

Influence of Polyhalite on Biometric, Yield Parameters and Yield of Rice (*Oryza sativa* Var. (ADT43)) Grown in Alluvial Soils of Tamil Nadu

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Abstract

A field experiment was carried out in the Sivapuri village, Chidambaram taluk, Tamil Nadu during kharif of 2024 to study the effect of polyhalite on biometric, yield parameters and yield of rice (*Oryza sativa* var. (ADT43)) grown in alluvial soils of Tamil Nadu and included eight treatments viz., T₁- Control, T₂-NP + K (0), T₃-NP + 50% K as MOP, T₄-NP + 50% K as Polyhalite, T₅-NP + 100% K as MOP, T₆-NP + 100% K as Polyhalite, T₇-NP + 150% K as MOP, T₈-NP + 150% K as Polyhalite. The highest growth characters viz., plant height (103.1 cm), chlorophyll content (44.5 SPAD value) and dry matter production (87.5 g pot⁻¹), yield characters viz., no. of grains panicle⁻¹ (81.23), panicle length (28.53 cm) was obtained under T₈ (NP + K 150% as Polyhalite). Further, this treatment showed an increase in grain and straw yield respectively over control.

Key words: *Oryza sativa* Var. ADT43, Alluvial soil, Growth, Polyhalite, Potassium, Yield

Rice (*Oryza sativa* L.) is the most significant cereal crop in developing nations and serves as the staple food for more than half of the global population, particularly in East and Southeast Asia. Archaeological findings indicate that rice cultivation in India dates back to 1500-1000 B.C. Since ancient times, rice has been a vital source of sustenance in the humid regions of Asia and to a lesser extent in West Africa. Its introduction to Europe and the America has further expanded its role in human diets. Although rice is cultivated in 42 countries worldwide, China and India remain the leading producers [1]. Rice (*Oryza sativa* L.) stands as a vital staple crop globally, providing sustenance for a significant portion of the world's population [2]. Worldwide rice production in 2023-2024 is 513.54 MMT [3]. China ranks first in rice production, followed by India and Bangladesh. India's rice production for the year 2023-2024 was estimated to be 1367 LMT. Tamil Nadu has a total rice production of 7.56 Mha with an area of 2.16 Million hectares and with a yield of 3500 kg ha⁻¹ in the crop year 2022-23 [3].

With the growing global population, a significant challenge in the future will be producing more rice on less land with reduced water and labour resources. Addressing this issue will require innovative agricultural research and technologies that enhance rice production efficiency. In this regard, polyhalite may serve as a suitable fertilizer, as it provides four essential nutrients and is less water-soluble than conventional fertilizers, potentially allowing for a slower nutrient release. Potassium, a vital macronutrient, significantly influences plant biometry and yield. The declared minimum nutrient

composition of polyhalite includes 48% sulfur trioxide (SO₃), 14% potassium oxide (K₂O), 6% magnesium oxide (MgO), and 17% calcium oxide (CaO). After extraction, the mineral is processed to produce granules of varying sizes (ICL Fertilizers, Cleveland, UK). Unlike a mixture of salts, polyhalite is a singular crystalline structure, which means its nutrients are released into solution proportionally, a characteristic confirmed by research [4]. This proportional release is expected to behave similarly in polyhalite-soil interactions, though the individual nutrients will interact with the soil based on its properties. One key advantage of using polyhalite as a fertilizer, compared to conventional salts, is its slower nutrient release rate. The leaching of K, Ca, Mg and S from polyhalite occurs more gradually than from commonly used soluble salts [5]. Therefore, this study aims to investigate the influence of polyhalite on rice growth and yield in alluvial soils. By assessing its impact on key growth parameters and yield components, this research endeavors to elucidate the efficacy of polyhalite as a soil amendment in rice cultivation.

MATERIALS AND METHODS

The experiment was carried out in farmers field, Sivapuri village, Chidambaram taluk, Tamil Nadu during kharif season of 2024. The field is situated at a latitude of 11°36'N and a longitude of 79°71'E, with an altitude of +5.79m above sea level, approximately 15 km from the Bay of Bengal. The soil was neutral in pH (7.2), non-saline (EC- 0.94 dSm⁻¹), low in available nitrogen (186 kg ha⁻¹) and medium in available

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phosphorus (14 kg ha⁻¹) and potassium (212.1 kg ha⁻¹). The short duration rice variety ADT-43 was transplanted into the field @ 2 seedlings/hill. The recommended fertilizer dose of 150, 50, and 50 kg ha⁻¹ of N, P₂O₅, and K₂O, respectively, is referred to as the standard (100%). Half of the N dose was applied basally in the form of urea (46% N) and the remaining 50% was split into two equal amounts and top dressed at tillering and panicle initiation stages. Phosphorus was applied basally in the form of superphosphate (SSP, 16% P₂O₅). Potassium was applied according to the designated treatments in the form of MOP and polyhalite. The experiment includes eight treatments., T₁- Control, T₂-NP + K (0), T₃-NP + 50% K as MOP, T₄-NP + 50% K as Polyhalite, T₅-NP + 100% K as MOP, T₆-NP + 100% K as Polyhalite, T₇-NP + 150% K as MOP, T₈-NP + 150% K as Polyhalite. The experiment was laid out in randomized block design with three replications. Five plants from each plot were used for the determination of crop developmental stages - tillering, panicle initiation and harvest. The experimental crop was harvested plot-wise by cutting the stem closer to ground level. Grains were separated by hand threshing, winnowed, cleaned, and sun dried to bring the moisture content to the standard level (14%). The straw was sun dried. The Statistical analysis for all parameters was done by

procedure described by Sheoran *et al.* [6] at 5% significant level.

RESULTS AND DISCUSSION

Plant height

The data depicted in (Table 1) indicated that the plant height was significantly influenced by application of polyhalite. The maximum plant height of 33.64, 55.56 and 110.86 cm at active tillering, panicle initiation and at harvest stage, respectively, were recorded with the application of NP + 150% K as polyhalite (T₈). Between two different potassium sources, polyhalite was significantly more effective than MOP. Increased plant height with higher potassium application levels may be attributed to the synergistic effect of potassium on nitrogen uptake, which enhanced metabolic and meristematic activities, ultimately promoting greater plant height in rice [7]. The increase in plant height due to potassium application is linked to enhanced biochemical reactions, including peroxidase and catalase activity, which promote cell division, inhibit reactive oxygen species formation, reduces oxidative stress, delay senescence and stimulate vegetative growth [8-9].

Table 1 Plant height (cm) as influenced by different sources of potassium in rice

Treatments	At tillering	At panicle initiation	At harvest
T ₁ : Control	33.6	55.6	77.3
T ₂ : 100% N and P alone	35.5	59.4	84.9
T ₃ : 100% N and P + 50% K as MoP	38.0	62.9	88.8
T ₄ : 100% N and P + 50% K as Polyhalite	40.6	65.6	92.8
T ₅ : 100% N and P + 100% K as MoP	43.5	68.5	97.7
T ₆ : 100% N and P + 100% K as Polyhalite	46.1	72.0	102.2
T ₇ : 100% N and P + 150% K as MoP	49.0	74.8	106.1
T ₈ : 100% N and P + 150% K as Polyhalite	51.9	77.9	110.9
SE _D	0.65	1.07	1.74
CD (p=0.05)	1.41	2.28	3.74

Dry matter production

The dry matter production of rice was significantly affected by different potassium treatments as shown in (Table 2) which found that the application of 150% k as polyhalite along with recommended dose of N and P (T₈) has significantly improved the DMP of rice while compared to the application of 200% k as MOP among with recommended dose of N and P (T₇). The highest DMP was recorded as 4089 and 7559 kg/ha at active tillering and panicle initiation stage respectively and the lowest DMP was recorded under control plot. The increased

DMP in polyhalite applied treatments is due to the potassium which plays a crucial role in transporting photosynthates from leaves to grains, thereby increasing the plant's dry matter content [10]. Higher potassium availability enhances plant height, likely due to the interaction between auxin and light, which influences apical dominance. Auxin, as a growth stimulant, becomes active, leading to increased plant height and improved dry matter production. Potassium deficiency, which triggers stress responses, including auxin synthesis can negatively impact plant growth [11].

Table 2 Dry matter production (kg ha⁻¹) as influenced by different sources of potassium in rice

Treatments	At tillering	At panicle initiation
T ₁ : Control	2185	4352
T ₂ : 100% N and P alone	2422	4973
T ₃ : 100% N and P + 50% K as MoP	2710	5453
T ₄ : 100% N and P + 50% K as Polyhalite	2987	5852
T ₅ : 100% N and P + 100% K as MoP	3259	6271
T ₆ : 100% N and P + 100% K as Polyhalite	3547	6692
T ₇ : 100% N and P + 150% K as MoP	3824	7144
T ₈ : 100% N and P + 150% K as Polyhalite	4089	7559
SE _D	75.39	130.71
CD (p=0.05)	161.72	280.36

Chlorophyll content (SPAD values)

The appraisal for chlorophyll content (Table 3) of rice leaves revealed that there was a significant difference found among the treatments experimented. The experiment showed

that the maximum chlorophyll content of 35.39 and 44.23 (SPAD values) at active tillering and panicle initiation, respectively, were recorded with application of NP + 150% K as polyhalite over control. The treatments next in order were T₇,

T₆, T₅, T₄, T₃, T₂ and T₁. The increase in leaf chlorophyll content can likely be attributed to magnesium, a central component of the chlorophyll molecule, directly influences chlorophyll synthesis. The magnesium content in polyhalite contributes to increased chlorophyll levels in plant tissues, aligning with the findings of Kleiber *et al.* [12] and Gowthami *et al.* [13].

Polyhalite, as a source of Sulphur, plays a crucial role in enhancing chlorophyll content by ensuring the availability of this essential nutrient. Sulphur is also essential for maximizing the efficiency of nitrogen fertilizers, which contributes to increased plant height, chlorophyll content and dry matter accumulation in rice [14].

Table 2 SPAD (chlorophyll content) as influenced by different sources of potassium in rice

Treatments	At tillering	At panicle initiation
T ₁ : Control	20.98	26.12
T ₂ : 100% N and P alone	24.14	30.02
T ₃ : 100% N and P + 50% K as MoP	26.12	32.71
T ₄ : 100% N and P + 50% K as Polyhalite	27.66	35.27
T ₅ : 100% N and P + 100% K as MoP	29.74	37.56
T ₆ : 100% N and P + 100% K as Polyhalite	30.84	39.82
T ₇ : 100% N and P + 150% K as MoP	33.16	42.13
T ₈ : 100% N and P + 150% K as Polyhalite	35.39	44.23
SE _D	0.52	0.69
CD (p=0.05)	1.12	1.45

Yield parameters

The outcome of rice under different potassium treatments on yield parameters viz., no. of grains panicle⁻¹ and panicle length at harvest stage significantly varied and presented in (Table 4). Among the treatments, T₈ recorded highest no. of grains panicle⁻¹ (118), panicle length (25.89 cm). The improvement in no. of grains/ panicle and panicle length might be associated with adequate potassium application through polyhalite enhances enzyme activity, maintains optimal cell pH, influences photosynthesis, and facilitates sugar transport within the plant system, leading to an increase in the number of grains per panicle and panicle length [15].

Grain and straw yield

The grain and straw yield of rice was significantly influenced by different polyhalite. The data on yield are set out in (Table 4). The results revealed that application of NP + 150%

K as polyhalite recorded the highest grain and straw yield of 5856 and 7586 kg/ha, respectively. The treatments next in order were T₇, T₆, T₅, T₄, T₃, T₂ and T₁. The lowest yield was observed in control, T₁(2350 kg/ha of grain and 3856 kg/ha of straw). Between the two potassium sources, polyhalite was significantly more effective than muriate of potash (MoP). The increased yield might be due to the application of potassium. Potassium is essential for activating starch synthase, which plays a crucial role in starch accumulation, resulting in heavier grains [16]. The increase in filled grains due to potassium application may be attributed to an extended physiologically active period of the flag leaf during grain filling. Potassium also plays a vital role in the transport and distribution of photosynthetic products, establishing osmotic potential in the phloem, thereby aiding in the transfer of photosynthates from source to sink organs, ultimately enhancing yield [17].

Table 4 Yield attributes and yield as influenced by different sources of potassium in rice

Treatments	Panicle length (cm)	No. of grains panicle ⁻¹	Grain yield (kg/ha)	Straw yield (kg/ha)
T ₁ : Control	20.56	81.2	2350	3856
T ₂ : 100% N and P alone	22.15	90.8	3125	4126
T ₃ : 100% N and P + 50% K as MoP	22.53	94.9	3651	5024
T ₄ : 100% N and P + 50% K as Polyhalite	22.82	99.0	4072	5483
T ₅ : 100% N and P + 100% K as MoP	24.05	103.2	4528	5972
T ₆ : 100% N and P + 100% K as Polyhalite	24.53	108.2	4912	6580
T ₇ : 100% N and P + 150% K as MoP	24.78	113.3	5338	7069
T ₈ : 100% N and P + 150% K as Polyhalite	25.89	117.6	5856	7586
SE _D	0.09	1.89	139.12	173.66
CD (p=0.05)	0.19	3.98	298.42	372.51

CONCLUSION

This study concluded that polyhalite, as a single fertilizer, serves as an effective alternative source of potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S), meeting the nutritional needs of crops and supporting healthy growth. The application of 150% K through polyhalite, along with the recommended doses of nitrogen (N) and phosphorus (P), significantly improved the growth parameters, yield attributes,

and overall yield of rice in the alluvial soils of Tamil Nadu. Due to its slow nutrient-releasing properties, polyhalite plays a crucial role in retaining nutrients and making them available to crops during critical growth stages. However, further research is needed to fully understand the mechanisms by which polyhalite enhances soil health and crop productivity. Nonetheless, recent findings indicate that polyhalite could be a valuable soil amendment for improving soil fertility, correcting nutrient imbalances, and boosting crop yields.

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