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ORIGINAL RESEARCH ARTICLE

Diversity assessment of rice varieties in Khairahani Municipality, Chitwan District, Nepal

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ABSTRACT

The study aims to assess varietal diversity in the Khairahani municipality of Chitwan district of Nepal. A cross-sectional survey and stratified random sampling were employed, surveying 100 households across all 13 wards. The survey focused on examining the effectiveness of varieties cultivated by farmers. Rice, the main staple crop in the Chitwan district, was found to consist of 19.20% of hybrid seeds, 9.74% of local seeds, and 71.06% of improved seeds. All hybrid seeds surveyed were registered, with 77.42% improved seeds and 20.59% of local seeds. Additionally, Chaite-5 was the most prevalent variety, followed by Sabitri and Hardinath-1 among the improved varieties, while Gorakhnath 509 dominates the hybrid category. The study applied the Shannon-Wiener Index to analyze genetic diversity, evenness, and richness among rice varieties. The diversity index for the rice genotype in Khairahani was 2.87, indicating an effective number of varieties of 17.71, a richness score of 32, and an evenness score of 0.49, suggesting moderate to high rice diversity. Agro-vets are the main suppliers of seeds, which were found to be 47%, 15% from preserved seeds, 49% from both agro-vet and preserved sources, 15% from co-operatives, and 13% from neighbors. The study suggested that registered hybrids varieties are prevalent due to higher yields, and easy accessibility, but local landraces are at risk due to their low production. Therefore, approaches aimed at promoting local rice varieties are essential for protecting genetic diversity in Khairahani municipality, Chitwan district.

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INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of more than 60% of the world's population (Nawaz *et al*., 2022; Banjade *et al*., 2023). About 92 % of the global production is in the Asian region, where about 59% of the world population lives and use rice in their daily kitchen in various way (Khanal *et al*., 2024a). Globally, rice production is forecast to reach 523.9 million tonnes (milled basis) in 2024/2025, implying an expansion of 0.8 percent from the previous year. Among the top 10 rice-producing countries that cover almost 85% of the world's rice production, India and China contribute more than half of the total. More than 3 billion people get 30-75% of their daily calorie intake from rice, which is significant on a worldwide scale as a primary source of food (Paudel *et al*., 2013; Khanal *et al*., 2024b). Rice is the most important food crop in terms of area, production, and livelihood and Nepal's most preferred staple food crop. It fulfills more than 50% of the calorie requirement of the Nepalese people (Banjade *et al*., 2024). Additionally, rice is currently grown in half of the total cropped area and accounts for more than half of the total

food grain production in the country (Malla *et al.*, 2022). It occupied about 1.47 million hectares with a production of about 5.62 million tons and productivity of 3.81 tons per hectare in fiscal year 2078/2079 BS. It contributes approximately 20% of the country's agricultural gross domestic product. About 73% of the total rice is growing in the plain region of Nepal, whereas the hills and high hills occupy only about 24% and 3%, respectively (Chandio *et al.*, 2022). The government of Nepal first time recommended the CH-45 rice variety in 1959 (Joshi, 2017a). Until this year, more than 123 rice varieties have been released and registered in Nepal. Among these varieties, 50 are hybrid rice imported mainly from China and India. Landraces occupy about 10% of the total rice area, and there are 9% upland types of rice landraces. More than 1000 genotypes are introduced annually from IRRI for evaluation (Joshi, 2017b). There are many landraces with specific traits useful for breeding and have the potential for greater yield.

Chitwan is known for its rice agricultural diversity in Nepal. It stands as a significant contributor to rice cultivation, covering 27,403 hectares and yielding 104,544 metric tons with a productivity of 3.83 Mt/ha, where the spring season has 20,980 metric tons' production with 4,975 hectares' area and the main season has 83,564 metric tons with the 22,428-hectare area (MoALD, 2023). It is cultivated across the district; east Chitwan, west Chitwan, and Madi are pocket areas for rice cultivation. In Chitwan, different rice varieties, such as Sawa Mansuli, Bar, Sabitri, Moti, Gorakhnath, and Jiramsino, are cultivated. The main aim of this study is to provide guidelines for future breeding programs by identifying the genetic variability within local rice varieties, which can help conserve unique genetic traits. Raising awareness among farmers about the benefits of varietal diversity can help balance the adoption of high-yield varieties.

MATERIALS AND METHODS

Site selection

The study was conducted in the Chitwan district, southwestern part of Bagmati province, situated at latitude 27°36´21.60´´ N, longitude 84°22´47.28´´ E. Chitwan is the inner terai of Nepal, located between the Mahabharat and Siwalik ranges, which provide varied climatic and soil conditions conducive to rice cultivation. Our study was conducted in Khairahani municipality, Chitwan, comprising 13 wards. The households to be surveyed were those with more than 20 katha of land, ensuring that the study focuses on significant rice farmers within the municipality.

Study design and sampling

This study was survey-based research to assess rice varietal diversity in Khairahani municipality, Chitwan. The collected data provides a comprehensive overview of the phenomenon or group to identify trends and patterns used for the decision-making process of varietal selection in rice farming. Stratified random sampling was used to ensure the sample was representative of the population. Given the total number of households with more than 20 katha of land across the 13 wards, a sample size of 100 families were used for the survey. The population of households with more than 20 katha of land was divided into 13 strata, corresponding to the 13 wards of the municipality. The sample size was allocated proportionally to each ward based on the number of households with more than 20 katha of land. This ensures that each ward is represented in proportion to its size. From each ward, households were randomly selected to meet the proportional sample size allocated to that ward.

Data collection and analysis

A structured questionnaire was used to collect qualitative data from selected farmers. A detailed questionnaire was asked to randomly selected eastern Chitwan rice farming farmers to gain insight into their farming practices, variety selection, and challenges. The questionnaires were close-ended, allowing farmers a more detailed exploration of key topics. Field observations were conducted to validate survey responses and assess the genetic diversity of rice farms. This included, observing the prevalence of pests and diseases and the management practices employed by farmers. Data entry and analysis were done using the Statistical Package for Social Science version 17 (SPSS) and Microsoft Excel.

Shannon-Weiner Index

The Shannon-Weiner index was calculated to measure the richness and evenness of the rice variety.

$$H=-\Sigma pi \times Inpi$$

Where pi = proportion of individuals of species i, and In is the natural logarithm, and S = species richness. The value of H ranges from 0 to H_{max}. H_{max} is different for each community and depends on species richness.

RESULTS AND DISCUSSION

Varietal diversity of rice

The survey found 32 types of varieties more prevalent in the Khairahani, Chitwan. The most cultivated genotype is Chaite-5 with 15%, followed by Sabitri 12%, whereas Gorakhnath 509 dominates hybrid varieties with 11%. Bagari and Jogini are the landraces that are least cultivated (Figure 1). Shannon-Weiner yields a value of 2.8743 for the rice varieties most prevalent in Khairahani municipality of Chitwan. The more the value of the Shannon-Weiner index, the more diverse the community is and Shannon-Weiner index value of different rice varieties are presented in Table 1. The effective number of rice varieties is 17, which means there are 17 'virtual' varieties having relative abundance and evenness is found to be 0.4909, indicating moderate to high diversity.

Table 1. Shannon-Weiner index for the cultivated varieties of rice.

Name of variety	Frequency	pi	Ln pi	pi * Ln pi
Chaite-5	53	0.151862464	-1.884780009	-0.286227337
Sabriti	42	0.12034384	-2.117402304	-0.254816323
Goraknath	40	0.114613181	-2.166192468	-0.248274208
Hardinath-1	36	0.103151862	-2.271552984	-0.234314921
Gangotri	23	0.065902579	-2.719577706	-0.179227184
Garima	21	0.06017192	-2.810549484	-0.169116158
Mukabla	16	0.045845272	-3.0824832	-0.141317281
Godabari	13	0.037249284	-3.290122565	-0.122554709
Chandan	12	0.034383954	-3.370165272	-0.115879608
Mansuli	12	0.034383954	-3.370165272	-0.115879608
Anadi	9	0.025787966	-3.657847345	-0.094328442
Kuber	9	0.025787966	-3.657847345	-0.094328442
MPR 505	7	0.020057307	-3.909161773	-0.078407256
Sona Kaveri	6	0.017191977	-4.063312453	-0.069856375
US 312	5	0.014326648	-4.24563401	-0.060825702
Katarni	5	0.014326648	-4.24563401	-0.060825702
Taichung	5	0.014326648	-4.24563401	-0.060825702
Ganga kaveri	4	0.011461318	-4.468777561	-0.051218081
Sama	4	0.011461318	-4.468777561	-0.051218081
Chaukote	4	0.011461318	-4.468777561	-0.051218081
Dudhraj Satari	4	0.011461318	-4.468777561	-0.051218081
Jerry	3	0.008595989	-4.756459634	-0.040886472
Jira Masino	3	0.008595989	-4.756459634	-0.040886472
Kanajira	3	0.008595989	-4.756459634	-0.040886472
Pokheri	2	0.005730659	-5.161924742	-0.029581231
Mirjhai Masino	2	0.005730659	-5.161924742	-0.029581231
Madhukari	1	0.00286533	-5.855071922	-0.01677671
Upaj	1	0.00286533	-5.855071922	-0.01677671
Idea	1	0.00286533	-5.855071922	-0.01677671
Jogini	1	0.00286533	-5.855071922	-0.01677671
Bagari	1	0.00286533	-5.855071922	-0.01677671
Yemeni	1	0.00286533	-5.855071922	-0.01677671
Total	349	1	0	-2.874359423

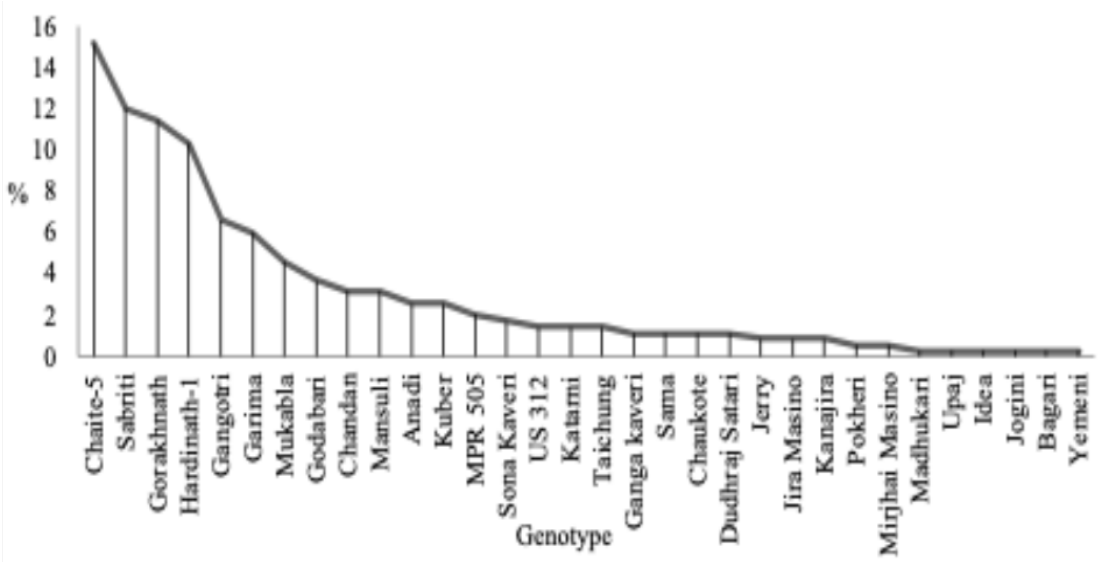

Figure 1. *Varietal distribution of rice at study area.*

Diseases of rice

We have found that the most prevalent disease of rice in Khairahani, Chitwan is leaf blast (37%) followed by neck blast (31%) and bacterial blight (17%). The higher occurrence of these 3 diseases is maximum in this region (Figure 2). Similar finding was observed in the experiment conducted by (Bhusal & Neupane, 2021), where the blast is responsible for a 10-20% yield reduction of rice every year.

Insects of rice

According to the result of our survey, 4 major kinds of insects were causing damage to the rice field in terms of their production. The most common insect causing harm to the rice fields was stem borer (31.4%), followed by brown plant hopper (BPH) (28.02%) and rice leaf roller and rice bug (16.91%). Other observed insects are aphids, cutworm's white grubs, etc. (Figure 3). The higher dose of fertilizer than the recommended dose for normal rice cultivation also favors a favorable environment for pests and disease occurrences in hybrid varieties of rice (Sah & Bal, 2020).

Registration status of varieties

Among the households surveyed, improved and hybrid varieties constituted a slightly larger share compared to landraces. The most cultivated improved varieties were Chaite-5 and Sabitri, which have gained popularity due to their superior agronomic traits and market performance. On the other hand, the most frequently grown landraces included Jerry and Anadi, which are valued for their adaptability to local conditions and the ability to save seeds for future planting. In Khairahani municipality, 56% of rice varieties are registered types (Figure 4). This includes well-established commercial new varieties, which farmers widely use due to their higher yield potential and market availability. Among the registered hybrid varieties, Gorakhnath, Garima, US 312, and IDEA are more common among the farmers. In contrast, 44% of the rice varieties were unregistered. Unregistered varieties comprised of local and improved varieties like Gangotri, Godabari, Anadi, etc, may not have official approval or registration in Nepal. Farmers may still grow these varieties due to perceived advantages such as better yields, adaptability, or resistance to specific pests or diseases, but they lack formal recognition or regulatory oversight (Joshi & Bauer, 2006).

Source of seeds

The seeds used by households in Khairahani municipality are from different sources. The different kind of seeds used were hybrids, landraces and improved seeds. The most common source was agrovet suppliers (Figure 5). Farmers nowadays mostly preferred buying seed from agrovets in combination to the seeds locally preserved by traditional method. The other sources were agriculture cooperatives, and small farmers groups, etc.

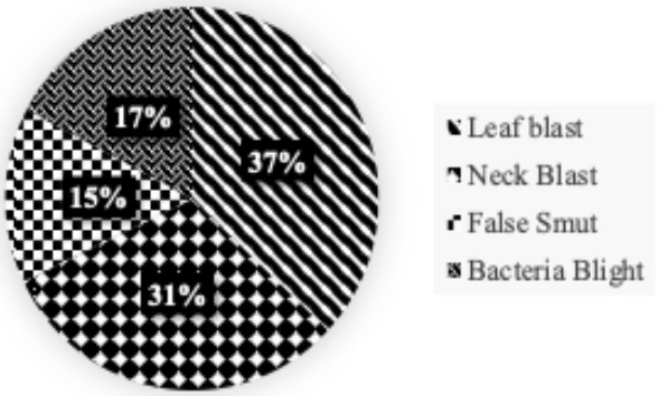

Figure 2. *Disease prevalence in cultivated rice at study area.*

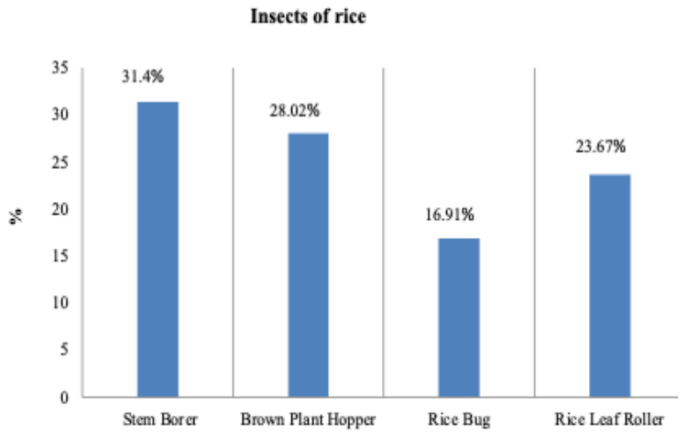

Figure 3. *Prevalent insects in rice field at study area.*

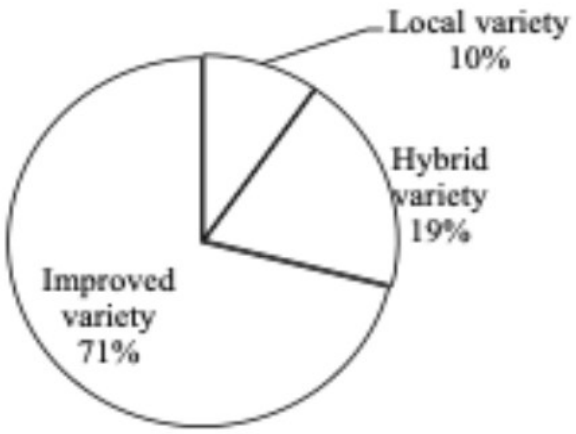

Figure 4. *Types of rice cultivars cultivated by local farmers at study area.*

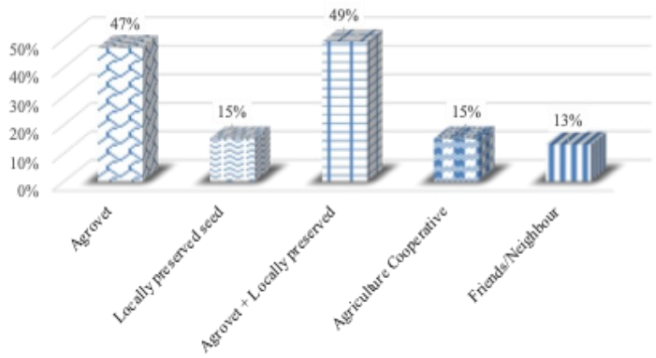

Figure 5. *Major sources of seed input for rice farming at study area.*

Conclusion

Rice is cultivated mainly in the rainy and spring seasons and is diverse, bearing a moderate to high index value when computed by the Shannon-Weiner diversity index. This research highlights the diversity of rice varieties in Khairahani municipality, with 32 varieties identified across 100 households. Insect like stem borer, BPH and diseases like blast were major concerns affecting rice cultivation. The attraction of farmers towards improved and hybrid seeds was observed because of the higher production and high yield of varieties, leading to higher income generation. The study shows a gradual shift towards modern varieties, but maintaining varietal diversity is essential for sustainable agriculture. Continued insect and disease management efforts and the promotion of hybrid and local varieties can contribute to balanced rice varietal diversity. Increasing awareness about the benefits of using local landraces and enhancing support for open pollinated varieties could improve conservation of local rice varieties. Additionally, initiatives encouraging economic diversification among farmers could support more sustainable agricultural practices, benefiting local food security and the broader agricultural landscape.

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DECLARATIONS

Author's contribution: Conceptualization, D.K., R.B. and D.B.; methodology, D.K., R.B. and D.B.; software, S.T. and N.B.; validation, D.K., R.B. and D.B.; formal analysis, D.K., N.B., and S.T.; investigation, R.B.; resources, R.B. and D.B.; data curation, R.B., D.B., and N.B.; writing—original draft preparation, D.K., R.B. and D.B.; writing—review and editing, D.K. and D.B.; visualization, D.K. and S.T.; supervision, D.K., N.B. and S.T.; project administration, R.B.; funding acquisition, R.B. All authors have read and agreed to the published version of the manuscript.

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Ethics approval: This study did not involve any animal or human participant and thus ethical approval was not applicable.

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Additional information: No additional information is available for this paper.

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