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RESEARCH ARTICLE

EFFECT OF CROP ESTABLISHMENT METHODS ON YIELD OF SPRING RICE AT KHAIRAHANI, CHITWAN, NEPAL

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ABSTRACT

The experiment was carried out to know the effect of crop establishment methods on yield of spring rice at Khairahani, Chitwan in 2020. The research was layout on Randomized Complete Block Design with 4 treatments and 5 replications. Treatments on the research plot were mechanical transplanting, wet direct seeding, dry direct seeding and manual transplanting of rice. Hardinath-1 variety of rice was planted on 2075-12-17 in research plot. Observations on plant growth parameter (plant height, number of tillers per m^2) at different dates of observation and yield attributes (effective tillers, length of panicle, total grain per panicle, Thousand Grain Weight, grain yield, straw yield, Harvest Index) were recorded. Data entry was done in MS Excel and statistical analysis was done using R-studio. From the research, effective tillers per meter square were 433.12, 492, 260.7 and 305, panicle length was 24.82 cm, 22.20cm, 23.52cm and 23.32cm, grains per panicle were 185.8, 159.2, 121.4 and130.4, thousand grain weight was 24.3gm, 22.9gm, 24.1gm and 24.6gm, sterility percentage was 23.51, 21.43, 21.54 and 18 respectively in mechanical transplanting, wet direct seeding, dry direct seeding and manual transplanting of rice. The highest grain yield (6.46t/ha), straw yield (11.98t/ha), gross returns (NRs 155.62 thousands ha-1) and net returns (NRs 81.28 thousands ha-1) with a benefit cost ratio of 2.1 was found in mechanical transplanting followed by manual transplanting with 5.10 t/ha grain yield and 9.40 t/ha straw yield. Similarly, wet direct seeding had grain yield of 3.40 t/ha and straw yield of 6.48t/ha. The lowest grain yield (2.36t/ha), straw yield (3.72 t/ha), gross returns (NRs 56.57 thousands ha-1), net returns (NRs -9.97 thousands ha -1) and B:C ratio(0.84) was observed in dry direct seeding of rice. With an average of 4.33 t/ha grain yield in different methods of crop establishment, mechanical transplanting of rice was found the superior and lucrative method of crop establishment with highest B:C ratio.

KEYWORDS

Profitability, economic analysis, planting methods, yield components.

1. INTRODUCTION

Rice, being principal food grain crop in Nepal followed by maize and wheat, is ranked second worldwide after wheat in terms of area coverage, production, productivity and preference (Tripathi et al., 2019; Gowda, 2012). Rice contributes 7% to GDP and 20% to AGDP. The total area under rice cultivation is 1.46 million ha producing 5.56 million metric tonne with productivity 3.81mt/ha (MOALD, 2019). Out of total rice supplement, spring rice contributes to only 8% while main season rice contributes to 92% (MoAD, 2015). Boro rice and Bhadaiya rice is also practiced in few districts of Terai occupying less than 1% of the total area (CDD, 2015). In Chitwan 29,700 ha is covered by monsoon rice and 4600 ha is covered by spring rice (4000 ha in eastern Chitwan and 500 in western Chitwan) with productivity 4.4t/ha (DADO, 2016).

The decreasing trend in rice cultivation is mainly due to decreased availability and increasing cost of labor resulting higher cost of cultivation in conventional methods of planting i.e manual transplanting (Kamboj, et al., 2013). Transplanting is dominating method of crop establishment in Asia (Pandey and Velasco, 2005). Transplanting alone costs about 15% of total rice production cost and delayed transplanting due to labor shortage causes substantial loss in yield (Ponnuswamy et al., 1999). In contrary, machine transplanting requires considerably less time and labor than manual transplanting (1–2 ha/person/day versus 0.07 ha/person/day) as well as has high net return and B: C ratio (IRRI, 2016; Sheeja et al., 2012). Rice crop can be cultured by two principal methods: Direct Seeding (DSR) and Transplanting (TPR) based on land preparation and crop establishment techniques. DSR, at the cropping system level, not only address the issue of labor scarcity and the rising cost of cultivation by avoiding puddling and reducing labor requirements but also bring opportunity for early rice establishment, as less water is needed for these methods and can be achieved by utilizing pre-monsoon rainfall or supplemental irrigation (Kar, et al., 2018). However, reported the yield decline in DSR, which may be due to various reasons viz., soil sickness, plant auto toxicity and presence of *G. graminis* var. graminis in dry-seeded rice fields (Vermeulen, 2007; (Ventura & Watanabe, 1978; Olofsdotter, 2001; Jensen et al., 2001; Prabhu and Filippi, 2002).

In order to increase the profitability and area of production of spring rice in Chitwan district, proper method of rice cultivation should be disseminated among the farmers. They are still following the traditional methods. This research helps farmer to upgrade their planting methods to

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reduce the labor force required for transplanting and their higher wages. A study was conducted in eastern Chitwan, Nepal to evaluate effect of different planting methods of rice on yield, yield components and economics of production.

2. Materials and Methods

2.1 Experimental site

The experiment was conducted at Khairahani, Chitwan (Latitude 27.5784^0 N and Longitude 84.5391^0 E). The soil report of experimental field showed low content of Nitrogen, phosphorus and organic matter, medium Potassium content while Ph was best suited for rice cultivation as shown in Table 1.

Table 1: Soil report of the experimental field

Farmer	N	P	K	OM	PH	Texture
1	0.09	23.8	114.4	1.84	6.4	Clayey loam
2	0.11	25	120	1.86	5.9	Clayey loam
3	0.09	25.2	119.39	1.84	6.3	Clayey loam
4	0.08	24.2	121.2	1.7	6	Clayey loam

2.2 Experimental design and treatment details

Crop variety planted in research field was Hardinath-1 with four treatments and five replications under Randomized Complete Block Design and plot size of 3*2 m^2.

The treatments for crop establishment methods were as follows:

T1: Mechanical transplanting (15*15 cm^2)
T2: Dry direct seeding of rice using drum seeder (20*10 cm^2)
T3: Wet direct seeding of rice using seed cum fertilizer drill (18*10 cm^2)
T4: Manual transplanting (20*20 cm^2)

For mechanical transplanting seedlings was raised on plastic tray while for manual transplanting was raised on sunken dry seed bed. Pre-germinated seeds were sown in wet direct seeding of rice while dry seeds were sown in dry direct seeding of rice in the same day of nursery establishment for manual and mechanical transplanting of rice. The experimental field was ploughed two times before sowing using tractor drawn disc plough to make soil loose and friable. Weeds and stubbles were removed manually. Well decomposed FYM was incorporated in the field about half a month ago at the rate of 6mt ha^{-1}. Inorganic fertilizers i.e. nitrogen, phosphorus, potash was applied on the field just before rice transplantation @ 195: 100: 66 kg ha^{-1} were applied through Urea (46%N), DAP (18% N and 46% P_2O_5) and MOP (60% K_2O). Nitrogen was applied in splitting dose. One third of nitrogen, full dose of phosphorus and potash were applied as basal dose at final land preparation. Remaining two third dose of nitrogen was applied at tillering stage (75 DAS) and panicle initiation stage (105 DAS) in equal split. Pre-emergence herbicide named Pretilachlor @ 2.5ml/lit of water was sprayed on all field within 3-4 days after transplanting and direct seed sowing which was followed by post emergence herbicide Bispyribac-Na @ 0.5ml/ lit of water after 21 days of sowing at the research field according to the recommendation of CSISA (Cereal System Initiatives South Asia).

3. Observations

3.1 Crop growth related data

3.1.1 Plant height

Ten plants were randomly selected from each plot and height was recorded at 15 days interval up to 105 days after sowing and averaged it. Plant height was measure from their base to the tip of top leaf during vegetative growth and to the tip of panicle during reproductive stage.

3.1.2 Number of tillers

Total numbers of tillers per 0.25 m2 were counted from each plot at 15days interval and expressed them into per meter square. Tiller number was determined by manual counting.

3.2 Yield attributes

3.2.1 Number of effective tillers

Total numbers of effective tillers per m2 were count and recorded just before harvesting.

3.2.2 Length of panicle

Length of ten randomly selected panicles were measured from it basal node to tip of topmost grain just before harvesting and mean were calculated.

3.2.3 Filled grains per panicle

Total numbers of filled grains was counted from ten randomly selected panicles and average them to find average grains per panicle after harvesting.

3.2.4 Sterility percentage

Total unfilled, shriveled grains per panicle were counted from randomly selected 20 panicles of net plot and sterility percentage was calculated by using following.

$$\text{Sterility percent} = \frac{\text{Total number of unfilled grains per panicle}}{\text{Total numbers of grains per panicle}} \times 100$$

3.2.5 Thousand grain weight

Thousand grains were taken from grain yield of each plot and weighed with the help of portable automatic electric balance and expressed in gram.

3.2.6 Grain and straw yield

Total crop was harvested from the 5 m^2 plot to record grain yield. Grain yield and straw yield was taken at harvest of crop from each plot. The crop was dried, threshed, cleaned and measured properly. Grain yield was computed per ha for each treatment at 14% moisture using formula suggested (Paudel, 1995).

$$\text{Grain yield (Kg/ha) at 14 \% moisture} = \frac{(100-\text{MC})\times\text{Plot yield(kg)}\times 10000(\text{m2})}{(100-14)\times\text{net plot area (m2)}}$$

Where, MC is the moisture percentage of grain

Sample of straw was sun dried for 10 days and measured again with the help of portable electric balance.

3.2.7 Harvest Index

Harvest index was obtaining by using formula given below:

$$\text{HI} = \frac{\text{Economic Yield}}{\text{Biological yield}}$$

Where, economic yield refers to weight of grains and biological yield refers to total weight of grain and straw

3.3 Economic analysis

3.3.1 Cost of cultivation

Cost of cultivation for each treatment will be calculated based on prevailing market prices for different agri-inputs like labor, seed, fertilizer, machines and others.

3.3.2 Gross return

Economic yield (grain + straw) will be converted into gross return (NRs/ha) on the basis of local market price.

3.3.3 Net return

It will be computed by deducting the cost of cultivation from gross return.

3.3.4 Benefit-cost ratio (B: C ratio)

It will be calculated by using following formula.
B: C ratio = Gross return / Cost of cultivation.

3.4 Data entry and analysis

Data was properly recorded in excel sheet after each observation. Recorded data were subjected to analysis of variance, mean separation, LSD using R-studio. MS EXCEL was used for construction of graph, tables and MS WORD was used for interpretation of analyzed data through R-studio. A simple regression was established among selected parameters using MS EXCEL.

4. Results and Discussion

4.1 Plant height

Plant height of rice was significantly influenced by crop establishment methods. The tallest plant height (76.14 cm) was recorded from mechanical transplanting which was statistically similar with wet direct seeding (75.66 cm) and dry direct seeding (72.1 cm). The highest plant height in mechanical transplanting was mainly because younger seedlings were transplanted which have more vigor, root growth and lesser transplant shock because of lesser leaf area during initial growth stages which stimulate the cell division causing more stem elongation and ultimately have increased plant height as reported in (Tomar et al., 2016).

Table 2: Influence of crop establishment methods on plant height (cm) and number of tillers per meter square at Khairahani, Chitwan, 2020.

Treatments	Plant height(cm)	Number of tillers per meter square
Establishment methods		
Mechanical TPR	76.14^{a}	456^{a}
Wet DSR	75.66^{a}	496.3^{a}
Dry DSR	72.1^{a}	323.62^{b}
Manual TPR	63.78^{b}	542.02^{a}
SEm	1.37	22.38
LSD(=0.05)	4.49	87.61
CV (%)	4.53	13.99
Grand mean	71.92	454.49

Note: Treatment means separated by DMRT and columns represented with same letter (s)are non-significant at 5% level of significance; LSD, Least Significant Difference; CV, Coefficient of Variation; SEm, Standard Error mean; DSR, Direct seeding of rice; TPR, Transplanting of Rice.

4.2 Number of tillers per meter square

Highest number of tillers per meter square was observed in manual transplanting of rice (Table 2). Earlier transplanting reduces the transplanting shock at a more convenient point in the growth cycle when they could rebound faster and had little effect on tiller age in case of mechanical and manual transplanting (Uphoff, 2002). In dry DSR, dry condition, low nutrient availability and less assimilation resulted in a smaller number of tillers (Jat et.al, 2009; Ladha et al., 2009).

4.3 Yield attributing characters

Highest number of the effective tiller (492 m^{-2}) was observed on the wet direct seeding, while subsequently lowest (260.7 m^{-2}) on dry direct seeding probably due to high tiller mortality rate and higher crop weed competition which was statistically similar with puddled manual transplanting (305 m^{-2}). The longest panicle length (24.82 cm) was observed on puddled mechanical transplanting because it provides more room for both canopy and root growth resulting in increased uptake of nutrients which would have favored increased panicles (Sheeja et al., 2012). A group resarchers also found test weight did not differ significantly on account of method of crop establishment (Gill et al., 2008).

However higher amount of thousand grain weight (24.6 g) was recorded on puddled mechanical transplanting. According to a study test weight is governed by varietal character (Budathoki et al., 2018). Highest sterility percentage (23.84%) was recorded on dry DSR, might be due to nutrient drainage by weeds, less absorption of nutrient by plant and dryness of pollen grains by intense solar radiation (Gathala et al., 2011). Lowest sterility percentage (18.7%) was recorded on puddled manual transplanting due to more grain filling period with earlier root development and efficient utilization of available nutrients for photosynthesis. Decrease in sterility is also due to increased assimilation of food material through photosynthesis on account of vigorous root and shoot growth, which ultimately led to higher dry matter production at each of the stages of observation (Tomar et al., 2016). Similar result has been reported (Hussain et al., 2012).

Table 3: Influence of crop establishment methods on yield attributing characters on different dates of observation at Khairahani, Chitwan, 2020.

Treatments	Yield attributes				
	ET(no/m^2)	PL(cm)	FGPP	TGW(gm)	S%
Establishment methods					
Mechanical TPR	433.12^{b}	24.82^{a}	133.8^{a}	24.3^{a}	20.20^{ab}
Wet DSR	492^{a}	22.20^{c}	106^{bc}	22.9^{a}	21.74^{ab}
Dry DSR	260.7^{c}	23.52^{b}	92.2^{c}	24.1^{a}	23.84^{a}
Manual TPR	305^{c}	22.32^{c}	119.2^{ab}	24.6^{a}	18.7^{b}
SEm	24.55	0.28		0.31	
LSD (=0.05)	51.74	1.02	17.45	1.94	3.52
CV (%)	10.07	3.21	11.22	5.88	12.11
Grand mean	372.71	23.22	112.8	23.98	21.12

Note: Treatment means separated by DMRT and columns represented with same letter (s)are non-significant at 5% level of significance; LSD, Least Significant Difference; CV, Coefficient of Variation; SEm, Standard Error mean; ET, Effective Tiller; PL, Panicle Length; FGPP, Filled Grains Per Panicle; TGW, Thousand Grain Weight; S, Sterility; DSR, Direct seeding of rice; TPR, Transplanting of Rice.

4.4 Yield and Harvest Index

Highest yield was recorded in mechanical transplanting than other methods due to proper spacing which facilitate proper tillering and utilization of nutrient in the soil. The result was in line with (Bhardwaj et al., 2018). Lower amount of grain yield (2.36 t ha^{-1}) was harvested from the dry direct seeding which is in line with (Regmi et al., 2020; Mali et al., 2018). It was due to lesser of effective tiller m-2 and increased inter and intra plant competition for available growth resources on account of heavy weed infestation. Higher biological yield was recorded under mechanical and manual transplanting, probably due to greater dry matter production per unit area, caused by better nutrient absorption from the soil, and the increased rate of metabolic processes, higher light absorption and photosynthetic activity with more number of leaves (Tomar et al., 2016). The result was in line with (Yadav and Singh, 2006). The highest HI (62.4%) was observed on dry direct seeding of rice in line with due to better assimilate partitioning from source (leaf) to sink (panicles) (Sarkar and Das, 2003).

Table 4: Influence of crop establishment methods on yield and harvest index on different dates of observation at Khairahani, Chitwan, 2020.

Treatments	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	HI (Percentage)
Establishment methods			
Mechanical TPR	6.46^{a}	11.98^{a}	57.4^{b}
Wet DSR	3.40^{c}	6.48^{b}	55.8^{b}
Dry DSR	2.36^{d}	3.72^{c}	62.4^{a}
Manual TPR	5.10^{b}	9.40^{a}	58^{b}
SEm	0.36	3.08	0.01
LSD (=0.05)	0.73	2.74	0.037
CV (%)	11.41	25.18	4.58
Grand Mean	4.33	7.89	24.9

Note: Treatment means separated by DMRT and columns represented with same letter (s)are non-significant at 5% level of significance; LSD, Least Significant Difference; CV, Coefficient of Variation; SEm, Standard Error mean; t ha^{-1}, ton per hectare; HI, Harvest Index; DSR, Direct seeding of rice; TPR, Transplanting of Rice.

4.5 Economic analysis

Highest cost of cultivation in manual transplanting was mainly because of more labor for transplanting and their high wages. Lowest cost of cultivation was incurred in wet DSR due to less labor force requirement and less land preparation of field as compared to transplanting of rice. Highest gross return was obtained from mechanical TPR with 155.62 thousand ha^{-1} while lowest from dry DSR (56.57 thousands ha^{-1}) mainly because of economic and biological yield (Mali et al., 2018). The highest net return was obtained from mechanical TPR (81.28 thousands ha^{-1}) due to higher yield and relatively low cost of cultivation followed by manual transplanting (35.65 thousands ha^{-1}) and wet direct seeding (18.21 thousands ha^{-1}). In dry DSR, there was loss of 9.97 thousands ha^{-1} due to low yield to balance the cost of cultivation. Mechanical TPR had the

statistically highest B:C ratio followed by manual TPR (1.41) and wet DSR (1.24). Dry DSR with the lowest B:C ratio of 0.85 had incurred loss. Some researchers reported the highest gross return, net return, B:C ratio in mechanical transplanting of rice (Sheeja et al., 2012; Mali et al., 2018).

Table 5: Influence of crop establishment methods on economic analysis on different dates of observation at Khairahani, Chitwan, 2020

Treatments	Economic parameters			
	Total cost of cultivation NRs.ha^{-1}('000)	Gross return NRs.ha^{-1}('000)	Net return NRs.ha^{-1}('000)	B:C ratio
Establishment methods				
Mechanical TPR	74.48	155.62^{a}	81.28^{a}	2.10^{a}
Wet DSR	63.87	82.10^{c}	18.21^{c}	1.29^{b}
Dry DSR	66.50	56.51^{d}	-9.99^{d}	0.85^{c}
Manual TPR	87.29	122.97^{b}	35.65^{b}	1.41^{b}
SEm (±)		5.27	5.27	0.076
LSD (=0.05)		15.90	15.89	0.23
CV, %		11.3	37.68	12.10
Grand mean		104.32	31.28	1.41

Note: Treatment means separated by DMRT and columns represented with same letter (s)are non-significant at 5% level of significance; LSD, Least Significant Difference; CV, Coefficient of Variation; SEm, Standard Error mean; DSR, Direct seeding of rice; TPR, Transplanting of Rice.

5. Conclusion

Planting method had significant impact on the yield and economics of the area. With an average of 4.33 t/ha grain yield in different methods of crop establishment, mechanical transplanting of rice was found the superior method of crop establishment. Mechanical transplanting recorded the highest grain yield (6.46 tha-1) as well as gross returns (NRs 155.62 thousands ha-1) and net returns (NRs 81.28 thousands ha-1) with a benefit cost ratio of 2.1), while dry DSR registered the lowest grain yield (2.36 t ha-1), gross returns (NRs 56.57 thousands ha-1) and net returns (NRs -9.97 thousands ha -1). Since wet direct seeding has statistically similar B: C ratio with manual transplanting, wet direct seeding is also a good choice to the place where nursery preparation isn't feasible.

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