ASSESSING THE CONTRIBUTION OF NUTRIENTS TO YIELD OF RICE VARIETIES THROUGH OMISSION PLOT TECHNIQUES IN LAMJUNG, NEPAL

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ABSTRACT

As fertilizers are considered productivity-enhancing inputs of agriculture, field research was conducted to canvass the contribution of fertilizers through meticulously designed omission plots. A field experiment was conducted during the rainy season 2018 at Sundarbazar-7, Lamjung. The experiment's main objective was to evaluate soil's nutrient-supplying capacities and estimate nutrient requirements in hybrid (US312) and inbred (Sukhadhan-2) rice varieties. The experiment was carried out in RCBD with three replications and 10 treatments.: US 312+60:30:20kg NPKha^{-1} (T_1), US312+0:30:20kg NPKha^{-1} (T_2), US312+60:0:20kg NPKha^{-1} (T_3), US312+60:30:0kg NPKha^{-1} (T_4), US312+0:0:0kg NPKha^{-1} (T_5), Sukhadhan-2+60:30:20kg NPKha^{-1} (T_6), Sukhadhan-2+0:30:20kg NPKha^{-1} (T_7), Sukhadhan-2+60:0:20kg NPK ha^{-1} (T_8), Sukhadhan 2+60:30:0kg NPK ha^{-1} (T_9), Sukhadhan-2 +0:0:0kg NPKha^{-1} (T_{10}). Results revealed that the highest grain yield was obtained from T_1 (4.98 t ha^{-1}) followed by T_4 (4.76 t ha^{-1}) and T_3 (4.54 t ha^{-1}), while the lowest grain yield was obtained from T_{10} (2.47 t ha^{-1}) which were statistically significant. The highest grain yield of T_1, $T_{3,}$ and T_4 was positively supported by effective tillers/m^2, effective grains/panicle, flag leaf area, green leaf number per culm, panicle length, root length, and weight. Soil test data showed that organic carbon (1.63%) and total nitrogen (0.15%) were also found highest in T_1 while the lowest was found in T_{10} and $T_{7,}$ respectively. The benefit-cost ratio was also highest in T_1 (1.98). The use of a hybrid rice variety (US312) with a balanced dose of fertilizer under rainfed conditions would be better to get a higher yield in the western mid-hills of Nepal.

Keywords: growth, yield, economics, rice, Lamjung

INTRODUCTION

The cereal grain referred to as rice (*Oryza sativa* L.) is a member of the family of Gramineae. Asian rice *(Oryza sativa)* and African rice *(Oryza glaberrima)*, are the two types of rice that are most widely grown (Manful & Graham-Acqyuaah, 2016). Roughly 90% of the world's rice is produced in Asia, making it the world leader in rice production (Fukagawa & Ziska, 2019). The data shows that the global rice production area covers 165.25 million ha, yielding 787.29 million tons with an average productivity of 4.8 t ha^{-1}(FAO, 2022). China contributed 27% of the total production followed by India with 25% (FAO, 2022). Rice provides up to 50% of the daily caloric intake for millions of people in Asia who live in poverty, making it essential for food security (Muthayya *et al*., 2014). Meanwhile, in Nepal only 1.47 million hectares of land have been utilized for rice production, yielding 5.1 million tons with a productivity of 3.47 t ha^{-1} (MOALD, 2022). Rice in Nepal is cultivated across various ecological regions as low as 60m above sea level in Terai to 3050 m above sea level in Chhaumjul of Jumla (Paudel, 2011).

The government of Nepal has suggested some methods to boost rice productivity and production, but these have not proven to be very successful. Without considering the site-specific fertilizer prescription based on the soil and climate, blanket fertilizer is applied across vast regions (Dobermann et.al, 2002). The fertility of the soil greatly impacts the outcome, even in instances in which all the different facets of crop production are operating at their maximum effectiveness. Low yield attributes in Nepal are primarily due to sub-optimal crop management practices including nutrient management (Sherchan and Karki, 2006). Rainfall and the residual nutrients in the soil are the primary factors influencing rice cultivation in Nepal, which restricts the maximum yield. The use of local cultivars in a traditional growing system is another significant factor restricting yield (Timsina et. Al, 2012).

Applying fertilizers in a balanced manner both organic and inorganic preserves soil fertility and boosts agricultural output without harming the environment (Shrestha et. Al, 2020). Furthermore, an imbalance in nutrient availability not only leads to low and poor-quality yields but can also deplete soil nutrient reserves, causing a shortage over time (Maharjan and Gupta, 2009). So, to ensure the adequate nutrient supply to the rice as per the requirement omission plot technique can be performed (Rawal *et al.,* 2018). The yield obtained from this type of omission plot except the nutrient of interest (the dropping nutrient), naturally corresponds with the omitted nutrient's native soil supply capacity, which has been seen as essential to nutrient management tools. The primary goal of the omission plot technique is to determine the precise amount of fertilizer needed depending on the nutrients already present in the soil and rice plant's ability to absorb nutrients. This study attempts to determine the best practices to maintain increased rice yields in the rainfed rice ecosystems of Nepal's mid-hill regions.

MATERIALS AND METHODS

Experimental location, soil properties, and climatic status

The study was carried out under low rainfall conditions in Sundarbazar, Lamjung. At 700 meters above sea level, the research area is located in the subtropical zone with latitude $28^0$12'N and longitude $84^0$41'E. The lowest temperature ranges from 6 to 10°C, while the highest temperature is 39°C. Mostly monsoon occurs in June and July and on average it receives 2000 mm of rainfall annually. The average air humidity in May rises to 50%, and in December and January, it reaches nearly 100%. The experimental site had clay loam soil and was characteristic of a typical rainfed area.

Table 1: Initial physio-chemical properties of the soil in the experimental field

Details	Mean	Test Method
pH	5.67	pH Meter
Sand (%)	44.19	ASTM Hydrometer method
Slit (%)	37.67	ASTM Hydrometer method
Clay (%)	18.14	ASTM Hydrometer method
Soil type	Loam	ASTM Hydrometer method
Organic carbon (%)	1.39	Walkey and Black
Total Nitrogen (%)	0.14	Kjeldhal
Available Phosphorous (kg/ha)	31.63	Modified Olsen
Available Potassium (kg/ha)	142.30	Flame Photometer

The rating chart provided by the soil laboratory of the Forest Research and Training Center, Ministry of Forest and Environment, Government of Nepal on 23rd February 2019 was utilized to assign values to the details mentioned in the table above.

Description of experiment design, treatment details, materials, and cultural practices

The experiment was carried out in two factorial Randomized Complete Block Design (RCBD) with 3 replications and 10 treatments. The detail of the treatment combination is illustrated in Table 2.

Table 2: Treatment combinations of experimental site.

Treatment	Factor A (Variety)	Factor B (Fertilizer)
T_1	US-312	60: 30: 20 kg NPK ha^{-1}
T_2	US-312	0: 30: 20 kg NPK ha^{-1}
T_3	US-312	60: 0: 20 kg NPK ha^{-1}
T_4	US-312	60: 30: 0 kg NPK ha^{-1}
T_5	US-312	0: 0: 0 kg NPK ha^{-1}
T_6	Sukhadhan-2	60: 30: 20kg NPK ha^{-1}
T_7	Sukhadhan-2	0: 30: 20 kg NPK ha^{-1}
T_8	Sukhadhan-2	60: 0: 20 kg NPK ha^{-1}
T_9	Sukhadhan-2	60: 30: 0 kg NPK ha^{-1}
T_{10}	Sukhadhan-2	0: 0: 0 kg NPK ha^{-1}

The performance of five different fertilizer arrangements as factor B and two different rice varieties as factor A were assessed. On June 23, the seeds were spread at a rate of 20 kg ha-1 for US-312 and 50 kg ha-1 for Sukhadhan-2. The main field was puddled and leveled with the help of a rake and spade along with the incorporation of farm-yard manure. In plots where nitrogen was recommended to be zero, single super phosphate (SSP) was used exclusively in place of diammonium phosphate (DAP). Full dosages of P and K were given as basal doses, whereas nitrogen was given in three split doses. To stop water and fertilizer from moving from one plot to another, a total of 30 6m2 plots were created with bunds that were 25 cm broad and every plot was 50 cm apart. After 32 days, healthy seedlings devoid of deformities were transplanted in the prepared plots. Timely irrigation was implemented to maintain the field flooded up to 50% heading, and throughout the rice's remaining reproductive stage, the water was turned off.

Description of observations taken during the research period

Harvesting was done from the net plot (2.2m×2m=4.4m^2). 50% heading, days to Maturity, plant height at maturity (cm), flag leaf area (cm^2), effective tillers /m^2, grain yield (t ha^{-1}), straw yield (t ha^{-1}), etc. were taken. Days to 50% heading were determined by first selecting a 1m^2 area in the main plot randomly, then counting the number of tillers within that area that had 50% panicle emergence. Maturity days were defined as the dates on which all of the plants in the plot displayed maturity. The measuring scale was used to measure the length of the leaf in the flag leaf area as well as the distance between the base and tip of the leaf. For the breadth of the leaf, the leaf was folded into four equal-length sections, and the length of the marks was averaged. The area of the leaf is calculated by multiplying its length by its average breadth. Ten hills were chosen at random from each plot as it reached maturity. The average height was determined using a measuring scale from the soil's surface to the main tiller's panicle tip. The number of leaves per major culm was determined by counting all of the active leaves on the chosen slopes. To determine the length of the panicle, the primary panicle of the chosen hill was measured. Number of tillers from each of the ten hills that were chosen at random. In each plot, a 1 m^2 area was chosen, and the number of effective tillers was tallied; tillers that did not contain even one grain were considered ineffective.

The formula used to calculate the total biomass yield was: Biological yield = (grain yield + straw yield).

The panicles were manually threshed after sun drying, and the result was noted as grain yield (t ha^{-1}). After correcting for grain moisture content, the net plot yields for each treatment were used to calculate the grain yield per hectare. Similarly, the biological yield was subtracted from the net plot yield to determine the straw yield (t ha^{-1}). From ten panicles chosen at random from each plot, the number of filled grains was calculated as the effective number of grains per panicle. Data averages were calculated. Additionally, the average number of unfilled grains from chosen panicles within each plot was considered to figure out the number of unproductive grains per panicle. 1000 grains were weighed using an electronic balance to get the test weight. Grams were used to express it. Using an electronic balance, the grams of each panicle were determined. Panicle weight was defined as the average weight of ten panicles.

Statistical Analysis

Data were collected and organized in Microsoft Excel-2010, and for each parameter analysis of variance was performed using the Randomized Complete Block Design (RCBD) as outlined in GENSTAT 15th Edition. Treatment means were compared using the least significant difference (LSD) test at $P \leq 0.05$.

RESULTS AND DISCUSSIONS

Effect on phenological characters

Days to 50% heading

Following the results, 50% of the heading was delayed in fertilizers with 0:30:20 kg NPK/ha and 0:0:0 kg NPK ha^{-1} when nitrogen fertilizer was not applied (Table 3). The hybrid and inbred groups showed notable genetic variability in the maturation period. Table 1 shows that F4 had the largest flag leaf area, followed by F1 and F3. Sustainable crop production demands a balanced intake of nutrients (Rawal *et al*., 2017). According to Chen *et al.* (2022), a nitrogen shortage typically causes chlorosis, sluggish growth, and stunted growth.

Maturity days

When the maturation days for the two factors—fertilizers and variety—were compared (Table 3), the hybrid variety US-312 with full fertilizer (60:30:20 kg NPK ha^{-1}) matured more quickly than the next variety and other treatments together. Higher fertilization doses have also been shown to accelerate maturity, according to Adhikari *et al*. (2021). To show how different fertilizer treatments affected plant height at three distinct stages of plant growth—25 DAT, 50 DAT, and 75 DAT—an experiment was carried out where plant height was higher in all stages in the treatment with a double fertilizer dose of 200:60:60 kg NPK ha^{-1} than in the other treatments.

Flag leaf area (cm^2)

Table 3 demonstrates that F4, F1, and F3 had the biggest flag leaf areas, respectively. As nitrogen's supply rises, it also contributes significantly to the flag leaf's increased area. Greater leaf area is the result of more nitrogen fertilizer as photosynthetic activity rises. Lack of nitrogen eventually results in decreased levels of N, leaf area, chlorophyll concentration, and photosynthetic activity, all of which sharply reduce biomass and grain output (Berenguer *et al.*, 2009).

Table 3: Effect of varieties and fertilizer in different phenological characters of rice in the experiment during 2018

Varieties (Factor A)	**50% HD**	**MD**	**FLA cm^2**
US 312	101^{a}	132^{a}	33.94^{a}
Sukhadhan-2	97^{b}	128^{b}	28.19^{b}
F test (5%)	**	**	**
LSD	0.3822	0.3525	2.731
Fertilizer (Factor B)			
60: 30: 20 kg NPK ha^{-1} (F_1)	98^{b}	132^{a}	32.71^{a}
0: 30: 20 kg NPK ha^{-1} (F_2)	99^{a}	130^{cd}	30.19^{ab}
60: 0: 20 kg NPK ha^{-1} (F_3)	98^{b}	130^{c}	32.29^{a}
60: 30: 0 kg NPK ha^{-1} (F_4)	98^{b}	131^{b}	32.86^{a}
0: 0 :0 kg NPK ha^{-1} (F_5)	99^{a}	129^{d}	27.28^{b}
F test (at 5%)	**	**	NS
LSD	0.6042	0.5573	4.318
A*B	**	NS	NS
Grand mean	98	130	1.07

Description: *: Significant at 0.05 level of significance; **: Significant at 0.01 level of significance; NS: Non-significant; 50% HD: 50% Heading; MD: Maturity days; FLA cm^2: Flag leaf area in centimeter square

Effect on growth parameters

Plant height

The height of Sukhadhan-2 was greater than that of US-312 (Table 4). Numerically the highest (23.92 cm) panicle length was found in US-312 and the lowest (21.02 cm) in Sukhadhan-2. F3 showed the highest panicle length followed by F1 and F4 (Table 4). US-312 produced more leaves *i.e.* five compared to Sukhadhan-2 (four). The shoot portion i.e. the height of the plant is a key factor that determines crop development and its productivity which is believed to be governed by both genetic and environmental factors (Yang *et al.,* 2021).

Panicle length

Different rice cultivars had a substantial effect on panicle length. US-312 had the longest panicle (23.92 cm), while Sukhadhan-2 had the shortest (21.02 cm) (Table 4). The results showed that the interaction between fertilizer management and cultivars substantially affected panicle length. The panicles ranged in overall length from 19.82 cm to 23.73 cm. F3 has the largest panicle length, followed by F1 and F4. F5 has the shortest panicle length, 19.82cm. These data indicate that nitrogen plays a crucial part in the increase in panicle length. It promotes rapid growth of leaves and panicle length. Higher nitrogen doses result in lengthier panicles. Extended panicles produce a greater amount of quantity of grain. Giri *et al.* (2022) reported a statistically equivalent finding in which increasing the nitrogen fertilizer caused panicle length to go up.

Green leaves / main culm

We notice that, in terms of variety, none of the green leaves differ considerably from one another. Sukhadhan-2 produced four leaves, whilst US-312 produced five. Interestingly, there aren't any appreciable variations in the fertilizers when analyzed in terms of fertilizer. Every fertilizer has virtually the same number of leaves. Its genetic attribute could be responsible for the varietal variation in leaf count. We may infer that hybrid varieties work better than variable nitrogen dosages to enhance the number of leaves for photosynthetic activities. Tian-yao *et al.* (2016), carried out a comparable kind of experiment in which two large-panicle varieties with high filled-grain percentage (HF) and two check large-panicle varieties with low filled-grain % (LF) were cultivated in the field. After 12 days after harvesting, HF had a considerably greater number of green leaves on the culm than LF, suggesting that HF had less leaf senescence during the filling period.

Table 4: Effect of varieties and fertilizer in different growth parameters of rice in the experiment during 2018

Varieties (Factor A)	Plant height (cm)	Panicle length (cm)	Green leaves/ Culm
US 312	89.25^{b}	23.92^{a}	5^{a}
SUKHADHAN-2	97.62^{a}	21.02^{b}	4^{b}
F test (5%)	**	**	*
LSD	2.718	0.852	0.39
Fertilizer (Factor B)			
60: 30: 20 kg NPK ha^{-1} (F_1)	96.86^{a}	23.49^{ab}	5^{a}
0: 30: 20 kg NPK ha^{-1} (F_2)	91.38^{b}	22.24^{b}	5^{a}
60: 0: 20 kg NPK ha^{-1} (F_3)	95.52^{ab}	23.73^{a}	5^{a}
60: 30: 0 kg NPK ha^{-1} (F_4)	98^{a}	23.06^{ab}	5^{a}
0: 0:0 kg NPK ha^{-1} (F_5)	85.41^{c}	19.82^{c}	5^{a}
F test (at 5%)	**	**	NS
LSD	4.297	1.346	0.621
A x B	NS	NS	NS
Grand mean	93.43	22.47	4.673

Description: * Significant at 0.05 level of significance ** Significant at 0.01 level of significance; NS: Non-significant

Effect on yield attributing characters

Effective and non-effective tiller

Number of effective tillers/m^2 and no. of non-effective tillers/m^2 was found to be significantly different with the variety. There was a significant difference in the no. of effective tillers in terms of fertilizer (Table 5). Fertilizers F1, F3, and F4 are significantly at par with each other. Following Singh *et al.* (2014) experiment, we found that US312 had a higher grain setting per panicle than Sukhadhan-2 and that applying nitrogen afterward is known to improve tiller productivity. Nitrogen at first increases the cytokinin level in the nodes of the tiller which encourages the germination of tiller primordium (Liu *et al.,* 2011).

Effective grain and non-effective grain

We discovered that US-312 had a greater grain setting per panicle than Sukhadhan-2. Genetics may be the reason for the increased amount of grain. There were notable variations in the nutritional contents among the effective grains per panicle. Table 5 shows that fertilizers F1, F3, and F4 are remarkably at par with each other. An increase in panicle length and the combined effect of fertilizer doses may have contributed to the rise in effective grains per panicle. Because of the restricted growth of the plants caused by the lack of chemical fertilizer (Maryam & Amiri, 2014), F5 received less effective grain and was unable to develop effective grains per panicle.

Typically, late-emerging tillers do not contribute significantly to the grain yield of rice (Wang *et al.,* 2017); however, theoretically, they possess the potential for high productivity, due to the totipotency of rice coleoptile tissue (Oinam & Kothari, 1995). The variety among the ineffective grain differed significantly, but the fertilizer impact was not statistically significant. Due to hybrid rice's greater sensitivity to NPK fertilizer (Kamal *et al.,* 2015), plants will grow more densely and be more susceptible to disease, bug, and pest infestation. As a result, the number of non-effective grains is higher in hybrid rice than in improved rice.

Table 5: Effect of varieties and fertilizer in different yield attributing characters of rice in the experiment during 2018

Varieties (Factor A)	**ET/m^2**	**NET/m^2**	**EG/P**	**NEG/P**
US-312	203^a	19^a	141.5^a	43^a
Sukhadhan-2	188.^{b}	15^b	100.2^b	25^b
F test (5%)	*	*	**	**
LSD	13.18	3.901	9.11	5.14
Fertilizer (Factor B)				
60: 30: 20 kg NPK ha^{-1} (F1)	205^a	16^a	128^a	28^b
0: 30: 20 kg NPK ha^{-1} (F2)	192^a	16^a	113^{ab}	32^{ab}
60: 0: 20 kg NPK ha^{-1} (F3)	209^a	17^a	129.^{a}	32^{ab}
60: 30: 0 kg NPK ha^{-1} (F4)	210.^{a}	15^a	125^a	37^{ab}
0: 0:0 kg NPK ha^{-1} (F5)	163^b	20^a	101^b	40^a
F test (5%)	**	NS	*	NS
LSD	20.85	6.168	14.41	8.12
A* B	NS	NS	NS	*
Grand mean	196	17	120.8	33.7

Description: * Significant at 0.05 level of significance, ** Significant at 0.01 level of significance; NS: Non-significant; ET/m^2: Effective tillers per meter square; NET/m^2: Non-effective tillers per meter square; EG/P: Effective grains per panicle; NEG/P: Non-effective grains per panicle

Effect on Yield Parameters

Grain yield (t/ha)

Regarding fertilizers and varieties, there was a considerable variation in grain production. When it came to the relationship between fertilizer and variety, it was discovered to be insignificant. The variety US-312 produced the most grain (4.293 t ha^{-1}), followed by F1 with 4.604 t ha^{-1} (Table 6). Ding *et al.* (2014) state that applying nitrogen fertilizer can raise panicle count, spikelet count, and number of full spikelets by enhancing cytokinin, all of which have a significant impact on rice output capacity. The effects of NPK fertilizer on the growth and yield of several rice varieties grown in Sabah were investigated in an experiment carried out by Grace *et al.* in 2018. The fertilizer doses used were F1 (60:30:30 kg NPK ha^{-1}), F2 (90: 30: 60 kg NPK ha^{-1}), and F3 (120: 30: 90 kg NPK ha^{-1}). The fertilizer produced grain yields of 3.31 t ha^{-1}, 4.35 t ha^{-1}, and 4.58 t ha^{-1}, in that order. In terms of grain yield, the outcomes of this experiment mirror the results of ours as well. Thus, we can conclude that increased NPK fertilizer dosages result in increased yields.

Straw yield

F4 (5.947 t ha^{-1}), F1 (5.878 t ha^{-1}), F3 (5.822 t ha^{-1}), and F2 (5.214 t ha^{-1}) had the highest straw yields, while F5 (3.956 t ha^{-1}) had the lowest (Table 6) The number of leaves, flag leaf area, and plant height are some of the variables that affect straw yield. Because F4 has a higher yield of these factors, the fertilizer produces a higher yield of straw. The observations made by Ullah *et al.* (2016) about straw yield as a result of nitrogen application were identical.

Test weight (g)

The many nitrogen sources, variations, and combinations of these fertilizers have a major impact on the weight of one thousand grains. Hybrid rice had the maximum weight per thousand grains (Table 6) and F1 had the greatest test weight (23.62 g) in the fertilizer case same as research held by Kumar *et al.* (2007). It is a well-established fact that N and P are the primary nutrients needed for tillering, root development, and overall plant vigor, all of which have an impact on test weight and filled grains at the end (Kumar *et al.,* 2018).

Sterility %

The sources, types, and combinations of nitrogen significantly varied the percentage of spikelet that grew that were sterile. F1 (17.97%), F3 (19.01%), F2 (21.13%), and F4 (21.86%) had the lowest spikelet sterility, while F5 (27.34%) had the highest. The reason for the sterility in varieties was due to the higher requirement of irrigation and fertilizer. When such favorable conditions are not met, the plant becomes stressed and may become impotent. This conclusion is reinforced by the experiment conducted by Ullah *et al.* (2016).

Table 6: Effect of varieties and fertilizer dose on different yield parameters of rice in the experiment during 2018

Varieties (Factor A)	Gyd t/ha	Stryd t/ha	TW (g)	STR%
US 312	4.29[a]	6.0[a]	23.53[a]	23.16[a]
Sukhadhan-2	3.54[b]	4.73[b]	20.84[b]	19.77[b]
F test (5%)	**	**	**	*
LSD	0.26	0.4	0.32	2.57
Fertilizer (Factor B)				
60: 30: 20 kg NPK ha^{-1} (F_1)	4.61[a]	5.88[ab]	23.62[a]	17.97[b]
0: 30: 20 kg NPK ha^{-1} (F_2)	3.82[c]	5.21[b]	22.05[c]	21.13[b]
60: 0: 20 kg NPK ha^{-1} (F_3)	4.16[bc]	5.82[ab]	22.67[b]	19.01[b]
60: 30: 0 kg NPK ha^{-1} (F_4)	4.30[ab]	5.95[a]	22.93[b]	21.86[b]
0: 0: 0 kg NPK ha^{-1} (F_5)	2.70[d]	3.96[c]	19.67[d]	27.34[a]
F test (5%)	**	**	**	**
LSD value	0.4189	0.63	0.51	4.06
A*B	NS	NS	**	*
Grand mean	3.917	5.363	22.18	21.46

Description: * Significant at 0.05 level of significance, ** Significant at 0.01 level of significance; NS: Non-significant; Gyd t ha^{-1}: Grain yield per hectare; Stryd t/ha: Straw yield per hectare; TW (g): Test weight in grams; STR%: Sterility in percentage.

CONCLUSIONS

Using varying fertilizer dosages, research was done to assess the growth, production, and yield qualities of hybrid and inbred rice. The study showed that balanced NPK fertilization and the selection of suitable rice varieties are crucial for growth and yield. It has shown that hybrid rice outperformed inbred rice when exposed to varying fertilizer dosages. This suggests that for the nutrients to interact with one another and aid in the availability and absorption of additional nutrients, they must be given to the plant in a balanced dosage. In the mid-hills of Nepal, yields and productivity can be increased from this approach of nutritional integration. These results highlight the selection of varieties and targeted nutrient management to support sustainable and productive cultivation. However, this was an initial attempt towards proper fertilization and variety. Thus, further studies are needed for a fuller understanding of nutrient uptake and varietal suitability.

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