LR-5544
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RESEARCH ARTICLE **Legume Research- An International Journal**

Effect of Potassium on Growth, Yield and Nutrient Uptake under Rice-Lentil Cropping System in Acid Soil

Naorem Arunkumar Singh[1], Indira Sarangthem[1], Nongthombam Surbala Devi[1],
Laikhuram Banarjee Singh[1], Wangnem Rekhung[1], Nongmaithem Shitaljit Singh[1], Kalu Ram Yadav[1]

10.18805/LR-5544

ABSTRACT

Background: Potassium deficiency is a major constraint in rice-lentil cropping systems on acidic soils, where intensive cultivation and imbalanced fertilization accelerate nutrient depletion. Inclusion of pulses in rice-based cropping system improves soil health and increase system productivity benefitting both the rice and pulse crop. This study evaluated the effects of K fertilization on crop performance and nutrient availability in acidic soils from 2022 to 2024.

Methods: The study was conducted in Lourembam, Thoubal District, Manipur (24.644573°N, 94.074931°E; 769 m above sea level) under Central Agricultural University, Imphal, Manipur during 2022-2023 and 2023- 2024. The field experiment was laid out in randomized block design (RBD) with 7 K levels (0, 10, 20, 30, 40, 50, 60 kg K_2O ha^{-1}) and 3 replications with rice (var. RC Maniphou-13) during the *Kharif* season, followed by lentil (var. IPL-316) during *Rabi* season without additional fertilization. The crop for each treatment was harvested and threshed separately and yield per plot was recorded.

Result: Results revealed that 40 kg K_2O ha^{-1} with recommended N and P significantly improved rice plant height, tiller number, filled grains, grain and straw yield and K uptake ($P<0.05$). Lentil grown after 50 kg K_2O ha^{-1} in rice showed the highest seed and stover yield, despite receiving no direct fertilization. Overall, this research provides a strong foundation for optimizing potassium use in acid soils and sets the stage for more advanced, data-driven approaches to nutrient management in sustainable cropping systems.

Key words: Acidic soil, Nutrient uptake, Potassium, Rice-Lentil cropping system, Yield.

INTRODUCTION

Potassium is one of the most essential macronutrients required by plants in large quantities, playing a critical role in crop growth, development and stress resilience. Despite its importance, potassium deficiency in agricultural soils is becoming increasingly prevalent due to intensive cropping systems, imbalanced fertilization and excessive removal of crop residues (Tisdale *et al.,* 1985). Over time, intensive cultivation practices have reduced the soil's ability to release non-exchangeable K, necessitating alternative management strategies to maintain soil fertility (Lalitha and Dhakshinamoorthy, 2014). This deficiency leads to poor root development, reduced lodging resistance, lower yields and increased susceptibility to diseases and environmental stresses (Srinivasarao *et al.,* 2003). In rice (*Oryza sativa* L.), potassium is crucial for maintaining stomatal function, enzyme activity and osmotic balance, particularly under drought and salinity stress (De Datta and Mikkelsen, 1985). Rice in hilly and shifting cultivation systems of Northeast India shows clear yield and growth responses when K availability is improved *via* agronomic interventions and balanced fertilization. Improved *Jhum* practices and full recommended nutrient management increased yields markedly and raised soil available K, while site experiments in hill ecosystems reported higher yield components and NPK uptake under recommended fertilization practices (Kumar *et al.,* 2015; Layek *et al.*, 2023 and Vijaykumar *et al.,* 2021). Studies reported that increased K concentration and uptake in grain and straw with higher K rates, corresponding to greater biomass accumulation and grain yield (Vijaykumar *et al.,* 2021). Local experimental evidence from northeastern plains and multi-site trials elsewhere indicates beneficial responses across a broad K range and split/top-dress timings often improve efficiency; however, exact hill-specific numeric optima are not established. Trials showed positive responses up to 80 kg K ha^{-1} with split applications improving biomass and yields and multi-site analyses suggested moderate rates (≈93-135 kg ha^{-1}) as reasonable in other rice agroecosystems, with K120 often giving good yield versus no-K controls (Singh and Prasad, 2020). Soil surveys in Assam reported 1 N NH_4OAc-extractable K averaging 48-63 mg kg^{-1}, classed as low, with a majority of plant samples showing moderate to extreme K deficiency

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[1]Department of Soil Science and Agricultural Chemistry, College of Agriculture, Central Agricultural University, Imphal-795 004, Manipur, India.

Corresponding Author: Naorem Arunkumar Singh, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Central Agricultural University, Imphal-795 004, Manipur, India.
Email: naoremarun@gmail.com

How to cite this article: Singh, N.A., Sarangthem, I., Devi, N.S., Singh, L.B., Rekhung, W., Singh, N.S. and Yadav, K.R. (2025). Effect of Potassium on Growth, Yield and Nutrient Uptake under Rice-Lentil Cropping System in Acid Soil. *Legume Research*. 1-9. doi: 10.18805/LR-5544.

Submitted: 11-07-2025 **Accepted:** 26-09-2025 **Online**: 17-10-2025

(Dutta and Zaman, 2013). In Manipur, the State Agriculture Department recommends applying 30 kg ha^{-1} of K for rice cultivation, while the ICAR Research Complex for the North Eastern Hill (NEH) Region, Manipur Centre suggests a K application rate of 40 kg ha^{-1} for lentil crops. However, continuous rice cultivation with inadequate K replenishment has led to negative K balances in many rice-growing regions, diminishing soil K reserves and buffering capacity. Similarly, in lentil (*Lens culinaris*), an important protein-rich legume, potassium plays a vital role in nodulation, grain quality and protein synthesis (Islam *et al.,* 2018). Despite its nutritional and soil-enriching benefits through biological nitrogen fixation, lentil production remains low in regions like Manipur due to insufficient potassium fertilization. Given these challenges, this study aims to evaluate the impact of potassium on growth, yield and nutrient uptake of rice and lentil under rice-lentil cropping system. The findings will contribute to better fertilization strategies, helping farmers achieve higher yields while maintaining soil health in intensive cropping systems.

MATERIALS AND METHODS

The experiment was conducted in Lourembam, Thoubal District under Central Agricultural University, Imphal, Manipur, India during *Kharif* and *Rabi* season of 2022–2023 and 2023-2024. The experimental site was located at 24.644573°N latitude and 94.074931°E longitude and at an elevation of 769 m above mean sea level. Soil is clay in texture and acidic (pH 5.42), organic carbon (1.58%), CEC of 16.30 cmol (p+) kg^{-1}, low in available nitrogen (225.79 kg ha^{-1}), medium in available phosphorus (24.83 kg ha^{-1}) and available potassium (212.48 kg ha^{-1}). The experiment was laid out in randomized block design (RBD) with 7 K levels and 3 replications. The K levels of the experiment during *Kharif* rice (var. RC Maniphou-13) were 0, 10, 20, 30, 40, 50 and 60 kg K_2O ha^{-1}. During *Rabi* season, no fertilizers were applied in lentil crop (var. IPL-316). For all the treatments, recommended dose of nitrogen and phosphorus were applied @ 60 and 40 kg ha^{-1} respectively. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. At harvest, grain and straw for rice and seed and stover yields for lentil were recorded. Grain and straw samples for rice and seed and stover samples for lentil crop for each treatment were used for determination of nitrogen content by modified Kjeldahl's method, phosphorus content - Di-acid digestion and yellow colour development method and potassium content- Flame photometric method (Jackson, 1973). The data collected from the field experiment were subjected to analysis of variance (ANOVA) using the procedure described by Gomez and Gomez (1984) for a randomized block design (RBD). Treatment means were compared using the least significant difference (LSD) test at a 5% probability level ($p \leq 0.05$). Standard errors of mean (SEm ±) and critical differences (CD) were calculated for significant effects. All statistical analyses were performed in R software (version 4.3.1) using the packages *agricolae* for ANOVA and multiple comparison tests, stats for basic models and dplyr for data handling.

RESULTS AND DISCUSSION

Yield and yield attributes of rice

The increasing potassium application significantly increased the number of effective tillers per sq. m of rice at all growth stages, with the greatest differences observed between K level 0 kg K_2O ha^{-1} (254) and higher potassium levels (20, 30, 40, 50, 60) kg K_2O ha^{-1}. In the case of K level 40 kg K_2O ha^{-1} (410), significant differences were found when compared to 20, 30, 50 and 60 K levels, with p-values <0.05 as given in Table 1. Potassium application has been linked to a significant rise in the number of effective tillers in rice plants. Mirza *et al.* (2010) reported that increase in number of tillers in rice plants was due to influence of different fertilizer combinations. This may also be probably due to increased availability and quick accessibility of nutrients. Similar findings were reported by Siavoshi *et al.* (2011) and Gebreslassie (2016).

Data in Table 1 revealed that K level of 40 kg K_2O ha^{-1} (190) showed significantly higher and increase in grain number compared to 50 kg K_2O ha^{-1} (172) and 60 kg K_2O ha^{-1} (168). This suggests that the highest potassium levels (50 and 60 kg K_2O ha^{-1}) did not result in the highest number of filled grains per panicle compared to the 40 kg K_2O ha^{-1}. In an experiment, the application of K not only enhanced potential photosynthetic activity but also reduced sodium (Na) and magnesium (Mg) concentrations. This adjustment improved the ratios of K/Na, K/Mg and K/Ca, which are critical for effective grain filling (Bohra and Doerffling, 1993).

Among the different levels of K, maximum test weight (28.52 g) was observed under 40 kg K_2O ha^{-1} followed by 30 kg K_2O ha^{-1} (28.20 g), 50 kg K_2O ha^{-1} (27.84 g) and 20 kg K_2O ha^{-1} (27.71 g). Potassium application shown to substantially boost the yield of various rice varieties, with optimal rates typically between 40 and 60 kg K_2O ha^{-1}. This level of application has been associated with improved grain weight and a reduction in pest infestations (Sarwar, 2012).

K level of 0 kg K_2O ha^{-1} recorded significantly lower yield (4020 kg ha^{-1}) than most other K levels. The highest grain yield was observed under 40 kg K_2O ha^{-1} (5620 kg ha^{-1}), which was significantly superior to all other treatments ($p<0.001$). Overall, the potassium levels could be ranked in descending order of effectiveness as 40>30>50>60>20 >10 ≈0 kg K_2O ha^{-1}. Increase in yield of rice might be due to prolonged availability of K in soil, significant decrease in number of chaffy grains, increased tillering and concentration of K in straw and grain. Similar findings was also reported by Ravichandran and Sriramachandra sekharan (2011). In this study, 40 kg K_2O ha^{-1} (6720 kg ha^{-1}) and 30 kg K_2O ha^{-1} (6500 kg ha^{-1}) observed the most effective K levels for increasing straw yield of rice, with

Table 1: Effect of potassium levels on yield attributes and yield of rice under the rice-lentil cropping system in acid soil (mean of 2022-2023 and 2023-2024).

K dose (kg K_2O ha^{-1})	Effective tillers (m^{-2})			Filled grains (panicle^{-1})			Test weight (g^{-1} 1000 seed)			Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})		
	2022-2023	2023-2024	Mean	2023-2024	2023-2024	Mean	2022-2023	2023-2024	Mean	2023-2024	2023-2024	Mean	2022-2023	2023-2024	Mean
0	252	256	254^f	110	107	109^e	27.27	27.02	27.15^e	4250	3800	4020^f	5310	5460	5380^f
10	275	274	275	143	134	138^d	27.46	27.39	27.42^{de}	4500	3870	4180^{ef}	5470	5630	5550^e
20	320	306	313^d	161	159	160^c	27.99	27.43	27.71^{cd}	4630	4080	4360de	5770	5930	5850^d
30	365	356	361^b	191	179	185^a	28.44	27.96	28.20^{ab}	5320	5050	5180^b	6500	6500	6500^b
40	421	399	410^a	195	184	190^a	28.77	28.28	28.52^a	5870	5370	5620^a	6650	6780	6720^a
50	349	331	340^c	173	170	172^b	28.18	27.51	27.84^{bc}	5160	4530	4840^c	6100	6240	6170^c
60	345	339	342^c	167	169	168^{bc}	27.82	27.43	27.62^{cd}	4700	4470	4580^{cd}	6090	6200	6140^c
SEm(±)	5.50	7.27	4.66	1.23	1.23	3.48	0.26	0.24	0.13	100	70	80	60	60	20
							CD ($p \leq 0.05$)								
K level	16.94	22.41	16.15	3.79	3.79	9.32	0.81	NS	0.35	300	230	280	180	200	90
Year	-	-	8.63	-	-	4.98	-	-	0.19	-	-	150	-	-	50
K level × Year	-	-	NS	-	-	S	-	-	NS	-	-	NS	-	-	NS

consistent performance across both years. Studies have demonstrated that potassium application rates between 40 and 80 kg ha^{-1} can led to significant increases in straw yield. This is in conformity with the findings reported by Khan *et al.* (2006).

Yield and yield attributes of lentil

Potassium application significantly influenced lentil growth and yield parameters under residual fertility conditions in the rice-lentil cropping system.

Data presented in Table 2 showed that the number of branches per plant was highest in K level 50 kg K_2O ha^{-1} (21), followed by 40 kg K_2O ha^{-1} (20), which was at par with K level 60 kg K_2O ha^{-1} (20), all significantly exceeding 0 kg K_2O ha^{-1} (13). In a study, Singh *et al.* (2011) reported that secondary branches per plants were increasing with increasing the level of nutrient. Pods per plant of lentil crop recorded the highest values in K level 50 kg K_2O ha^{-1} (99) and 60 kg K_2O ha^{-1} (90), significantly surpassing 0 kg K_2O ha^{-1} (46). This improvement might be due to the fact that potassium acts as catalytic agent in activating a number of enzymes and synthesis of peptide bonds (Sahay *et al.*, 2013). Similar findings were also reported by Srinivasarao *et al.* (2003).The highest test weight (28.40 g) was observed in K level 50 kg K_2O ha^{-1}, significantly greater than the control 0 kg K_2O ha^{-1} (24.07 g), indicating better grain filling due to improved K availability. Application of potassium at higher levels resulted in higher seed weight which may be probably due to its involvement in translocation of photosynthates and its ability to develop well- developed bold seeds. These findings are in close agreement with those of Ali *et al.* (2007).

The analysis of results shown in Table 2 indicated that the seed yield of lentil was observed highest in K level 50 kg K_2O ha^{-1} (762 kg ha^{-1}) across all comparisons, while 0 kg K_2O ha^{-1} (544 kg ha^{-1}) the lowest. This may also be due to the excess K applied in K levels 50 kg K_2O ha^{-1} and 60 kg K_2O ha^{-1} in rice which remained in the soil, making more potassium available for the lentil crop leading to more nutrient uptake and growth. Similar results was also reported by Fratini and Ruiz (2001). Stover yield was maximized in K level 50 kg K_2O ha^{-1} (1219 kg ha^{-1}), followed by 60 kg K_2O ha^{-1} (1108 kg ha^{-1}). This might be due to the cumulative effect of yield attributing characters and enhanced photosynthetic efficiency and greater diversion of assimilates towards reproductive organs. Similar findings were also reported by Farjam *et al.* (2014).

Nutrient content and uptake in rice

The N content in grain and straw of rice was statistically significant which ranges from 0.93% to 1.13% and 0.32% to 0.63%. The phosphorus content due to different K levels in grain of rice varied from 0.26% to 0.42% and in straw from 0.08% to 0.24%. Potassium content in rice grain was non significantly affected by different levels of K but was statistically significant in straw which ranges from 2.29% to 3.38% as observed in Table 3. It was observed that potassium content in rice straw was higher than that of

Table 2: Effect of residual potassium on yield attributes and yield of lentil grown after rice under the rice-lentil cropping system (mean of 2022-2023 and 2023-2024).

K dose (kg K_2O ha^{-1})	No. of branches (Plant^{-1})			No. of pods (Plant^{-1})			Test weight (g^{-1} 1000 seed)			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean
0	14	13	13^{d}	47	45	46^{d}	24.84	23.29	24.07^{d}	587	501	544^{e}	713	742	727^{e}
10	15	15	15^{d}	52	47	50^{d}	25.93	23.99	24.96^{c}	649	535	592^{e}	797	827	812^{d}
20	17	19	18^{c}	74	49	62^{cd}	26.14	24.45	25.30^{c}	668	546	607de	1011	972	992^{c}
30	18	19	19^{bc}	74	62	68^{c}	26.90	25.19	26.05^{b}	714	611	662^{cd}	967	957	961^{c}
40	19	21	20^{ab}	84	60	72^{bc}	27.38	26.10	26.74^{b}	740	622	681^{bc}	979	1031	1005^{c}
50	20	22	21^{a}	98	992	99^{a}	28.73	28.06	28.40^{a}	774	750	762^{a}	1230	1209	1219^{a}
60	19	21	20^{ab}	91	89	90^{ab}	28.67	27.06	27.86^{a}	810	669	740^{ab}	1128	1088	1108^{b}
SEm (±)	0.23	0.38	0.49	2.03	3.54	5.35	0.38	0.26	0.20	13	22	21	60	34	18
								CD ($p \leq 0.05$)							
K level	0.72	1.18	1.70	6.25	10.91	9.90	1.19	0.81	0.71	42	68	65	187	106	63
Year	-	-	NS	-	-	18.52	-	-	0.38	-	-	35	-	-	NS
K level × Year	-	-	S	-	-	S	-	-	NS	-	-	NS	-	-	NS

Table 3: Influence of potassium levels on nutrient content (%) in grain and straw of rice (mean of 2022-2023 and 2023-2024).

K dose (kg K_2O ha^{-1})	Nitrogen content (%)						Phosphorus content (%)						Potassium content (%)					
	Grain			Straw			Grain			Straw			Grain			Straw		
	2022-2023	2023-2024	Mean	2022-2023	2022-2023	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean
0	0.91	0.95	0.93^{e}	0.29	0.36	0.32^{e}	0.24	0.28	0.26^{d}	0.05	0.10	0.08^{d}	0.25	0.22	0.23^{e}	2.27	2.32	2.29^{d}
10	0.95	1.01	0.98^{d}	0.41	0.45	0.43^{d}	0.28	0.32	0.30^{cd}	0.05	0.11	0.08^{cd}	0.27	0.26	0.27^{de}	2.37	2.45	2.41^{d}
20	1.09	1.14	1.11^{ab}	0.57	0.62	0.59^{ab}	0.37	0.44	0.41^{a}	0.12	0.19	0.15^{b}	0.41	0.31	0.36^{cde}	3.18	3.24	3.21^{ab}
30	1.07	1.11	1.09^{bc}	0.50	0.57	0.54^{bc}	0.30	0.36	0.33^{bc}	0.10	0.19	0.15^{bc}	0.65	0.73	0.69^{ab}	2.93	3.00	2.97^{bc}
40	1.08	1.18	1.13^{a}	0.60	0.66	0.63^{a}	0.39	0.45	0.42^{a}	0.21	0.27	0.24^{a}	0.84	0.91	0.88^{a}	3.35	3.40	3.38^{a}
50	1.05	1.10	1.07^{bc}	0.47	0.52	0.49^{cd}	0.30	0.35	0.33^{bc}	0.11	0.14	0.13^{bcd}	0.53	0.60	0.56^{bc}	2.84	2.88	2.86^{c}
60	1.03	1.08	1.05^{c}	0.47	0.52	0.50^{c}	0.34	0.38	0.36^{b}	0.11	0.17	0.14^{bc}	0.48	0.56	0.52^{bcd}	2.52	2.58	2.55^{d}
SEm(±)	0.01	0.01	0.12	0.01	0.01	0.36	0.01	0.01	0.23	0.02	0.02	0.58	0.06	0.06	0.03	0.05	0.05	0.07
									CD ($p \leq 0.05$)									
K level	0.02	0.03	0.41	0.04	0.04	0.27	0.04	0.04	0.69	0.05	0.05	0.34	0.18	0.19	0.12	0.16	0.15	0.02
Year	-	-	0.86	-	-	0.78	-	-	0.93	-	-	0.59	-	-	NS	-	-	0.01
K level × Year	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS

grains in all the K levels. Krishnappa *et al.* (1990) reported that K application increased K content in rice. In terms of nutrient ratios, potassium application raises the concentration of K in rice straw while simultaneously decreasing levels of sodium (Na) and magnesium (Mg). This adjustment improves the ratios of K/Na, K/Mg and K/Ca ratios (Bohra and Doerffling, 1993).

Data in Fig (1 to 6) showed that K level 40 Kg K_2O ha^{-1} recorded the highest uptake of N, P and K in grain and straw of rice with other level comparisons. This might be due to

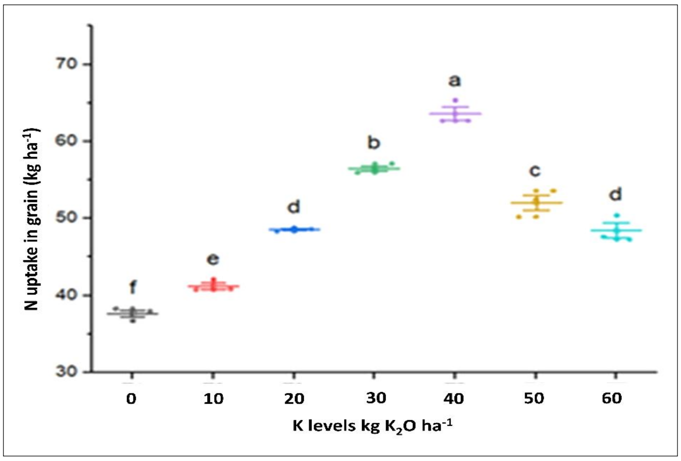

Fig 1: Nitrogen uptake (kg ha^{-1}) in rice grain as influenced by potassium levels (mean of 2022-2023 and 2023-2024).

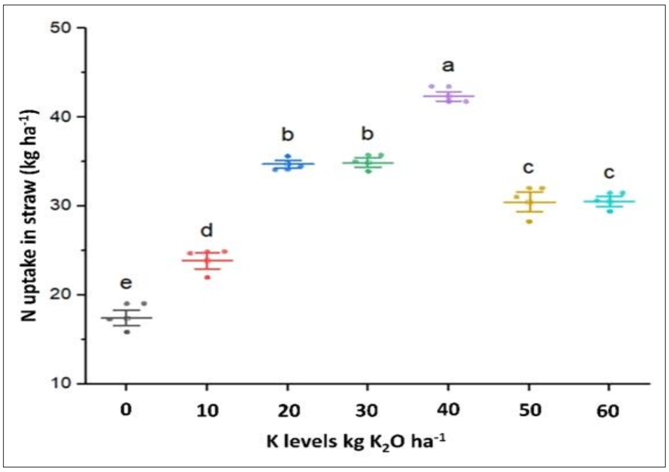

Fig 2: Nitrogen uptake (kg ha^{-1}) in rice straw as influenced by potassium levels (mean of 2022-2023 and 2023-2024).

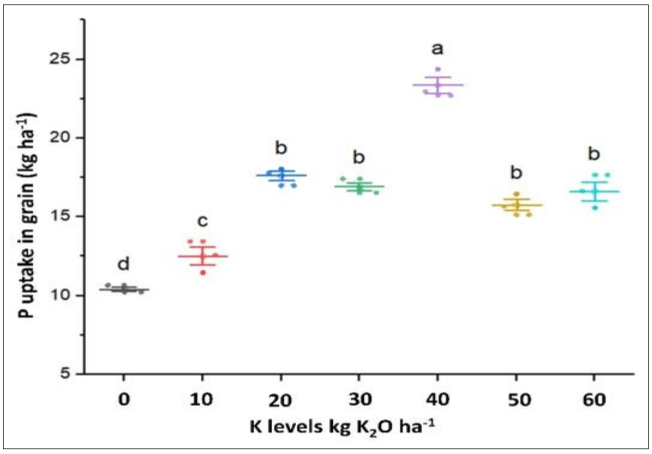

Fig 3: Phosphorus uptake (kg ha^{-1}) in rice grain as influenced by potassium levels (mean of 2022-2023 and 2023-2024).

the fact that nutrients are absorbed by plants proportionately as the available nutrients pool in soil solution increases. This was very close with the findings reported by Singh *et al.* (2005) and Rayar (1990). In a study, Frederick *et al.* (2025) reported that a significant increase in yield, yield components and NPK uptake of rice was noted with increase in potassium levels from 0 to 30 and 60 kg ha^{-1}.

Nutrient content and uptake in lentil

The percentage of N, P and K concentration in lentil seed and stover was recorded maximum in K level 50 kg K_2O ha^{-1} and 60 kg K_2O ha^{-1}, although they did not differ significantly from each other and the lowest in 0 kg K_2O ha^{-1} and 10 kg K_2O ha^{-1} (Table 4). Similarly, 50 kg K_2O ha^{-1} and 60 kg K_2O ha^{-1} both observed the highly effective nutrient uptake of N, P

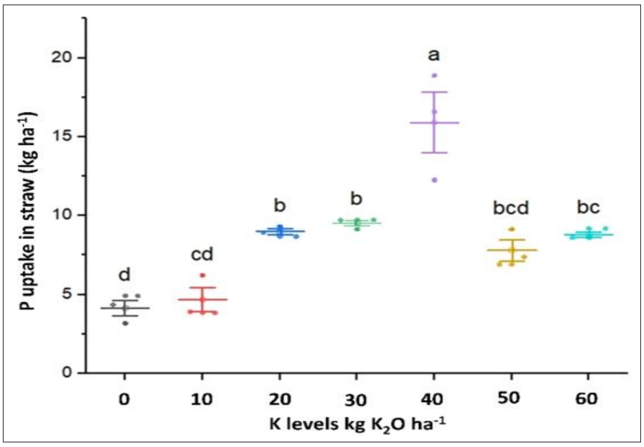

Fig 4: Phosphorus uptake (kg ha^{-1}) in rice straw as influenced by potassium levels (mean of 2022-2023 and 2023-2024).

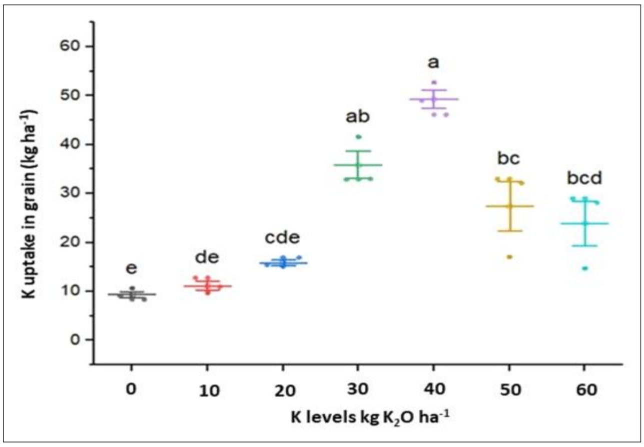

Fig 5: Potassium uptake (kg ha^{-1}) in rice grain as influenced by potassium levels (mean of 2022-2023 and 2023-2024).

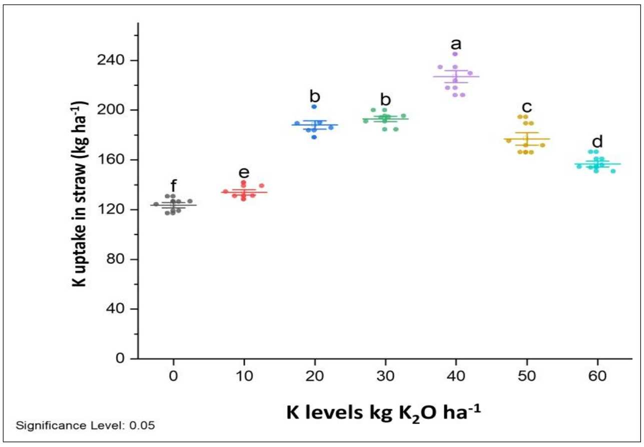

Fig 6: Potassium uptake (kg ha^{-1}) in rice straw as influenced by potassium levels (mean of 2022-2023 and 2023-2024).

Table 4: Effect of residual potassium on nutrient content (%) in seed and stover of lentil (mean of 2022-2023 and 2023-2024).

K dose (kg K_2O ha^{-1})	Nitrogen content (%)						Phosphorus content (%)						Potassium content (%)					
	Seed			Stover			Seed			Stover			Seed			Stover		
	2022-2023	2023-2024	Mean	2022-2023	2022-2023	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean
0	3.93	3.97	3.95^{c}	0.88	0.94	0.91^{d}	0.23	0.28	0.25^{c}	0.12	0.17	0.15^{e}	1.46	1.52	1.49^{d}	1.24	1.31	1.28^{c}
10	3.96	4.02	3.99^{bc}	0.99	1.04	1.01^{d}	0.28	0.35	0.32^{c}	0.13	0.18	0.15^{de}	1.47	1.52	1.50^{d}	1.35	1.40	1.37^{c}
20	4.77	4.84	4.81^{ab}	1.34	1.39	1.37^{c}	0.41	0.49	0.45^{b}	0.16	0.23	0.19^{cde}	1.68	1.73	1.71^{c}	1.62	1.69	1.66^{b}
30	4.71	4.78	4.74^{abc}	1.36	1.42	1.39^{c}	0.41	0.50	0.46^{b}	0.17	0.24	0.21^{cd}	1.96	2.06	2.01^{b}	1.60	1.68	1.64^{b}
40	4.79	4.85	4.82^{a}	1.72	1.80	1.76^{b}	0.46	0.51	0.48^{ab}	0.22	0.27	0.25^{c}	2.29	2.34	2.32^{a}	1.77	1.80	1.78^{b}
50	5.13	5.18	5.16^{a}	2.13	2.18	2.16^{a}	0.58	0.61	0.60^{a}	0.35	0.42	0.38^{a}	2.44	2.53	2.48^{a}	2.13	2.20	2.17^{a}
60	4.95	5.01	4.98^{a}	1.97	2.01	1.99^{ab}	0.51	0.56	0.54^{ab}	0.28	0.34	0.31^{b}	2.39	2.45	2.42^{a}	2.06	2.15	2.10^{a}
SEm(±)	0.18	0.17	0.36	0.07	0.06	0.59	0.03	0.03	0.71	0.02	0.02	0.32	0.04	0.04	0.24	0.04	0.05	0.32
									CD ($p \leq 0.05$)									
K level	0.54	0.53	1.01	0.21	0.20	0.97	0.08	0.09	0.92	0.05	0.05	1.07	0.11	0.12	0.81	0.13	0.14	0.30
Year	-	-	0.78	-	-	0.26	-	-	0.65	-	-	0.78	-	-	0.94	-	-	0.16
K level × Year	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS

Table 5: Effect of potassium levels on nutrient uptake (kg ha^{-1}) by seed and stover of lentil (mean of 2022-2023 and 2023-2024).

K dose (kg K_2O ha^{-1})	Nitrogen uptake (kg ha^{-1})						Phosphorus uptake (kg ha^{-1})						Potassium uptake (kg ha^{-1})					
	Seed			Stover			Seed			Stover			Seed			Stover		
	2022-2023	2023-2024	Mean	2022-2023	2022-2023	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean	2022-2023	2023-2024	Mean
0	23.20	19.93	21.56^{d}	6.27	6.98	6.62^{f}	1.34	1.41	1.38^{f}	0.88	1.31	1.10^{e}	8.60	7.63	8.11^{e}	8.84	9.76	9.30^{f}
10	25.66	21.48	23.57^{d}	7.86	8.61	8.24^{e}	1.82	1.90	1.86^{e}	1.06	1.43	1.25^{e}	9.54	8.16	8.85^{de}	10.74	11.59	11.16^{e}
20	31.83	26.41	29.12^{c}	13.52	13.56	13.54^{d}	2.77	2.66	2.72^{d}	1.64	2.19	1.91^{d}	11.25	9.45	10.35^{d}	16.41	16.45	16.43^{d}
30	33.65	29.21	31.43^{bc}	13.31	13.51	13.41^{d}	2.95	3.06	3.01^{cd}	1.66	2.29	1.97^{d}	14.00	12.56	13.28^{c}	15.54	16.01	15.78^{d}
40	35.42	30.17	32.79^{b}	16.85	18.61	17.73^{c}	3.38	3.17	3.28^{c}	2.20	2.82	2.51^{c}	16.95	14.57	15.76^{b}	17.32	18.57	17.95^{c}
50	39.72	38.87	39.30^{a}	26.16	26.33	26.24^{a}	4.49	4.60	4.55^{a}	4.25	5.08	4.67^{a}	18.89	18.95	18.92^{a}	26.22	26.63	26.42^{a}
60	40.17	33.52	36.84^{a}	22.27	21.92	22.10^{b}	4.16	3.75	3.96^{b}	3.12	3.74	3.43^{b}	19.40	16.43	17.92^{a}	23.25	23.37	23.31^{b}
SEm(±)	1.19	1.15	1.10	1.20	0.73	0.35	0.17	0.20	0.10	0.21	0.13	0.06	0.33	0.39	0.51	1.18	0.79	0.23
									CD ($p \leq 0.05$)									
K level	3.66	3.56	3.21	3.71	2.26	1.18	0.53	0.63	0.34	0.66	0.42	0.25	1.04	1.21	1.68	3.65	2.44	0.76
Year	-	-	1.71	-	-	NS	-	-	NS	-	-	0.13	-	-	0.90	-	-	0.41
K level × Year	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	S	-	-	NS

and K compared to lower K levels, but there was no yield advantage to increasing the potassium level beyond 50 kg K_2O ha^{-1} for maximizing uptake in seed and stover as shown in Table 5. This may be due to the involvement of potassium nutrient to increase the crop growth with increase in utilization and translocation of other essential nutrient especially N to plant and synergy between N and K in soil system resulting in boosting crop yield (Guo and Zhu, 2004; Bruns and Ebelhar, 2006).

Limitations and future scope

The present study focused primarily on the agronomic and nutrient response of rice- lentil cropping system to potassium fertilization under acid soil conditions. Economic analysis of treatments was not conducted, which restricts direct recommendations on the profitability of different potassium levels. In addition, the experiment was carried out over two years at a single location; therefore, the findings should be validated under diverse agro-ecological conditions and longer-term trials before drawing generalized recommendations. Future investigations should integrate both agronomic and economic analyses to identify the economically optimal potassium dose for rice-lentil systems. Multi-location and multi-season trials across varied soil types and altitudes in the North-Eastern region would help refine recommendations and capture site-specific responses. Long-term studies are also needed to evaluate the residual and cumulative effects of potassium on soil fertility, nutrient balances and system sustainability. In addition, incorporating advanced approaches such as soil test-based fertilizer recommendations, nutrient budgeting and precision agriculture tools could further improve potassium management strategies in acid soils.

CONCLUSION

The present study clearly demonstrates that potassium (K) plays a pivotal role in enhancing crop productivity and soil health in a rice-lentil cropping system under acid soil conditions. Application of potassium significantly improved plant growth, yield attributes and final yields of rice with K level 40 kg K_2O ha^{-1} and lentil with 50 kg K_2O ha^{-1} consistently producing the highest grain and biomass yields. Notably, rice grain yield increased from 4020 kg ha^{-1} under no K application (0 kg K_2O ha^{-1}) to 5620 kg ha^{-1} under K level (40 kg K_2O ha^{-1}), while lentil seed yield rose from 544 kg ha^{-1} to 762 kg ha^{-1}, highlighting the substantial yield benefits of optimal potassium nutrition. These findings underscore the importance of balanced fertilization practices and soil-specific nutrient management for sustainable agriculture. However, further research is needed to refine potassium recommendations under varied soil textures, altitudes and climatic conditions.

Conflict of interest

The authors declare that there are no conflicts of interest within them.

REFERENCES

Ali, A., Nadeem, M. A., Tahir, A.T.M. and Hussain, M. (2007). Effect of different potash levels on the growth, yield and protein contents of chickpea (*Cicer arietinum* L.). *Pakistan Journal of Botany*. **39(2):** 523-527.

Bohra, J.S. and Doerffling, K. (1993). Potassium nutrition of rice (*Oryza sativa* L.) varieties under NaCl salinity. *Plant and Soil*. **152**: 299-303.

Bruns, H.A. and Ebelhar, M.W. (2006). Nutrient uptake of maize affected by nitrogen and potassium fertility in a humid subtropical environment. *Communications in Soil Science and Plant Analysis*. **37(1-2)**: 275-293.

De Datta, S.K. and Mikkelsen, D.S. (1985). Potassium Nutrition of Rice. Munson R D(Ed). Madison, WI, USA: American Society of Agronomy, Crop Science Society of America, Soil Science Society of America: 665-699.

Dutta, S. and Zaman, A.S.N. (2013). Potassium indexing of summer rice grown in the shallow tube well command areas of central Brahmaputra Valley Zone of Assam, India. *Agricultural Science Digest*. **33(4)**: 259-263. doi: 10.5958/j.0976-0547.33.4.021.

Farjam, S., Kazemi-Arbat, H., Siosemardeh, A., Yarnia, M. and Rokhzadi, A. (2014). Effects of salicylic and ascorbic acid applications on growth, yield, water use efficiency and some physiological traits of Chickpea (*Cicer arietinum* L.) under reduced irrigation. *Legume Research*. **38(1)**: 66-71. doi: 10.5958/0976-0571.2015.00011.9.

Fratini, R. and Ruiz, M.L. (2001). Comparative study of different cytokinins in the induction of morphogenesis in Lentil (*Lens Culinaris Medik*.). *In vitro Cellular and Developmental Biology- Plant*. **38:** 46-51.

Frederick, M.P., Reddy, M.D., Shankar, T. and Pal, A. (2025). Effect of different nitrogen and potassium levels on yield and nutrient uptake of RNR15048 during summer season in Southern Odisha. *Indian Journal of Agricultural Research*. **59(5):** 752-755. doi: 10.18805/IJARe.A-6109.

Gebreslassie, H.B. (2016). Effect of potassium fertilizer on crop production. *Journal of Natural Sciences Research*. **6(7):** 81-86.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. (2nd Edn.). John Wiley and Sons. pp: 680.

Guo, X. and Zhu, H. (2004). Effects of different rates of nitrogen and potash on yield and quality of Cabbage. *Plant Nutrition and Fertilizers*. **10(2):** 161-166.

Islam, M.M., Karim, M.R., Oliver, M.M.H., Urmi, T.A., Hossain, M.A. and Haque, M. (2018). Impacts of trace element addition on Lentil (*Lens culinaris* L.). *Agronomy*. **8(7):** 100.

Jackson, M.L.W. (1973). Soil chemical analysis. Practice Hall of India Private Limited, New Delhi.

Khan, R., Gurmani, A.R., Gurmani, A.H. and Zia, M.S. (2006). Effect of potassium application on crop yields under wheat-rice system. *Sarhad Journal of Agriculture*. **23(2):** 277.

Krishnappa, M., Gowda, K.N., Shankarnarayan, V.K., Maharudrappa, K. and Khan, M.M.R. (1990). Effect of graded levels and split application of potassium on its availability and yield of rice. *Journal of Potassium Research*. **6(4):** 156-161.

Kumar, R., Kumar, M., Kumar, A. and Pandey, A. (2015). Productivity, profitability, nutrient uptake and soil health as influenced by establishment methods and nutrient management practices in transplanted rice (*Oryza sativa*) under hill ecosystem of North East India. *Indian Journal of Agricultural Sciences.* **85(5):** 634-639.

Lalitha, M. and Dhakshinamoorthy, M. (2014). Forms of soil potassium-A review. *Agricultural Reviews*. **35(1):** 64-68. doi: 10.5958 /j.0976-0741.35.1.008.

Layek, J., Das, A., Mishra, V.K., Lal, R., Krishnappa, R., Hazarika, S., Mohapatra, K.P., Ansari, M.A., Pramanick, B., Kumar, M., Ramkrushna, G.I., Saha, S., Babu, S. and Tahashildar, M. (2023). Improved agronomic practices and high yielding Rice varieties maintain soil health and enhance yield and energy use efficiency under shifting cultivation landscapes of Eastern Himalayas. *Land Degradation and Development.* **34(15):** 4751-4767.

Mirza, H., Ahamed, K.U., Rahmatullah, N.M., Akhter, N., Nahar, K. and Rahman, M.L. (2010). Plant growth characters and productivity of wetland rice (*Oryza sativa* L.) as affected by application of different manures. *Emirates Journal of Food and Agriculture*. **22(1):** 46-58.

Ravichandran, M. and Sriramachandrasekharan, M.V. (2011). Optimizing timing of potassium application in productivity enhancement of crops. *Karnataka Journal of Agricultural Sciences.* **24(1):** 75-80.

Rayar, A. (1990). Effect of neem seed crush blended urea on dry matter yield and N use efficiency in rice (*Oryza sativa* L.). *Madras Agricultural Journal*. **77(1)**: 44-47.

Sahay, N., Singh, S.P. and Sharma, V.K. (2013). Effect of cobalt and potassium application on growth, yield and nutrient uptake in lentil (*Lens culinaris*. L.). *Legume Research*. **36(3):** 259-262.

Sarwar, M. F. (2012). Effects of potassium fertilization on population buildup of rice stem borers (Lepidopteron pests) and rice (*Oryza sativa* L.) yield. *Journal of Cereals and Oilseeds*. **3(1):** 6-9.

Siavoshi, M., Nasiri, M. and Laware, S.L. (2011). Effect of organic fertilizer on growth and yield components in rice (*Oryza sativa* L.). *Journal of Agricultural Sciences*. **3(3):** 217.

Singh, G. and Prasad, S. (2020). Optimizing dose and timing of potassium application in enhancement of potassium uptake and yield in rice. *Journal of Pharmacognosy and Phytochemistry*. **9(2):** 165-170.

Singh, G., Ram, H., Sekhon, H.S., Aggarwal, N. and Khanna, V. (2011). Effect of nutrient management on nodulation, growth and yield of Lentil (*Lens culinaris Medik.*) genotypes. *American-Eurasian Journal of Agronomy*. **4(3)**: 46-49.

Singh, P.K., Bhardwaj, V. and Sharma, S.K. (2005). Nutrient requirement for optimum yield of hybrid rice in mollisols. *Annals of Agricultural Research*. **26(4):** 561-567.

Srinivasarao, C., Masood, A., Ganeshamurthy, A.N. and Singh, K.K. (2003). Potassium requirements of pulse crops. *Better Crops International*. **17(1):** 8-11.

Tisdale, S.L., Nelson, W.L. and Beaton, J.D. (1985). Soil fertility and fertilizers. (4.ed.). New York: Macmillan u.a.

Vijaykumar, S., Kumar, D., Ramesh, K., Govindasam, P., Jinger, D., Khanam, R., Saravanane, P., Subramanian, E., Joshi, E., Sharma, V.K. and Rajpoot, S. K. (2021). Potassium nutrition in rice: A review. *Oryza.* **58(3):** 341-353.