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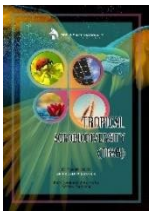

RESEARCH ARTICLE

STUDY OF INJUDICIOUS FERTILIZER APPLICATION BY RICE *(Oryza sativa* L.*)* FARMERS IN KANCHANPUR, NEPAL

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ABSTRACT

The cross-sectional survey was conducted in Shuklaphanta municipality, Kanchanpur, among 124 households during April 2023. Data was collected using a random sampling technique with semi-structured questionnaires, complemented by focus group discussions to validate the survey findings. Results showed that the use of farmyard manure *(*9.6 tons/ha*)* was 1.6 times more than the recommended dose *(*6 tons/ha*)*, but the efficiency of manure was decreased due to poor preparation and improper application in the field. With regards to chemical fertilizers, diammonium phosphate *(*83 kg/ha*)* was used in higher amounts than recommended dose, while urea *(*99kg/ha*)*, muriate of potash *(*32 kg/ha*)* and zinc sulfate *(*5kg/ha*)* were used less by farmers *(*recommended dose of Urea, DAP, MOP and zinc sulfate is 192, 65, 50 and 9.5 kg/ha respectively*)*. The use of fertilizers varied significantly by ethnicity and farm size, with $p < 0.05$ in both conditions. Tharu farmers used the highest quantities of urea and Diammonium phosphate among ethnic groups, while the Brahmin community favored farmyard manure. Farmers lacked awareness regarding the benefits of using micronutrients, leading to fertilizer imbalance. Problems were ranked using a problem matrix, and the lack of timely fertilizer availability was ranked as the most severe problem, followed by the higher cost of fertilizers and the low subsidy on fertilizers. Hands-on training related to correct fertilizer application can be the best option for rice-producing farmers to enhance production.

KEYWORDS

Farmer, Inorganic fertilizer, Organic fertilizer, Rice, Use Gap

1. INTRODUCTION

Rice, a member of the *Oryza* genus within the Poaceae *(*Gramineae*)* family, is widely distributed throughout the tropics and subtropics regions of the world *(*Dunna and Roy, 2013*)*. In Nepal, it is the most significant cereal crop in terms of total area cultivated, dietary preferences of the people, and economic impact *(*Pant et al., 2020*)*. Rice is cultivated in an area of 1,477,378 hectares with a production of 5,130,625 metric tons and a yield of 3.47 metric tons per hectare in the year 2021/22 all over Nepal. In the kanchanpur district, it is cultivated in an area of 48,745 hectares, with main season rice in 48,515 hectares and spring rice in 230 hectares. The total production of rice was 1,32,465 metric tons, and the total yield was 2.72 metric tons per hectare in the same year in this district. Agriculture, forestry, and Fishing contribute 24.12 % to the total GDP, and the contribution of Paddy alone is 13.6 % to the agricultural GDP of Nepal in the year 2022/223 *(*MoALD, 2023a*)*. The recommended dose for Nitrogen, Phosphorus, Potassium, Zinc, and boron is 100: 30: 30: 2: 1 kilograms per hectare in Kanchanpur *(*MoALD, 2023b*)*. Although the active demand for chemical fertilizers is just 8 lakh metric tons, the total demand for these fertilizers is more than 15 lakh metric tons. The government was only able to provide fewer than 4 lakh metric tons in response to this demand. The supply of chemical fertilizers is never greater than the demand for active fertilizers *(*Vista et al., 2022*)*. Although Nepal is a major producer of rice in South Asia, its productivity and profitability are relatively low when compared to other nations in the region *(*Amgain et al., 2021*)*. In Nepal, most of the time, nutrients are used inefficiently and unevenly, which reduces nutrient usage efficiency and profitability *(*Timsina et al., 2013*)*. Nepalese farmers face fertilizer issues like shortages, low quality, high costs, and detrimental effects on soil fertility, while the government struggles with timely, adequate distribution nationwide *(*Bhattarai and Dhakal, 2014*)*. Nepal's research lacks focus on factors affecting smallholders' adoption of seeds, fertilizers, and techniques, leading to low technology uptake *(*MoAD, 2015*)*.

This study investigates the fertilizer application gap among rice farmers in Kanchanpur district. It aims to assess current fertilizer use, identify major challenges, and explore knowledge gaps. Key areas include farmers' socio-demographic characteristics, the difference between recommended and actual fertilizer use, and their awareness of proper application. The findings will inform policies to promote effective fertilizer practices, improve rice productivity, and support sustainable agriculture, contributing to food security and local development.

2. MATERIALS AND METHODS

2.1 Research site

The study was conducted in the Shuklaphanta Municipality, which has 28°54′37″ N latitude and 80°20′51″ E longitude, located in Kanchanpur district and Sudurpashchim province of Nepal. Shuklaphanta municipality covers an area of 162.57 km^2. It ranges in altitude from 230 m above mean sea level. The average annual rainfall of the area is 1,575 mm. The average maximum and minimum temperatures are 38°C and 9°C. Major ethnic groups in the municipality include Chhetri, Tharu, Brahmin, and Dalit *(*Statistics Office Kanchanpur, 2018*)*. This municipality comprises a total population of 53,969 and 12058 households *(*NPHC, 2021*)*.

2.2 Research Design

For this research, a convergent parallel mixed method *(*qualitative and quantitative*)* was used. Respondents were allowed to give markings from 1 to 10, and the highest number was given to the most severe problem in case of problem ranking during the study of the perception.

2.3 Sampling Population and Sample Size

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Total number of holdings in Shuklaphanta municipality = 10,166 (NSCA, 2023)

According to Yamane's formula,

Sample population (n) = $\frac{N}{1+Ne^2}$ (assuming 95 % confidence level and p = 0.5)

where, N = Population size and e = level of precision

Calculating sample size at an error margin of 10 % gives,

n = $\frac{10,166}{1+10,166(0.1)^2}$ = 99

So, the minimum sample size for this population is 99.

2.4 Data collection techniques and procedures

Primary data was collected through a cross-sectional survey, and Focus Group Discussions (FGDs) were carried out to validate the survey data. A random sampling technique was applied to interview farmers. Secondary sources of data were collected from the municipality, reports of government institutions, internet searches, journals, and other publications. A semi-structured questionnaire was prepared, and a field survey was conducted in April 2023 among 124 respondents.

2.5 Data Analysis

The data collected from the survey and FGD were analyzed using statistical software such as SPSS and MS Excel. Descriptive statistics such as mean, frequency, percentage, and standard deviation were calculated in most cases. Kruskal-Wallis test was used to test the significant difference between the variables. Tables and graphs were used to represent results based on requirements.

2.6 Hypothesis used

The Kruskal-Wallis test was used in this analysis, which is a nonparametric hypothesis test that compares three or more independent groups. The Kruskal-Wallis test assesses data by assigning ranks to the values, ordering them from lowest to highest. It then calculates the average rank for each group. If the test reveals statistically significant differences, it means that the average group ranks are not equal. In such cases, the group with a higher mean rank is considered superior compared to the others.

3. Results and Discussion

3.1 Basic household characteristics

Farmers were asked different questions that provided information about their age, sex, area of rice cultivation, education qualification, and ethnicity. These characters have an impact on their agricultural activities and livelihood too.

Table1: Basic Household Characteristics of Farmers

Variable		Frequency	Percent
Sex	Male	100	80.6
	Female	24	19.4
Age	<20	2	1.6
	Above 60	7	5.6
	21-40	54	43.5
	41-60	61	49.3
Ethnicity	Chhetri	55	44.4
	Brahmin	35	28.2
	Tharu	23	18.5
	Dalit	11	8.9
Education	≥Bachelor's degree	14	11.3
	Illiterate	22	17.7
	Secondary level	38	30.6
	Basic level	50	40.4
Total Respondents: 124			

National statistics report that 17% of farmers in Nepal are illiterate NSO (2023), and the findings of this survey align with that. Among total respondents, 80.6 % were male and 19.4 % were female. According to national statistics, 67.6 % of agricultural households are male-headed, and 32.4 % are female-headed (NSCA, 2023). The result of this survey is higher than national statistics, and this may be due to more social taboos prevailing in this region, which promotes males as the head of the family. Research also found that males have more control over agricultural resources and decision-making in Kanchanpur (Kalauni and Joshi, 2020). The Chhetri caste was found to be the most dominant, having 44.4 % abundance, followed by Brahmin, Tharu, and Dalit castes at 28.2 %, 18.5 %, and 8.9 % respectively. National Population and Housing Census 2021 NPHC (2021) also provided similar findings to this research. The maximum area of rice cultivation was 6 ha, and the minimum was 0.2 ha, with a mean of 0.6ha. The Tharu ethnic group was found cultivating rice in larger areas than other ethnic groups. The mean yield of rice among respondents was found to be 3.51 tons per ha, with a maximum of 5 and a minimum of 1.5 tons per ha. The reason behind the low productivity of rice might be the high level of subsistence farming, lack of cultivation of high-yielding varieties suitable in this region, less and untimely availability of inputs such as seeds and fertilizers, labor shortage in the peak agriculture season, and so on (MoALD, 2021).

3.2 Types of fertilizer used by rice farmers

The survey conducted in 2023 revealed that 84.7% of respondents used a combination of organic and inorganic fertilizers, while 7.2% relied solely on organic fertilizers, and 8.1% exclusively used inorganic fertilizers. Despite the increasing use of chemical fertilizers in Nepal, organic fertilizers were applied by 92% of farmers either alone or in combination with chemical fertilizers, likely due to the prevalence of livestock farming for dairy production and religious purposes in the region. The findings also indicated that 55.6% of farmers reported using a greater amount of chemical fertilizers compared to the past 15 years, 19.4% increased their use of organic fertilizers, and 25% maintained the same level of fertilizer usage over this period. NSCA (2023) also found an increasing trend of chemical fertilizers in Nepal, and increasing use of nitrogenous fertilizer was noted in South Asia by (Aryal et al., 2021).

3.2.1 Organic fertilizer

The primary organic fertilizer sources in this region were Farmyard Manure (FYM), vermicompost, sugarcane press mud, mustard cake, grain legumes, and green manure. Among respondents, 37.9% used FYM as their sole organic fertilizer, while 8.1% relied exclusively on chemical fertilizers. Notably, no respondents used other organic fertilizer sources without incorporating FYM. Press mud (1.6%), vermicompost (3.5%), and mustard cake (4.8%) are ranked as the least adopted options among all organic fertilizers. Black gram and sesame were sown along the bunds of rice fields by 25% and 3% of the respondents, respectively. Other crops used for incorporation in the field before rice growing included mung bean (6%) and Dhaincha (*Sesbania cannabina*) (5.1%). Relay cropping with lentils was practiced by only 5% of respondents. Black gram was the most widely cultivated legume crop, likely due to its dual purpose, nutritional benefits, and its role in traditional dishes prepared during festivals and special occasions in the region.

Over 65% of respondents reported using partially decomposed farmyard manure (FYM) in their fields, which reduces its effectiveness in enhancing crop yields. The average amount of FYM applied by respondents was 9.6 tons per hectare, more than 1.5 times the recommended dose of 6 tons per hectare for rice cultivation in Nepal. The higher application of organic manure is likely attributed to the region's livestock-based farming systems. In Sudurpaschim Province, Kanchanpur District accounts for 17% of the province's cattle and buffalo population, the second-highest

among all nine districts. This high livestock density supports the widespread availability and use of FYM in the region (MoALD, 2022).

Despite the extensive use of organic farmyard manure in the fields, rice productivity in this region remains unsatisfactory and falls below its potential yield. This could be attributed to nutrient losses caused by leaching and sun drying, as organic manure is often left exposed in the field for extended periods, as well as the incomplete decomposition of compost manure. To address these issues, farmers require training on proper manure preparation and application techniques. Additionally, strengthening agricultural extension activities in the region is essential to bridge this gap and enhance productivity.

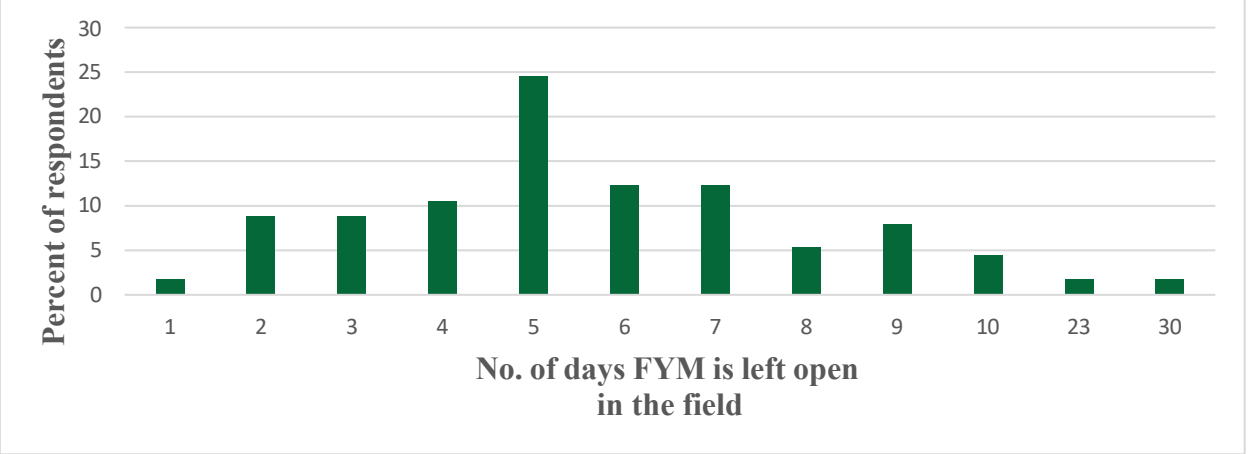

Figure 1: Days of FYM left in the field before plowing

Among the 114 organic fertilizer users surveyed, the duration for which organic manure was left exposed in the field ranged from 1 to 30 days, with an average of 6.15 days. Notably, 19.3% of respondents left organic manure in the field for over a week, extending up to a month. Similarly, a study reported that many farmers in Nepal left organic manure in the field for extended periods, leading to a significant loss of efficiency (Baral et al., 2020). This inefficiency is primarily attributed to nutrient losses caused by leaching due to rainfall and drying from sun exposure, highlighting the need for improved manure management practices

3.2.2 Chemical Fertilizers

Table 2: Types of chemical fertilizers used

Fertilizer	Frequency	Percent
Organic fertilizer only	9	7.2
Urea only	2	1.6
Urea, DAP, MOP, Zinc	34	27.4
Urea, DAP	39	31.5
Urea, DAP, MOP	40	32.3
Total	124	100.00

More than 60 % of respondents were not using any micronutrients as nutrient sources and were found dependent on Urea, DAP, and MOP among inorganic fertilizer sources. Research by Takeshima (2019) also found Urea, DAP, and MOP as the major chemical fertilizers used in Nepal. Farmers lacked awareness regarding the benefits of using micronutrients in rice cultivation. Among all micronutrients, zinc was only used by 27.4% of respondents. Even though the use of boron and zinc as micronutrients in rice cultivation is recommended, no farmers were found using boron, and the use of zinc is also very poor (MoALD, 2023b). Furthermore, only 60% of respondents used MOP as a potassium source, indicating an imbalance in the application of nutrients in the fields. Author also found that zinc deficiency is most widespread in the terai part of Nepal, and very few farmers were cultivating crops using the micronutrients (Andersen, 2007).

Table 3: Stage of application of chemical fertilizers

Stage of Application		Frequency	Percent
Urea	Field preparation	47	37.9
	Field preparation, Tillering	63	50.8
	Field preparation, Tillering, and panicle initiation	5	4.1
DAP	Basal dose only	100	82.3
	Basal and Tillering	13	10.5
MOP	Basal dose only	74	59.7
Zinc	Basal dose only	34	27.4
Total chemical fertilizer user = 115 and Total respondents = 124			

MoALD (2023b) ; Vista et al. (2022) suggested using the total amount of phosphorus, potassium, and zinc during the final preparation of land and using nitrogen in 3 split doses equally at final field preparation, tillering, and panicle initiation phase is appropriate for rice cultivation. However, results showed that most of the farmers used fertilizers without observing the condition of crop development precisely. More than 90 % of respondents were dependent on rainfall for irrigation after transplanting, and they all used fertilizer after rainfall, rather than using it at the panicle initiation stage exactly. Nitrogen was also not divided into split doses precisely, and they were using it according to their own experience. Poor and improper application of fertilizer was observed in this region.

Table 4: Amount of Chemical fertilizers used in Kg/ ha

Statistics	Amount of Urea	Amount of DAP	Amount of MOP
Minimum	30	30	6
Maximum	300	180	120
Mean	99	83	32
Std. Deviation	53.346	42.192	35.424

According to the study, the recommended dose of N*:* P*:* K*:* Zn fertilizer in rice for the kanchanpur district is 100 *:* 30*:* 30*:* 2 kg per hectare (MoALD, 2023b). Based upon this recommendation, the required amount of Urea, DAP, MOP, and zinc sulfate is 192, 65, 50, and 9.5 kg/ha. Results showed a higher use of DAP and a lower use of Urea, MOP, and Zinc sulfate in this region. Urea was used in smaller amounts may be due to more use of organic manure, having an average use of 9.6 tons/ha. There was higher use of DAP, which is more than 27 % as compared to the recommended dose. A balanced dose of fertilizer is required in this region to increase productivity in rice.

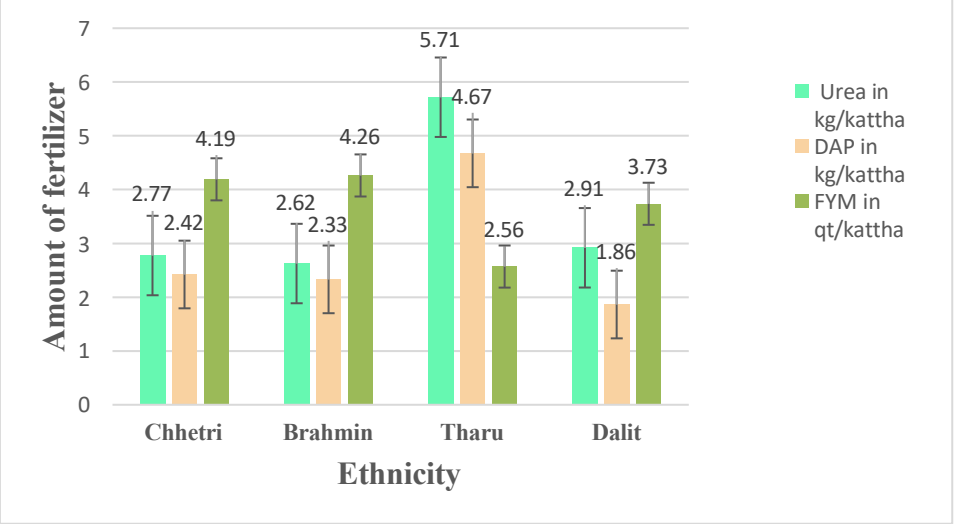

Figure 2: Significance difference test among the applied amounts of Urea, DAP, and FYM with ethnicity

Kattha and Bigha are the primary land measurement units in this region, where 1 Kattha is equal to 338.63 square meters, and 1 Bigha is equal to 20 kattha. From the Kruskal-Wallis test, a significant difference between *(i)* the amount of urea used and ethnicity, *(*ii*)* the amount of DAP used and ethnicity *(*iii*)* the amount of organic farm yard manure used and ethnicity was tested at a 95 % confidence level and 5 % margin of error. Figure 2 shows that the Tharu caste used the highest amount of urea and DAP, statistically significant, having a p-value < 0.05, and other ethnic groups were statistically similar in using Urea and DAP. The Tharu community has used the least amount of organic FYM statistically, and other ethnic groups were statistically similar but higher than Tharu in using FYM. More use of inorganic fertilizers such as urea and DAP by the Tharu ethnic group, and more use of organic FYM by Brahmin, Chhetri, and Dalit communities might be due to the livestock-focused agriculture system of the non-Tharu community. Cattle are mostly reared by non-Tharu ethnic groups due to their religious importance in their community.

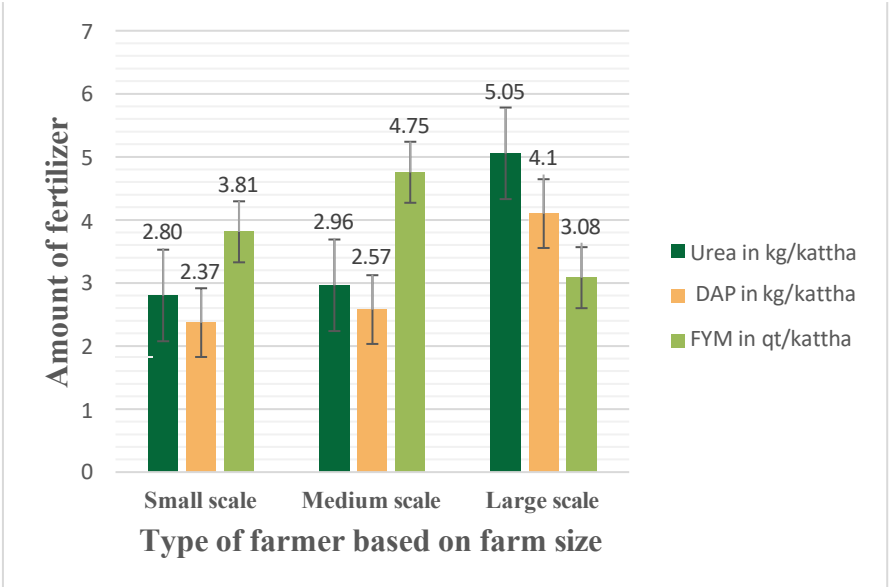

Figure 3: Significance difference test among the applied amounts of urea, DAP, and FYM with an area of the farm size

Landholdings are categorized as follows: small scale for ≤ 15 Kattha, medium scale for 16 – 30 Kattha, and large scale for > 30 Kattha. From the Kruskal Wallis test, the significant difference between (i) the amount of urea used and the area of the farm (ii) the amount of DAP used and the area of the farm (iii) the amount of organic farm yard manure used, and area of the farm was tested in 95 % confidence level and 5 % error of margin. Figure 3 shows that large-scale farmers have used the highest amount of urea and DAP, statistically having a p-value < 0.05. Although the use of Urea and DAP in the sample population was different between small and medium-scale farmers, they were statistically similar in using Urea and DAP in the true population. Medium-scale farmers have used the highest amount of organic FYM.

Table 5: Problem ranking

Problems	Mean	Std. Deviation
No timely availability of fertilizer	8.81	0.932 **(1)**
Higher cost of fertilizer	8.53	0.915 **(2)**
Low subsidy on fertilizer	7.8	1.524 **(3)**
Lack of a sufficient amount of fertilizer	7.1	1.456 **(4)**
No easy access to the nearby market	6.73	1.443 **(5)**
Total respondents: 124		

Respondents were allowed to give a mark to these five problems according to their severity, and a scale was provided between 1 to 10. A high value represents a more severe problem in the region. Among these five problems mentioned in Table 5, 'Lack of timely fertilizer availability' was ranked as the most severe problem, and 'No easy access to nearby market' was ranked as the least severe problem. According to The Kathmandu Post (2021), only 63 % of fertilizer is supplied compared to the total chemical fertilizer demand, and contractors are always late in supplying fertilizers in the country. This status has created huge problems in farming practices, and farmers are not getting fertilizer for rice and wheat cultivation.

3.3 Focus Group Discussions

This research is driven by the theory of diffusion of Innovation (DOI). Focus group discussions (FGDs) were carried out in coordination with the Agriculture Service Centre of Shuklaphanta municipality, kanchanpur, in the presence of 12 farmers, 4 leader farmers, and 2 representatives of the Agriculture Service Centre. Every farmer has certain changes in their practice of cultivating rice, from a few small changes to the adoption of different modern technologies. Farmers have adopted various technologies to enhance their agricultural practices and productivity. These include incorporating mustard cake and cultivating crops like Dhaincha and Mung bean as rotational crops, Black gram and sesame as integrated crops, and Lentil as a relay crop with rice. They have also begun using vitamins as nutritional supplements and chemical fertilizers to boost productivity. Mechanization has replaced traditional methods, such as substituting bullock plowing with tractors or tillers and replacing manual threshing with mechanized threshers. Additionally, farmers maintain proper spacing or isolation distances when cultivating rice for seed purposes, apply weedicides and pesticides, and use modern and hybrid rice varieties. Transplanting practices have also evolved, with a shift from using 4-5 seedlings to 2-3 seedlings and increasing the spacing between seedlings from less than 10 cm to about 20 cm. The adoption of these technologies has been facilitated through self-practice, peer learning, media, and training provided by organizations like the Agriculture Knowledge Centre and other institutions.

4. Conclusions

This study highlighted both inefficiencies and gaps in fertilizer application. The results showed that the use of farmyard manure (9.6 tons/ha) exceeded the recommended dose (6 tons/ha) by 1.6 times, but its effectiveness was reduced due to poor preparation and improper application. Chemical fertilizer usage was imbalanced, with diammonium phosphate (83 kg/ha) exceeding recommendations, while urea (99 kg/ha), muriate of potash (32 kg/ha), and zinc sulfate (5 kg/ha) were applied in lower quantities compared to their recommended doses of 192, 65, 50, and 9.5 kg/ha, respectively. Fertilizer use varied significantly by ethnicity and farm size ($p < 0.05$). Among ethnic groups, the Tharu community applied the highest quantities of urea and diammonium phosphate, while the Brahmin community preferred farmyard manure. Large-scale farmers used the highest amounts of urea and diammonium phosphate, whereas medium-scale farmers applied the most organic manure. A notable lack of awareness about the benefits of micronutrients and the implications of imbalanced fertilizer use was observed. The problem matrix ranked the unavailability of fertilizers on time as the most severe challenge, followed by high costs, low subsidy levels, insufficient quantities, and limited access to nearby markets. FGDs indicated that farmers had made various changes in their rice cultivation practices, ranging from minor adjustments to adopting modern technologies. These technologies were learned through self-practice, peer exchange, media, and training organized by agencies such as the Agriculture Knowledge Centre.

Hands-on training focused on proper fertilizer application presents a promising solution for enhancing rice productivity. Addressing the highlighted challenges and gaps through targeted interventions can significantly improve sustainable agricultural practices, increase yields, and contribute to the overall well-being of rice farming communities.

References

Amgain, L.P., Timsina, J., Dutta, S., Majumdar, K., 2021. Nutrient expert ® rice - an alternative fertilizer recommendation strategy to improve productivity, profitability and nutrient use efficiency of rice in Nepal. Journal of Plant Nutrition. 44(15), 2258 –2273. https://doi.org/10.1080/01904167.2021.1889590.

Andersen, P., 2007. A review of micronutrient problems in the cultivated soil of Nepal: an issue with implications for agriculture and human health. Mountain Research and Development. 27(4), 331–335. https://doi.org/10.1659/mrd.0915.

Aryal, J.P., Sapkota, T.B., Krupnik, T.J., Rahut, D.B., Jat, M.L., Stirling, C.M., 2021. Factors affecting farmers' use of organic and inorganic fertilizers in South Asia. Environmental Science and Pollution Research International. 28(37), 51480–51496. https://doi.org/10.1007/s11356-021-13975-7.

Baral, B., Pande, K., Gaihre, Y., Baral, K., Sah, S., Thapa, Y., 2020. Farmers' fertilizer application gap in rice-based cropping system: a case study of Nepal. SAARC Journal of Agriculture. 17(2), 267–277. https://doi.org/10.3329/sja.v17i2.45311.

Bhattarai, S.P., Dhakal, D.D., 2014. Opportunities for recycling of agricultural wastes for manufacturing of high value fertilizer for sustainable agricultural industry in Nepal, in: Shrestha, B., Timsina, J., Devkota, B. (Eds.), Skill, Knowledge and Innovation Transfer to Nepal: Proceedings of the Workshop, "Skill, Knowledge and Innovation Transfer to Nepal", Sydney, Australia, 19 July 2014. pp. 30–39.

Central Bureau of Statistics., 2021. National Population and Housing Census 2021. Government of Nepal. https://censusnepal.cbs.gov.np

Dunna, V., Roy, B., 2013. Rice (Oryza sativa L.), in: Roy, B. (Ed.), Breeding, Biotechnology and Seed Production of Field Crops. New India Publishing Agency, New Delhi, pp. 71–122.

Kalauni, D., Joshi, A., 2020. Gender role in rural farming system: a case from Kanchanpur district of Nepal. Nepalese Journal of Agricultural Sciences. 19, 31–40.

MoAD., 2015. Statistical Information On Nepalese Agriculture 2015/16. Ministry of Agriculture and Livestock Development, Nepal.

MoALD,. 2022. Livestock Statistics of Nepal 2020/21. Ministry of Agriculture and Livestock Development, Nepal.

MoALD., 2021. Agriculture Development Strategy (ADS) Joint Sector Review (JSR) Third Annual Report. Ministry of Agriculture and Livestock Development, Nepal.

MoALD., 2023a. Statistical information on Nepalese agriculture 2021/22. Ministry of Agriculture and Livestock Development, Nepal.

MoALD., 2023b. Agriculture and Livestock Diary 2080. Agriculture Information & Training Center, Hariharbhawan, Lalitpur, Nepal

National Statistics office., 2023. National Sample Census of Agriculture 2021/22. www.nsonepal.gov.np.

Pant, C., Joshi, P.P., Gaire, R.H., Dahal, B., 2020. Effect of site specific nutrient management approach in productivity of spring rice in Kanchanpur, Nepal. Malaysian Journal of Halal Research. 3(1), 24–30. https://doi.org/10.2478/mjhr-2020-0004.

Statistics office Kanchanpur., 2018. Local level profile Kanchanpur. Statistics office, Kanchanpur, Nepal.

Takeshima, H., 2019. Use of chemical fertilizers in Nepal—issues and implications, in: Thapa, G., Kumar, A., Joshi, P. (Eds.), Agricultural Transformation in Nepal. Springer, Singapore, pp. 231–260. https://doi.org/10.1007/978-981-32-9648-0_9.

The Kathmandu Post, 2021. Chemical fertiliser shortage is a perennial problem. It stems from multiple factors (accessed 27 August 2021).

Timsina, D. J., Sen, N. P., Neupane, R. K., Amgain, L. P., & Majumdar, K., 2013. Transfer, Evaluation and Dissemination of an Innovative Fertilizer Management Tool (Nutrient Expert ®) for Increasing Crop Yields and Farmers' Income in Eastern Nepal, in: Shrestha, B., Timsina, J., Devkota, B. (Eds.), Skill, Knowledge and Innovation Transfer to Nepal: Proceedings of the Workshop, "Skill, Knowledge and Innovation Transfer to Nepal", Sydney, Australia, 19 July 2014. pp. 24–29.

Vista, S.P., Devkota, S., Shrestha, S., Kandel, S., Rawal, N., Amgain, R., Joshi, S., Paneru, P., Rayamajhi, K., Timilsina, S., 2022. Fertilizers in Nepal. National Soil Science Research Centre, NARC, Khumaltar, Lalitpur.