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RESEARCH ARTICLE

EFFECT OF SPLIT APPLICATION OF POTASSIUM ON MAIZE YIELD (*ZEA MAYS* L.) IN JHAPA, NEPAL

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ABSTRACT

A field experiment was conducted during spring 2025 at Jhapa rural municipality ward no 6, Jhapa district of Nepal to study the effect of split application of potassium in maize to enhance the yield. The experiment followed a Randomized Complete Block Design (RCBD) with seven treatments and three replications using the open-pollinated maize variety Arun-2. The results showed clear differences among treatments where the three-split potassium treatment, (20+20+20 kg K ha^{-1}), performed the best. Plants under this treatment had slightly delayed silking and maturity, which helped extend the grain-filling period. This treatment also produced the longest cobs (19.6 cm), thickest girth (42.7 mm), highest shelling percentage (75.19%), and the lowest sterility (7.36%). It recorded the highest kernel number per row (35.86), test weight (356.68 gm), and the greatest yield (4.40 t ha^{-1}). Treatments (30+15+15 and 20+40 kg K ha^{-1}), were close in performance, while the control gave the lowest results for every parameter. The improvement in yield with split potassium application was mainly due to better nutrient absorption, efficient use of photosynthates, and delayed leaf drying, which allowed for a longer grain-filling period. Hence, applying potassium in three splits-20 kg at planting, 20 kg at knee-high, and 20 kg at tasseling was the most effective approach for improving maize yield and related traits under the climate and soil conditions of Jhapa. This practice can help farmers use potassium more efficiently, maintain soil health, and increase maize productivity in the terai region of Nepal.

KEYWORDS

Grain filling period, Maize yield, Nutrient use efficiency, Potassium management, Split application

1. INTRODUCTION

Agriculture is the major source of livelihood and employment of Nepalese people (Dulal and Marahatta, 2020). Agriculture contributes about 23% of the national GDP, whereas maize alone contributes 25.02% to the total cereal production, and among the crops, maize is the second staple crop only after rice (Dhakal et al., 2022). Maize (*Zea mays* L.) is one of the world's leading crops cultivated in tropics, sub-tropics, and temperate regions (Neupane et al., 2020). Jhapa district, located in the terai region of Nepal, offers a highly favorable environment for maize cultivation due to its fertile soils and suitable climatic conditions (MoALD, 2023). The national average maize yield remains significantly lower (2.59 t ha^{-1}) than the yield levels achieved in developed countries (6 - 10 t ha^{-1}) (Kandel and Shrestha, 2020). Lack of proper utilization of fertilizer could be one of the main reasons behind low output (Kandel, 2021). A lack of adequate potassium leads to nutrient mining from soil, visible deficiency symptoms, and reduced yield and quality. Despite its importance, potassium deficiency is widespread across various climates due to limited understanding of potassium movement within soil pools and excessive dependence on native K reserves (Singh et al., 2021). Potassium further activates essential enzymes for photosynthesis, thereby improving vegetative growth and promoting early phenological development (Mahmood et al., 2000). Potassium is not a structural component of any cell organelle; however, it plays a major regulatory function in plant growth and development (Singh et al., 2021).

2. MATERIALS AND METHODS

The research was done at Jhapa rural municipality ward 6 of Jhapa district which is in terai region of province 1 of Nepal. Three separate doses of nitrogen and single dose of phosphorus were administered, whereas the treatment wise potassium was delivered at different stages of maize. First dose at land preparation, second was at knee height stage and 3rd was distributed at tasseling stage. The experiment was laid out in a Randomized Complete Block Design (RCBD). There were 7 treatments and each treatment was replicated three times. Altogether, there were 21 individual plots having 60 plants per plot. Treatment T_1 served as the control with no potassium application. Treatment T_2 received 60 kg K ha^{-1} as a single basal dose. In Treatment T_3, potassium was applied at 30 + 30 kg K ha^{-1} in two equal splits, while Treatment T_4 received 40 + 20 kg K ha^{-1} and Treatment T_5 received 20 + 40 kg K ha^{-1} as split applications. Treatment T_6 consisted of three equal split applications of potassium at 20 + 20 + 20 kg K ha^{-1}, whereas Treatment T_7 received potassium at 30 + 15 + 15 kg K ha^{-1} in three split doses. The experiment was laid out with three replications, each consisting of seven plots of uniform size (3.6 × 2.5 m^2), and treatments within each replication were assigned randomly using a lottery method. The maize variety Arun-2 was selected due to its suitability for hot and windy spring conditions, lodging resistance, early maturity, local availability, and affordability for farmers. Planting was carried out following the recommended spacing of 60 × 25 cm (row-to-row × plant-to-plant). Two seeds were sown per hill to ensure uniform plant stand under potential germination constraints, and ten plants per plot were randomly selected and tagged for data collection.

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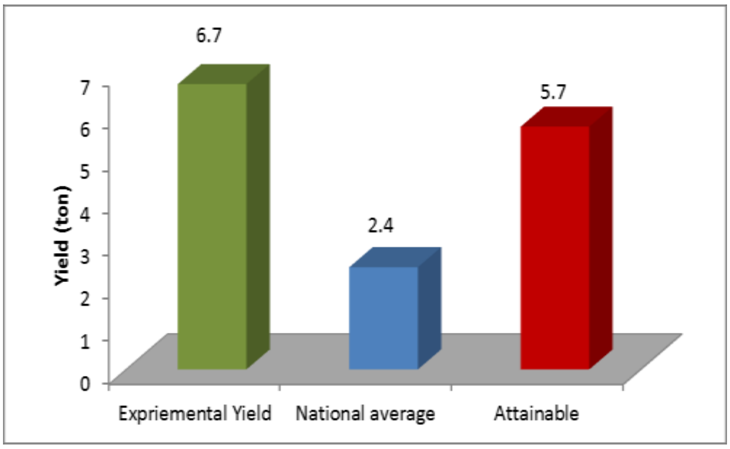

(NMRP, 2017)

Figure 1: Yield gap (t ha-1) of maize in Nepal

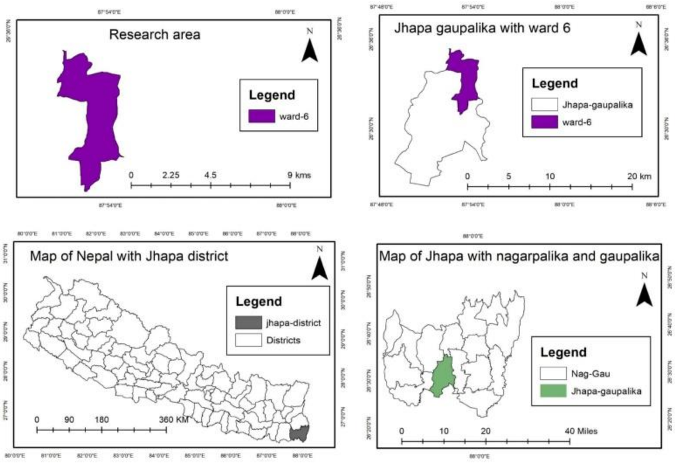

Figure 2: Map of research area

According to (Krishi Diary, 2081), the recommended fertilizer dose for maize includes 10 t ha^{-1} of farmyard manure, 130 kg ha^{-1} nitrogen, 30 kg ha^{-1} phosphorus, and potassium applied according to treatment requirements. Well-decomposed FYM was incorporated during field preparation, and fertilizers were applied as a basal dose with half urea, full DAP, and treatment-wise MOP, while the remaining urea and MOP were split between the knee-high and tasseling stages. Irrigation was applied as needed based on soil moisture, with water supplied at critical growth stages (knee-high and tasseling). Earthing up was performed at 30 DAS, while weeding was carried out at 20 and 40 DAS to reduce competition; thinning at 25 DAS maintained one healthy plant per hill. Indicators of cob maturity include husk color turns pale brown. It was harvested when moisture % is about 12-15%. Harvesting was done after 25-30 days of tasseling.

To evaluate the impact of split potassium applications on maize grain yield and its attributes, physical quality data were collected from tagged plants at specified intervals as required. Eight tagged plants per plot were used for phenological observations, recorded when 50% of plants reached a specific stage. Observations included days to tasseling, silking, and physiological maturity (indicated by black layer formation and ear husk senescence). Yield attributes assessed included sterility percentage, cob length and diameter, kernel rows per cob, kernels per row, test weight, shelling percentage, and grain yield (calculated per hectare based on filled ear weight, shelling percentage, grain moisture, and harvested area).

Collected data were organized by observed parameters and analyzed using MS-Excel and R-Studio for variance and other statistical analyses. Findings were interpreted and compared with relevant literature.

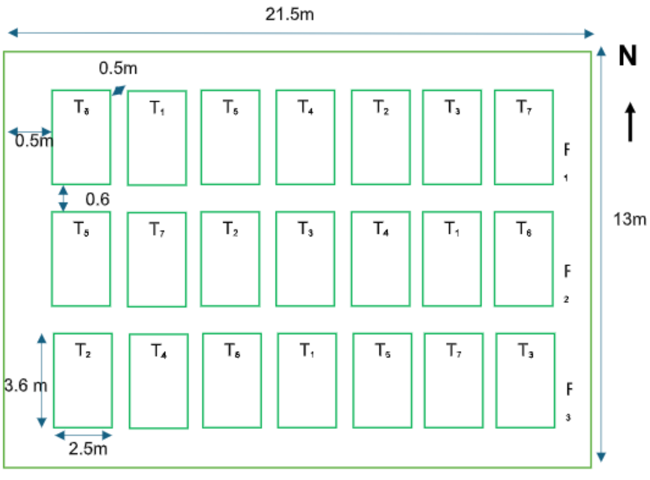

Figure 3: Layout of field

Table 1: Physico-chemical Properties of Soil in the Experimental Field

Parameter	**Value / Status**
Soil texture	Sandy loam
Soil pH	6.0
Nitrogen (%)	0.08 (Moderate)
Phosphorus (kg ha^{-1})	57.30 (High)
Potassium (kg ha^{-1})	109.00 (Slightly low)
Organic matter (%)	1.66 (Moderate)

Note: Soil fertility status was classified based on standard soil test rating guidelines.

3. RESULTS AND DISCUSSION

3.1 Phenology

Days to tasseling ranged from 49.34 to 54.30 days. The control (49.34 days), 20+20+20 kg K ha^{-1} (49.80 days), and 60 kg K ha^{-1} (50.00 days) were statistically at par and recorded the earliest tasseling, while 30+30 kg K ha^{-1} (51.10 days) and 40+20 kg K ha^{-1} (51.00 days) were intermediate. Delayed tasseling was observed in 20+40 kg K ha^{-1} (53.00 days) and 30+15+15 kg K ha^{-1} (54.30 days), though differences were statistically non-significant. Days to silking varied from 55.67 to 61.00 days, with the earliest silking in 20+20+20 kg K ha^{-1} (55.67 days), which was statistically at par with the control (57.30 days), 60 kg K ha^{-1} (57.67 days), and 40+20 kg K ha^{-1} (57.67 days). The longest silking period was recorded in 30+15+15 kg K ha^{-1} (61.00 days), but overall differences were non-significant. Physiological maturity differed significantly and ranged from 76.10 to 87.00 days. The control matured earliest at 76.10 days and was statistically inferior to all split potassium treatments. Maturity in 60 kg K ha^{-1} (79.30 days), 40+20 kg K ha^{-1} (80.16 days), and 30+30 kg K ha^{-1} (81.50 days) were statistically at par, while further delay was observed in 20+40 kg K ha^{-1} (82.60 days) and 30+15+15 kg K ha^{-1} (84.10 days). The longest maturity period was recorded in 20+20+20 kg K ha^{-1} (87.00 days).

Applying potassium in multiple stages influenced crop development. The three equal split schedule of 20+20+20 kg K ha^{-1} extended the crop's growth cycle, with maturity occurring later than in the control plots. This longer grain filling phase is beneficial because it allows more assimilates to be stored in the kernels. Amanullah et. al (2016) reported that staggered potassium application sustains leaf activity and prolongs photosynthesis. Similarly, Asif and Anwar (2007) observed that potassium enhances nutrient uptake, which delays senescence. These findings are relevant in Jhapa, where extended grain filling can improve yield however, noted that potassium responses vary depending on soil fertility in soils already, with limited effects rich in exchangeable potassium (Wang et al., 2013).

Table 2: Effects of split application of potassium in phenology of Maize in Jhapa, Nepal, 2025

Treatments	**50% Tasseling (days)**	**50% Silking (days)**	**Physiological maturity (days)**
Control	49.34	57.30	76.10^{c}
60 Kg K ha^{-1}	50.00	57.67	79.30^{bc}
30+30 Kg K ha^{-1}	51.10	59.16	81.50^{b}
40+20 Kg K ha^{-1}	51.00	57.67	80.16^{bc}
20+40 Kg K ha^{-1}	53.00	59.67	82.60^{ab}
20+20+20 Kg K ha^{-1}	49.80	55.67	87.00^{a}
30+15+15 Kg K ha^{-1}	54.30	61.00	84.10^{ab}
F-Test	NS	NS	**
SEm (±)	0.68	0.56	1.32
LSD (0.05)	4.13	4.04	4.45
CV (%)	4.53	4.18	3.071
Grand mean	51.21	54.23	81.57

Note: ** indicates significance at 1%, NS: Non-significant, SEm: standard error of mean, LSD: least significant difference, CV: coefficient of variation, Different Letters represent the ranking of treatment according to DMRT at 0.05 level of significance.

3.2 Yield attributes

Cob length ranged from 11.21 to 19.60 cm. The shortest cobs were produced in the control (11.21 cm), which was statistically inferior to all potassium-applied treatments. Cob length under 60 kg K ha^{-1} (13.40 cm), 30+30 kg K ha^{-1} (14.78 cm), and 40+20 kg K ha^{-1} (14.73 cm) were statistically at par. Higher cob lengths were recorded in 20+40 kg K ha^{-1} (17.10 cm) and 30+15+15 kg K ha^{-1} (18.34 cm), while the maximum cob length was observed in 20+20+20 kg K ha^{-1} (19.60 cm). Cob diameter followed a similar trend, varying from 31.49 to 42.70 mm. The control recorded the minimum diameter (31.49 mm). Cob diameter under 60 kg K ha^{-1} (36.24 mm) and 30+30 kg K ha^{-1} (36.77 mm) were statistically at par, while 40+20 kg K ha^{-1} recorded a slightly lower value (33.67 mm). Higher diameters were recorded in 20+40 kg K ha^{-1} (38.61 mm) and 30+15+15 kg K ha^{-1} (40.60 mm), with the maximum diameter in 20+20+20 kg K ha^{-1} (42.70 mm).

Significant increases in cob length and diameter under the three-split potassium regime are consistent with field studies showing split potassium or adequate soil potassium supply increases ear development and kernel set (He et al., 2022). soil potassium (higher rates, split application) increased ear length and kernel number per ear; improvement is linked to enhanced carbohydrate supply and cell expansion during ear development (Amanullah et al., 2016).

As reported that increases in potassium up to an optimum increased maize yields and yield components (ear and grain mass) in long-term experiments consistent with my research larger ear dimensions where potassium was applied in well-timed splits (He et al., 2022).

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Table 3: Effects of split application of potassium in yield attribute of maize in Jhapa, Nepal, 2025

Treatments	**Cob Length (cm)**	**Cob Diameter (mm)**
Control	11.21^{c}	31.49^{c}
60 Kg K ha^{-1}	13.40^{bc}	36.24^{abc}
30+30 Kg K ha^{-1}	14.78^{abc}	36.77^{abc}
40+20 Kg K ha^{-1}	14.73^{abc}	33.67^{bc}
20+40 Kg K ha^{-1}	17.10^{ab}	38.61^{abc}
20+20+20 Kg K ha^{-1}	19.60^{a}	42.70^{a}
30+15+15 Kg K ha^{-1}	18.34^{ab}	40.60^{ab}
F-Test	*	*
SEm (±)	1.10	1.46
LSD (0.05)	5.01	6.73
CV (%)	18.06	10.19
Grand mean	15.60	37.15

Note: *indicates significance at 5%, SEm: standard error of mean, LSD: least significant difference, CV: coefficient of variation, Different Letters represent the ranking of treatment according to DMRT at 0.05 level of significance

Shelling percentage ranged from 60.86 to 75.19%. The control recorded the lowest shelling (60.86%), which was statistically inferior. Shelling under 60 kg K ha^{-1} (62.15%) was statistically at par with the control, while moderate improvement was observed in 40+20 kg K ha^{-1} (67.40%) and 30+30 kg K ha^{-1} (69.07%). Higher shelling percentages were recorded in 20+40 kg K ha^{-1} (72.37%) and 30+15+15 kg K ha^{-1} (73.58%), which were statistically at par, while the highest shelling percentage was recorded in 20+20+20 kg K ha^{-1} (75.19%). Sterility percentage showed an opposite trend and ranged from 7.36 to 16.74%. The highest sterility was observed in the control (16.74%), followed by 60 kg K ha^{-1} (14.00%), which were statistically at par. Moderate sterility was recorded in 40+20 kg K ha^{-1} (12.03%) and 30+30 kg K ha^{-1} (11.49%). Lower sterility was observed in 20+40 kg K ha^{-1} (9.70%) and 30+15+15 kg K ha^{-1} (8.36%), which were statistically at par, while the minimum sterility was recorded in 20+20+20 kg K ha^{-1} (7.36%).

Such improvement is linked to enhanced water-use efficiency, enzyme activation, and assimilate movement promoted by potassium (Amanullah et al., 2016). However, as reported, potassium cannot fully offset stress during pollination adequate nitrogen and favorable weather are still critical for kernel set (Ul-Allah et al., 2020).

Some studies on irrigated duplex soils or fields with adequate exchangeable potassium found **no cob size or yield response** to extra. That suggests cob size responses depend on **initial soil** potassium **pools** and interactions with nitrogen and water (Ghimire et al., 2024).

Table 4: Effects of split application of potassium in yield attribute of maize in Jhapa, Nepal, 2025

Treatments	**Shelling (%)**	**Sterility (%)**
Control	60.86^{c}	16.74^{a}
60 Kg K ha^{-1}	62.15^{bc}	14.00^{ab}
30+30 Kg K ha^{-1}	69.07^{abc}	11.49^{bc}
40+20 Kg K ha^{-1}	67.40^{abc}	12.03^{bc}
20+40 Kg K ha^{-1}	72.37^{ab}	9.70^{cd}
20+20+20 Kg K ha^{-1}	75.19^{a}	7.36^{d}
30+15+15 Kg K ha^{-1}	73.58^{a}	8.36^{cd}
F-Test	*	**
SEm (±)	2.10	1.23
LSD (0.05)	9.84	3.76
CV (%)	8.06	18.56
Grand mean	68.66	11.38

Note: *, ** indicates significance at 5% and 1%, SEm: standard error of mean, LSD: least significant difference, CV: coefficient of variation, Different Letters represent the ranking of treatment according to DMRT at 0.05 level of significance

Kernel rows per cob ranged from 10.10 to 14.50. The control recorded the lowest number of rows (10.10). Values under 60 kg K ha^{-1} (11.26) and 40+20 kg K ha^{-1} (11.73) were statistically at par. Higher rows were observed in 30+30 kg K ha^{-1} (12.50) and 20+40 kg K ha^{-1} (13.56). The 30+15+15 kg K ha^{-1} treatment recorded 13.80 rows, which was statistically at par with 20+40 kg Kha^{-1}, while the maximum rows per cob were recorded in 20+20+20 kg K ha^{-1} (14.50). Kernels per row ranged from 24.70 to 35.86. The control recorded the lowest value (24.70). Kernels per row under 60 kg K ha^{-1} (27.10) and 40+20 kg K ha^{-1} (28.26) were statistically at par. Moderate values were recorded in 30+30 kg K ha^{-1} (30.06). Higher kernel numbers were observed in 20+40 kg K ha^{-1} (32.03) and 30+15+15 kg K ha^{-1} (32.00), which were statistically at par, while the highest kernels per row were recorded in 20+20+20 kg K ha^{-1} (35.86).

The three split treatments produced more kernel rows 14.5 and kernels per row 35.86. These results affirm that steady potassium supply enhances reproductive success and reduces kernel abortion under field stress. Studies similarly observed increased grain set and reduced sterility when K was applied in multiple splits by (Amanullah et al., 2016 and He et al., 2022).

Potassium increases grains per ear, reduces kernel abortion and improves shelling percentage under moisture stress mechanisms: improved water relations, carbohydrate translocation, enzyme activation. As review and experiments show potassium can improve grain set, weight and yield under stress, supporting my research of reductions in sterility and increased shelling (Amanullah et al., 2016). Ullah (2009) Kernel set improvements require good pollination conditions; potassium cannot fix poor pollination or extreme heat during silking. Some reports warn that potassium effects on kernel number are mediated by pollination success and other stresses i.e., potassium helps but only if pollination conditions and nitrogen availability permit kernel set (Ul-Allah et al., 2020).

Table 5: Effects of split application of potassium in yield attribute of maize in Jhapa, Nepal, 2025

Treatments	**Number of rows per Cob**	**Kernels per row**
Control	10.10^{c}	24.70^{c}
60 Kg K ha^{-1}	11.26^{bc}	27.10^{bc}
30+30 Kg K ha^{-1}	12.50^{abc}	30.06^{bc}
40+20 Kg K ha^{-1}	11.73^{abc}	28.26^{bc}
20+40 Kg K ha^{-1}	13.56^{ab}	32.03^{ab}
20+20+20 Kg K ha^{-1}	14.50^{a}	35.86^{a}
30+15+15 Kg K ha^{-1}	13.80^{ab}	32.00^{ab}
F-Test	*	**
SEm (±)	0.59	1.40
LSD (0.05)	2.56	5.08
CV (%)	11.55	9.52
Grand mean	12.50	30.00

Note: *, ** indicates significance at 5% and 1%, SEm: standard error of mean, LSD: least significant difference, CV: coefficient of variation, Different Letters represent the ranking of treatment according to DMRT at 0.05 level of significance

Cob weight ranged from 103.17 to 133.17 gm. The control recorded the lowest cob weight (103.17 gm). Cob weight under 60 kg K ha^{-1} (109.30 gm) and 40+20 kg K ha^{-1} (113.67 gm) were statistically at par. Higher cob weights were observed in 30+30 kg K ha^{-1} (119.33 gm) and 20+40 kg K ha^{-1} (123.50 gm). The 30+15+15 kg K ha^{-1} treatment recorded 128.00 gm, which was statistically at par with 20+40 kg K ha^{-1}, while the highest cob weight was observed in 20+20+20 kg K ha^{-1} (133.17 gm). Thousand-grain weight ranged from 273.67 to 356.68 gm. The control recorded the lowest test weight (273.67 gm). Test weight under 60 kg K ha^{-1} (310.30 gm) and 40+20 kg K ha^{-1} (322.00 gm) were statistically at par. Higher values were recorded in 30+30 kg K ha^{-1} (331.20 gm), 20+40 kg K ha^{-1} (340.00 gm), and 30+15+15 kg K ha^{-1} (344.00 gm), which were statistically at par, while the highest test weight was recorded in 20+20+20 kg K ha^{-1} (356.68 gm). Grain yield ranged from 2.70 to 4.40 t ha^{-1}. The control produced the lowest yield (2.70 t ha^{-1}), which was statistically inferior. Yield under 60 kg K ha^{-1} (2.88 t ha^{-1}) and 40+20 kg K ha^{-1} (3.30 t ha^{-1}) were statistically at par. Higher yields were recorded in 30+30 kg K ha^{-1} (3.65 t ha^{-1}), 20+40 kg K ha^{-1} (4.01 t ha^{-1}), and 30+15+15 kg K ha^{-1} (4.16 t ha^{-1}), which were statistically at par, while the highest grain yield was obtained in 20+20+20 kg K ha^{-1} (4.40 t ha^{-1}).

Cob weight and test weight were highest under the equal split, at 133.17 gm and 356.68 gm respectively, outperforming single and uneven split schedules. Grain yield peaked under the equal split at 4.40 t ha^{-1}, higher than every other treatment and substantially above the control. It may be attributed to

- increased test weight with increasing potassium, they relate this to improved carbohydrate supply and sink strength. (Amanullah et al., 2016)
- long-term and interactive studies show potassium often increases grain weight when nitrogen status is adequate (Zhang: interactive nitrogen×potassium effects).

Where nitrogen or photosynthetic area is limiting, potassium addition alone may not raise test weight many studies emphasize **balanced nitrogen, potassium and phosphorus.** As emphasize that crop response to potassium occurs only in approximate 25% of trials on average; test weight increase is likely in potassium limited fields (Roobroeck et al., 2021).

Enzyme activation increased the intensity of assimilation and the movement of assimilates from leaves to grains, which raised test weight. Adequate potassium enhanced photosynthetic activity and root uptake of nitrogen and other nutrients, maintained leaf greenness, and delayed senescence, thereby extending the physiological maturity and lengthening the grain filling period. Enhanced carbohydrate metabolism and translocation directed more assimilates to the grain sink, producing heavier kernels, and the greater test weight reflected larger accumulations of proteins and other reserve substances in the seeds (Y. Wang et al., 2025).

The grain yield is higher due to the improvement of other yield attributes as a whole and also due to the increment of the resistance to the lodging which is very helpful in the storm and windy weather of Jhapa, Nepal. Potassium also plays vital role in improvement of water use efficiency, cell division, plant growth, quick translocation of assimilates from the leaf to the grains which yields higher than the control.

As reported that across global trials only a fraction show potassium response; effect sizes vary (Roobroeck et al., 2021).

Table 6: Effects of split application of potassium in yield attribute of maize in Jhapa, Nepal, 2025

Treatments	**Cob weight (gm)**	**Test weight (gm)**	**Grain Yield (t ha^{-1})**
Control	103.17^{c}	273.67^{c}	2.70^{d}
60 Kg K ha^{-1}	109.30^{bc}	310.30^{b}	2.87^{cd}
30+30 Kg K ha^{-1}	119.33^{abc}	331.20^{ab}	3.65^{abc}

Table 7 (cont): Effects of split application of potassium in yield attribute of maize in Jhapa, Nepal, 2025

40+20 Kg K ha^{-1}	113.67^{abc}	322.00^{b}	3.30^{bcd}
20+40 Kg K ha^{-1}	123.50^{ab}	340.00^{ab}	4.01^{ab}
20+20+20 Kg K ha^{-1}	133.17^{a}	356.68^{a}	4.40^{a}
30+15+15 Kg K ha^{-1}	128.00^{ab}	344.00^{ab}	4.16^{ab}
F-Test	*	*	**
SEm (±)	4.00	10.33	0.24
LSD (0.05)	18.09	30.99	0.82
CV (%)	8.57	5.35	12.84
Grand mean	118.6	325.42	3.5

Note: *, ** indicates significance at 5% and 1%, SEm: standard error of mean, LSD: least significant difference, CV: coefficient of variation, Different Letters represent the ranking of treatment according to DMRT at 0.05 level of significance

4. CONCLUSION

The experiment demonstrated that split application of potassium significantly enhances maize yield and yield-related traits under the soil and climatic conditions of Jhapa, Nepal. Among the tested treatments, three equal split application of 20 kg K ha^{-1} at planting, knee-high, and tasseling stages proved to be the most effective strategy. This practice ensures sustained potassium availability during critical growth stages, improves nutrient uptake, prolongs grain-filling, and ultimately increases yield. Therefore, adopting split potassium application can help farmers in Jhapa and similar agro-ecological zones to optimize fertilizer use, maintain soil fertility, and achieve higher maize productivity.

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