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Economic feasibility and yield of different treatments of potassium management in light textured soil on *rabi* onion var. Agrifound light red of Western (UP)

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Abstract

A field experiment was carried out to assess the economic feasibility of different nutrient management treatments in light-textured soil on Rabi onion (var. Agrifound Light Red) under the agro-climatic conditions of Western Uttar Pradesh. The study was conducted at the Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), during the Rabi seasons of 2020–21 and 2021–22. The significantly highest bulb yield ranged from 200.13 to 215.07 q ha⁻¹ in the first year and 297.83 to 322.00 q ha⁻¹ was recorded in T₁₁ (NP + K₅₀ – 100% basal through Polyhalite), which was statistically at par with T₉ (NPS + K₇₅ – 50% basal + 50% at bulb formation stage) producing 275.46 and 306.00 q ha⁻¹, followed by T₁₀ (NPS + K₇₅ – 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage) with 270.10 and 291.00 q ha⁻¹ during 2020–21 and 2021–22, respectively. The lowest yield (200.13 and 215.07 q ha⁻¹) was obtained from the control treatment (T₁: N₁₀₀ P₅₀ S₄₀) in both years. Yield improvement under T₁₁ was 48%, 35%, 18%, and 12% higher in 2020–21, and 49%, 35%, 25%, and 14% higher in 2021–22, compared to T₁, T₂, T₅, and T₈, respectively. The application of 150% of the recommended potassium dose in two splits, as in T₉ (NPS + K₇₅ – 50% basal + 50% at bulb formation stage), resulted in yield increases of 25%, 14%, 9%, 7%, and 2% in the first year, and 28%, 20%, 19%, 17%, and 5% in the second year, over T₂, T₄, T₅, T₇, and T₁₀, respectively. Similarly, the T₁₀ treatment (NPS + K₇₅ – 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage) achieved higher yields by 34%, 22%, 14%, 7%, and 1.92% during 2020–21 and by 35%, 22%, 17%, 13%, and 3.68% in 2021–22, compared to T₁, T₂, T₃, T₅, and T₈, respectively. Overall, the results clearly indicate that applying the recommended dose of potassium through Polyhalite produces yields comparable to those obtained with 150% potassium application through the conventional fertilizer (MOP), demonstrating its efficiency and economic advantage in Rabi onion cultivation.

Keywords: Potassium management, Economic feasibility and onion production

Introduction

Because of the long-held belief that Indian soils are naturally rich in potassium, this essential nutrient has often been overlooked in intensive agricultural systems. This misconception has led to the neglect of potassium fertilization, resulting in the progressive depletion of soil K reserves. Over time, continuous cropping and unbalanced fertilizer use—with excessive nitrogen (N) and phosphorus (P) but insufficient potassium (K)—have caused severe potassium mining, where the amount of K removed by crops far exceeds the amount replenished by fertilizers. Consequently, K deficiency in soils and crops has become a growing concern in Indian agriculture.

With the advent of high-yielding varieties (HYVs), increased cropping intensity, and greater use of N and P fertilizers, the native potassium reserves in soil have been increasingly depleted. The availability of potassium to plants depends on the dynamic equilibrium among its different forms in the soil, which is influenced by factors such as the type of clay minerals, rate of weathering, and cation exchange capacity. These forms include:

- Water-soluble K, which is immediately available for plant uptake.

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- Exchangeable K, held on negatively charged clay surfaces and also available to plants.
- Fixed K, trapped between clay layers but slowly released over time.
- Lattice K, incorporated within primary K-bearing minerals and largely unavailable.

Although non-exchangeable and total K contents are generally much higher than water-soluble or exchangeable forms, the balance among these fractions controlled by soil's physico-chemical properties determines the effective potassium supply to plants. Because of the inherently high native K in some soils, the crop response to applied K fertilizer is often low, even though plants continue to extract significant amounts of potassium, leading to gradual depletion of soil reserves.

Onion (*Allium cepa* L.), being a shallow-rooted and potassium-loving crop, requires relatively large quantities of available nutrients, especially in the upper soil layer. Like other root and tuber crops, onion shows a strong response to potassium fertilization. Adequate K nutrition is essential for several metabolic and physiological processes, including:

- Synthesis and translocation of carbohydrates and sugars,
- Protein formation,
- Enzyme activation,
- Enhanced resistance to pests, diseases, and environmental stress,
- Improved stalk and stem strength, and
- Better bulb development, storage quality, and yield (Pachauri *et al.*, 2005) [6].

Furthermore, potassium plays a vital role in maintaining osmotic balance, regulating cell division and elongation, and supporting carbohydrate and protein metabolism crucial for plant growth and productivity (Marschner, 1995) [5].

An adequate potassium (K) concentration in onion bulbs is vital not only for achieving higher yield but also for ensuring good storage quality. Potassium deficiency in onion is typically manifested by browning of leaf tips in older leaves, weak plant growth, and poor bulb development. Therefore, the timely application of an appropriate quantity and suitable source of potassium during critical growth stages is essential for maintaining optimum crop growth, bulb quality, and productivity.

Onion is a nutrient-exhaustive crop that removes large amounts of macronutrients from the soil, necessitating regular replenishment to sustain soil fertility. For instance, to produce a 40 t ha⁻¹ bulb yield, the crop requires approximately 120 kg N, 50 kg P, and 160 kg K per hectare. However, in practice, farmers often apply lower nutrient levels, typically around 100 kg N, 50 kg P₂O₅ (≈30 kg P), and 50 kg K₂O (≈41 kg K) per hectare, with potassium being the most under-applied element (Deshpande *et al.*, 2013) [4].

Deshpande *et al.* (2013) [4] reported that the highest gross income (₹258,720 ha⁻¹) and net profit (₹183,386 ha⁻¹) were obtained under the highest potassium application rate of 150 kg K₂O ha⁻¹. As the cost of cultivation was relatively insensitive to the additional cost of potassium fertilizer, higher yields directly

translated into greater profitability. Profit margins increased markedly—by about 50% over the control—with the first K application (33 kg K₂O ha⁻¹) and continued to rise with increasing K levels, particularly beyond 86 kg K₂O ha⁻¹.

Based on these findings, it can be concluded that potassium fertilization remains economically beneficial up to the highest tested rate (150 kg K₂O ha⁻¹). Although yield increments beyond 100 kg K₂O ha⁻¹ were not statistically significant, the corresponding increases in income and net profit suggest that generous potassium application is financially viable, ensuring both stable yield performance and economic returns for onion growers. Deshpande *et al.* (2013) [4].

Materials and Methods

The field experiments were conducted during the Rabi seasons of 2020–21 and 2021–22 at the Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh). Meerut is located along National Highway 58, which connects Delhi and Dehradun. Geographically, the experimental site lies between 28.40° and 28.00° N latitude and 77.00° and 78.00° E longitude, at an elevation of approximately 237 meters above mean sea level (MSL). The experiment was performed in the Indo-Gangetic plains of western Uttar Pradesh, specifically at the university's Crop Research Centre, located at 29.080783° N latitude, 77.70091° E longitude, and an altitude of 218 meters above MSL. The climatic condition of Meerut is semi-arid to subtropical, characterized by hot summers, cool winters, and moderate rainfall. The study consisted of 11 treatment combinations, arranged in a Randomized Block Design (RBD) with three replications. The treatments were randomly assigned within each replication, following standard experimental procedures to minimize bias and ensure statistical reliability. The cost of cultivation for each treatment was calculated separately based on the prevailing local market prices of all inputs used during the crop's growth period. The term cost of cultivation refers to the total expenditure incurred from land preparation to harvesting and threshing, encompassing all production-related expenses. It is generally expressed on an area basis (per hectare), whereas the cost of production is expressed on a yield or quantity basis (per quintal). For the purpose of the present economic analysis, both cost of cultivation and cost of production were considered interchangeable terms in evaluating the economic feasibility of different treatments.

The monetary value of bulb yield was calculated in ₹ ha⁻¹ based on the minimum support price (MSP) and the prevailing local market prices of onion bulbs during the respective cropping seasons. The gross return (₹ ha⁻¹) for each treatment was obtained by multiplying the total bulb yield with its corresponding market price, calculated separately for each treatment.

The net return (₹ ha⁻¹) for each treatment was then derived by subtracting the total cost of cultivation from the gross return using the formula:

$$B : C \text{ ratio} = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

Table 1: Experiment treatment combination of potassium management

T ₁	Control (N ₁₀₀ P ₅₀ S ₄₀ K ₀)
T ₂	NPS + K ₅₀ (K 100% at basal)
T ₃	NP S + K ₅₀ (K 50% basal + 50% at bulb formation stage)
T ₄	NPS + K ₅₀ (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage)
T ₅	NP S + K _{62.5} (K 100% at basal)
T ₆	NPS + K _{62.5} (K 50% basal + 50% at bulb formation stage)
T ₇	NPS + K ₆₃ (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage)
T ₈	NPS + K ₇₅ (K 100% at basal)
T ₉	NPS + K ₇₅ (K 50% basal + 50% at bulb formation stage)
T ₁₀	NPS + K ₇₅ (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage)
T ₁₁	NP + K ₅₀ (100% basal through Polyhalite)

Table 2: Effect of different level

Treatments	Onion yield q/ha	
	2020-21	2021-22
T ₁	200.13	215.07
T ₂	220.22	237.81
T ₃	235.67	247.07
T ₄	241.03	253.05
T ₅	252.28	255.83
T ₆	260.33	268.77
T ₇	255.08	260.78
T ₈	265.00	280.67
T ₉	275.46	306.00
T ₁₀	270.10	291.00
T ₁₁	297.83	322.00
SE m±	8.74	9.34
CD	25.78	27.54

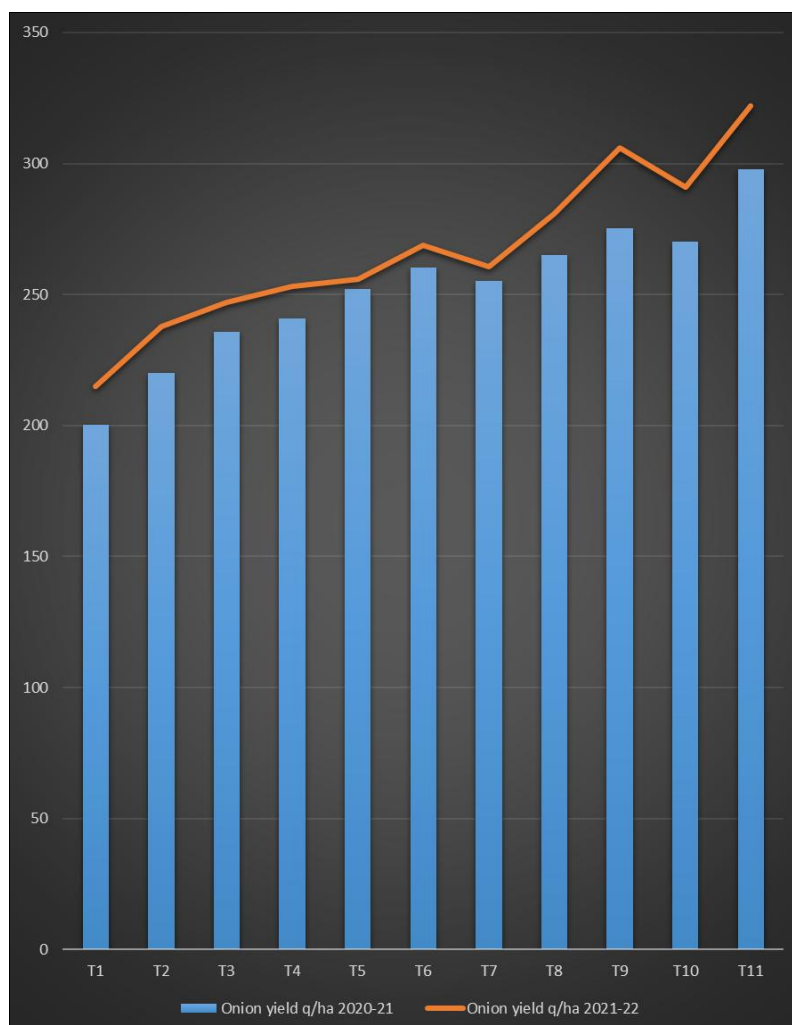
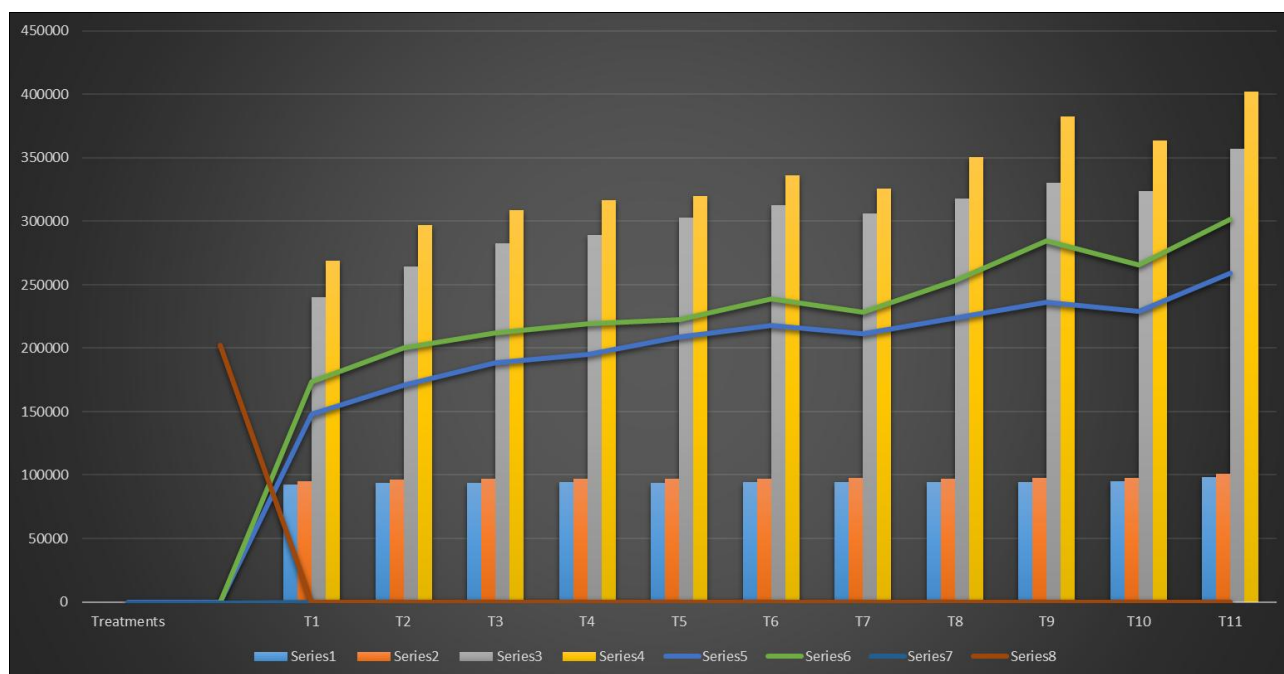
**Fig 1:** Effect of different level and timing of potassium application on onion yield q ha⁻¹

Table 3: Effect of different level and timing of K application on economics of different treatments of Onion

Treatments	Cost of cultivation		Gross return		Net return (Rs. / ha)		B:C ratio	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
T ₁	92393	95349	240156	268833	147763	173484	2.60	2.82
T ₂	93643	96682	264260	297258	170617	200576	2.82	3.07
T ₃	93933	96972	282800	308842	188867	211870	3.01	3.18
T ₄	94223	97262	289232	316313	195009	219050	3.07	3.25
T ₅	93955	97015	302737	319792	208781	222776	3.22	3.30
T ₆	94245	97305	312400	335958	218155	238653	3.31	3.45
T ₇	94535	97595	306096	325979	211561	228384	3.24	3.34
T ₈	94268	97349	318000	350833	223732	253484	3.37	3.60
T ₉	94558	97639	330551	382500	235993	284861	3.50	3.92
T ₁₀	94848	97929	324120	363750	229272	265821	3.42	3.71
T ₁₁	98107	101063	357400	402500	259293	301437	3.64	3.98

**Fig 2:** Effect of different level and timing of K application on economics of different treatments of Onion

Results and Discussion

The onion bulb yield showed significant variation among the treatments, primarily influenced by the levels and sources of potassium applied (Table 2; Fig. 2) during both the 2020–21 and 2021–22 Rabi seasons. The bulb yield ranged from 200.13 to 215.07 q ha⁻¹ in the first year and from 297.83 to 322.00 q ha⁻¹ in the second year across different treatments. The highest bulb yield of 297.83 q ha⁻¹ (2020–21) and 322.00 q ha⁻¹ (2021–22) was recorded in T₁₁ (NP + K₅₀ – 100% basal through Polyhalite), which was statistically at par with T₉ (NPS + K₇₅ – 50% basal + 50% at bulb formation stage) producing 275.46 q ha⁻¹ and 306.00 q ha⁻¹ in the respective years. This was followed by T₁₀ (NPS + K₇₅ – 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage), which yielded 270.10 q ha⁻¹ and 291.00 q ha⁻¹ during the first and second years, respectively. The lowest yield of 200.13 q ha⁻¹ (2020–21) and 215.07 q ha⁻¹ (2021–22) was obtained in the control treatment (T₁: N₁₀₀ P₅₀ S₄₀). The yield under T₁₁ showed an increase of 48%, 35%, 18%, and 12% in 2020–21 and 49%, 35%, 25%, and 14% in 2021–22 over T₁, T₂, T₅, and T₈, respectively. The treatment T₉ (NPS + K₇₅ – 50% basal + 50% at bulb formation stage), which represents 150% of the recommended dose of potassium applied in two splits, recorded yield increases of 25%, 14%, 9%, 7%, and 2% during 2020–21 and 28%, 20%, 19%, 17%, and 5% during 2021–22 over T₂, T₄, T₅, T₇, and T₁₀, respectively.

Similarly, the T₁₀ treatment (NPS + K₇₅ – 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage) resulted in higher yields by 34%, 22%, 14%, 7%, and 1.92% in the first year and 35%, 22%, 17%, 13%, and 3.68% in the second year when compared to T₁, T₂, T₃, T₅, and T₈, respectively. From the results, it is evident that the application of the recommended dose of potassium through Polyhalite (T₁₁) produced yields comparable to those obtained with 150% potassium application through conventional fertilizer (MOP). This indicates that Polyhalite can serve as an efficient and cost-effective alternative source of potassium for achieving high productivity and better economic returns in Rabi onion cultivation. The ultimate goal of any research or technological advancement in agriculture is its adoption by farmers, which largely depends on its economic feasibility and profitability. The gain or loss from any agricultural practice is determined by the balance between input costs and output returns. A concise assessment of the economic feasibility of the present investigation is discussed below.

During the Rabi seasons of 2020–21 and 2021–22, the cost of cultivation varied from ₹92,393 to ₹98,107 ha⁻¹ and ₹95,349 to ₹1,01,063 ha⁻¹, respectively. The maximum cultivation cost was incurred under the treatment T₁₁ (K₅₀ – 100% basal through Polyhalite), followed by T₉ (NPS + K₇₅ – 50% basal + 50% at bulb formation stage), due to the higher cost of potash source and nutrient management. Conversely, the lowest cost of

cultivation was recorded in the control treatment (T_1) where no potassium was applied. The highest gross return of ₹3,57,400 ha^{-1} (2020–21) and ₹4,02,500 ha^{-1} (2021–22) was achieved under T_9 (NPS + K_{75} – 50% basal + 50% at bulb formation stage), while the minimum gross return of ₹2,40,156 ha^{-1} and ₹2,68,833 ha^{-1} was observed in the control treatment (T_1 : N_{100} P_{50} S_{40}) during the respective years. However, the highest net return of ₹2,59,293 ha^{-1} (2020–21) and ₹3,01,437 ha^{-1} (2021–22) was obtained from T_{11} (K_{50} – 100% basal through Polyhalite), owing to the superior yield performance and effective nutrient utilization. The lowest net return was recorded in the control treatment (T_1).

Similarly, the maximum benefit–cost (B:C) ratio of 3.64 (2020–21) and 3.98 (2021–22) was also obtained under T_{11} , while the minimum B:C ratio of 2.60 and 2.82 was observed in T_1 , where potassium was not applied. The economic evaluation of treatments clearly indicated that the application of potassium through Polyhalite, in combination with sulphur, significantly enhanced the gross income, net profit, and benefit–cost ratio. The application of 50 kg K ha^{-1} through Polyhalite proved to be the most profitable treatment, primarily due to the increase in bulb yield resulting from improved potassium availability and utilization. These findings are in close agreement with the results of Dudhat *et al.* (2010) ^[1], Meena *et al.* (2014) ^[2], and Tesfay & Girmay (2019) ^[3], who also reported that higher doses of potassium fertilizer than the recommended rate led to improved bulb yield and increased net returns, thereby confirming the economic advantage of adequate potassium fertilization in onion cultivation.

Conclusion

- On the basis of two-year field experiments, it can be concluded that the recommended dose of potassium and general practice of application through common fertilizer is not sufficient to give desired onion yield. Application of 150% of RDF of potassium *i.e.* T_9 (NPS + K_{75} -50% basal + 50% at bulb formation stage) in two split dose achieved maximum yield and able to build up water soluble and exchangeable form of potassium in soil.
- In the study it is found that application of polyhalite to supplement recommended dose of potassium yielded higher bulb yield. Higher yield with polyhalite by supplementary recommended dose may be due to its chemical and physical properties. It acts as slow release multi nutrient source. The net return and B:C ratio was also maximum under T_{11} (NP + K_{50} -100% basal through Polyhalite).

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