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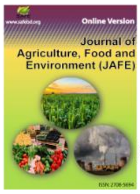

Original Article

Effect of Different Spacing Practices on Yield and Yield Attributes of Spring Rice in Dhanusha, Nepal

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A B S T R A C T

An experimental study was conducted to determine the effect of spacing on the yield and yield-attributing parameters of a pipeline genotype of spring rice, IR 10L 152, in a farmer's field in Lalgadh, Dhanusa. Five spacings, viz., 15cm×15cm, 20cm×15cm, 25cm×15cm, 20cm×20 cm, and 25cm×20cm, were replicated four times each in a randomized complete block design (RCBD). Results showed that different spacing performed significantly better on yield-related characters (plant height, number of tillers, panicle length, number of effective and non-effective tillers, number of filled and unfilled grain, and grain yield). The highest plant height at 90DAT (104.74cm), panicle length (23.68cm), number of effective tillers per hill (18.69), number of total grains per panicle (141.25), and number of filled grains per panicle (125.25) were found with 25cm×20cm spacing. Despite all the attributes being superior to other treatments (spacing), yield (t/ha) was found to be low (4.13 t/ha) for 25cm×20cm spacing when compared to 20cm×20cm spacing, with the highest yield of 4.88 t/ha among all treatments. The total number of plants per plot was low for 25cm×20cm due to greater spacing, which significantly reduced the net yield per plot. Incontrast, the lowest plant height at 90 DAT (97.56cm), panicle length (19.10cm), number of effective tillers per hill (14.04), number of grains per panicle (123.0), and number of filled grains per panicle (107.25) were found with 15cm×15cm spacing. The study revealed that 20cm×20cm spacing was found to be ideal for obtaining the maximum grain yield of the spring rice genotype in Dhanusa district.

Introduction

Rice (*Oryza sativa* L.) is one of the most important and widely consumed grains, serving as a major staple food for more than 3.5 billion people in the world (CGIAR, 2016). Rice ranks third in the world in terms of production, with a total yield of 502.98 million metric tons (Shahbandeh, 2023). The present demand for rice (520 million metric tons) is expected to increase to 555 million metric tons by the year 2035 (FAO, 2017). Although there are two species of rice, *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice), known for their commercial importance, *Oryza sativa* is the most cultivated crop worldwide with its three sub-species, namely indica, japonica, and javanica, in its commercial production zone (Gadal *et al*., 2019). China is the largest producer of paddy, followed by India, Bangladesh, Indonesia, and Vietnam, with Nepal ranking in the fifteenth position worldwide (Shahbandeh, 2023). Rice, the major and most prestigious staple crop of Nepal, covers the maximum area in terms of area coverage and is grown in 73 districts among a total of 77 districts in Nepal (Paudel, 2011). From a total cultivated area of 1,473,474 hectares, a total production of 5,621,710 metric tons was achieved last year with a productivity of 3.2 tons per hectare (ton/ha) (MoALD, 2022). Rice is cultivated in three distinct agroecological zones of Nepal, with percentage area coverage of 68%, 28%, and 4% in plains, hills, and mountains, respectively (Gauchan *et al*., 2014; MoALD, 2020).

Plant variety itself is a significant determinant of yield, and yield-attributing characteristics of rice and input factors affecting yield, along with spacing, play a crucial role in the optimum production of rice grains. Plant density has significant effects on rice production since interplant spacing influences rice growth, development, and yield in every circumstance (Sultana *et al.*, 2012). More plant spacing means more functional leaves, leaf area, and total number of tillers per square unit area, which thus linearly increases the performance of individual plants (Shrirame *et al.*, 2000; Devi and Singh, 2000). Closer plant spacing leads to more competition for growth factors such as water, nutrients, and light, hindering the yield of the crop, and wider spacing leads to less production per unit area (Gozubenli, 2010; Kandil *et al.*, 2010). Crop yield is a function of nutrient availability, moisture, solar radiation, and other growth input factors; thus, an optimum population of plants is crucial for an optimum level of production (Baloch *et al.*, 2002). The varietal character of the plant has a significant influence on the spacing of plants maintained for optimum yield. Varieties with shorter plant durations require relatively lower spacing than varieties with longer plant durations for optimum yield performance (Patra & Nayak, 2001). In the case of aged seedlings of short duration rice varieties, closer spacing and a large number of seedlings per hill have been found to compensate for yield loss per unit area of land caused by a higher number of plants and tiller population (Das *et al.*, 1988).

Tillering is mostly supported by spacing between plants because of proper input availability according to spacing (Tyeb *et al.*, 2012). Alam (2006) and Shrirame *et al.* (2000) also reported the maximum number of effective tillers per m^2 at the optimum level of spacing. Bhowmik *et al.* (2012), from their field experiment, reported a difference in yield and other characters (number of tillers, grain yield, number of panicles) in the NERICA 1 variety at different levels of spacing. Plant spacing directly alters plant yield-attributing characters and plant physiology through intra-specific competition because underground competition occurs mainly for nutrition (Oad *et al.*, 2001). Proper spacing is essential to remove both above-ground and underground competition. Appropriate spacing enables the farmer to maintain proper plant density in his field. Hence, a farmer can avoid overpopulation on a given plot of land, which has a negative effect on yield (Baloch *et al.*, 2002). Enough space, along with other favorable conditions, allows the plant roots to grow profusely both vertically in deeper parts of soil and horizontally to cover a large area, and when roots are spread to a larger volume of soil, they trap more nutrients, which results in the development of larger plants with a larger number of tillers. Proper spacing can increase yield by 25 to 40% over improper sources (IRRI, 1997). Plant spacing affects plant population, biomass, number of grains per panicle, and tillering of rice per hill (Hasanuzzaman *et al.*, 2009).

In Nepal, various types of varieties are released according to different agro-ecological zones, but their optimum yield by exploiting all their characteristics is yet to be enhanced. Plant geometry differs with geography as well as the type of variety. Although Dhanusa district is the hub of rice production during the main season, there is a lower yield of spring rice. The major reason behind this is poor irrigation facilities and a lack of technical know-how in spring rice cultivation to exploit its full potential. Among many agronomic practices, optimum spacing is crucial for the efficient utilization of resources, leading to yield maximization. High spacing leads to lower production per unit area due to improper utilization of area, and lower spacing causes low production due to high competition among plants for input resources. Thus, this research aimed mainly at testing different plant geometries of pipeline rice variety IR 10L 152 for its optimum yield enhancement in the Dhanusa district of Nepal.

2. Materials and Method

2.1 Experimental site

The experimental study was conducted in Tulasi, Mithila municipality, which is under the command of the Agriculture Knowledge Centre (AKC) under the PMAMP. Mithila municipality is located in the northern part of Lalgadh, Dhanusha. It lies at a latitude of 26° 55' 35" north and a longitude of 85° 57' 15" east, with a total coverage of 187.93 km^2 (72.56 sq m). The study site was a low-land plain area dominated by alluvial clay soil. The research was carried out during the spring season of 2022, from February 25 to June 30.

2.2 Experimental detail

The experiment was laid out in one factorial randomized complete block design (RCBD) with four replications and five treatments.

Table 1. Treatments used for the experimental study.

S.N.	Treatments	Spacing
1.	T1	15cm × 15 cm
2.	T2	20cm × 15 cm
3.	T3	25cm × 15 cm
4.	T4	20cm × 20 cm
5.	T5	25cm × 20cm

BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4
R1T5	R2T3	R3T4	R4T2
R1T1	R2T1	R3T5	R4T4
R1T4	R2T5	R3T3	R4T1
R1T2	R2T2	R3T1	R4T3
R1T3	R2T4	R3T2	R4T5

Figure 1. Layout of the experimental field.

2.2.1 Experimental materials

The major experiment material that was used in research was a pipeline genotype of spring rice, IR 10L 152. The pipeline genotype, IR 10L 152, is a thick grain-type rice with an average plant height of 105 cm, a mean thousand grain weight (TGW) of 25 grams, and an average maturity day of 125 days from the date of sowing. The average estimated production capacity of these pipeline genotypes is 4.8 t/ha. In general, the genotype is recommended for Terai, inner Terai, and areas in the mid-hill up to 700 meters above mean sea level.

2.2.2 Experimental design

Design: RCBD
No. of Replications: 4
No. of Treatments: 5
Individual plot size: 3 × 2 m^2
Spacing between replications: 0.5m
Spacing between treatments: 0.25m

2.3 Cultivation Practice

2.3.1 Nursery bed preparation

At first, the nursery bed was prepared by plowing, and the field was ploughed twice with a tractor, making the soil tilth. Pre-germinated seeds were sown in a prepared field. The application of chemical fertilizer was zero, and well-decomposed FYM at 15 kg FYM/ha was applied.

2.3.2 Field preparation

The main field was heavily ploughed and tilled twice. The size of the main field was 14.5 × 11.5 m^2, with 20 different plots (3 × 2 m^2).

2.3.3 Main field preparation

The main field was heavily plowed twice by power tillers and then puddled. The area of the main field was 166.75 m^2 with 20 different plots (3 m × 2 m). The actual plant stand coverage area was 120 m^2.

2.3.4 Fertilizer application

As a source of NPK, urea (46% N), DAP (46% P), and MOP (60% K) were applied at RDF (120:60:40 NPK kg/ha). The entire P and K dose and a half dose of nitrogen were applied as the basal dose in all treatments. A half dose of nitrogen was applied to the standing crop by top dressing into two equal splits at the tillering stage and panicle initiation stage of the crop. The seedlings were transplanted manually in line at different spacing treatments.

2.4. Intercultural Operations

2.4.1 Weeding and inter-cultural operation

Weeds are unwanted plants that are not main crops. Weed control was done through different herbicides and hand-weeding. Manual weeding was done at 30 and 60 DAT. Rice requires more water at critical stages: vegetative, panicle initiation, and grain filling. The main source of irrigation was a nearby pump.

2.4.2. Harvesting and threshing

Harvesting was done manually with the help of sickles from each net plot area of 3 × 2 m^2. The harvested crop was left on the field for 1 day for sun drying. The sun-dried crop was threshed, followed by winnowing and cleaning. Cleaned grain was weighted to determine grain yield.

2.5 Observation and measurement

2.5.1. Growth parameter

2.5.1.1. Plant height (cm)

Five random plants from every plot were selected and tagged for the measurement of plant height at every 30-day interval. The final data was recorded on 90 DAS. Plant height was measured from the base of the plant above the ground to the tip of the uppermost leaf or panicle of rice, i.e., the apex. The average of the sample plants was represented as plant height and expressed in cm.

2.5.1.2. Number of tillers per plant

In the observation of 5 randomly selected hills, tillers per square meter were recorded with the help of a quadrate (1m × 1m) in each stage of the crop, and the average values were used to obtain the tiller per plant from 30 DAT to 90 DAT.

2.5.2. Yield and yield-attributing parameters

2.5.2.1 Number of effective tillers per square meter

The number of effective tillers per square meter was calculated for each plot just before harvesting the crop. The tiller with filled grains was recorded as an effective tiller and worked out as an effective tiller per plant.

2.5.2.2. Panicle length

From each plot, five panicles from each hill of five different plants were randomly selected from sampling rows on either side of the plot. The length of each panicle was measured using a scale. The length was measured from the tip of the topmost grain to the attachment of the lowermost panicle. The mean was calculated, and the average length was expressed in cm.

2.5.2.3. Number of filled grains per panicle

From each selected panicle (panicle used for determining length), the number of filled grains per panicle was counted.

2.5.2.4. Thousand-grain weight

Thousand-filled grains from each plot were counted, and weight was taken with an electronic digital balance.

2.5.2.5 Grain yield

The crop from the net plot area of each plot was harvested to record the grain yield. The crop was dried, threshed, cleaned, and again sun-dried. The final weight was taken with an electronic digital balance, and the data was converted into tons per hectare (t/ha).

2.6 Statistical Analysis

All the recorded data were arranged systematically treatment-wise under four replications based on various observed parameters. Experimental data were analyzed using R Studio with R Stat Software, 4th edition, and treatment means were separated using Duncan's Multiple Range Test (DMRT) at a 5% level of significance. As referenced in Gomez & Gomez (1984), a simple correlation and regression were established among the selected parameters to study the relationships.

3. Results and Discussion

3.1 Agronomic Characters

3.1.1 Plant height

The data were collected at 30 DAT, 60 DAT, and 90 DAT. The effect of spacing on plant height is illustrated in Table 5.

Table 2. Effect of Spacing on Plant Height of Pipeline Genotype of Spring Rice, IR 10L 152 at Lalgadh, Dhanusa, Nepal, 2022.

Treatment (Spacing)	Plant height at 30 DAT (cm)	Plant height at 60 DAT (cm)	Plant height at 90 DAT (cm)
15cm×15 cm	42.96^{c}	71.69^{d}	97.56^{c}
20cm×15 cm	43.85^{c}	76.17^{c}	98.44^{c}
25cm×15 cm	50.47^{b}	78.54^{b}	101.53^{b}
20cm×20 cm	52.17^{ab}	78.98^{ab}	102.15^{b}
25cm×20cm	53.80^{a}	80.61^{a}	104.74^{a}
LSD(0.05)	1.929	1.767	1.643
SE_m (+-)	0.280	0.258	0.238
F-probability	<0.001	<0.001	0.001
CV, %	2.57	1.49	1.06
Grand Mean	48.65	77.20	100.88

Note: Treatment means separated by DMRT and columns represented with the same letter (s) are non-significant at the 5% level of significance; DAT: days after transplanting; LSD: Least

Significant Difference; SE_m: Standard error of the mean deviation; CV: Coefficient of Variance.

Different spacing intervals were found to have significant effects on plant height at all growth stages. The tallest plant height was recorded at a spacing of 25cm × 20 cm, followed by 20cm × 20cm. At 30 days after transplanting, the highest plant height (53.80cm) was observed at a spacing of 25cm × 20 cm, which was statistically similar to the spacing of 20cm × 20cm (52.17 cm) and statistically significant with a spacing of 25cm × 15cm (50.47 cm). Similarly, at 60 DAT, the plant height (80.61cm) was significantly higher at a spacing of 25cm × 20 cm, which was statistically similar to the plant height at a spacing of 20cm × 20cm (79.98cm). The lowest plant height (76.17cm) was observed for spacing 20cm × 15cm at 60 DAT. At 90 DAT, the tallest plant height (104.74 cm) was observed at 25cm × 20cm spacing, which was statistically significant with 20cm × 20cm spacing (102.15 cm). Plant heights at 90 DAT were statistically non-significant between spacing treatments of 20cm × 15cm (98.44 cm) and 15cm × 15cm (97.56cm). This could be due to the greater spacing causing minimum competition and resulting in maximum vegetative growth. Greater spacing might have resulted in maximum utilization of nutrients, which led to more cell elongation and cell division in the meristematic tissue of plants, which play a key role in increasing plant height. These results are in accordance with the findings of Akondo and Hossain (2019). Further, Ogbodo *et al.* (2010) also observed that plant height was significantly higher when crops were transplanted at a wider spacing (30 cm × 30 cm) than at a closer spacing (10 cm × 10 cm and 20 cm × 20 cm).

3.1.2 Number of tillers per plant

The data were collected on 30 DAT, 60 DAT, and 90 DAT, respectively. The different levels of spacing significantly influenced the number of tillers at all growth stages.

Table 3. Effect of spacing on tiller number of pipeline genotype of spring rice, IR 10L 152 at Lalgadh, Dhanusa Nepal, 2022.

Treatment (Spacing)	Average number of tillers/plant at 30 DAT	Average number of tillers/plant at 60 DAT	Average number of tillers/plant at 90 DAT
15cm×15 cm	17.38^{d}	17.10^{c}	15.15^{e}
20cm×15 cm	18.95^{c}	17.68^{c}	16.18^{d}
25cm×15 cm	21.23^{b}	19.45^{b}	17.83^{c}
20cm×20 cm	22.03^{ab}	20.86^{a}	18.98^{b}
25cm×20cm	23.23^{a}	21.32^{a}	20.45^{a}
LSD(0.05)	1.259	0.982	1.020
SE_m (+-)	0.183	0.142	0.148
F-probability	<0.001	<0.001	<0.001
CV, %	3.969	3.305	3.739
Grand Mean	20.58	19.28	17.72

Note: Treatment means separated by DMRT and columns represented with the same letter (s) are non-significant at the 5% level of significance; DAS: days after sowing; LSD: Least Significant Difference; SE_m: Standard error of the mean deviation; CV: Coefficient of Variance.

At all growth stages, spacing showed significant effects on the number of tillers per square meter. At 30 days after transplanting, the highest number of tillers (23.23 tillers per plant) was recorded in rice planted at 25cm × 20cm spacing, followed by 20cm × 20cm (22.03 tillers per plant). The number of tillers per plant in T5 (25cm × 20cm) was found to be statistically significant with other treatments (T1, T2, and T3) and statistically similar with T2 (20cm × 20cm). At 60 DAT, rice seedlings transplanted at 25cm × 20cm showed the maximum number of tillers (21.32 tillers per plant), which was statistically similar with 20cm × 20cm (20.86 tillers per plant). The number of tillers per plant was statistically non-significant for spacing 15cm × 15cm (17.10 tillers per plant) and 20cm × 15cm (17.68 tillers per plant). At 90 DAT, the maximum number of tillers (20.45) was observed at a spacing treatment of 25cm × 20 cm, followed by 20cm × 20cm (18.98 tillers/plant), and the result obtained was statistically significant at the 1% level of significance. Similarly, at 90 DAT, all the treatments showed significant results compared to each other, with the lowest number of tillers per plant for the spacing treatment of 15cm × 15cm (15.15 tillers per plant). The tiller number increased and reached its maximum at 30 DAT, and thereafter there was a decline in tiller number per meter square due to tiller mortality. The result indicated that spacing treatments of 25cm × 20cm were found to be more effective in increasing the number of tillers.

Moro *et al.* (2016) reported that growth attributes were significantly affected by spacing. Wider spacing resulted in the production of more tillers per stand than closer spacing. There was a significant increase in the number of tillers per stand with increased spacing. The usefulness of greater spacing on tiller production was also observed by Mirza *et al.* (2009), as their findings reported that closer spacing reduced the number of tillers and increased tiller mortality.

3.2 Yield-attributing characters of planted Spring rice

Table 4. Different yield-attributing characters of the pipeline genotype of spring rice, IR 10L 152, affected by spacing treatments at Lalgadh, Dhanusa, Nepal, 2022.

Treatment (Spacing)	Panicle Length (cm) at 120 DAS	Number of effective tillers per plant	Number of Grains Per Panicle (GPP)	Number of Filled Grains Per Panicle (FGPP)	Thousand Grain Weight (TGW)	Yield (t/ha)
15cm×15 cm	19.10^{c}	14.04^{c}	123.00^{c}	107.25^{b}	20.60^{c}	4.20^{c}
20cm×15 cm	19.35^{c}	15.22^{c}	131.50^{b}	109. 5^{b}	22.07^{b}	4.11^{c}
25cm×15 cm	21.73^{b}	16.56^{b}	134.50^{ab}	119.2 5^{a}	22.17^{b}	4.49^{b}
20cm×20 cm	22.18^{b}	17.08^{b}	138.75^{a}	122.75^{a}	24.63^{a}	4.88^{a}
25cm×20cm	23.68^{a}	18.69^{a}	141.25^{a}	125.25^{a}	25.03^{a}	4.13^{c}
LSD(0.05)	1.408	1.237	7.209	8.099	0.767	0.148
SE_m (+-)	0.204	0.180	1.046	1.175	0.111	0.0215
F-probability	<0.001	<0.001	<0.01	<0.01	<0.001	<0.001
CV, %	4.31	4.920	3.497	4.500	2.175	2.21
Grand Mean	21.21	16.322	133.8	116.8	22.90	4.36

Note: Treatment means separated by DMRT and columns represented with the same letter (s) are non-significant at the 5% level of significance; DAS: days after sowing; LSD: Least Significant Difference; SE_m: Standard error of the mean deviation; CV: Coefficient of Variance.

3.2.1 Panicle length

The mean value of panicle length in the response to various spacing treatments was highly significant. The longest panicle length (23.68 cm) was recorded at a spacing of 25cm × 20 cm, followed by 20cm × 20cm (22.18 cm). The panicle length was statistically non-significant at the 1% level of significance. Bozorgi *et al.* (2011) and Awan *et al.* (2011) also found the highest panicle length from more plant spacing than other treatments in their experiment. Further, Akondo and Hossain (2019), from their field experiment on the effect of plant spacing on newly developed rice varieties, found the highest panicle length from the largest spacing (20cm × 25cm).

3.2.2. Effective tillers per plant

A significant result was obtained while studying the effect of spacing treatments on the number of effective tillers per plant. The highest number of effective tillers (18.69 per plant) was found in the treatment of spacing 25cm × 20 cm, followed by a statistically significant tiller number (17.08 per plant) for spacing 20cm × 20 cm, which was also statistically similar with the effective tiller number per plant of rice planted at a spacing of 25cm × 15cm (16.58 per plant). The least number of effective tillers per plant was observed in the spacing treatment of 15cm × 15cm (14.03 per plant), which was statistically similar to the number of effective tillers as observed for 20cm × 15cm (15.22 per plant). Haque *et al.* (2015) also recorded the maximum number of total tillers and effective tillers per hill at the widest spacing (25cm × 20cm) of their experiment on aman rice. Mirza *et al.* (2009) and Akondo and Hossain (2019) also observed that closer spacing reduced the number of effective tillers and increased tiller mortality, resulting in fewer panicles.

3.2.3. Filled grains per panicle

The number of filled grains per panicle was significantly influenced by spacing treatments. Maximum filled grain per panicle (125.25) was recorded at a spacing of 25cm × 20cm, which was statistically similar with spacing treatments of 20cm × 20cm (122.75) and 25cm × 15cm (119.25). The least filled grain (107.25) was observed for the 15cm × 15cm spacing treatment, which was statistically similar to 20cm × 15cm (109.5).

Rajesh and Thanunathan (2003) reported that the use of wider spacing led to less below- and above-ground competition for better grain filling, a higher grain weight, and a higher number of filled grains per panicle. On the other hand, the highest unfilled grains per panicle were found in 15 cm × 15 cm spacing. Generally, it can be concluded that higher spacing had better performance in terms of number of grains per panicle as compared to lower spacing due to less competition for nutrients, air, and light, creating a better environment for crop growth, as reported by Moro *et al.* (2016).

3.2.4. Thousand-grain weight

Spacing treatments had both significant and non-significant effects on the thousand-grain weight because the thousand-grain weight is governed mostly by varietal character. Thousand-grain weights were significantly higher for seedlings transplanted at greater spacings of 25cm × 20cm (25.03 gm) and 25cm × 20cm (24.63) in comparison to lesser spacing treatments. Rajesh and Thanunathan (2003) and Akondo and Hossain (2019) also had similar findings, as the use of wider spacing led to less below- and above-ground competition for higher thousand grain weights.

3.2.5 Effect of Spacing on Grain Yield

Grain yield is determined by the function of various yield-attributing characters (effective tiller per plant and per m^2, panicle length, filled grain per panicle, thousand-grain weight, etc.), environmental factors, input applied, and their management. The grain yield of rice was found to be significantly affected by spacing treatments. A significantly superior grain yield (4.88 t/ha) was recorded for rice planted at a spacing of 20cm × 20 cm, which was statistically significant with all the other treatments. The lowest yield (4.11 t/ha) was recorded for the 20 cm × 15cm spacing treatment, which was statistically similar (non-significant) with yields obtained from T5 (25cm × 20cm) and T1 (15cm × 15cm). Despite a higher number of tillers per plant, a higher plant height, and a higher number of grains per panicle, yield (tha-1) for spacing treatment 25cm × 20cm was lower when compared to 20cm × 20cm spacing, for which all those attributes were lower when compared to T5 (25cm × 20cm). This might be due to the net effect of other attributes contributing to yield, like the number of plants per plot, as more spacing between the plants will automatically limit the total number of plants in a field or plot. Similar findings were reported by Rajesh and Thanunathan (2003) and Akondo and Hossain (2019) in their experimental studies. Dunn *et al.* (2020) also found higher yields from lower plant density than greater plant density in their field experiment. Further, Anwari *et al.* (2019) also found a direct relationship between plant spacing up to optimum and yield-attributing characteristics of rice, ultimately giving more yield from larger spacing (20cm × 25cm) than correspondingly closer spacings.

3.3 Effect of Spacing on Maturity Days

The effect of spacing on maturity days of the pipeline genotype of spring rice, IR 10L 152, was found to be statistically non-significant for different spacing treatments used in the experimental research.

Table 5. Effect of Spacing on Maturity Days of Pipeline Genotype of Spring Rice, IR 10L 152 at Lalgadh, Dhanusa, Nepal, 2022.

Treatment (Spacing)	Days To Maturity
15cm×15 cm	123.25^{a}
20cm×15 cm	122.25^{ab}
25cm×15 cm	122.25^{ab}
20cm×20 cm	123.00^{a}
25cm×20cm	119.75^{b}
LSD(0.05)	3.169
SE_m (+-)	0.46
F-probability	<0.05
CV, %	1.69
Grand Mean	122.10

Note: Treatment means separated by DMRT and columns represented with the same letter (s) are non-significant at the 5% level of significance; LSD: Least Significant Difference; SE_m: Standard error of the mean deviation; CV: Coefficient of Variance.

The maturity days of the spring rice genotype under study averaged 122.10 days. The longer maturity period was observed in T1 (15cm × 15cm) with 123.25 days, and the shorter maturity period was observed in T5 (25cm × 20cm) with 119.75 days.

3.4 Correlation regression studied

To assess the relationship between growth parameters, yield-attributing traits, and grain yield, simple correlation coefficients were analyzed.

3.3.1. Effective tillers and yield

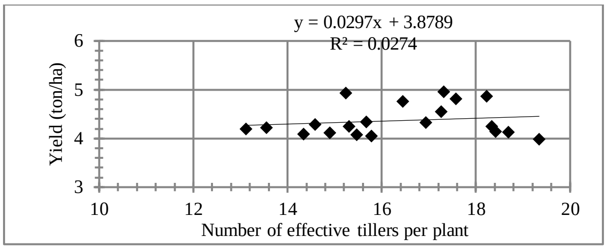

Figure 2. Linear relationship between effective tillers and grain yield of spring rice observed at Lalgadh, Dhanusa (2022).

When the yield per hectare was taken into consideration, the effective tillers were found to contribute only 2.74 percent to the total grain yield of rice. This might be because fewer plants were able to occupy the whole plot due to the larger spacing, whose loss was way too high to be overcome even by the greater number of effective tillers per plant when widely spaced. The study indicated that there was an increase in grain yield with an increase in the number of effective tillers per plant, but only to a certain limit of spacing, as greater spacing reduced the overall number of plants in a plot, resulting in a low yield.

3.3.2. Panicle length and yield

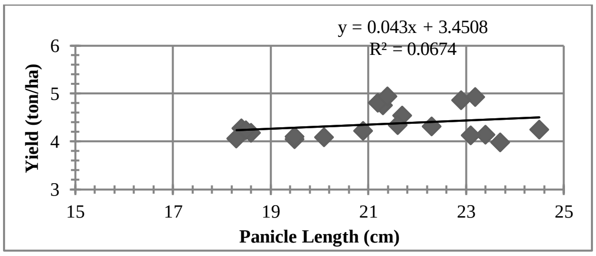

Figure 3. Polynomial relationship between panicle length and grain yield of spring rice as influenced by spacing in Lalgadh, Dhanusa, 2022.

Panicle length had a 6.74% contribution to paddy grain yield, with the remaining contribution due to other factors. The figure showed a linear relationship between grain yield and panicle length, which indicated that there was an increase in grain yield with an increase in panicle length. But the overall contribution of panicle length would have been way more than 6.74% if only the number of seedlings planted had been equal for the various plots. T5 (25cm × 20cm) had all the major yield-contributing attributes higher in comparison to other treatments, but due to the lower number of plants per plot (resulted due to greater spacing), yield per hectare was comparatively low. This ultimately affected the overall contribution of panicle length to total yield.

3.3.3 Filled grain and yield

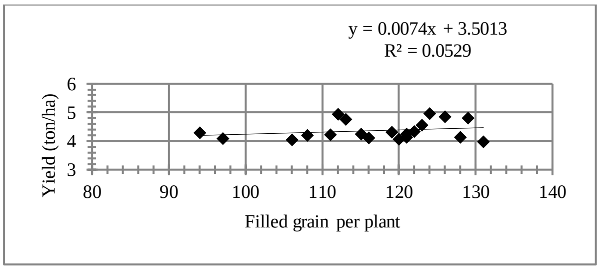

Figure 4. Relationship between panicle length and grain yield of spring rice as influenced by spacing in Lalgadh, Dhanusa, 2022.

The filled grains per panicle accounted for about 5.29% of the rice grain yield, but this percentage might have been greater if each of the experiments had been conducted with equal numbers of plants per plot rather than equal-sized plots. Other components formed the remaining proportion of the rice grain yield. The figure indicated that there was an increase in grain yield with an increase in the number of filled grains per panicle, but other parameters, such as the total number of plants per square meter, would have a higher contribution to the overall yield of the plot or field.

4. Conclusion

The growth and yield attributing parameters such as plant height, tiller number per plant, effective tiller per plant, panicle length, filled grains per panicle, and yield were significantly different at different spacing treatments. The highest yield of rice was statistically best at a spacing of 20cm × 20cm. The major conclusion drawn from the research is that, among different spacing treatments, spacing of 20cm × 20cm was found to be better for spring rice cultivation in terms of yield, indicating its validity. The spacing between seedlings of the pipeline genotype of spring rice, IR 10L 152, should be maintained at 20cm × 20cm for a higher yield. Further research efforts should be made using these spacings in a number of other varieties in different agro-climatic locations of the country for validation.

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