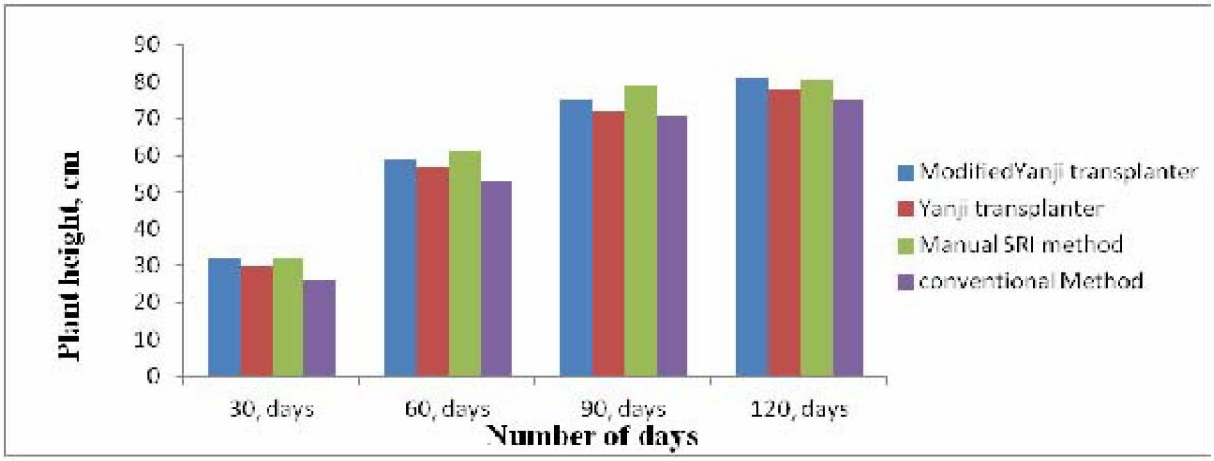

Fig 1. Variation of plant height with the time period of existing & modified Yanji transplanter, Manual SRI Method and farmer's method.

Table 4. Comparison of number of tillers per hill.

Number of tillers per hill	Modified Yanji transplanter	Existing Yanji transplanter	Manual SRI method	Farmers method
30 days	23	18	25	16
60 days	37	29	44	24
90 days	47	36	51	35
120 days	49	37	54	37

Mat feeding and adjustments of modified transplanter is more (26.06 per cent) compared to existing transplanter (16.2 per cent) and others engine shut down of existing machine is 0.43 per cent of total time of operation of rice transplanter. The fuel consumption of modified and existing transplanter were 0.5 l h^{-1} and 5.0 l ha^{-1}.

Table 2 shows the planting particulars of transplanter with proposed modifications compared to original transplanter. The hill to hill spacing was maintained as 23cm and number of plants per hill is 2 and depth of transplanting is 2.2 cm in modified gear arranged machine, whereas hill to hill spacing was 12 cm and number of plants per hill 4 and depth of transplanting was 2.2 cm. The intra row (hill to hill) spacing was improved due to the reduction in planting speed when compared with relative forward speed with modified transplanter the spacing was increased and similarly number of plants were decreased due altered finger movement in modified transplanter. The changes in movement of the fingers and reduced forward speed resulted in better holding and placement of reduced number of plants i.e., 4 to 2 numbers per hill. The number of plants per hill and missing hills were observed by the uniformity of seedling in the mat. The missing hill percentage is same in the both the operations i.e. 6 per cent and the floating seedling is less in modification machine method and more in existing machine method. The mean depth of transplanting is same in both operations is 2.2 cm and it was varied by the softness and texture of soil in different field conditions. The mean hill to hill spacing is in both the operations are 23 cm and 12 cm and angle of planted seedling is noted was $87^0$and 85^0.

Fig 3 shows the plant height and number of tillers per hill of rice crop of modified Yanji transplanter, existing Yanji transplanter operations, manual SRI transplanting and farmer's method of transplanting. The transplanted plots were noted at 30 days interval time after the date of transplanting. The comparison of modified transplanter and manual SRI method the plant height were approximately same (81 cm, 80.5 cm). and numbers of tillers per hill were more in manual SRI method (54) compared to modified transplanter (49).

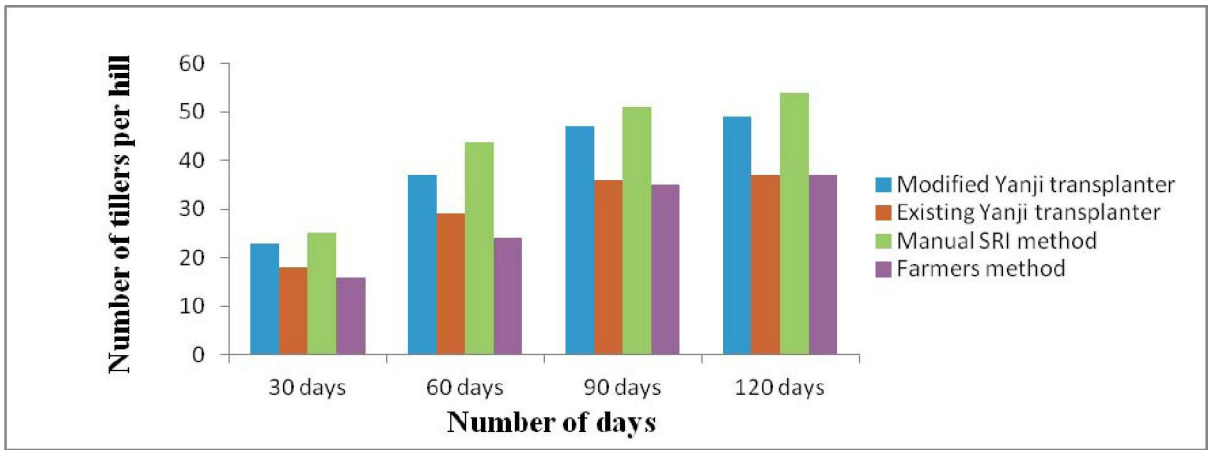

Fig 2. Variation of number tillers per hill with the time period of Modified & existing transplanter, manual SRI method and farmer's method.

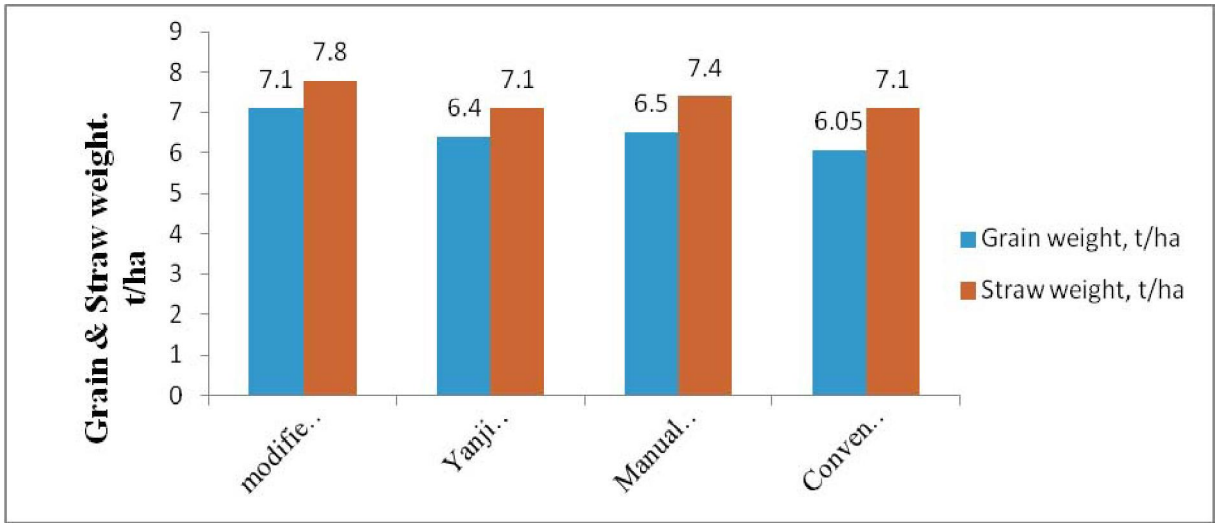

Fig 3. Grain and straw yields of modified & existing yanji transplanter, manual SRI method and farmers method.

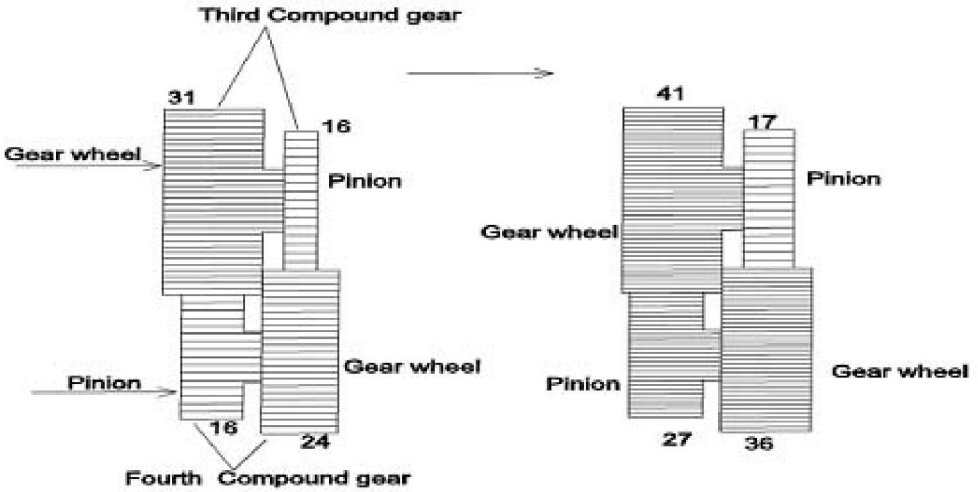

Fig 3.3 Existing Machine gear teeth

Fig 3.4 Modified machine gear teeth

Fig 4. Existing and modified machine gear teeth.

Table 5. Cost of operation of modified Yanji 8 row paddy transplanter and existing Yanji 8 row paddy transplanter.

S.No.	Activity	Person-h ha^{-1}	Modified transplanter Cost (Rs ha^{-1})	Yanji transplanter Cost (Rs ha^{-1})
1	Cost of operation of Yanji 8 row paddy transplanter			
	i.Fixed cost	8	333.00	430.83
	ii.Variable cost	3	1557.74	2015.59
	iii.The cost of operation	1		
	(a) Cost of polythene		300.00	300.00
	(b)Nursery raising (nursery preparation and management etc.)		350.00	350.00
	(c)Nursery mat cutting, transport and tray loading		131.25	131.25
	(d) Operator costIv. Cost of traysi. Modified Yanj		400.00	400.00
	i transplanter (80 trays)		8000.00	9500.00
	ii.Existing Yanji transplanter (95 trays)			
	Total cost of transplanting		11,671.99	13,127.67
2	**Activity**		Manual SRI transplanting	
	Cost of operation			
	(a) Cost of polythene (20 m x 1.3 m)		300.00	
	(b) Nursery raising (nursery bed preparationand management etc.)	4 12	175.00	
	(c) Nursery uprooting	300	525.00	
	(d) Transplanting		13,125.00	
	Total cost of transplanting		14,125.00	
3	**Activity**		Conventional transplanting	
	Cost of operation			
	(a) Cost of polythene (20 m x 1.3 m)	4	300.00	
	(b) Nursery raising (nursery bed preparationand management etc.)	12	175.00	
	(c) Nursery uprooting		525.00	
	(d) Transplanting		10,937.50	
	Total cost of transplanting		11,937.75	

Table 6. Gross and net income of Existing & Modified yanji transplanter, manual SRI and farmers transplanting.

S.No	Parameters	Modified Yanji transplanting (Rs.ha^{-1})	Yanji transplanting (Rs.ha^{-1})	Manual SRI transplanting (Rs.ha^{-1})	Farmers transplanting (Rs.ha^{-1})
1	Gross returna.grain @	97980	88320	89700	83580
	Rs. 1380/qb.straw @	7800	7100	7400	7100
	Rs. 1000/t total gross income	105780	95420	97100	90680
2	Cost of cultivation	34871	36327	37325	35135
3	Net income	70909	59092	59775	55542

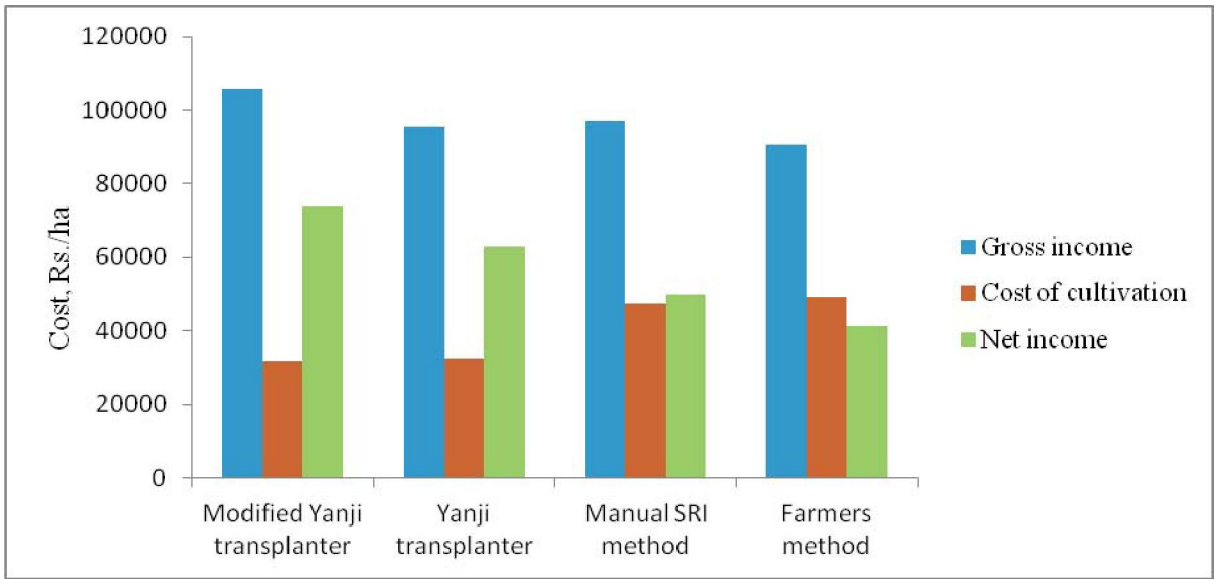

Fig 5. Grass income, cost of cultivation and net income of modified & existing Yanji transplanter, Manual SRI and Conventional method.

Yield Attributes

Fig 5 shows the results of modified, existing transplanter, manual SRIand farmers methods were noted at the time of harvesting. The grain and straw yield was more as compared to all the operations.

Gross income and net incomes of rice transplanting

The total cost of cultivation were less and gross income were more in modified Yanji transplater (Rs. 11,671.99 and Rs.10,5780) compared to three operations, existing Yanji transplanter were Rs. 13,127.67 and Rs. 95,420.00, manual SRI method were Rs.14,125.00 and Rs.97,100.00 and conventional method were Rs.11,937.75 and Rs 90,680.00respectively. The net income was more in modified Yanji transplanting compared to manual SRI transplanting (Rs. 70,909.00 and Rs. 59,775.00). It was concluded that the modified Yanji transplanting get the additional income compared to manual SRI Method and farmers method as shown in Table 6 and Figure 6.

Conclusions

By replacing the pair of gears at drive wheel, the speed ratio changed from 0.774 for existing to 1.394 for modified Yanji 8 row transplanter. There by plant to plant distance from 12 cm in existing transplanter to 23 cm in modified transplanter was achieved. The actual field capacity of modified Yanji 8 row paddy transplanter was found to be 0.1169 ha ho1 with field efficiency of 74.28 per cent while in case of existing Yanji transplanter was 0.1030 ha h^{-1} with field efficiency

of 84.46 per cent. The average working speed of both modiefied and existing transplanter was calculates as 0.810 and 0.643 km h^{-1}.The missing hills were observed as 6 per cent with both existing and modified transplanting operations. Floating hills were 12 percent in existing machine and 6 per cent in modified machine and no damamged hills were observed in both operations. The grain and straw yield for the mechanical (modified machine and existing machine), manual SRI and conventitional method was 7.1 t ha^{-1} respectively.A net profit obtained with existing Yanji transplanter, modified Yanji transplanter, manual SRI and conventional transplanting was Rs. 56,318, 68,600, 63,400 and 57,430 ha^{-1} respectively. The net income was 18 per cent, 8 per cent and 16 per cent more with modified transplanter when compared to existing transplanter, manual SRI and conventional transplanting respectively.

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