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Research Article

Effects of varieties and planting geometries on growth and yield of rain-fed rice in Dailekh, Nepal

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ABSTRACT
A study was conducted at outreach sites of Horticulture Research Station, Dailekh with the objective of understanding effects of variety selection and spacing under rain-fed condition, during two rainy seasons of 2016 and 2017. Experiment was conducted in two factorial Randomized Complete Block Design where the research sites were replication itself. First factor was variety, including Khumal-10 and farmer's variety. The second factor was spacings at 20 cm x 20 cm, 20cm x 15 cm, 15 cm x 15 cm, and farmer's practice. Effect of Khumal-10 was significantly superior in each of the parameters studied, except days to heading and maturity. Khumal-10, alone contributed 21.6% more yield compared to the farmer's variety and also had the tallest plant (127.5 cm) and longest panicle (23.4 cm). Similarly, transplantation at spacing of 15 cm x 15 cm was significantly outstanding with 28.6% more grain yield, unlike in transplantation with farmer's practice. Furthermore, integrated management of rice with Khumal-10 transplanted at spacing of 15 cm x 15 cm is recommended for Dailekh condition, since it resulted significantly promising grain yield of 5.5 t/ha, which is 71.9% more in comparison to grain yield from farmer's variety transplanted in farmers´ practice. Also, the economic benefit was highest with 75.8% more B:C ratio in case of improved variety Khumal-10 transplanted at 15 cm x 15 cm spacing.

Keywords: Crop geometry, rice, spacing, variety, yield

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INTRODUCTION

Rice ranks first in terms of area (1363 thousand hectares), production (4299 thousand tons) and livelihood of the people of Nepal, engaging 65.6% of the national population in the agricultural operation (ABPSD, 2016). It accounts for one-fifth (20%) of the agricultural GDP. Rice only accounts for more than 50% of the total calories of Nepalese people (Kharel et al., 2018: Gadal et al., 2019). To feed ever increasing population, rice production in Nepal has to be increased over 6.0 million tons by 2020 to meet the growing demand of ever-increasing population (Kharel et al., 2018). However, the productivity has been very low measuring 3.15 t/ha (ABPSD, 2016). Majority of rice is cultivated under the rain-fed condition in Nepal, due to which the yields are not only low in upland but also in the lowland rain-fed areas. Rice is cultivated at altitudes ranging from 60 to 3050 m above seas level. This variability permits farmers in flexibility for adoption of many varieties (Shrestha *et al.,* 2012).

Several rice varieties have been developed by NARC but the yield gap exists between the research stations and the farmer's field, all over the country. Although, the potential yield of rice varieties come to be 4.89 t/ha, the yield gap between the potential yield and actual yield at the farm level is 54% per unit of land area (CDD, 2015). The human population of the world is increasing geometrically and IRRI (2009) has mentioned that by 2025, the growing need of human population will require 25% more rice. The land area is fixed. Moreover, the cultivable land is degrading with the time spend. Thus, food problem caused by ever-increasing population could be addressed by technology development such as domain based suitable varieties and crop management techniques such as crop geometry, water, nutrient and disease-pest management and also integrated management of such techniques.

Dailekh is one of the remote districts of Nepal and is situated in the far-flung sides of mid-western region with agriculture as the basic walk of life of the people. A study by CBS (2013) shows that out of 32139 hectares (ha) of cereal grains cultivation area, the paddy cultivation consists only 1062 ha land including the early, main and upland paddy area, with main season paddy occupying majority of 6544 ha land area. ABPSD (2016) recorded the production area of rice in Dailekh to be 8307 ha, with production of 5580 tons of grains and 1822 kg ha^{-1} yield. Mostly, the rice cultivation is done in the rain-fed condition in this district. The miserable condition of rice production in terms of lesser production area and lesser productivity in this district may be due to the long dry spell ruling over the cropping season, drying of the water resources along with the outdated technologies prevailing in the rice cultivation. Since successful rice production is the outcome of interaction of several production factors such as variety, spacing, soil nutrient and water management and disease, pest and weed management, a proper management of such factor would induce a best yield of rice.

Integrated Crop Management (ICM) is the holistic approach for solving all the problems related to crop production and combining the best traditional methods with appropriate modernized technology, balancing the economic production of crops with positive environmental management. Depending on the need and profitability, farmers integrate new technologies with existing farmer's practice, which is referred to as ICM (Ladha et al., 2009). The recent studies have reported greater improvement in yield with ICM technique in

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comparison with individual crop production factor (Regmi et al., 2009; Qin et al., 2013; Peng et al., 2015).

Farmer's field yield of rice could be increased with the appropriate selection of varieties recommended to the area. Crop varieties play a distinctive role in maximizing the yield by improving the input use efficiency as the genetic potential of variety limits the expression of its yield and affects plant growth in response to environment condition. Similarly, spacing depends upon the expected growth of a particular crop in a given set of agro-climate, which determines the plant density in field. The lack of knowledge and necessary information on plant population management practices is still a major constraint. Rice growth is known to be affected both qualitatively and quantitatively by plant population densities. The closer spacing of 15 cm x 10 cm, 15 cm x 15 cm and 15 cm x 20 cm were found superior to wider spacing of 30 cm x 10 cm, 20 cm x 20 cm and 15 cm x 25 cm by producing more effective tillers per unit area, higher plant height, higher leaf area index and total dry matter accumulation by several authors viz. Chandrakar et al. (1994), Jashim et al. (2011) and Rasool et al. (2013). The optimum plant spacing maintains better conditions for plant growth, which results in timely beginning of the tillering, reproductive and sink formation. Thus, the establishment of optimum plant population in a unit area is the contributory factors which helps determine the greater yield of rice.

The farmers of the Dailekh district have been practicing their own method of rice transplantation, which is random transplantation without proper spacing between rows and plants. Also, their own farmer's variety has been in use for ages. The reason behind farmers following their prevalent farmer's variety may be the lack of extension service or outreach researches and also the lack of demonstration about the new innovative and integrative method of rice cultivation. Further, the various socio-economic aspects like unavailability of domain-specific improved varieties in such remote areas and farmer's urge for more straw yield for their livestock compromising the grain yield could be another reason. Needless to mention that the production of rice through their farmer's variety practice is not satisfactory, agronomist challenge is to find remedy to these problems. Hence, this research had been conducted in the outreach sites of HRS, Dailekh to exhibit the importance of variety and spacing in the rice cultivation and to demonstrate the effects of their interactions in various yield parameters and yield of rain-fed rice, eventually developing a recommendable technology for higher grain yield.

MATERIALS AND METHODS

Experimental location, design and planting methods

An experiment was conducted to study the effects integration of different crop management techniques in rice production at outreach sites of HRS, Dailekh district. Experiment was carried out in RCBD with three replication each during 2016 and 2017. There two factors in the experiment: genotypes (varieties) and spacing. Seed bed was prepared at the last week of June of both years and seedling was transplanted during mid- July with plant to plant and row to row spacing of (20x20) cm, (20x15) cm, (15x15) cm, and farmers practice, according to the treatment factor. The two varieties studied were Khumal-10 and the farmer's variety. Khumal-10 variety was procured from National Rice Research Program (NRRP), Hardinath.

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The duration for maturity of Khumal-10 is recorded to be 136 (107 to 170) DAS with attainable yield of 4.78 t ha^{-1} and is recommended variety for hilly areas of Nepal (ABPSD, 2019). The local variety is the prominent rice variety of the research site farmers which was procured from the farmer's household. Each plot size was maintained at 3m x 4m= $12m^2$. The recommended dose of FYM at the rate of 6 t/ha and fertilizers at the rate of 100:30:30 kg NPK/ha was applied along with implementation of other package of practices. All phosphorous (in the form of DAP), potassium (in the form of MOP) and half dose of nitrogen (in the form of Urea) recommended for rice was applied and incorporated in the soil before transplanting. The remaining half dose of N was split into two doses: one fourth is applied as a top dressing 20-30 days after transplanting and the next one fourth is applied 40-50 days after transplanting.

Data collection

The regular field monitoring and supervision was conducted for data recording, appropriate intercultural operations and providing technical suggestions to the farmers about timely weeding and irrigation, if possible. The data on days to heading was collected on the frequent field visits, at the stage of 50% emergence. Days to maturity was recorded later with the observation of change in color and dryness in panicles. Rest of the parameters studied was noted during the time of harvest. Ten sample plants of each plot were taken randomly for measurement of the average plant height and their respective average panicle length. The effective tillers per hill were counted by taking 15 sample hills per plot, at the standing crop stage before harvesting. The panicle length was measured from the basal spikelet branching to the apical grain. The crop was harvested, threshed and moisture of harvested grains was maintained to 12% by sun-drying and the final grain yield was recorded.

Climatic condition during the experimental period

All the required metrological data during the experimentation were taken from the metrological station of Mid and Far-Western Regional Meteorological office, Surkhet. The experimentation duration was from July to November each year. The total rainfall of 1428 mm and 1467.2 mm was received during the entire period of experimentation from June to November in 2016 and 2017 respectively. In 2016, the highest rainfall was recorded in July (586.6 mm) and minimum or no rainfall was recorded in April, November, and December (0 mm). During intensive growth period up to 60 DAT, the crop received average rainfall of 305.6 mm per month with total rainfall of 122.4 mm in 2016. The mean maximum temperature up to 60 DAT (before start of heading) was found to be 27.18 °C ranging from 28.4 °C in June to 27.5 °C in September during 2016. Similarly, the mean minimum temperature up to 60 DAT (before start of heading) was found to be 19.58 °C ranging from 19.3 °C in June to 19.3 °C in September. After 60 DAT (after start of heading) the mean maximum temperature was found to be 23.9 °C and mean minimum temperature was found to be 14.3 °C. The highest mean maximum temperature recorded in June (28.4 °C) and the lowest mean minimum temperature recorded in November (11.7 °C) during the crop period.
Similarly, in 2017, the highest rainfall was recorded again in July (607.2 mm) and the month of November recorded no rainfall. The crop received average rainfall of 209.1 mm per month with total rainfall of 1254.6 mm in 2017. The mean maximum temperature up to 60 DAT (before start of heading) was found to be 27.80 °C ranging from 31.5°C in June to 28°C in September during 2017. Similarly, the mean minimum temperature up to 60 DAT (before

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start of heading) was found to be 20.1°C ranging from 20.8°C in June to 19.6 °C in September. After 60 DAT (after start of heading) the mean maximum temperature was found to be 25.8°C and mean minimum temperature was found to be 15.55°C. The highest mean maximum temperature recorded in June (31.5°C) and the lowest mean minimum temperature recorded in November (13.2°C) during the crop period. Benefit cost ratio was estimated using formula adopted by Shrestha et al. (2019), Subedi et al. (2019) and Shrestha (2015).

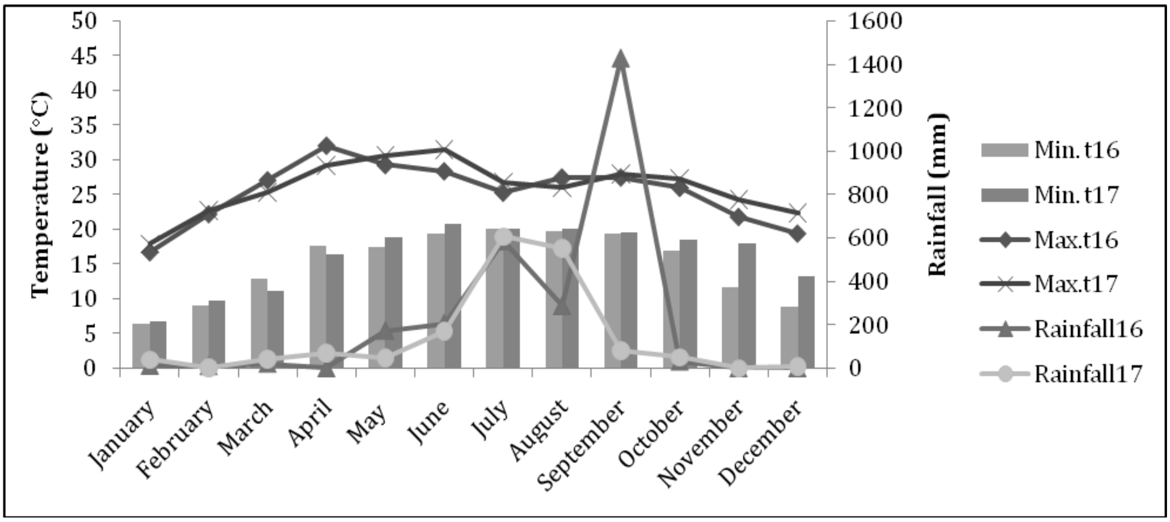

Figure 1. Weather data during the experimentation period at HRS, Dailekh, Nepal during 2016 and 2017.

Statistical analysis

The weather data and observational data were recorded and entered into MS-Excel 2016.
The analysis of variance was performed using two factorial RCBD design to derive variance components in the GenStat statistical package (16th edition) (Payne et al., 2009; Sharma et al., 2019). The mean comparisons among treatment means were estimated by the least significant difference (LSD) test at 5% levels of significance (Jan et al., 2009; Kandel & Shrestha, 2019; Sharma et al., 2016; Shrestha, 2019; Baral et al., 2016).

RESULTS AND DISCUSSION

Effect of genotype (varieties)

Effect of varieties under study showed highly significant effect on plant height (PH) and effective tillers (ET). Similarly, very highly significant effect was seen on panicle length (PL) and yield whereas non-significant effects were on days to heading (DH) and maturity (DM). The plant height was measured significantly highest in the Khumal-10 variety, in both of the research conducted years, with the mean height of 127.5 cm in Khumal-10 while the farmer's variety averaged to the height of 112.4 cm. Similarly, the number of effective tillers per hill was counted significantly highest in the farmer's variety as compared to the improved variety of rice (Khumal-10) in each of the year, which showed the mean effective tillers per hill of 10 and 8 respectively. The highest number of effective tillers per hill in the improved variety was contributed by its genetic ability. Similar finding was reported by Islam et al. (2013) and

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Emeteas et al. (2018) who explained the reason of variation in the number of effective tillers per hill is due to the genetic makeup of varieties. The number of effective tillers per hill was significantly influenced by the varieties Alam et al. (2012). This shows, besides the unavailability of the improved variety, the higher preference of the farmers to their rice variety is due to such higher number of effective tillers per hill, contributing to the higher straw yield as they have to rear their livestock along with agricultural production.

Furthermore, panicle lengths varied with very high significant differences each year. Khumal-10 with significantly longest panicle (25.2 cm) was measured in the initial year followed by shortest panicle (22.8 cm) in farmer's variety. In later year, the Khumal-10 and farmer's variety again recorded the respective maximum (23.4 cm) and minimum (20.8 cm) panicle length. The overall analysis showed the longest panicle of 23.4 cm in Khumal-10 and the average shortest panicle in farmer's variety with 20.8 cm. This variation assessed in the panicle length may be due to genetic background of varieties. Similar, results were supported by Idris and Matin (1990), Islam et al. (2013) and Hasan et al. (2015).

The yield analysis showed non-significant effect of variety over the grain yield in the initial year. However, in the later year, grain yield was recorded significantly highest (4.3 t/ha) in the Khumal-10 variety followed by the lowest grain yield (3.3 t/ha) in farmer's variety. Overall, the average grain yield was found highest (4.5 t/ha) in Khumal-10 whereas, the average grain yield was lowest (3.7 t/ha) in farmer's variety. Sohel et al. (2009) reported that these variations in grain yield among the cultivars might be due to genetic makeup of the varieties, which is also supported by Islam and Salam (2017). The highest grain yield in Khumal-10 variety resulted due to the cumulative effects of higher number of effective tillers per hill and longer panicle length. The grain yield is the function of interplay of various yield components such as the number of productive tillers, spikelets per panicle and 1000 grains weight (Hassan et al., 2003). The finding of our research is accordance with Alam et al. (2012) who explained that the characters contributing highest grain yield such as number of total tillers per hill, number of effective tillers $hill^{-1}$, panicle length, fertile spikelets $panicle^{-1}$ and 1000-grain weight probably contributed to the highest grain yield. Although days to heading and maturity was seen with non-significant effects of genotypes over the year of experimentation, heading was significantly earlier (86 DAS) in farmer's variety during the initial year and days to maturity was earlier (119 DAS) in Khumal-10 in the later year.

Effect of spacing

The effect of spacing pooled over the years was seen significantly highest on days to heading, panicle length and yield whereas the remaining parameters were detected with non-significant differences. In 2017, days to heading was significantly earlier (86 DAS) in the plots with seedling spaced at (20x15) cm which is similar in the cumulative observation of both years. Days to heading was followed insignificantly by (15x15) cm (88 DAS) over the year where the late heading (92 DAS) was observed in (20 x 20) cm spacing. The days to maturity was seen with significant effect of spacing only in the initial year with earliest maturity (119 DAS) in (15x15) cm followed with insignificant difference by farmer's practice (120 DAS). In 2017, both panicle length and yield differed with high significance showing the longest panicle (22.6 cm) and highest yield (4.4 t/ha) in (15 x 15) cm spacing. The overall effect of spacing with significantly longest panicle (23.2 cm) and highest yield (4.5 t/ha) was

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observed in (15 x 15) cm followed by (20 x 20) cm (22.8 cm and 4.1 t/ha respectively). Contrastingly, the farmers practice cumulatively showed the shortest panicle (20.3 cm) and minimum yield (3.5 t/ha). Our findings showed that the closer spacing of (15x15) cm as the best spacing for the condition of Dailekh district. However, several authors have recommended several spacing in rice for the better crop management and higher yield that is based on the prevalent environmental, edaphic, and climatic conditions of the research area along with the varietal requirement. The production of highest grain yield at spacing of (15×20) cm was reported by Uddin et al. (2011). Buri et al. (2016) have recommended wider spacing of (25 x 20) cm and (20 x 20) cm for rain-fed lowland rice production in Ghana.

Table 1: Effects of genotypes and spacing in the performance of rice under the ICM at the outreach sites of HRS, Dailekh, 2016 and 2017

	Days to Heading (DAS)			Days to Maturity (DAS)			Plant Height (cm)		
Treatments	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
Varieties									
Khumal-10	89	90	89	122	117	119	135.9	122.5	127.5
Farmer’s variety	86	89	88	122	120	121	124.7	104.9	112.4
F-test	*	NS	NS	NS	*	NS	*	*	**
LSD (0.05)	2.889	2.191	1.737	3.216	2.482	2.040	11.02	9.36	6.66
Spacing (cm)									
(20x20)	88	94	92	126	119	121	132.2	118.9	123.9
(20x15)	87	86	86	123	119	120	132.8	109.1	117.9
(15x15)	87	89	88	119	119	119	127.9	116.7	120.9
Farmer's Practice	88	89	89	120	119	119	128.4	110.2	117.0
F-test	NS	**	**	*	NS	NS	NS	NS	NS
LSD (0.05)	4.086	3.099	2.456	4.549	3.510	2.885	15.59	13.42	9.43
Interaction									
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD(0.05)	5.778	4.382	3.474	6.433	4.964	4.080	22.05	18.73	13.33
CV (%)	3.8	3.8	3.9	3	3.2	3.4	9.7	12.7	11.1

*Note: LSD= Least Significant Difference, CV= Coefficient of Variation. NS, * and ** indicate non-significant, significant at P<0.05 and significant at P<0.01 respectively.*

Interaction effect of genotype and spacing

The interaction effect of variety and spacing was significant in panicle length and highly significant in yield whereas the effect was insignificant in days to heading, days to maturity, plant height, and effect tillers. Significantly longest panicle (25.3 cm) was measured on the Khumal-10 variety with transplanting of seedlings at (15x15) cm spacing. However, the shortest panicle length (18.6 cm) was recorded in the farmer’s variety transplanted with the farmer’s practice. Similarly, significantly highest grain yield (5.5 t/ha) was recorded in the Khumal-10 variety spaced at (15x15) cm which was contrasted by the lowest grain yield (3.2 t/ha) in farmer’s variety transplanted in the farmer's practice. This shows the superior effect of Khumal-10 variety at the spacing of (15x15) cm in terms of grain yield. Plants grown at wider spacing get more area of land around them to absorb nutrition and solar radiation for

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better photosynthetic process, which enhance the performance of individual plants. However, the grain yield per plot does not entirely depend on the performance of individual plant but also depend on the total number of plants per unit area and the yield attributes of the plants. The adoption of (15x15) cm spacing i.e. 44 hills m^{-2} had recorded superior grain yield over (20x15) cm and (20x20) cm (i.e. 33 and 25 hills m^{-2}) by Pasha and Ramireddy (2016). However, Uddin et al. (2011) have recommended the medium spacing of (15x20) cm for the variety BRRI dhan44 in the medium lowland ecosystem of Bangladesh. All the varieties performing better for their yield contributing characters with wider spacing of (50x50) cm was reported by Zaman et al. (2015).

Table 2: Effects of genotypes and spacing in yield components of rice under the ICM at the outreach sites of HRS, Dailekh, 2016 and 2017

	Effective Tillers per hill			Panicle Length (cm)			Yield (t/ha)		
Treatments	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
Varieties									
Khumal-10	8	8	8	25.2	22.4	23.4	4.7	4.3	4.5
Farmer's variety	9	10	10	21.8	20.2	20.8	4.3	3.3	3.7
F-test	*	**	**	**	**	**	NS	**	**
LSD (0.05)	1.564	1.411	0.994	1.3	1.105	0.887	0.624	0.511	0.422
Spacing (cm)									
(20x20)	9	10	10	23.4	22.5	22.8	4.2	4.1	4.1
(20x15)	9	9	9	23.8	21.1	22.1	4.7	3.8	4.1
(15x15)	8	8	8	24.2	22.6	23.2	4.8	4.4	4.5
Farmer's Practice	8	8	8	22.5	19.0	20.3	4.4	3.0	3.5
F-test	NS	NS	NS	NS	**	**	NS	**	**
LSD (0.05)	2.212	1.996	1.405	1.839	1.563	1.254	0.883	0.722	0.597
Interaction									
F-test	NS	NS	NS	*	NS	*	NS	**	**
LSD(0.05)	3.128	2.823	1.987	2.601	2.211	1.774	1.248	1.021	0.845
CV (%)	21.1	24.8	22.8	6.3	8	8	15.8	20.7	20.6

*Note: LSD= Least Significant Difference, CV= Coefficient of Variation. NS, * and ** indicate non-significant, significant at P<0.05 and significant at P<0.01 respectively.*

The further analysis of the significant effect of variety and spacing interaction over the panicle length of rice shows the longest measurement (25.3 cm) of panicle in Khumal- 10 transplanted at the spacing of (15x15) cm, followed by the panicle of the same variety transplanted at spacing of (20x20) cm, (20x15) cm, and Farmer's practice respectively. The length of the longest panicle of Khumal-10 variety at (15x15) cm spacing was 36.02% more than the panicle length of Farmer's variety transplanted with farmer's practice. The longer panicles in Khumal-10 was followed by the comparatively shorter panicles of farmer's variety transplanted at several spacing, similar to Khumal-10.

Table 3: The interaction effect of variety and spacing in the panicle length of rice

Variety	Spacing (cm)			
	(20x20)	(20x15)	(15x15)	Farmer's Practice
Khumal-10	23.3	23.1	25.3	22.0
Farmer's variety	22.4	21.1	21.1	18.6

Table 4: The interaction effect of the variety and spacing in the grain yield of rice

Variety	Spacing (cm)			
	(20x20)	(20x15)	(15x15)	Farmer's Practice
Khumal-10	4.3	4.2	5.5	3.9
Farmer's variety	4.0	4.0	3.6	3.2

The significant effect of interaction of variety and spacing over the yield of rice was further analyzed to specifically observe the best management practice among the applied practices. The grain yield from the Khumal-10 variety, transplanted at the spacing of (15x15) cm was noticed with maximum grain yield of 5.5 t/ha, which was followed by (20x20) cm and (20x15) cm. The transplanting of improved variety Khumal-10, however, did not produce the better yield in comparison to farmer's variety rice transplanted with spacing maintenance. The largest yield of Khumal-10 at spacing of (15x15) cm was 71.9% more than the yield from farmer's variety transplanted by the farmer's practice. The highest yield of rice of the improved variety has been found to be resulted from the longest panicle length, genetic makeup for higher grain yield potential and better spacing of (15x15) cm for the condition of Dailekh district. Similarly, the positive correlation was found between the panicle length and the grain yield under interaction effects of variety and spacing.

The effects of interaction of varieties with spacing in the economic term was analyzed. This showed that the highest cost (NRs. 74287.5) was in cultivating both the varieties in the farmer's practice. However, the cost was lowest (NRs. 66274.5) in transplanting both the varieties at spacing of (20x20) cm. Likewise, Khumal-10 variety transplanted with the spacing of (15x15) cm, showed the highest economic benefit (NRs. 163500), net profit (NRs. 90815) and B:C ratio (2.25), which was followed by Khumal-10 variety transplanted with the spacing of (20x20) cm in each case of economic benefit (NRs. 127625), net profit (NRs. 61350) and B:C ratio (1.93) respectively. However, the lowest economic benefit (NRs. 95225), net profit (NRs. 20938) and B:C ratio (1.28) as observed in farmer's variety transplanted with farmer's practice of transplantation.

Table 5: Effect of varieties and spacing in the cost, benefit, net income and B:C ratio

Treatments	Cost (NRs.)	Benefit (NRs.)	Net profit (NRs.)	B:C ratio
Khumal-10 @ (20x20) cm spacing	66274.76	127625	61350	1.93
Khumal-10 @ (20x15) cm spacing	69142.54	127048	57905	1.84
Khumal-10 @ (15x15) cm spacing	72684.92	163500	90815	2.25
Khumal-10 @ Farmers practice	74287.47	115860	41572	1.56
Farmer's variety @ (20x20) cm spacing	66004.76	119057	53052	1.80
Farmer's variety @ (20x15) cm spacing	68872.54	120930	52058	1.76
Farmer's variety @ (15x15) cm spacing	72684.92	108635	35950	1.50
Farmer's variety @ Farmers practice	74287.47	95225	20938	1.28

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CONCLUSION

Based on the results it is concluded that, for the Dailekh district, Khumal-10 variety is superior to the farmer's variety with highest grain yield. Besides the longest panicle and highest grain yield, the spacing of (15x15) cm is the best practices for better tillers per hill, though with insignificant variation. Since, the number of effective tillers per hill is insignificantly greater in farmer's variety than in Khumal-10, the Khumal-10 variety could be a better choice for farmers as they will have 71.9% more grain yield at (15x15) cm and also could harvest the required straw for their livestock. Similarly, the cultivation of improved variety like Khumal-10 and transplanting it at the spacing of (15x15) cm results the highest B:C ratio by 75.8% in comparison to the cultivation of farmer's variety in the farmer's practice of spacing. Thus, it is recommended to practice the selection of improved variety and improved spacing techniques for resulting high benefits of yield and monetary return from rain-fed rice cultivation, for the condition of Dailekh district.

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Authors' contributions

Kiran Pariyar:	Performed experiment, recorded data, and wrote the manuscript
Pradip Sapkota:	Designed and performed experiment
Salina Panta:	Helped in experiment and recording data
Shashi Ram Sharma:	Helped in experiment and recording data
Tika Bahadur Karki:	Helped in supervision of the experiment

Conflict of interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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