EFFECT OF CROP ESTABLISHMENT METHODS ON PERFORANCE OF RICE IN RUPANDEHI, NEPAL

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ABSTRACT

An on-station experiment was conducted to assess the growth, productivity and profitability of rice under various crop establishment methods at the agronomy farm of Paklihawa Campus, Rupandehi, Nepal in 2019. The experiment was laid out in Randomized Complete Block Design with five treatments and four replications. The treatments included: Traditional Transplanting–Random (TTR), Traditional Transplanting–Line (TTL), System of Rice Intensification (SRI), Wet Direct Seeded Rice-Line (WDSRL) and Wet Direct Seeded Rice-Broadcasting (WDSRB). The results showed that plant height, number of tillers at 40 DAT, number of grains per panicle, 1000 grain weight, grain yield, straw yield and grain sterility percentage were significantly influenced by crop establishment methods, whereas number of tillers at 60 DAP, number of effective tillers at harvest, panicle length and harvest index were not significantly different among the treatments. TTR method produced the highest grain yield (4.58 t/ha), straw yield (7.25 t/ha) and benefit-cost ratio (3.28) followed by TTL. Hence, traditional transplanting method of rice establishment was found better than WDSR and SRI in terms of productivity and profitability. Direct seeding and SRI could also be an attractive alternative to transplanting because of lower labor requirement and cost of production.

Keywords: *benefit-cost ratio, direct-seeded rice, transplanting method, system of rice intensification, yield*

INTRODUCTION

Rice (*Oryzae sativa* L) is a semi-aquatic annual grass plant and one of the most important cereal crops for more than half of the world's population (Juliano, 1993). Rice ranks first in terms of area cultivated, production and part of livelihood of the people in Nepal (Ajaib, 2014). It is cultivated in 1.46 million hectares with a production of 5.1 million metric tons and productivity 3.4 tons/hectare (MOAD, 2017). Rice sector accounts for 44% of the total food grain production and contributes about 20 percent to the Agriculture Gross Domestic Product (AGDP) and almost 7 percent to GDP (CDD, 2015). It accounts for more than 50 percent of the total calories of the Nepalese people proving itself as indispensable part of livelihood (Kharel et al., 2018). Rice is grown in three agro-ecological regions (Terai and inner Terai; mid hills; and high hills) and three land types (lowland, midland and upland) under two water regimes (irrigated and rainfed). However, it is predominately cultivated in Terai region and lowlands under rainfed conditions (Gadal et al., 2019).

There is a huge gap between the potential and actual yield of rice at farmers' fields which is largely attributed to poor crop management practices (Amgain and Timsina, 2005). Crop establishment methods (CEMs) are one among crop management practices that determine the productivity and profitability of rice farming. Rice cultivation in our country is predominantly practiced by transplanting methods done manually in random geometry. Only few farmers and research stations practice transplanting of rice in line, either manually or mechanically by using rice transplanter. Direct seeded Rice (DSR) is another method of crop establishment done either manually or mechanically under two different soil conditions: dry and wet DSR. Manually, DSR is mostly done by broadcasting the seed on dry or puddled soil conditions. Only few farmers and research stations practice DSR mechanically by using seed drill machine under dry soil and drum seeder under wet soil conditions. Another method of crop establishment that is gaining popularity in eastern Terai region is the System of Rice Intensification (SRI). The five major components of the SRI are: (1) the use of young seedlings at the two-leaf stage (8–15 days with one seedling per hill), (2) wide plant spacing of 25 cm x 25 cm to as much as 50 cm - 50 cm, (3) use of rotatory weeder, (4) the addition of organic matter (manure and/or compost) to supply adequate nutrients, and (5) intermittent wetting and drying of soil for its aeration during the vegetative stage (Stoop et al. 2002).

Choice of crop establishment methods depends upon the biophysical and socioeconomic factors like climatic condition, soil condition, social structure, availability of labor, availability of agri-inputs and machineries, economic status of farmer and others. There are both positive and negative aspects of different CEMs. Random transplanting is a traditional method which is widely practiced by Nepalese farmers although it is labor, capital, water and energy intensive (Rao, 2010). Mechanical transplanting, labor and cost saving, is limited only to the rich farmers who can afford machines. DSR, although is labor, water, energy and cost saving, is practiced in limited area due to lower yield owing to poor seedling establishment and high weed infestation (Singh et al., 2005). SRI is a resource saving and high yielding technology, but is limited to farmers in eastern region, due to poor extension programs.

In the research site farmers have been predominately practicing traditional random transplanting method. Indigenous and traditional knowledge, skill and techniques are also well recognized by the modern scientists. However, it is necessary to study the economics of this popular method as compared to others. Therefore, this study attempts to find out the better choice of CEMs at the research site in terms of growth parameters, productivity and profitability of rice production.

MATERIALS AND METHODS

An on-station experiment was conducted from May to November, 2076 at agronomy farm of Paklihawa Campus, Rupandehi, Nepal. The experimental site was located at $27^{0}28'$ North Latitude and $83^{0}27'$ East Longitude at an elevation of 110 meter above sea level. The field was lowland with loamy soil, low organic matter content (1.7%), low total nitrogen (0.09%), high available phosphorus (386.12 kg/ha), medium available potassium (114.4%) and neutral pH (7.3). The agro-climatic feature of experimental site is shown in graph (Figure 1).

The experiment was conducted using Randomized Complete Block Design with four replications separated by 1.0 m border within which five treatments were randomly allocated and separated by 0.5 m inter plot space. The treatments assigned were:

T1= Traditional Transplanting–Random (TTR)
T2=Traditional Transplanting–Line at 20cm×20cm (TTL)
T3= System of Rice Intensification at 30cm×30cm (SRI)
T4=Wet Direct Seeded Rice -Line at 20cm×Continuous (WDSRL)
T5=Wet Direct Seeded Rice -Broadcasting (WDSRB)

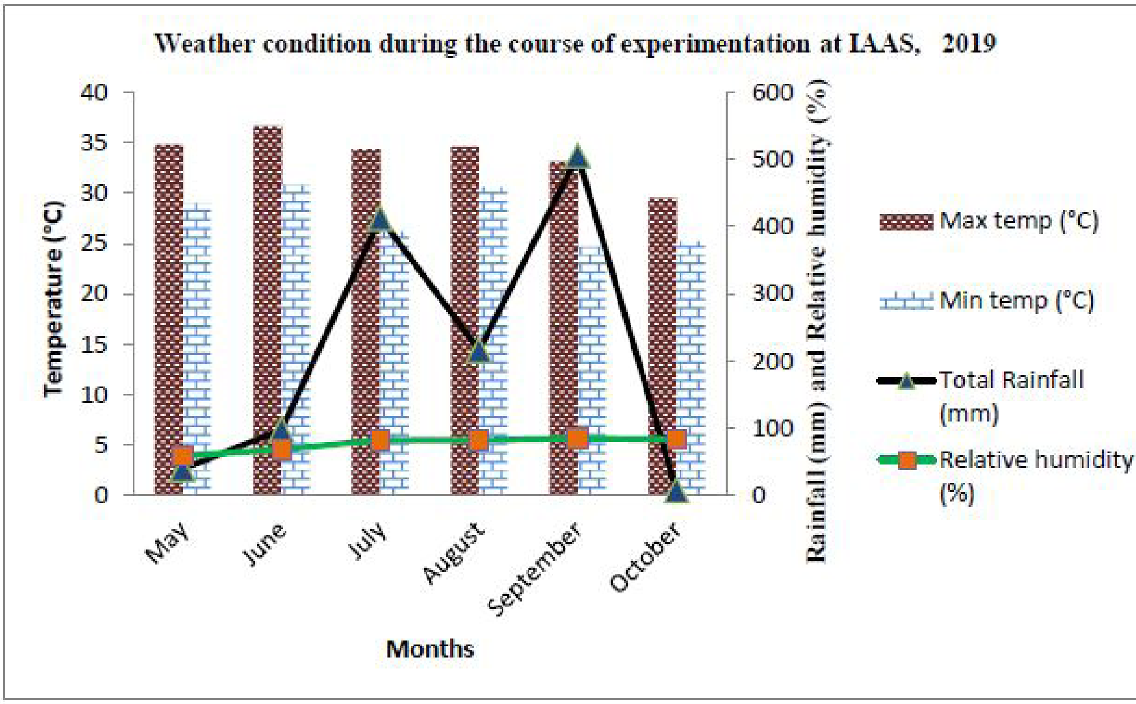

Figure 1. Weather condition during experimentation at Paklihawa, 2019

The maximum temperature recorded was 36.65^{0}C in the month of June whereas the minimum temperature recorded was 24.65^{0}C in the month of September. The total rainfall recorded was 1278.5mm and the mean relative humidity recorded was 76.43% during the research period.

The experimental plot was prepared by plowing the field under irrigated condition with the help of tractor drawn cultivator and rotavator followed by planking. Layout was done with twenty experimental units of 6 m^2. Plots were fertilized with 6 t/ha dry weight of FYM and 100:30:30 NPK kg/ha. The entire amount of phosphorus, potash and half dose nitrogen were applied as basal dose and remaining half dose of nitrogen was top dressed after 30 DAP and 60 DAP in equal amount. The variety used was Samba Mansuli sowing and transplanting were done on 18th July, 2019 in the experiment. For TTL methods, four week old seedlings were uprooted from wet nursery bed and transplanted in line maintaining 20×20 cm spacing and in TTR by farmers' method. In case of SRI, two week old seedlings were uprooted from the trays and transplanted immediately maintaining 30×30 cm spacing. In case of wet dry seeded rice, WDSRL plots were sown continuously in lines with 20 cm spacing and whereas, seed was broadcasted uniformly in WDSRB plots. Water was maintained in plots at critical stages such as tillering and panicle formation stages. Two hand weeding were done at 30 DAP and 60 DAP.

Traditional transplanting plots were harvested at 131 DAP, whereas SRI and DSR plots were harvested at 121 DAP. Growth parameters were recorded at 40 and 60 DAP and at harvest. Five sample plants were tagged for data recording of plant height, panicle length, grains per panicle and sterility percentage, while one m^2 quadrants was made for number of tillers/m^2, 1000 grain weight, grain yield and straw yield . After harvesting, grain and straw were sun dried and yield was adjusted at 13% moisture content. Data were analyzed for analysis of variance with the help of R-Studio program and mean differences were adjudged by Least Significant Difference from the reference of Gomez & Gomez, (1984). The cost of each inputs and services incurred during the production was recorded and benefit-cost ratio was calculated.

RESULTS AND DISCUSSION

Effect of crop establishment methods on growth parameters of rice

There was significant difference in plant height of rice due to the different CEMs in all studied durations (Table 1). The results revealed that the tallest plant was obtained from TTR at all measured times which was statistically similar with TTL and shortest plant height was obtained from WDSRL which was statistically similar with WDSRB and SRI. Taller plants in transplanted plots could be due to less weed competition compared to DSR methods. Moreover, lower plant population might be the reason for taller plants in transplanted plots. Bhandari et al., (2020), Kumar & Jnanesha, (2017) and Kumhar et al., (2016) also found the tallest plant height in TT method compared to other methods.

Number of tillers/m^2 was significantly influenced by different CEMs at 40 DAP but not at 60 DAP (Table 1). Highest number of tillers/m^2 was recorded in WDSRB (636) at 40 DAT and in WDSRL (542.12) at 60 DAP, whereas the lowest number was recorded in SRI at both 40 and 60 DAT. The higher number of tillers per m^2 in WDSR is due to higher seed rate, higher plant population and narrow spacing. In contrast, a lower tiller per m2 in SRI was due to lower seed rate, lower plant population and wider spacing. However, the SRI plot had the higher number of tillers per hill.

Table 1. Plant height and number of tillers per m^2 of rice as affected by crop establishment methods at Paklihawa, 2019

Treatments	Plant height(cm)			No. of tillers/m^2	
	At 40 DAS/T	At 60 DAP	At harvest	At 40 DAP	At 60 DAP
TTR	61.37^a	69.18a	89.05a	549.75a	439.50
TTL	58.73^a	66.42ab	86.61ab	508.12a	433.12
SRI method	42.44^b	55.04bc	75.15bc	189.62b	290.62
WDSRL	38.38^b	45.86c	70.62c	539.25a	542.12
WDSRB	40.16^b	50.09c	70.36c	636.00a	514.37
F test	***	**	*	*	ns
CV(%)	12.70	14.81	10.06	34.21	24.91
SEM(±)	1.36	1.89	1.76	37.07	24.73
LSD	9.439	13.08	12.15	255.42	170.43
Grand Mean	48.22	57.32	78.361	484.55	443.95

Note: CV=Coefficient of variation, LSD=Least Significant Difference, SEM (±)=Standard error of mean,= Significant at 0.5 level of significance,**= Significant at 0.01 level of significance,***=Significant at 0.001 level of significance, ns=Non-significant.*

Effect of crop establishment methods on yield attributing characters of rice

Effective tillers per m^2 at harvest was not significantly influenced by CEMs (Table 2). The highest number of effective tillers/m^2 was obtained from WDSRL (459.50) followed by WDSRB (439.875), and the lowest in SRI (297.37). Higher number of effective tillers/m^2 in WDSR could be due to the higher number of tillers/m^2 obtained at 40 DAS and 60 DAS (Table 1). Moreover, it is due to higher seed rate and plant population. Sah et al., (2007) also reported higher number of effective tillers/m^2in DSR method compared to the TT methods.

There was no significant differences in panicle length due to CEMs (Table 2). However, the maximum panicle length was observed in TTR (19.63cm) and minimum in WDSRB (16.89 cm). Number of effective tillers/m^2 showed negative correlation (-0.159^{ns}) with panicle length which indicated that lower number of effective tillers/m^2 caused higher panicle length in TTR plots (Table 3). Bhardwaj et al., (2018), Kumar & Jnanesha., (2017) and Kumhar et al., (2016) also obtained the highest panicle length in transplanting method compared to DSR methods.

The number of grains per panicle was significantly affected by CEMs (Table 2). The highest number of grains per panicle was observed in transplanted plots. The number of grains per panicle showed positive correlation with panicle length (0.580**) and negative correlation with number of effective tillers/m^2(-0.405^{ns}) which indicates that longer panicle length and lower number of effective tillers contributed to higher grains per panicle in transplanted plots (Table 3). Javaid et al., (2012) also reported that transplanted rice produced significantly higher number of spikelet per panicle compared to DSR methods.

Thousand grain weight was significantly affected by the CEMs (Table 2). The higher 1000 grain weight in transplanted plots might be due to higher accumulation of photosynthates in grains as there is lower competition for space, nutrient and water. The negative correlation between effective tillers/m^2 and 1000 grain weight (-0.019^{ns}) supports the above statement. The lower sterility percentage of grains might be another reason for higher 1000 grain weight in transplanted plots as there is negative correlation between them (-0.495*). Kumhar et al., (2016) also obtained similar results in his experiment.

Table 2. Grain yield and yield attributes of rice as affected by crop establishment methods at IAAS, Paklihawa, 2019

Treatments	No. of effective tillers/m^2 at harvest	Panicle Length	No. of grains/ panicle	1000 grain weight(g)	Grain yield at 13% (t/ha)	Straw yield (t/ha)	Harvest Index (%)	Sterility percentage (%)
TTR	336.75	19.63^{a}	168.40^{a}	15.59^{a}	4.58^{a}	7.25^{a}	38.54	7.85^{b}
TTL	339.12	18.50^{ab}	135.65^{ab}	15.83^{a}	4.02^{ab}	5.65^{ab}	40.83	8.32^{b}
SRI method	297.37	17.90^{ab}	126.00^{bc}	14.00^{b}	2.85^{b}	4.10^{b}	41.09	18.34^{a}
Wet DSRL	459.50	18.17^{ab}	96.00^{c}	14.00^{b}	2.68^{b}	4.28^{b}	36.95	25.77^{a}
Wet DSRB	439.87	16.89^{b}	106.45^{bc}	14.92^{ab}	2.55^{b}	4.52^{b}	35.95	17.88^{a}
F test	ns	ns	*	*	*	*	ns	**
CV(%)	21.06	8.92	19.575	5.59	29.18	24.17	10.45	39.15
SEM (±)	17.63	0.36	5.53	0.18	0.21	0.28	0.90	1.36
LSD	121.53	2.50	38.15	1.27	1.50	1.97	6.23	9.28
Grand Mean	374.52	18.219	126.5	14.86	3.34	5.16	38.67	15.63

*Note: CV=Coefficient of variation; LSD=Least Significant Difference; SEM (±)=Standard error of mean, *= Significant at 0.5 level of significance; **= Significant at 0.01 level of significance; ***=Significant at 0.001 level of significance; ns=Non-significant*

Effect of crop establishment methods on yield of rice

Grain yield was significantly affected by the CEMs (Table 2). Higher grain yield was observed in transplanted plots, while it was lower in WDSR. The higher yield in transplanting plots could be due to higher panicle length, grains per panicle and 1000 grain weight, as there is positive correlation between grain yield and those yield attributing parameters (0.639**, 0.667**, and 0.649**). This result suggests that the improvement in yield attributes have increased grain yield in transplanting plots. The yield attributing characters like panicle length, grains per panicle and 1000 grain weight have contributed 40%, 44% and 42% to grain yield respectively (Table 3). Moreover, lower sterility percentage of grain was another reason for higher grain yield in transplanting plots which is revealed by the negative correlation between them (-0.653**). Kumar & Jnanesha, (2017) and Kumar et al., (2018) also obtained higher grain yield in transplanted method compared to DSR method. Similar results was also obtained by Javaid et al., (2012) and Rahman et al., (2019).

There was significant difference observed among different CEMs in respect of straw yield (Table 2). The maximum straw yield was obtained from transplanting plots. The reasons behind are similar to those of grain yield. Kumhar et al., (2016), Rahman et al., (2019), and Kumar & Jnanesha, (2017) also obtained similar result in their research.

Harvest index was not significantly different among the treatments (Table 2). However, the highest harvest index was obtained from SRI method (41.09%) followed by transplanting. Higher harvest index in SRI and traditional transplanting is related to their higher grain yield. Similar result was also obtained by Hossain et al., (2003) who reported the highest harvest index in SRI method compared to transplanting methods.

There was a significant difference in sterility percentage as affected CEMs (Table 2). The higher sterility percent was obtained from WDSR and lower from transplanting. The higher sterility percentage in WDSR was probably due to severe competition of tillers for resources on account of higher number of tillers per unit area. Similar findings was also obtained by Hossain et al., (2003) and Bhandari et al., (2020).

Table 3. Correlation coefficients among different agronomic parameters

	Plant Height	Effective Tillers	Panicle Length	Grains/ Panicle	1000 Grain Weight	Grain Yield	Sterility Percentage
Plant Height		-0.102^{ns}	0.648**	0.653**	0.719**	0.928**	-0.728**
Effective Tillers			-0.159^{ns}	-0.405^{ns}	-0.019^{ns}	0.024^{ns}	0.329^{ns}
Panicle Length				0.580**	0.307^{ns}	0.639**	-0.628**
Grains/ Panicle					0.392^{ns}	0.667**	-0.668**
1000 Grain Weight						0.649**	-0.495*
Grain Yield							-0.653**

*Note: **=significant at 0.01 level; *=significant at 0.05 level; ns = non-significant*

Benefit-cost analysis

Crop establishment had benefit cost ratio above 1, which indicates that rice farming is profitable at research site (Table 4). Any value greater than 2.0 is considered safe as the farmers gets Rs. 2.00 for every rupee invested (Reddy & Reddi, (2005).The highest BC ratio was observed for TTR (3.28) which implies that farmers are getting NRs. 3.28 on an average investment of NRs. 1 in rice cultivation. The total cost of production was found to be less in DSR and SRI methods compared to transplanting but due to lower yield BC ratio was found to be lower in both of them. Relatively higher yield and higher BC ratio made TTR method the most profitable method of rice establishment. Kumhar et al., (2016) and Rahman et al., (2019) recorded higher B:C in TTL method.

Table 4. Benefit-cost ratio calculation of crop establishment methods at Paklihawa, 2019

Treatments	Total cost of production (NRs/ ha)	Gross Return (NRs/ ha)	Net Return (NRs/ ha)	B:C Ratio
TTR	43,984.75	1,44,650	1,00,665.25	3.28
TTL	44,984.75	1,26,250	81,265.25	2.80
SRI method	38,284.75	89,600	51,315.25	2.34
Wet DSRL	41,184.75	84,680	43,495.25	2.05
Wet DSRB	41,784.75	81,020	39,235.25	1.93

CONCLUSION

Traditional transplanting methods are observed better than DSR and SRI methods in terms of productivity and profitability analysis. Among transplanting, traditional transplanting-random was found to be more productive and profitable because of relatively higher yield and higher BC ratio. Direct seeding and SRI could also be an attractive alternative to transplanting because of lower labor requirement and cost of production. However, to reach a specific conclusion and recommendation it is necessary to conduct multi-year and multi-location research that could give assured results to be extrapolated in similar agro-ecological domains.

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