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COMPARATIVE STUDY ON AGRONOMIC PRACTICES AND ECONOMICS OF IMPROVED AND HYBRID RICE PRODUCTION IN PYUTHAN DISTRICT OF NEPAL

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ABSTRACT
The study intends to compare the agronomic practices and economics of improved and hybrid rice production and identify the major problem faced by the rice growers in the Pyuthan district. Interviews with 60 randomly selected households (30 each of improved rice and hybrid rice growers) were conducted using a semi-structured questionnaire. Microsoft Excel and the Statistical Package for Social Sciences (SPSS) were used for data entry and analysis. Results showed that while the amount of urea used in hybrid rice (92.46±22.73 kg/ha) was significantly higher than it was in improved rice (65.08±18.42 kg/ha), the amount of seed used was significantly higher in improved rice (63.53±11.41 kg/ha) than hybrid rice (23.39±3.25 kg/ha). Most of the hybrid rice growers used 2-3 seedlings/hill with a spacing of 20 x 18 cm^2 whereas the improved rice growers used 4-6 seedlings/hill with a spacing of 9.33 x 7.00 cm^2. The manual method of hand weeding and harvesting with no insect, pest, or disease controlling methods was adopted by both types of growers. The productivity and benefit-cost ratio of hybrid rice (5.23±0.72 Mt/ha and 1.48±0.18 respectively) were found significantly higher than the improved rice (3.84±0.73 Mt/ha and 1.25±0.21 respectively). Taking the by-product into account the gross returns of hybrid rice per ha (NRs 172,577.50) was significantly higher than the improved rice (NRs 136,911.76). The gross margin of hybrid rice (NRs 56,593.81) was also higher compared to that of improved rice (NRs 27,629.76). The most serious problem for both the improved (I=0.94) and hybrid rice growers (I=0.90) was the lack of fertilizers in time and less access to quality seed. To improve rice production and profitability, the adoption of hybrid varieties along with addressing these hindrances can be suggested in the area.

KEY WORDS
Benefit-cost ratio, problem, production, rice growers.

The agriculture sector is the backbone of the Nepalese economy. The sector contributes about 26.98 % of the total gross domestic product (GDP) of Nepal (MoALD, 2020). Agriculture is the primary occupation of 65.6% of Nepalese people (CBS, 2013). Nepalese agriculture, though diversified, is mostly dominated by three major cereal crops; rice, wheat, and maize which jointly account for 30.92% of the Agricultural GDP of the country (MoALD, 2016). Indeed, these crops are vital for the food security of the country.

Rice is the grain that gives shape to diet, culture, economy, and the way of life in Nepal. It is the staple food and an important dominant crop in the agriculture sector of Nepal. More than 1,700 rice landraces are reported in Nepal and grown extensively under a wide range of agro-ecological conditions from lowland in Terai (50 masl) to high mountain valleys and mountain slopes (2,830 masl) (Gauchan, Magar, & Gautam, 2014). In Nepal, rice ranks first based on both area and production covering an area of 1,491,744 ha with a total production of 5,610,011 Mt and productivity of 3.76 Mt/ha in the fiscal year (FY) 2018/19 (MoALD, 2020). Nepalese farmers are cultivating rice for a long period including local varieties, improved, and open-pollinated varieties, and in recent years, they have also adopted hybrid varieties of rice (CDD, 2015). About 270 rice varieties including improved

(59), hybrids (54), and local (157) are grown in the different ecological zone of Nepal (CDD, 2015).

Improved rice varieties have played a significant role in increasing crop yield (CDD, 2015). More than 80% of the rice area in Nepal is covered by improved rice varieties (CDD, 2015). But nowadays the paradigm is slowly shifting towards hybrid rice varieties cultivation in Nepal. The main reason behind it is the high productivity of hybrid rice as compared to improved and local varieties as it has been proved practically for years that hybrid rice has more than 20% yield advantage over improved inbred varieties (Longping, 2004). Another reason may be the shifting of Nepalese agriculture towards commercialization rather than subsistence agriculture. Hybrid rice is reported to be introduced unofficially in Nepal in early 2000 through the India-Nepal border (CDD and ASoN, 2017). Most of the hybrid varieties of rice have been introduced by private seed traders in the country by importing either from India or China (CDD and ASoN, 2017). It has been reported that the hybrid rice varieties occupied about 7.4% of the total rice cultivated area in Nepal in 2015 (CDD, 2015).

Pyuthan district is one of the major cereals growing districts with rice being the third major crop after maize and wheat. In FY 2018/19, this district's total area and rice productions were 6,264 ha and 24,492 Mt, respectively, with productivity rate of 3.91 Mt/ha (MoALD, 2020). Farmers mainly cultivate Barkhe or Kharif rice in this district whereas spring rice is cultivated in a small area (MoALD, 2020). Farmers mainly cultivate improved rice varieties Radha-4, Radha-7, Radha-14, Ramdhan, Sabitri, and Radha-13. Now a day's hybrid varieties like U.S.308, U.S. 312, and unregistered Indian varieties are also cultivated by some progressive farmers.

METHODS OF RESEARCH

The study was conducted in Pyuthan municipality, a rice zone implemented area located in the Pyuthan district of the Lumbini province. The area is under the command zone of the Prime Minister Agriculture Modernization Project (PMAMP), Project Implementation Unit (PIU).

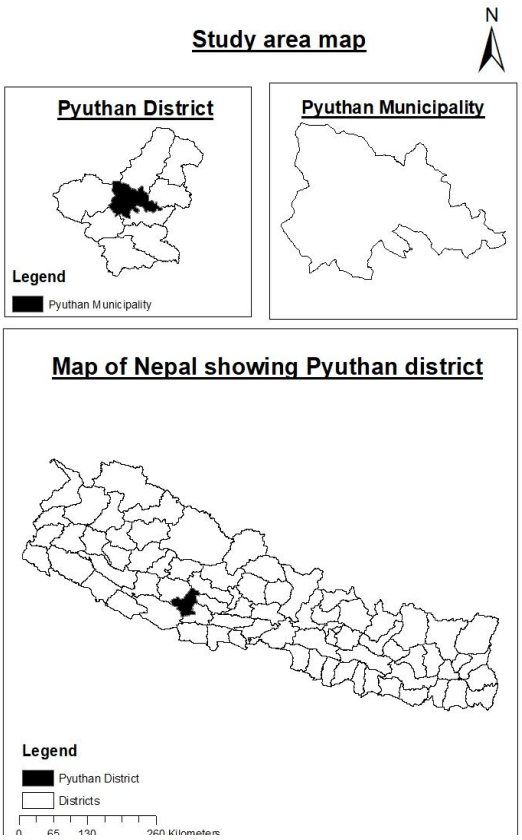

Figure 1 – Map of study of the area

Purposive random sampling was done for the selection of farm households. Altogether 60 households, 30 each of improved and hybrid rice-growing households were selected randomly for the household survey to fill up the questionnaire.

Research instruments include Preliminary Field Visits, Pre-testing of interview questionnaires, Household interview / Field survey, Key informant interview (KII), and Focus group discussion (FGD) from where the primary data were collected. And, the secondary data were obtained by reviewing different publications mainly produced by the Department of Agriculture, Ministry of Agricultural and Livestock Development, Central Bureau of Statistics, Nepal Agricultural Research Council (NARC), PMAMP Rice Zone Pyuthan, internet, and web pages.

The data were coded, tabulated, and analyzed using MS Excel and Statistical Package for the Social Sciences (SPSS). Descriptive statistics and frequency distribution analysis were used to describe socio-demographic parameters.

Gross margin is the value of output by the producer, which is computed at the farm gate price minus total variable cost.

$$\text{Gross margin} = \text{Gross return} - \text{Total cost}$$

Where: Gross return = Price × total quantity marketed (product + by-product); Total cost = sum of the materials cost and operational costs incurred in the production process.

The benefit-cost analysis was done after calculating the total cost and gross return from rice cultivation. The total cost of production was calculated by summing the materials cost and operational costs incurred in the production process. Rice being a short-duration crop, only the variable cost was considered to calculate the cost of production. For calculating gross return, income from the product, and by-product sale was accounted. Therefore, the benefit-cost analysis was carried out by using the formula:

$$\text{BC ratio} = \frac{Gross\ return}{Total\ cost}$$

Production constraints in rice cultivation were ranked with the use of the index. Scaling techniques, which provide the direction and extremity attitude of the respondent towards any proposition (Miah, 1993) was used to construct the index. The formula given below was used to find the index.

$$Iprob = \Sigma\ SiFi/N$$

Where: Iprob = Index value for intensity; Σ = Summation; Si = Scale value of ith intensity; fi = Frequency of ith response; N = Total number of respondents.

RESULTS AND DISCUSSION

The majority of the respondents were male and Chettri is the dominant ethnicity followed by Brahmin in the study area. The mean age of the improved and hybrid rice growing respondents is 49 years and 42 years respectively. Similarly, the average number of family members in both the improved and hybrid rice-growing household was 6. The education level of the respondents was either primary level or above that in both improved and hybrid rice growing households. The primary occupation of the household was agriculture/livestock followed by service and trade. Among the total household members, only 39.47% were directly involved in agriculture activities. The female population (42%) is slightly higher than the male population (38%) who are involved in agriculture. The average landholdings of improved and hybrid rice-growing farmers were 0.20 and 0.3 ha respectively. The area under rice cultivation of improved rice was 0.15 ha whereas that of hybrid rice was 0.19 ha.

Improved rice growers adopted recommended varieties such as Radha-7 (30%), Radha-9 (16.7%), Sabitri (23.3%), Radha-13 (10%), and Radha-14 (20%). Similarly, hybrid

growing farmers were found adopting either US 308 (26.77) or US 312 (72.33). 80% of the households follow rice-wheat-fallow cropping patterns for improved rice-growing areas whereas in hybrid rice-growing areas 50% of the households follow the cropping system. A greater proportion of the respondents cultivating hybrid rice than the respondents producing improved rice were found to follow the rice-winter vegetables-fallow pattern. This can be because farmers choose a particularly fertile area for hybrid rice farming and low maturity days of hybrid. It was found that not a single respondent followed the pattern of three crops per season. This might be because there aren't enough irrigation systems available in the spring or people don't have the technical know-how.

Seed soaking before sowing was practiced by all the households whereas seed treatment was not practiced in the study area. All (100%) of the improved rice growers used 4-6 seedlings/hill whereas 30% of hybrid rice growers used single seedling/hill and the remaining 70% used 2-3 seedling/hill. Hybrid rice seedlings receive 4-5 times more space than improved rice due to their lower seed rate which favors tillering in the nursery and makes it possible to transplant a single hybrid rice seedling/hill with 3-4 tillers compared with 3-4 improved rice seedlings/hill without any tiller (Virmani & Donald, 1996). But all the farmers cultivating hybrid rice were not found to be using a single seedling of rice per hill. This may be due to the technology gap and knowledge gap of farmers in the study area.

The average row to row by the plant to plant spacing in improved rice was 9.33×7.00 cm^2 whereas it was 20×18 cm^2 hybrid rice. Both the spacing was found significantly higher in ($p<0.05$) hybrid rice cultivation as compared to improved rice cultivation. Pandey & Tiwari (2012) reported that hybrid rice requires a spacing of 20 cm row-row and 15 cm plant-plant which was found to be followed by the hybrid rice growing farmers in the study area. All the respondents of both types of rice growers use a manual method to control the weed whereas no respondents had practiced methods to control insects and disease. Since machines frequently destroy straw, a valuable by-product, and difficulty in using mechanical methods on small, scattered landholdings, farmers typically choose the manual method over the mechanical method of harvesting.

The inputs such as seed, urea, DAP, and irrigation were applied by all the households growing both improved and hybrid rice varieties. The majority of respondents used organic manure (95%), and MOP (70%) but only a few used agrilime (40%). The inputs used by improved and hybrid rice were compared and analyzed by using a t-test as shown in Table 1. The quantity used of seed was significantly higher ($P<0.05$) for improved rice (65.08 kg/ha) than for hybrid rice (23.29kg/ha) whereas the quantity of Urea used was significantly higher ($p<0.05$) in hybrid rice (92.467 kg/ha) than improved rice (65.08 kg/ha). Hybrid rice growers used a higher amount of urea because they expected a higher yield in response to a higher urea dose from hybrid rice. Other inputs like organic manure, DAP, MOP, Agri-lime, and labor requirements were significantly at par ($P>0.05$) between improved and hybrid rice.

Table 1 – Inputs used in improved and hybrid rice per ha in the study area

Input parameters (In-ha)	Improved Rice	Hybrid Rice	Average
Seed(kg)	63.53±11.41a	23.39±3.25b	43.46±21.88
Organic manure (Quintal)	56.85±6.53a	56.77±7.8a	56.81±7.18
Urea(kg)	65.08±18.42b	92.46±27.33a	78.77±26.92
DAP (kg)	70.97±28.36a	80.50±26.48a	75.73±27.62
MOP (kg)	19.94±3.86a	19.89±5.54a	20.38±3.73
Agri Lime(kg)	603.29±35.14a	714.21±138.99a	681.86±128.12
Total labor (man-days)	108.11±47.89a	94.76±29.71a	101.43±40.08
I. Female Labor(man-days)	85.52±41.74a	74.76±24.88a	80.14±34.50
II. Male Labor(man-days)	22.58±9.03a	20.04±6.36a	21.29±7.85

**Mean values with different superscript letters in the same row were significantly different (P<0.05).*
Source: Field survey, 2020.

A study (Azad, Mustafi, & Hossian, 2008) noted that the seed requirement of hybrid rice was 15 kg/ha compared to 66 kg/ha of improved rice. The seed rate used by hybrid rice growers was found slightly higher than the recommended rate in the study area. This may be

due to the use of 2-3 seedlings/hill instead of a single seedling/ hill by about 70% of hybrid rice growers during transplantation. A study found that the chemical fertilizer used for hybrid rice was 12% higher than improved varieties (Husain, Hossian, & Janaiha, 2001). In the study chemical fertilizers (Urea+DAP+MOP) used for hybrid rice were 23% higher than improved varieties. None of the farmers had followed the rate of chemical fertilizers as recommended by MOALD. This may be to reduce the cost of production by farmers and the application of chemical fertilizers during the cultivation of other crops previously that year. A study reported that hybrid rice uses 4% less labor than improved rice (Lin, 1994) whereas this study showed that hybrid rice cultivation required 14 % less labor than improved rice. This may be due to higher spacing in the hybrid rice which reduces the labor requirements. A study (Joshi, Maharjan, & Piya, 2003) reported the average labor requirement for paddy cultivation in one ha in the mid-western development region was 103.8 man-days. In the present study, the average labor requirement was 101.43 man-days per ha.

The days to maturity for improved rice (140.83 days) were found significantly higher ($P<0.05$) than hybrid rice (125.00), while the productivity of hybrid rice (5.23 Mt/ha) was found to be higher by 36.19% than improved rice (3.84 Mt/ha) and the difference was statistically significant ($P<0.05$) as shown in Table 2. Hybrid rice yields 20-30% more than the improved rice with adequate management (IRRI, 1988).

Table 2 – Days to maturity and productivity of improved and hybrid rice in the study area

Parameter	Improved rice	Hybrid rice
Days to maturity	140.83±5.26a	125.00±0.0b
Productivity (Mt/ha)	3.84±0.73b	5.23±0.71a

**Mean values with different superscript letters in the same row were significantly different (P<0.05)*
Source: Field survey, 2020

The average cost of seed and urea was found significantly different ($p<0.05$) between hybrid and improved rice cultivation. The average cost for the seed of hybrid rice (NRs 12,863.89) was significantly higher than the average cost for the seed of improved rice (NRS 3,802.86). Similarly, the average cost of urea per hectare for hybrid rice (NRs 1,941.80) was found to be significantly higher than that of improved rice (NRs 1,366.84) as shown in Table 3.

Table 3 – Average cost of production of improved and hybrid rice in the study area

Cost parameters (In-ha)	Improved rice (NRs)	Hybrid rice (NRs)
Seed	3,802.26±1,690.49b	12,863.89±1,789.88a
Organic manure	5,685.21±653.15a	5,677.77±783.33a
Tillage cost	16,458.764±2,038.77a	15,702.22±2,371.36a
Urea	1,366.84±386.91b	1,941.80±574.10a
DAP	3,903.55±1,560.24a	4,427.50±1,456.58a
MOP	797.92±154.69a	830.14±146.40a
Agri lime	18,098.97±1,054.24a	21,426.47±4,169.98a
Irrigation cost	6,890.90±1,879.47a	7,611.11±849.08a
Total labor cost	52,278.03±21,939.62a	45,502.78±14,353.06a
Female labor cost	34,211.91±16,697.85a	29,626.11±10,188.48a
Male labor cost	18,066.23±7,228.69a	15,876.667±5,162.24a

**Mean values with different superscript letters in the same row were significantly different (P<0.05)*
Source: Field survey, 2020

A major portion of the input cost was incurred by labor in both the hybrid and improved rice cultivation as all the works during the cultivation of rice i.e. nursery preparation, transplantation, weeding, irrigation management, fertilizer application, harvesting, threshing, and transportation were done manually. The labor cost for improved rice (47.83%) was seen more than for hybrid rice (39.23%). The cost of seeds for hybrid rice (11.09%) was greater than for improved rice (3.47%) which is obviously due to the higher market price of hybrid seeds (Table 4).

Table 4 – Percentage-wise contribution of input cost in the study area

Parameters (in ha)	Improved rice (%)	Hybrid rice (%)
Seed	3.47	11.09
Organic manure	5.20	4.89
Tillage cost	15.06	13.53
Urea	1.25	1.67
DAP	3.57	3.81
MOP	0.73	0.71
Agri Lime	16.56	18.47
Irrigation cost	6.30	6.56
Total labor cost	47.83	39.23
Total	100	100

Source: Field survey, 2020

The cost per quintal (NRs 2271.53) and farm gate price (NRs 30.00) of improved rice were significantly higher than that of hybrid rice (Rs 1678.46 and Rs 27.6 respectively). However, total variable cost (NRs115983.69), gross returns (NRs 172577.50), gross margin (NRs 56593.81), and BCR (1.48) of hybrid rice were significantly higher than that of improved rice (NRs 109282.44, NRs 136911.76, NRs 27629.76, and 1.25 respectively). This means the cost of production of hybrid rice was marginally higher (6.13%) than improved rice (Table 5).

A study (Xie & Hardy, 2009) noted that the additional cost of production for hybrids averages 5% with a range of 1% to 18% across the countries. In the study, hybrid rice has a 104 % higher gross margin than improved rice. Also, the BCR of hybrid rice (1.48) is higher than that of improved rice (1.25). Thus, the cultivation of hybrid rice is more profitable than improved rice. Xie and Hardy (2009) also reported that the marginal returns of hybrids over inbred average about 27%, ranging from 23% to 119% across the countries and the benefit-cost ratio of hybrids (1.7) is marginally higher than that of inbred (1.6).

Table 5 – Economic indicators of improved and hybrid rice production in the study area

Parameter	Improved rice	Hybrid rice
Total variable cost (NRs)	109,282.44b	115,983.69a
Cost per quintal (NRs)	2,271.53a	1,678.46b
Farm gate price (NRs/kg)	30.00±1.64a	27.6±0.9b
Straw price (NRs./quintal)	400.00a	400.00a
Gross returns (Grain+Straw)	136,911.76±24,010.45b	172,577.50±21,909.21a
Gross margin (NRs)	27,629.76b	56,593.81a
BCR	1.25±0.21b	1.48±0.18a

**Mean values with different superscript letters in the same row were significantly different (P<0.05)*
Source: Field survey, 2020

The majority of the improved rice growers had their source of seed as their own stored (66.7%) and 56.7% from PMAMP whereas, 100% of hybrid rice growers had purchased seed from agro vets. The majority of improved (76.7%) and hybrid rice growers (60%) had purchased their fertilizers from agro vets.

Rice after harvest is mostly stored for household consumption by both improved rice growers (83.3%) as well as hybrid rice growers (73.3%) and only a few store some quantity and sell the surplus produce. Similarly, straw produced was mostly used as livestock feed by both improved (86.7%) and hybrid rice growers (73.3%). Only a few had sold the rice straw.

All the improved rice growers preferred it due to the better taste and traditional culture whereas the reason for the preference for hybrid rice was higher yield, profit, and, early maturity. Most of the improved rice growers (76.7%) rated the cooking quality of improved rice as high whereas half of the hybrid rice growers rated the cooking quality of hybrid rice as low and half rated medium.

The major production constraints reported by the farmers during rice cultivation are ranked in table 6. The most serious constraint for both the improved (I=0.94) and hybrid rice growers (I=0.90) was the lack of fertilizers in time and less access to quality seed (Table 6).

Since Nepal fully depends on fertilizers from our neighboring country India and its supply during peak hours is not satisfactory.

Table 6 – Production constraints for improved and hybrid rice production in the study area

Production constraints for rice growers	Improved rice production		Hybrid rice production	
	Index	Rank	Index	Rank
Inadequate irrigation facility	0.28	V	0.28	V
Lack of fertilizers in time and less access to quality seeds	0.94	I	0.90	I
Lack of technical Knowledge	0.673	II	0.686	III
Shortage of labor	0.653	III	0.72	II
Insect, disease, and weed infestation	0.453	IV	0.406	IV

Source: Field survey, 2020

Among the 3 major problems in the marketing of rice reported by the farmers, improved rice growers mostly faced the problem of the mill not buying in small amounts (73.3%) whereas hybrid rice growers mostly faced the problem of agents (70%) as shown in Table 7.

Table 7 – Problems in the marketing of rice in the study area

Major problem in the marketing of rice	Improved rice production		Hybrid rice production	
	Yes	No	Yes	No
Low farm gate price	21 (70.00)	9 (30.00)	20 (66.67)	10 (33.33)
Problem of agents	10 (33.33)	20 (66.67)	21 (70.00)	9 (30.00)
Mill doesn't buy in small amounts	22 (73.33)	8 (26.67)	18 (60.00)	12 (40.00)

Figures in parentheses indicate percentage
Source: Field survey, 2020

Improved rice growers' source of knowledge of rice cultivation was self-learning (100%), family and neighbor (53.3%), and PMAMP PIU (50%). In the case of hybrid rice growers (Table 8), the source of knowledge was self-learning (100%) and from agro vets (80%).

Table 8 – Source of knowledge about rice cultivation in the study area

Source of knowledge about rice cultivation	Improved rice growers		Hybrid rice growers	
	Yes	No	Yes	No
Self-learning	30 (100.00)	0 (0.00)	30 (100.00)	0 (0.00)
Family and neighbor	16 (53.33)	14 (46.67)	12 (40.00)	18 (60.00)
Agriculture Knowledge Centre	8 (26.67)	22 (73.33)	14 (46.67)	16 (53.33)
PMAMP PIU	15 (50.00)	15 (50.00)	9 (30.00)	21 (70.00)
Agro-vet	5 (16.67)	25 (83.33)	24 (80.00)	6 (20.00)
Radio & TV	5 (16.67)	25 (83.33)	1 (3.33)	29 (96.67)
Published media	8 (26.7)	22 (73.33)	10 (33.33)	20 (66.67)

Figures in parentheses indicate percentage
Source: Field survey, 2020

Table 9 – Suggestion of farmers to improve rice production in the study area

Suggestions for improving rice production	Respondents growing improved rice (%)		Respondents growing hybrid rice (%)	
	Yes	No	Yes	No
Subsidy in constructing and repairing small irrigation channel	30 (100.00)	0 (0.00)	30 (100.00)	0 (0.00)
Subsidy in modern equipment like mini-tiller, harvester	30(100.00)	0 (0.00)	30 (100.00)	0 (0.00)
Timely availability of chemical fertilizers	28 (93.33)	2 (6.67)	26 (86.67)	4 (13.33)
Availability of quality seeds	23 (76.67)	7 (23.33)	16 (53.33)	14 (46.67)
Regular training programs	8 (26.67)	22 (73.33)	12 (40.00)	18 (60.00)

Figures in parentheses indicate percentage.
Source: Field survey, 2020.

All the respondents suggested the concerned stakeholders should provide subsidies for the construction and repair of small irrigation channels and modern equipment. The majority of improved rice growers (93.3%) and hybrid rice growers (86.7%) suggested the timely availability of chemical fertilizers in time (Table 9).

CONCLUSION

Due to the quality of seed, wider spacing, high tillering capacity, and high urea application rates, the productivity of hybrid rice was higher in the study area as compared to improved rice. Although hybrid rice had greater seed and fertilizer costs, it was ultimately more profitable due to its higher yield, which raised the net return and benefit-cost ratio. Lack of timely availability of fertilizers, limited access to high-quality seeds, and inadequate technical support have hampered the rice production in the study area. The concerned stakeholders should focus on providing quality seeds and a regular supply of fertilizers in the peak periods. Thus, to improve rice production and profitability, the adoption of hybrid varieties along with addressing these hindrances is a must.

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