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RESEARCH ARTICLE

EFFECT OF DIFFERENT METHODS OF CROP ESTABLISHMENT ON GROWTH AND YIELD OF A SPRING RICE AT JANAKPURDHAM-17, DHANUSHA

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ABSTRACT

The study was conducted to know and evaluate the performance of different methods of crop establishment of Hardinath-1, spring rice, under RCBD with 5 treatments and 4 replications; treatments used were- Open, straight row, SRI, random and dry bed method of transplanting. The parameters like number of tillers per square meter, plant height, panicle length, effective number of tillers per square meter, thousand grain weight, grain yield in MT/ha and sterility percentage were accounted for the study. The findings suggest statistical similarity in grain yield for SRI (4.475 Mt/ha), straight row (4.45 Mt/ha) and open method of transplanting (4.45 Mt/ha), although the former, literally, being a slight superior among three. Random (20.00^{a}) and dry bed (19.64^{a}) method of transplanting were statistically at par and highest in value for sterility percentage followed by open (17.68^{b}), SRI (16.73^{bc}) and straight row (16.12^{c}) method, the least of all. SRI method of transplanting exhibited highest mean value for number of tillers/m^2 (294.4), thousand grain weight (22.87^{a}), effective number of tillers/m^2 (254.8^{a}), grain yield (4.475 t/ha) and second lowest sterility percentage and plant height after straight row method of transplanting. Straight row method of transplanting exhibited highest mean value for plant height (39.36 cm, 43.02 cm, 43.91 cm and 102.28 cm) and lowest sterility percentage (16.12^{c}) but, showed comparatively poor performance in other parameters in respect to SRI method of transplanting. Dry bed method, as a whole, comparatively exhibited the worst performance of all and thus, categorized as control treatment. This study suggests that SRI method of crop establishment is an easy and effective technique for improving physiological and yield attributing characters of spring rice.

KEYWORDS

SRI, Crop establishment techniques, Spring rice, Hardinath-1.

1. INTRODUCTION

Rice (*Oryzae sativa* L.) is a perennial grass belonging to family Poaceae/Graminae. There are about 23 species of rice out of which only two species have been known for their wide domestication and commercial value. These two species are *Oryzae sativa* (Asian rice) and *Oryzae glaberrima* (African rice) (Ajaib, 2014). Globally, rice ranks second to wheat in terms of area harvested, but in terms of importance as a food crop, rice provides more calories per hectare than any other cereal crops. Rice is the staple food of more than 60% of the world population. Rice is grown from 50 ° N latitude to 40 °S latitude from equator. In Nepal, rice ranks first both in terms of area cultivated, production and livelihood of people (Ajaib, 2014). More than 1, 700 rice landraces are reported in Nepal growing from 60 to 3,050 m altitude (Amod, 2011). The total area, production and yield of rice in Nepal are 14,69,545 ha, 51,51,925 MT, and 3506 kg/ha respectively (Anas et al., 2011). Rice is a widely cultivated crop of Nepal with about 51.45% of total edible cereal production in the country (Anas et al., 2011). Cereals provide 65 percent of the total Dietary Energy supplies to Nepalese people and out of which, 30 percent is contributed by rice alone (Awan, 2011).

In Nepal, rice is grown in three agro-ecological regions (Terai and inner terai- 67 to 900 masl, Mid hills- 1000 to 1500 masl, and High hills- 1500 to 3050 masl) and three major production environments; irrigated, rain-fed lowland and upland (Ajaib, 2014). The Terai region, considered the granary of the country, accounts for about 70 percent of the country's rice output, while the hill produces 26 percent and the mountain produces about 4 percent (Ajaib, 2014). Dhanusha district lies between latitude 25° 35' to 27° 50' due North and longitude 85°50' to 86°20' due East. The district is located in the elevation range of 60.89 to 609.76 metres above the sea level. The total area of the district is 1180 square kilometer. Rice is the major crop grown in almost all areas of Dhanusha. The area, production and yield in the fiscal year 2072/73 in Dhanusha district was 35,200ha, 1,21,100 Mt and 3.44 Mt/ha respectively (Awan, 2011). Also, the productivity of irrigated land in 2063 B.S was 3.2Mt per ha and in 2072 B.S it was 4.1 Mt per ha (Awan, 2011). The different source of irrigation in

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Dhanusha district consist of kamala irrigation ha project, the first irrigation ha project, second irrigation sector plan and many more sub-irrigation projects (Awan, 2011; Balachandra, 2007; Barison, 2003; Bedi, 2013; Cao, 2002; CDD, 2015; Ceesay, 2006). Main varieties of rice cultivated in this region are Lalka basmati, Sabitri, Hardinath-1, Ram dhan, Swarna sub-1, Sukkha-1, Sukkha-2 and Sukkha-3. Maximum land areas are under rain-fed condition.

1.1 OBJECTIVES

1.1.1 General objective

- To study and assess the feasibility of spring season rice cultivation practices in the Dhanusha district.

1.1.2 Specific objectives

- To be familiar with the various methods of rice crop establishment
- To assess the comparative advantage of one method of rice crop establishment over the other
- To suggest farmers to adopt the best crop establishment method depicted by the research

2. MATERIALS AND METHODS

2.1 Site selection and research design

Field experiment was carried out in the farmer's field at Tetariya Bazaar, Janakpurdham-17, located at Province No. 2 of Nepal. Seed rate of 40 kg/ha (Hardinath-1) was used for this purpose. Five treatments and four replications were taken. 100 grams of healthy, bold and pure seeds of Hardinath-1 variety of Spring season rice were allocated for each plot under various methods of crop establishment in single factorial RCBD design. Fertilizers were applied at 100:30:30 NPK kg/ha (Chapagain and Yamaji, 2010; Chaudhary, 2007; Chen et al., 2013; DADO, 2072/73; DADO, 2072/73). The net plot size was allocated as 9 square metre each. 100 cm was left between the plots and 1m in between the replication plots. FYM was applied 2 weeks before sowing date. Irrigation was given at 15 days' interval. Observation and measurement were recorded for number of tillers emerged, plant height, days of heading, days of floral initiation etc.

T1R1	T2R2	T5R3	T3R4
T3R1	T4R2	T4R3	T2R4
T5R1	T1R2	T2R3	T5R4
T2R1	T3R2	T1R3	T1R4
T4R1	T5R2	T3R3	T4R4

Layout of the Field
Inter-plot distance in between a replication: 100 cm
Inter-replication distance: 100 cm (1 Metre)
Treatments: A total of 4 replications each was constructed. The experiment was done in single factorial RCBD design.
The treatments are:
T1 – Open transplanting
T2- Straight row transplanting
T3- SRI system of rice cultivation
T4 – Random transplanting (Farmer's transplanting method)
T5 – Dry bed transplanting (Unpuddled transplanting)

3. OBSERVATIONS

3.1.1 Morphological observations

Random sampling was followed for sampling plants on parameters like number of tillers and plant height in cm. For sampling on further parameters, ten plants were randomly selected and tagged and data collection were made on the basis of morphological observation.

3.1.1.1 Plant Height (cm)

The height of the main shoot of randomly selected sample plants was measured from the base of the plant to the tip of the longest leaf. After panicle emergence, height was measured from the base of the plant to the tip of the panicle or leaf, which ever was longest. The observations were recorded at 27, 41, 56 DAT and at harvest.

3.1.1.2 Number of tillers/m²

The counting of tillers/m^2 was taken at each plot at 27, 41 and 56 DAT then, average was worked out.

3.1.2 Phenological studies

3.1.2.1 Days to tillering

Number of days from transplanting to 50% tillering in the field. It was recorded as 23 DAT on 21st April.

3.1.2.2 Days to Panicle initiation

Number of days from transplanting to 50% panicle initiation stage in the field. It was recorded as 54 DAT on 23rd May.

3.1.2.3 Days to heading and flowering

Number of days from transplanting to 50% heading and flowering in the field. It was recorded as 64 DAT on 1st June.

3.1.2.4 Days to maturity

Number of days from transplanting to complete maturity.

3.1.3 Yield attributing characters

3.1.3.1 Plant population/m2

Total number of plant/m row length was counted from selected randomly four rows in one metre row length in each plot.

3.1.3.2 Panicle length (cm)

Five panicles from each plot were selected randomly at the time of harvesting and length of each panicle was measured from the base to tip of panicle with the help of scale. Thereafter, mean length of panicle was calculated.

3.1.3.3 Number of grains/panicle

Total number of grains from five randomly selected panicles was counted. Thereafter, mean number of grains per panicle was computed.

3.1.3.4 Number of healthy (Filled) grains/panicle

Total number of grains from five randomly selected panicles were separated and counted. Later filled grains were counted manually. Thereafter mean filled grains per panicle were computed.

3.1.3.5 Number of chaffy grains/panicle

Chaffy grains were worked out by subtracting the filled grains from the total grains obtained from five randomly selected panicles as done for above observation. Then mean chaffy grains per panicle were worked out.

3.1.3.6 Test weight of grains (1000-grain weight)

Grain samples were drawn randomly from the total produce of each net plot at the time of weighing and 5000 grains were counted manually. Thereafter, the weight of these grains was recorded on electronic balance and mean test weight was computed by dividing the total weight of 5000 grains with 5.

3.1.4 Yields

3.1.4.1 Grain yield q/ha

After winnowing and cleaning, the grain yield obtained from each plot, were weighed on double pan balance. Later it was converted into grain yield q/ha by multiplying with appropriate factor.

3.2 Statistical analysis

The data recorded on different observations were tabulated and analyzed statistically by using the techniques of analysis of variance (ANOVA) through statistical package- Genestat, 15th edition. Critical difference at 0.05 probability level was worked out to compare the treatments when 'F' test was found significant and the means were compared using Duncan's Multiple Range Test. (DMRT)

4. Results and Discussion

The analysis of data provided various results which are presented and discussed below.

4.1 Number of tillers per square meter

Table 1: No. of tillers per square meter as influenced by crop establishment techniques

Treatments	No. of tillers per square metre
Open	219.8^{c}
Straight row	256.0^{b}
SRI	294.4^{a}
Random	202.0^{cd}
Dry bed	185.5^{d}
Grand mean	231.5
CV(%)	6.8
SEM(±)	7.82
$LSD_{0.05}$	24.09

Note: CV, Coefficient of variation; LSD, Least Significant Difference; SEM (±), Standard error of mean. Letters a, b, c, d represents the ranking of treatments according to DMRT at 0.05 level of significance. Number of tillers/m^2 was affected significantly by different methods of crop establishment. (Table 1). Analysis of data revealed that SRI method of transplanting produced maximum average number of tillers per square metre (294.4) as compared to straight row/line (256), open (219.8), random (202) and dry bed method of transplanting (Farooq et al., 2009; Gayathry, 2002; Guohua, 2003; Janarthanan, 2008; Joshy, 1997). Dry bed method produced significantly least average number of tillers per square metre (185.5). All the treatments responded differently to the parameter. The SRI planting with two-way rotary weeder weeding thrice at weekly interval starting from 15 DAT in transplanted rice produced more number of tillers per m^2 (Balachandra, 2007). Wider the spacing provided, the tillers per hill produced are higher (44) than closer spacing. In cluster planting (two or four seedlings together), there were initially more primary tillers and ultimately lesser tillers (40.0-42.2) per hill due to mutual competition (Barison, 2003; Kavitha, 2011; Krishi Diary, 2005; Krishna, 2008; Kumar, 2007; Ladha, 2009; Mallick, 1981; Manjunatha et al., 2010; MoAD,CBS and FAO, 2016; MoALD, 2018/19; MoALD, 2072/73; Mof, 2018; Mura, 2013-2015; Nissanka and Bandara, 2004; Pandey and Velasco, 2005). It was observed that the roots of rice plants have least competition under wider spacing so that growth is stimulated by sunlight and space for the canopy expansion (Bedi, 2013).

4.2 Panicle length in cm

Table 2: Panicle length as influenced by crop establishment techniques

Treatments	Panicle length in cm
Open	21.40^{b}
Straight row	23.38^{b}
SRI	25.53^{a}
Random	23.32^{b}
Dry bed	23.22^{b}
Grand mean	23.37
CV(%)	5.3
SEM(±)	0.618
$LSD_{0.05}$	1.904

Note: CV, Coefficient of variation; LSD, Least Significant Difference; SEM (±), Standard error of mean. Letters a, b, c, d represents the ranking of treatments according to DMRT at 0.05 level of significance

Panicle length was significantly affected by different method of crop establishment. (Table 2) Data analysis through Genestat and comparison using DMRT revealed that SRI method of transplanting produced highest average panicle length/cm i.e, 25.53 cm as compared to straight row (23.38 cm), open (21.40 cm), random (23.32 cm) and dry bed (23.22 cm) method of transplanting. When all the four components of SRI viz., young seedling, one seedling, square planting and conoweeding were combined, it gave more number of panicles per hill (17), panicle length (23 cm), panicle weight (2.13 g), number of filled grains per panicle (101) which ultimately resulted in higher grain (3682 kg ha^{-1}) and straw yield (5010 kg ha^{-1}) and improved harvest index (0.424) in short duration rice variety ADT 43 during kharif season (Balachandra, 2007; Prasad, 2004; Rajesh and Thanunathan, 2003; Raju, 2008; Rao et al., 2007; Reddy, 2005; Saha, 2010; Sanchez, 1973; Shao-hua, 2002; Sharma, 2003; Sheehy, 2004).

4.3 Plant Height

Table 3: Plant height as influenced by crop establishment techniques

Treatments	Plant height (cm)			
	25th April	10th May	25th May	At harvesting
Open	33.31^{b}	39.36^{b}	40.62^{b}	98.5^{bc}
Straight row	39.36^{a}	43.02^{a}	43.91^{a}	102.28^{a}
SRI	35.15^{b}	37.35^{b}	39.01^{b}	100.18^{ab}
Random	33.96^{b}	40.23^{ab}	41.93^{ab}	99.70^{ab}
Dry bed	34.33^{b}	38.72^{b}	40.40^{b}	96.08^{c}
Mean	35.222	39.736	41.174	99.348
CV (%)	7.6	5.2	4.4	2.0
SEM (±)	1.895	1.450	1.293	0.980
$LSD_{0.05}$	4.128.	3.159*	2.818*	3.020**

Note: CV, Coefficient of variation; LSD, Least Significant Difference; SEM (±), Standard error of mean. Letters a, b, c, d represents the ranking of treatments according to DMRT at 0.05 level of significance

Plant Height was affected significantly by the method of crop establishment. (Table 3) It is evident from the above table that the height of sample plants gradually increased in rate over successive growth stage till May and decreased afterwards (Singh, 1999; Solanki, 2011; Sridevi and Chellamuthu, 2007; Sridevi, 2011; Surendra, 2001). The highest recorded height of 39.36 cm, 43.02 cm, 43.91 cm and 102.28 cm was found under straight row method of transplanting. No statistical difference was found in between open, SRI, Random and Dry bed method of transplanting at 27 DAT however, a significant difference in height was exhibited at the time of harvesting. In an experiment conducted to test the productivity of System of Rice Intensification (SRI) method over the conventional rice farming systems in Sri Lanka, average plant height growth and leaf chlorophyll content during the growing stages were also similar among the treatments (Cao, 2002). The slight inferior response of SRI in respect to conventional method of transplanting may be due to detrimental weather condition and water stress during the mid-period of crop.

4.4 Sterility Percentage

Table 4: Sterility percentage as influenced by crop establishment techniques

Treatments	Sterility %
Open	17.68^{b}
Straight row	16.12^{c}
SRI	16.73^{bc}
Random	20.00^{a}
Dry bed	19.64^{a}
Grand mean	18.034
CV(%)	3.9
SEM(±)	0.347
$LSD_{0.05}$	1.071

Note: CV, Coefficient of variation; LSD, Least Significant Difference; SEM (±), Standard error of mean. Letters a, b, c, d represents the ranking of treatments according to DMRT at 0.05 level of significance

Sterility percentage was significantly affected by different methods of crop establishment as depicted by Table 4. Data analysis revealed that random method of crop establishment has significantly highest average sterility percentage (20%). However, there is no statistical difference between random and dry bed method of transplanting. Straight row/ line method of transplanting has least average sterility percentage (16.12%). In an experiment conducted at rice zone of Punjab, sterility percentage was maximum (16.46) in farmer's practice of random transplanting and was significantly different from line transplanting (10.34) and open transplanting (10.09) (CDD, 2015). In farmer's practice of random transplanting, the tiller mortality rate and sterility percentage is higher as compared to other methods since, there is greater competition for nutrient, space, water and light (Thakur, 2010; Thiyagarajan, 2002; Thiyagarajan, 2006; Tripathi, 2005a; Triveni, 2006).

4.5 Effective number of tillers per square meter

Table 5: Number of effective tillers per square meter as influenced by crop establishment techniques

Treatments	Effective tillers per square meter
Open	179.0^{c}
Straight row	214.8^{b}
SRI	254.8^{a}
Random	170.8^{cd}
Dry bed	146.2^{d}
Grand mean	193.12
CV(%)	10.2
SEM(±)	9.81
$LSD_{0.05}$	30.23***

Note: CV, Coefficient of variation; LSD, Least Significant Difference; SEM (±), Standard error of mean. Letters a, b, c, d represents the ranking of treatments according to DMRT at 0.05 level of significance

Different methods of crop establishment had significant effect on effective number of tillers per square method as depicted by table 5. SRI method of crop establishment exhibited significantly highest average effective number of tillers per square meter as compared to other methods followed by straight row method of transplanting. Dry bed method of transplanting exhibited the worst performance of all (Uphoff, 2009). The percentage of effective tiller production was highest in SRI method in both the seasons followed by seedling throwing method due to less number of tiller abortion. In other methods tiller abortion started 20 days earlier than SRI method and it continued till panicle initiation stage. A group researchers found in an experiment the increase in the productive tillers with SRI method was to the extent of 217% over traditional method (Ceesay, 2006; Chapagain and Yamaji, 2010). The increase in the effective tillers per plant might be due to the better spacing provided to the plants by planting in square method (Upphoff, 2002; Uprety, 2005; Wang, 2003; Yasmeen, 2010; Zhang, 2009). Profused tillering due to lower plant density was noticed under wider spacing compared to closer spacing. A group researchers stated that conversion of the majority of the tillers into productive tillers have facilitated better utilization of resource by the plant in SRI system (Chaudhary, 2007; Chen et al., 2013; DADO, 2072/73; Farooq et al., 2009; Gayathry, 2002; Guohua, 2003; Janarthanan, 2008; Joshy, 1997).

4.6 Thousand grain weight

Table 6: Thousand grain weight as influenced by crop establishment techniques

Treatments	Thousand grain weight
Open	21.37^{c}
Straight row	22.07^{b}
SRI	22.87^{a}
Random	20.82^{c}
Dry bed	21.47^{bc}
Grand mean	21.72
CV(%)	1.9
SEM(±)	0.2098
$LSD_{0.05}$	1.23***

Note: CV, Coefficient of variation; LSD, Least Significant Difference; SEM (±), Standard error of mean. Letters a, b, c, d represents the ranking of treatments according to DMRT at 0.05 level of significance

Different methods of crop establishment significantly affected thousand grain weight as depicted by table 6. The statistical analysis suggests that SRI method of crop establishment exhibited highest mean thousand grain weight (22.87^{a}) followed by straight row method of transplanting (22.07^{b}). However, there was no statistical difference in thousand grain weight among open (21.37^{c}) and random (20.82^{c}) method of transplanting and both exhibited the lowest mean value of thousand grain weight. Some researchers observed the individual grain weight of rice slightly varied due to planting of rice on different dates. Heavier grain weight was found in early planted crop and grain weight decreased with the delay transplanting. Probably the grain filling was hampered due to late planting and decreased individual seed weight.

4.7 Grain yield

Table 7: Grain yield as influenced by crop establishment techniques

Treatments	Grain yield t/ha
Open	4.45^{a}
Straight row	4.45^{a}
SRI	4.475^{a}
Random	4.1^{b}
Dry bed	4.25^{b}
Grand mean	4.345
CV(%)	2.3
SEM(±)	0.05
$LSD_{0.05}$	0.154

Note: CV, Coefficient of variation; LSD, Least Significant Difference; SEM (±), Standard error of mean. Letters a, b, c, d represents the ranking of treatments according to DMRT at 0.05 level of significance

Grain yield was significantly affected by different methods of crop establishment as exhibited in table 7. From the analysis, it was evident that there was no statistical difference in grain yield between open (4.45 t/ha), straight row (4.45 t/ha) and SRI (4.75 t/ha) method of transplanting although, SRI produced highest average grain yield. Also, there was no statistical difference in grain yield for random (4.1 t/ha) and dry bed (4.25 t/ha) method of transplanting. A research insisted no significant yield advantages for SRI over 'best management practices' (BMPs) documented experimentally except from Madagascar trials. Grain yield was found significantly higher in case of SRI method of crop establishment technique than that of conventional technique in both the years. The pooled mean value was also found to be higher in case of SRI technique than that of conventional method (Chen et al., 2013). In an experiment conducted to test the productivity of System of Rice Intensification (SRI) method with conventional rice farming systems in Sri Lanka, dry weight of stems, leaves, and roots and the total dry weights, leaf area and total root length per hill during the growing period and the tiller number per plant at heading were significantly higher in SRI compared to other treatments. However, all these parameters, when expressed per unit area basis, were not significantly different (Cao, 2002).

5. Conclusion

The effect of different crop establishment techniques in growth and yield of spring rice (Hardinath-1) was studied and the effect of crop establishment techniques on number of tillers/m^2, effective number of tillers/m^2, plant height, panicle length, thousand grain yield, grain yield and sterility was assessed. Three averaged data across different dates of 15 days' interval suggested that SRI method of crop establishment exhibited highest average number of tillers/m^2 (294.4), highest average effective number of tillers/m^2 (254.8), highest average thousand grain weight (22.87 gm), highest average panicle length (25.53 cm), highest grain yield (4.475 t/ha) and low sterility percentage (16.73%). Though, straight row method of transplanting exhibited lowest possible sterility percentage (16.12%) and highest mean values of plant height (39.36 cm, 43.02 cm, 43.91 cm and 101.98 cm), this method is not superior to SRI in other context of more significant differential parameters contributing to physiology and yield of spring rice. Dry bed method was evaluated as least productive method or control plot/treatment. All other treatments of crop establishment except dry bed method of transplanting performed better result than control treatment. Concluding at a point, SRI method of crop establishment proved to be the best alternative for crop establishment technique. The better performance of SRI method of transplanting may be due to increased microbial activity led by facilitation of aeration which caused increased enzymatic activities (amylase, catalase and dehydrogenase) and higher net photosynthesis in SRI rice.

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