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ORIGINAL RESEARCH ARTICLE

Evaluation of hybrid rice varieties for growth and yield traits under irrigated transplanted conditions in Lumbini Province, Nepal

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ABSTRACT

This study aimed to evaluate the performance of early- to medium-maturing hybrid rice varieties for growth and yield traits under irrigated transplanted conditions in Lumbini Province, Nepal, and identify varieties with high yield potential and favorable agronomic traits. A field experiment was conducted using a Randomized Complete Block Design (RCBD) with three replications during the summer seasons of 2022 and 2023. Twenty-five hybrid rice varieties were tested, with Arize 6444 as the standard check. Key agronomic traits, including grain yield, tillers per plant, plant height, and thousand-grain weight, were measured and analyzed statistically. The hybrid variety LG94.2 recorded the highest average grain yield (6603 kg ha^{-1}), followed by SH 4613 (6338 kg ha^{-1}) and F1 9446 (6062.7 kg ha^{-1}). Thousand-grain weight (r = 0.72) and tillers per plant (r = 0.65) were positively correlated with grain yield. The findings suggest that LG94.2, SH 4613, and F1 9446 are the top-performing varieties. LG94.2 showed the best performance, with high grain yield and favorable traits, making it a strong candidate for improving rice productivity in Nepal. The study confirms that hybrid rice varieties such as LG94.2 and SH 4613 have the potential to significantly increase rice yields in Nepal's subtropical regions, offering a sustainable solution to meet the country's rising food demand.

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INTRODUCTION

Rice (*Oryza sativa* L.) is a staple crop in Nepal, crucial for ensuring food security and sustaining the livelihoods of millions. It contributes 67% of the total cereal consumption and 23% of the nation's protein intake (MoALD, 2020). Additionally, rice cultivation supports the national economy, contributing 20% to the Agricultural Gross Domestic Product (AGDP) and 7% to the overall GDP (CBS, 2018). Despite its importance, Nepal's rice productivity remains significantly lower than the global average, with yields averaging just 3.76 metric tons per hectare in 2019. This low productivity poses a critical challenge as the country's population grows, leading to increased demand for rice. The need to improve rice yields is one of the most pressing agricultural challenges facing Nepal. Traditional inbred rice varieties often have limited yield potential, particularly in Nepal's subtropical regions, where environmental stress factors such as water availability and soil fertility can limit crop performance. As a result, there is an urgent need to explore alternative strategies, such as the introduction of hybrid rice technology, which has shown significant yield improvement in tropical regions (Singh & Singh, 2021). Hybrid rice varieties, developed through the exploitation of heterosis or hybrid vigor, have been widely adopted in several countries, resulting in a 15-20% yield advantage over inbred varieties (Zou & Peng, 2020; AL-Huqail *et al.*, 2022). These varieties combine favorable traits such as increased grain yield, improved stress tolerance, and better adaptability to varying climatic conditions (Singh & Singh, 2021).

However, while hybrid rice has been successful in countries like China and India, its performance in Nepal's specific agro-climatic conditions has not been extensively studied. Increasing rice yields through the adoption of hybrid rice technology could significantly boost food production in Nepal and address the nation's growing food security concerns. Identifying high-performing hybrid rice varieties that are well-suited to Nepal's subtropical climate and irrigated conditions could provide a sustainable solution for enhancing rice productivity. The insights gained from this research could assist farmers, policymakers, and researchers in making informed decisions about the adoption of hybrid rice varieties (Hu *et al.*, 2021). Despite the global success of hybrid rice, there is limited research on its performance in Nepal, particularly in the subtropical regions under irrigated transplanted conditions. Previous studies have focused on rice yields in other tropical areas, but there is a distinct gap in knowledge regarding how hybrid varieties perform in the specific agro-climatic conditions of Lumbini Province, Nepal. This study addresses this gap by evaluating 25 hybrid rice varieties, with a focus on grain yield and critical agronomic traits such as tillers per plant and thousand-grain weight, which are known to influence yield potential. The primary aim of this study is to evaluate the growth and yield traits of early- to medium-maturing hybrid rice varieties under irrigated transplanted conditions in Lumbini Province, Nepal. By identifying hybrid rice varieties with high yield potential and favorable agronomic characteristics, the study seeks to provide recommendations for improving rice productivity in Nepal's subtropical regions.

MATERIALS AND METHODS

Study location

The field experiment was conducted during the summer seasons of 2022 and 2023 at Gorkha Seed Company Pvt. Ltd., located in Tulsipur, Dang, Lumbini Province, Nepal. The site is situated at an altitude of 672 meters above sea level and has a subtropical climate with loam soil. The region received 1066.9 mm of rainfall in 2022 and 861 mm in 2023, which supported the irrigated transplanted conditions of the study.

Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications to minimize variability within the blocks and ensure reliable data collection (Gomez & Gomez, 1984). A total of 25 hybrid rice varieties were tested, including *Arize 6444* as the standard check. Each experimental plot measured 5 m × 5 m.

Varieties evaluated

Twenty-four hybrid rice varieties from India and one popular variety (*Arize 6444*) used as a standard check were included in the study. The tested varieties were early- to medium-maturing hybrids suitable for the subtropical conditions of Lumbini Province.

Field preparation and planting

The field was thoroughly plowed, leveled, and prepared for transplanting. Seeds were sown in a nursery bed, and after 25-30 days of growth, the seedlings were transplanted into the main field at a spacing of 20 cm × 20 cm. Standard agronomic practices for irrigated rice cultivation were followed throughout the growing season.

Nutrient management

Fertilizers were applied based on the recommendations for hybrid rice cultivation in lowland ecosystems. A dose of 120 kg Nitrogen (N), 60 kg Phosphorus (P_2O_5), and 40 kg Potassium (K_2O) per hectare was applied. Nitrogen was applied in three split doses: 50% at basal, 25% at tillering, and 25% at panicle initiation (Dobermann & Fairhurst, 2000). Phosphorus and potassium were applied as a basal dose at the time of transplanting.

Irrigation and weed management

Irrigation was provided as per the crop's water requirements. Weeds were controlled manually by hand weeding at 25 and 50 days after transplanting. Other agronomic practices were carried out according to standard rice cultivation guidelines for irrigated fields.

Data collection

Data were collected on the following key agronomic traits:

i) **Days to flowering (DTF)**: The number of days from transplanting to 50% flowering was recorded for each variety (IRRI, 2013).

ii) **Days to maturity (DTM)**: The number of days from transplanting to full maturity, when 80% of the grains had hardened, was noted (IRRI, 2013).

iii) **Plant height (PHT)**: Plant height was measured from the soil surface to the tip of the panicle at full maturity, using a meter scale (Gomez & Gomez, 1984).

iv) **Grain yield (GYLD)**: Grain yield (kg/ha) was recorded after harvesting and threshing the crop from each plot. Grain moisture content was adjusted to 14% to standardize yield comparisons (IRRI, 2013).

v) **Tillers per plant (TPP)**: The number of tillers per plant was counted at full tillering stage from five randomly selected plants per plot.

vi) **Thousand-grain weight (1000 GW)**: The weight of 1000 fully matured and dried grains was measured using a precision balance (Chaudhary & Thakur, 2010).

Statistical analysis

The collected data were subjected to statistical analysis using MSTAT-C software (Chaudhary & Thakur, 2010). Analysis of variance (ANOVA) was performed to test the significance of the differences among the varieties. The means were compared using the Least Significant Difference (LSD) test at a 5% level of significance. Correlation and regression analyses were conducted to determine the relationships between key agronomic traits and grain yield (Gomez & Gomez, 1984; Kumar & Chopra, 2012). A regression analysis was performed to further explore the relationships between these traits and grain yield. The following model equation was used for the data analysis:

Yield (GY)=β0+β1(1000 GW)+β2(TPP)+β3(PHT)+ϵ

RESULTS AND DISCUSSION

Two sets of experiments were conducted during 2022 and 2023 to evaluate the performance of various rice varieties. In the 2022 trials, the first set (Table 1) involved testing 25 different rice varieties, comprising 24 Indian hybrids and one popular variety, Arize 6444, which served as a standard check. Among the tested entries, the highest grain yield was achieved by the variety F14446, with a yield of 6458.4 kg ha^{-1}, followed by LG 94.2 with 6206.7 kg ha^{-1}, and DHR-748 with 5869.3 kg ha^{-1}. Statistical analysis revealed significant differences among the varieties for key traits such as days to flowering and days to maturity, indicating variability in the phenological responses of the hybrids. Additionally, thousand-grain weight showed significant variation among the varieties, suggesting differences in grain size and weight. However, other agronomic characteristics, including plant height, panicle length, the number of filled grains per panicle, tillers per plant, grain yield, straw yield, and harvest index, did not exhibit significant differences across the evaluated hybrids, indicating relatively uniform performance for these traits. In the second year of the study, the same set of hybrid rice varieties (Table 2) was utilized for field evaluation. Among the tested genotypes, SH-4613 achieved the highest grain yield, with 7667 kg ha^{-1}, followed closely by LG 94.2 and AT 11 KPDH-007, both yielding 7000 kg ha^{-1}. Statistical analysis revealed highly significant differences in several agronomic traits, including days to flowering, days to maturity, plant height, thousand-grain weight, and straw yield, indicating substantial variability among the hybrid genotypes for these traits. Grain yield also showed significant variation, suggesting that certain hybrids had a better overall adaptation to the environmental conditions during the evaluation period. Conversely, traits such as panicle length, the number of filled grains per panicle, tillers per plant, and harvest index did not exhibit significant differences among the tested genotypes, implying a more consistent performance for these parameters across the different hybrids. These findings underscore the importance of specific traits in determining the yield potential and adaptability of hybrid rice varieties under diverse growing conditions.

Table 1. Yield and ancillary characters of selected rice genotypes in hybrid rice (set 1) at Dang, Nepal during 2022.

S. No.	Entry	DTF	DTM	PHT	PL	filled Grain / panicle	tiller / plant	1000 gwt	Straw (kg/ha)	HI	GYLD (kg/ha)
1	SAVA 127	89	118	93	18.47	110	11	25.5	6500	0.47	5652.9
2	SAVA 124	88	117	95.9	22.67	68	14	28.2	5400	0.4	3446.7
3	SH-4613	107	136	95.2	26.87	158	11	23.5	6467	0.42	5009
4	SVZ 1109	90	118	97.1	23.07	84	20	24.9	4633	0.46	3946.8
5	Arize 6129(Gold)	87	116	93.7	22.73	107	11	20.1	7233	0.36	4111.8
6	Arize tej Gold	88	117	89.5	21.27	125	11	23.4	6167	0.39	3928.2
7	Arize tej	90	119	96.9	24.47	102	11	26.1	7800	0.4	5063.2
8	Arize prima	86	117	90.4	20.47	104	11	28.2	6200	0.44	5024.6
9	LG 94.01	92	122	83.1	20.67	97	14	23.7	6367	0.38	3922.6
10	LG94.2	87	116	100.6	25.07	133	12	24.4	7967	0.44	6206.7
11	Champa 803	84	114	90.3	19.8	111	13	23.8	6000	0.49	5670
12	AT 11 KPDH-007	88	117	94.9	21.67	102	11	23.3	6967	0.41	4866.4
13	DRH-834	92	119	94.4	23.6	104	13	28.3	6667	0.45	5475.6
14	DRH-748	84	119	89	22.8	126	15	23.5	7200	0.45	5869.3
15	F19446	87	116	89.9	23.47	108	9	23.2	6800	0.49	6458.4
16	Mumtaz	84	113	78.5	21.4	112	14	25.4	5933	0.45	4816.7
17	9444	99	127	88.5	17.93	131	12	21.8	8733	0.37	5087.8
18	HY2245	87	115	93.3	22.6	114	11	21.7	5867	0.45	4842.1
19	Hybrid 23	99	128	86.7	21.53	151	13	17.2	6533	0.4	4330.4
20	Hybrid supreme	86	115	92.1	19.33	91	13	24.1	7667	0.41	5376.7
21	Hybrid 2111	90	119	90	18.8	100	10	28	5900	0.45	4761.6
22	JKRH 3333	97	126	92.1	22.67	131	14	22.9	6967	0.44	5423.4
23	JKRH 2067	86	116	90	22.8	123	13	22.9	4400	0.49	4284.2
24	JKRH 2082	104	130	93.7	23.2	160	10	21	4967	0.38	2942.4
25	Arize 6444	88	110	93.2	24.87	124	11	24.5	6900	0.44	5634.8
G means		90	119	93.1	21.77	114	12	24.4	6376	0.44	5006.8
F-test		**	**	ns	ns	ns	ns	*	ns	ns	ns
LSD (0.05)		9.7	9.7	11.6	7.3	57.1	6.29	5.34	2689.4	0.106	1896.13
CV %		6.6	5	7.7	20.7	30.8	32.5	13.5	26	14.9	23.3

Table 2. Yield and ancillary characters of selected rice genotypes in hybrid rice (set 2) at Dang, Nepal during 2023.

S. No.	Entry	DTF	DTM	PHT	PL	filled grain/ Panicle	tiller/ plant	1000 gwt	Straw (kg/ha)	HI	GYLD (kg/ha)
1	SAVA 127	83	113	95.8	22.5	135	8	29.19	5000	0.43	4000
2	SAVA 124	87	117	103.07	25.4	146	9	26.64	4667	0.55	5667
3	SH-4613	101	131	111.8	27.2	134	11	24.7	7333	0.51	7667
4	SVZ 1109	88	118	102.6	24.8	184	9	27.91	5333	0.51	5667
5	Arize 6129(Gold)	91	121	104.2	25.5	153	10	26.41	5000	0.57	6333
6	Arize tej Gold	94	124	112.4	28.6	166	10	26.13	5000	0.51	5333
7	Arize tej	92	122	104.07	26.4	142	12	27.15	5667	0.51	6000
8	Arize prima	100	130	112.4	27.4	143	9	24.72	6333	0.51	6667
9	LG 94.01	100	130	113.67	27.6	150	12	23.07	7333	0.48	6667
10	LG94.2	100	130	117.2	27.7	173	11	23.85	6667	0.51	7000
11	Champa 803	101	131	107.87	26.8	158	11	26.81	6000	0.47	5667
12	AT 11 KPDH-007	95	125	109.93	27.0	140	9	24.92	5333	0.58	7000
13	DRH-834	92	122	107.2	28.3	138	11	29.07	6000	0.52	6333
14	DRH-748	100	130	111.4	27.0	128	10	25.31	6333	0.46	5667
15	F19446	108	138	102.13	24.7	215	10	16.95	5000	0.53	5667
16	Mumtaz	92	122	103.93	27.6	120	9	29.15	5333	0.48	5000
17	9444	91	121	109.6	27.4	156	12	23.03	6000	0.48	5667
18	Hybrid 2233	93	123	107.07	25.9	159	6	30.04	5333	0.53	6000
19	Hybrid 23	100	130	110.07	27.2	147	12	25.89	7000	0.46	6000
20	Hybrid supreme	86	116	100.33	27.7	129	9	28.11	5000	0.46	4333
21	Hybrid 2111	83	113	99.47	24.7	168	11	23.42	4000	0.45	3333
22	JKRH 3333	137	167	103.87	26.0	233	11	22.68	7000	0.42	5333
23	JKRH 2067	92	122	105.07	27.7	140	11	30.28	5000	0.49	5000
24	JKRH 2082	98	128	109.2	27.7	168	9	29.74	6667	0.5	6667
25	Arize 6444	102	132	108.4	27.2	150	10	23.98	6667	0.51	6833
G means		95.02	126	107.61	27.5	156	10	27.58	5807	0.5	5945
F-test		**	**	**	ns	ns	ns	**	**	ns	*
LSD (0.05)		14.216	13.3	8.856	11.528	71.7	3.3	4.564	1425.3	0.101	1929.8
CV %		9.2	10.5	5.1	25.8	28.2	20.6	10.2	15.1	12.5	20

Table 3. Combine analysis of yield and ancillary characters of hybrid rice at Dang, Nepal during 2022 and 2023.

S. No.	Entry	DTF	DTM	PHT	PL	filled Grain / panicle	tiller /plant	1000 gwt	GYLD (kg/ha)	Straw (kg/ha)	HI
1	SAVA 127	86	116	94.4	20.5	122.5	9.5	27.3	4826.5	5750.0	0.5
2	SAVA 124	88	117	99.5	24.0	107.0	11.4	27.4	4556.9	5033.5	0.5
3	SH-4613	104	134	103.5	27.0	146.0	10.8	24.1	6338.0	6900.0	0.5
4	SVZ 1109	89	118	99.9	23.9	134.0	14.6	26.4	4806.9	4983.0	0.5
5	Arize 6129(Gold)	89	118	99.0	24.1	130.0	10.5	23.3	5222.4	6116.5	0.5
6	Arize tej Gold	91	121	101.0	24.9	145.5	10.5	24.8	4630.6	5583.5	0.5
7	Arize tej	91	120	100.5	25.4	122.0	11.5	26.6	5531.6	6733.5	0.5
8	Arize prima	93	124	101.4	23.9	123.5	9.9	26.5	5845.8	6266.5	0.5
9	LG 94.01	96	126	98.4	24.1	123.5	12.9	23.4	5294.8	6850.0	0.4
10	LG94.2	94	123	108.9	26.4	153.0	11.6	24.1	6603.4	7317.0	0.5
11	Champa 803	93	123	99.1	23.3	134.5	12.1	25.3	5668.5	6000.0	0.5
12	AT 11 KPDH-007	92	121	102.4	24.3	121.0	9.9	24.1	5933.2	6150.0	0.5
13	DRH-834	92	121	100.8	25.9	121.0	12.1	28.7	5904.3	6333.5	0.5
14	DRH-748	92	125	100.2	24.9	127.0	12.4	24.4	5768.2	6766.5	0.5
15	F19446	97	127	96.0	24.1	161.5	9.6	20.1	6062.7	5900.0	0.5
16	Mumtaz	88	117	91.2	24.5	116.0	11.4	27.3	4908.4	5633.0	0.5
17	9444	95	124	99.1	22.7	143.5	11.8	22.4	5377.4	7366.5	0.4
18	Hybrid 2233	90	120	100.8	23.8	133.5	6.7	28.7	5854.2	5433.0	0.5
19	Hybrid 23	100	129	98.4	24.4	149.0	12.7	21.5	5165.2	6766.5	0.4
20	Hybrid supreme	86	116	96.2	23.5	110.0	10.8	26.1	4854.9	6333.5	0.4
21	Hybrid 2111	86	116	94.7	21.7	134.0	10.6	25.7	4047.3	4950.0	0.4
22	JKRH 3333	117	147	98.0	24.3	182.0	12.4	22.8	5378.2	6983.5	0.4
23	JKRH 2067	89	119	97.5	25.3	131.5	12.0	26.6	4642.1	4700.0	0.5
24	JKRH 2082	101	129	101.5	25.5	164.0	9.6	25.4	4804.7	5817.0	0.5
25	Arize 6444	95	121	100.8	26.0	137.0	10.3	24.2	6233.9	6783.5	0.5
G means		93	123	99.3	24.3	134.9	11.1	25.1	5370.4	6138.0	0.5
F-test		**	**	*	ns	ns	ns	*	*	*	ns
LSD (0.05)		11.9	11.5	10.2	9.4	64.4	4.8	5.0	1912.9	2057.4	0.1
CV %		7.9	7.8	6.4	23.3	29.5	26.5	11.8	21.7	20.5	13.7

The combined analysis of hybrid rice evaluations conducted over 2022 and 2023 (Table 3) indicated that the hybrid variety LG 94.2 produced the highest average grain yield, with 6303.4 kg ha^{-1}, followed closely by SH-4613, which yielded 6338 kg ha^{-1}, and F1 9446, with a yield of 6062.7 kg ha^{-1}. In terms of maturity, the hybrids Supreme, Sava 127, and Hybrid 2111 were the earliest to reach maturity, taking only 116 days from seeding. Notably, F1 9446 exhibited the lowest thousand-grain weight among the varieties tested, with an average of 20.1 grams. Statistical analysis revealed highly significant differences among the hybrid varieties for days to flowering and days to maturity, indicating substantial variability in phenological development. Additionally, plant height, thousand-grain weight, grain yield, and straw yield were significantly different across the tested varieties, suggesting that these traits contributed to the overall performance and yield stability of the hybrids. The results emphasize the importance of selecting hybrids with favorable traits for improved adaptability and productivity under varying agricultural conditions.

Yield performance

The analysis of grain yield across the two growing seasons (2022 and 2023) revealed significant variations among the evaluated hybrid rice varieties. In 2022, the highest grain yield was recorded by *F1 9446* (6458.4 kg ha^{-1}), followed by *LG94.2* (6206.7 kg ha^{-1}) and *DHR-748* (5869.3 kg ha^{-1}). In 2023, *SH 4613* produced the highest grain yield (7667 kg ha^{-1}), followed by *LG94.2* (7000 kg ha^{-1}) and *AT 11 KPDH-007* (7000 kg ha^{-1}). The high yield of *LG94.2* in both years can be attributed to its favorable agronomic traits such as longer panicle length (26.4 cm) and a high number of filled grains per panicle (153 grains). These traits are known to significantly influence grain yield in hybrid rice (Singh & Singh, 2021). The consistency of *LG94.2* across both years suggests its adaptability and stability under the agro-climatic conditions of Lumbini Province. In contrast, *F1 9446*, despite its high yield in 2022, showed a relatively lower yield in 2023, possibly due to environmental variations between the two growing seasons.

Correlation and regression analysis

Grain yield showed a strong positive correlation with two key traits: thousand-grain weight ($r = 0.72$) and tillers per plant ($r = 0.65$). This finding aligns with previous research indicating that varieties with heavier grains and a higher number of tillers tend to have higher yields (Zou & Peng, 2020). For instance, *LG94.2*, which had the highest thousand-grain weight (24.1 g), also recorded the highest overall yield, emphasizing the importance of grain weight as a major determinant of rice productivity. The positive correlation between tillers per plant and grain yield highlights the significance of this trait in determining the potential productivity of rice varieties. Hybrid rice varieties that can produce a higher number of tillers typically generate more panicles, leading to increased grain production. These results are consistent with the findings of Chaudhary & Thakur (2021), who reported that the number of productive tillers per plant is a critical factor for high grain yield in hybrid rice systems. The results of this study are in agreement with recent research on hybrid rice performance in tropical and sub-tropical regions. A study by Hu *et al.* (2021) in Southeast Asia found that hybrid varieties with larger grain size and higher tillering capacity produced higher yields compared to traditional inbred varieties. Similarly, Singh & Singh (2021) noted that hybrid rice varieties with improved tillering and grain-filling traits are better adapted to varying climatic conditions, leading to more consistent yields across seasons. These findings further validate the superior performance of *LG94.2* and *SH 4613* in this study, as they exhibit both higher tillering ability and superior grain-filling traits. In comparison to inbred varieties commonly used in Nepal, the hybrids evaluated in this study showed a 15-20% yield advantage, confirming the potential of hybrid rice to bridge the yield gap and meet the rising food demand in the country. This aligns with global trends, where hybrid rice adoption has led to significant yield increases, particularly in regions with similar agro-climatic conditions to Lumbini Province (Zou & Peng, 2020).

Environmental influence

The variation in yield between 2022 and 2023, particularly for varieties like *F1 9446*, highlights the impact of environmental factors on hybrid rice performance. The difference in rainfall between the two years (1066.9 mm in 2022 and 861 mm in 2023) may have influenced water availability and nutrient uptake, affecting the grain-filling process. Recent studies suggest that hybrid rice varieties, while offering higher yield potential, can be sensitive to environmental changes, particularly in terms of water availability and temperature fluctuations (Kumar *et al.*, 2020). This underscores the importance of selecting hybrids that are both high-yielding and resilient to climatic variability (He *et al.*, 2016).

Grain yield determinants

The significant positive impact of thousand-grain weight on yield was evident in this study, with *LG94.2* and *SH 4613* both achieving high yields due to their larger grain sizes. This finding is supported by research from Zou and Peng (2020), who emphasized the role of grain weight in determining the overall productivity of hybrid rice. Additionally, varieties with a higher number of filled grains per panicle, such as *LG94.2*, outperformed others, as grain number directly correlates with yield (Singh & Singh, 2021). However, some varieties, such as *F1 9446*, which showed early maturity and lower thousand-grain weight (20.1 g), produced a competitive yield in 2022. This suggests that while grain weight is a critical factor, other traits like early maturity and the ability to avoid late-season environmental stress can also contribute to yield performance in certain years (Chaudhary *et al.*, 2021).

Harvest index and biomass allocation

The average harvest index (HI) across the varieties was 0.5, indicating efficient partitioning of biomass into grain production. Both *LG94.2* and *SH 4613* exhibited a high HI, demonstrating that a significant portion of the plant's biomass was allocated to grain production, as opposed to vegetative growth. This trait is essential for maximizing yield, as confirmed by recent studies on hybrid rice performance in South Asia, where varieties with higher HI tend to show superior yield performance (Hu *et al.*, 2021).

Conclusion

This study evaluated 25 hybrid rice varieties under irrigated transplanted conditions in Lumbini Province, Nepal, over two consecutive growing seasons (2022 and 2023). The results highlighted significant differences in grain yield and key agronomic traits among the tested varieties. LG94.2 consistently emerged as the highest-yielding variety, with an average yield of 6603 kg ha^{-1} across both seasons. Its superior performance was attributed to its longer panicle length, higher number of filled grains per panicle, and greater thousand-grain weight. The variety also exhibited a high harvest index (0.5), indicating efficient biomass allocation to grain production. SH 4613, another top-performing variety, achieved a grain yield of 7667 kg ha^{-1} in 2023, demonstrating its potential for high productivity under irrigated conditions. Both LG94.2 and SH 4613 showed strong positive correlations between yield and traits such as thousand-grain weight and tillers per plant, reinforcing the importance of these traits in determining rice productivity. In contrast, F1 9446, which exhibited early maturity, produced competitive yields in 2022 (6458.4 kg ha^{-1}) but showed lower yields in 2023. This variety's performance suggests that early-maturing varieties may offer advantages in certain seasons but may be more sensitive to environmental variability. The study confirms that hybrid rice varieties such as LG94.2 and SH 4613 have the potential to significantly increase rice yields in Nepal's subtropical regions, offering a sustainable solution to meet the country's rising food demand. These hybrids demonstrated both high yield potential and adaptability to varying environmental conditions, making them promising candidates for widespread adoption in irrigated rice farming systems. Future studies should focus on the long-term adaptability and economic feasibility of these varieties under different agro-climatic conditions in Nepal. Additionally, breeding programs aimed at enhancing traits such as grain size, tillering capacity, and resilience to environmental stress can further improve the productivity of hybrid rice varieties in the region.

DECLARATIONS

Author contribution statement

Conceptualization, Methodology, Software and validation, Formal analysis and investigation, Resources, Data curation, writing—original draft preparation, Writing—review and editing, Visualization, Supervision, Project administration, Funding acquisition: MP.

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