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Foliar application of alternative potassium (K) source on growth and yield of rice (*Oryza sativa* l.)

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Abstract
Yellowing paddy lands due to the Potassium (K) deficiency was a recent problem in Sri Lanka caused by the non-application of Muriate of Potash fertilizer. Hence, the purpose of the current study is to overcome K deficiency by foliar application of a commercially available liquid K source that contains 7,500 ppm of K and to discover its effect on the growth and yield of the rice variety Bg 300. A polybag experiment was carried out at the Crop farm of Eastern University, Sri Lanka using completely randomized design (CRD) with four treatments and six replicates. Control, MOP application, 25% and 50% of liquid K solution foliar application were the four treatments used. Both the foliar applications resulted in statistically similar effects to the MOP fertilization on plant height, chlorophyll content, leaf K content and number of spikelets in a panicle. The results suggested that K was successfully absorbed by the leaves and MOP usage can be reduced through the foliar application of liquid K fertilizer. Applying 25% of the K solution is the best option to obtain a higher net benefit.

Keywords: Foliar application, potassium, rice, growth, yield

Introduction

Rice plants require both macronutrients and micronutrients, and each nutrient has its own distinct character and performs a specific role in plant metabolic processes (Shrestha *et al*., 2020) [11].Potassium (K) is important in various ways, it is involved in transporting membrane proteins and regulating intracellular osmotic pressure as an enzyme activator, carbohydrate transportation in rice and plant metabolism (Ye *et al*., 2019) [13].The Department of Agriculture has determined that potassium deficiency is the root cause of yellowing paddy cultivation, and it is due to inadequate application of K fertilizer and the non-application of Muriate of Potash (MOP) by the farmers. The high cost of fertilizers is a major barrier for Sri Lankan farmers (Ministry of Agriculture, 2023). The Ministry of Agriculture has not brought out any alternative solutions to the farmers other than advising them to give priority on application of MOP to solve the K deficiency problem pertaining to rice cultivation in Sri Lanka. Up to date Sri Lankan farmers are practicing soil fertilizer applications as per the Department of Agriculture fertilizer recommendations. Agreeing to Ferrari (2021) [8] foliar fertilization can alleviate nutrient deficiency faster than soil applications. Throne (1957) also stated that potassium absorbed by leaves was slightly more efficient in increasing dry weight than potassium absorbed at the same time by the root. In Sri Lankan context there is lack of research done on foliar application of alternative potassium source on rice cultivation. Therefore, this research aims to find out the success of foliar application of alternative potassium source with 7500 ppm K on the growth and yield of rice variety Bg 300.

Materials and Methodology

A field polybag experiment was conducted to examine the foliar application of commercially available potassium liquid fertilizer on the growth and yield of rice (Oryza sativa L.) variety Bg 300 at the Crop Farm, Faculty of Agriculture, Eastern University Sri Lanka (7°48'N,81°35'E) belongs to the low country dry zone agro ecological region of Sri Lanka.

The experiment was arranged in a Completely Randomized Design with four treatments and six replicates. Twenty-four polybags were maintained. The treatments were control (Used urea and TSP however no potassium fertilizer used), fertilizer recommendation for rice cultivation, 25% of alternative K source foliar application with Urea + TSP and 50% of alternative K source foliar application with Urea + TSP.

Alternative K source used for foliar application was a seaweed liquid fertilizer and its K content was determined by using the spectro-photometer at the soil science laboratory in the Department of Agricultural Chemistry. The rice seeds (Bg 300) needed for the experiment was taken from the Karadiyanaru seed farm.

For each treatment TSP and Urea was added as recommended by Department of Agriculture. While no K fertilizer was applied for treatment 1, MOP was applied for treatment 2 as recommended and for the treatment 3 and 4 the 7500 ppm K liquid fertilizer was foliar applied in 25% and 50% respectively. The foliar application was done for the T3 and T4 in the 4th and 6th week, parallel to the MOP application for the T2. The amount of fertilizer needed was calculated using the bulk density method. Two different concentrations as 25% and 50% of the K liquid fertilizer were prepared by diluting it in distilled water for the foliar application.

Growth parameters such as plant height, chlorophyll content (SPAD-502 plus chlorophyll meter), number of tillers and leaf length were taken. Length of the panicle, number of grains per panicle and 100 grain weight was taken as yield parameters. The data obtained from the experiments were subjected to Analysis of Variance (ANOVA) using the Minitab software. The mean separation was done by using Tukey's test at 5% significance level.

Results and Discussion

Plant height

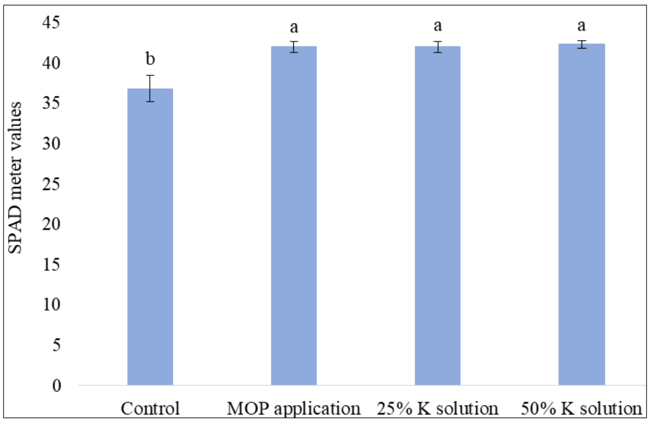
Table 1, illustrates the effect of different K fertilizer applications on plant height. It showed K fertilizer application significantly ($p < 0.05$) affected the plant height.

The height of the plants increased over time. The K-applied plants were much taller than the control treatment (T1). Plant heights of treatments applied with MOP (T2), 25% liquid fertilizer (T3) and 50% liquid fertilizer (T4) that contain 7500 ppm of K were significantly different from the T1 where no K fertilizer is applied. So, foliar application of liquid fertilizer was efficient as MOP application, as there was no significant difference caused on the plant height.
Hence, K has a direct effect on increasing the height of rice plants when applied in the vegetative stage. This finding can be supported with the Ali *et al.* (2016) [3] study on maize, in which they found higher plant heights in foliar K treatments. Another study revealed K ameliorated the negative effect of drought by increasing the plant height to a significant level when it was sprayed at the vegetative stage of wheat *(Triticum aestivum*L.*).*

Table 1: Effect of K fertilization on the plant height at 45 DAP, 60 DAP and 75 DAP

Treatment	45 DAP (cm)	60 DAP (cm)	75 DAP (cm)
Control	39.33 ± 0.62 b	44.33 ± 0.77 b	53.167 ± 0.79 b
MOP application	47.83 ± 0.95 a	54.75 ± 1.36 a	63.50 ± 2.11 a
25% K solution	45.50 ± 0.96 a	53.42 ± 1.19 a	60.50 ± 0.76 a
50% K solution	46.67 ± 1.56 a	52.25 ± 1.72 a	57.83 ± 2.21 ab
p value	0.000	0.000	0.002

DAP: Days after planting. 7500 ppm K solution was use. Values represents mean ± standard error of the six replicates. Mean value having the dissimilar letter(s) indicate significant at 0.05 level of significant by Tukey'sTest.



7500 ppm K solution was used. Columns represents mean error bars standard error of the six replicates. Mean value in a column having the dissimilar letter(s) indicate significant at 0.05 level of significant by Tukey'sTest.

Fig 1: Effect of different K fertilizer application on the chlorophyll content of rice (*Oryza sativa* L.)

Chlorophyll content

Figure 1, represents the variation of SPAD meter values in the four different K fertilizer applications. The results of the SPAD meter values showed that the application of K fertilizer significantly ($p<0.05$) affected the chlorophyll content of leaves.
The K applied treatments showed comparatively higher values when compared to the control treatment (T1), where no K fertilizer was applied. Hence there was a significant difference between the control treatment and K fertilizer applied treatments. The lowest SPAD meter value 36.86 was recorded in the control treatment. The K applied treatments were insignificant as similar effect was given in the MOP soil application and in the foliar application of liquid fertilizer. Hence K plays a vital role in enhancing the synthesis of leaf chlorophyll content in Bg 300 rice variety. This is supported with the prior findings of Asgharipour & Heidari (2011) [5] that foliar application of K in higher concentrationsenhanced the chlorophyll contents. Moreover, with reference to a previous finding on sorghum plants treated with KNO_3 had higher chlorophyll indices than those not treated. Besides that, plants treated with KNO_3 that were at water stress condition had a higher relative chlorophyll content (Ávila *et al*., 2020) [7].

Leaf Area

The table 2, below illustrates the mean values of the leaf area taken after 75 days of planting that was subjected to different K fertilizer applications. The statistical analysis revealed that the leaf area of the rice plants was significantly ($p<0.05$) affected by the K fertilizer application.
The K applied treatments gave significantly positive results on the leaf area compared to the control treatment (T1). The lowest leaf area 13.06 cm^2 was gained by the control treatment where no K fertilizer was applied. 25% of K liquid fertilizer foliar application showed similar significance with both the MOP applied treatment (T2) and 50% of K liquid fertilizer (T4) foliar application. The reason is that K is a crucial macro nutrient in plant growth and development. Also, absorption of K is increased by the foliar application where the photosynthesis is increased, thus enhancing the leaf area. Current study is consistent with Aslam *et al*., (2014) [6] that foliar application of K increased the constituents of the cell, especially protoplasm with the consequent increase in the leaf area. Another study on safflower and sunflower showed that applying potassium nitrate by foliar spray significantly enhanced the leaf area of both plants, regardless of whether the plants were growing in saline or non-saline conditions (Abeen & Ahmad, 2011) [1]. Therefore, the foliar application of K liquid fertilizer can be an acceptable substitute for MOP fertilizer.

Table 2: Effect of different K fertilizer applications on the leaf area

Treatment	Leaf Area (cm^2)
Control	13.06± 0.37c
MOP application	29.94 ± 0.77a
25% K Solution	27.21 ± 1.98 ab
50% K Solution	24.19 ± 0.86 b
p value	0.000

7500 ppm K solution was used. Values represents mean ± standard error of the six replicates. Mean value having the dissimilar letter(s) indicate significant at 0.05 level of significant by Tukey'sTest.

Leaf K content

Table 3, represents the variation of leaf K content of the rice plant at maturity stage based on the four different K fertilizer applications. The results showed there was a significant ($p<0.05$) difference in the K content of the leaf.

The K applied treatments showed comparatively higher values when compared to the control treatment (T1). Hence, they were statistically significant over the control treatment. The lowest K content 0.33% was recorded in the control treatment. The K applied treatments were insignificant to one another. Statistically similar effect was given in the MOP soil application as well as in both concentrations of the liquid fertilizer that were foliar applied. Hence, the amount of K absorbed through the leaves was alike to the K uptaken by the roots. So, the results indicate foliar application was effective and successful. Nevertheless, the drawback encountered was even the higher value of the K content recorded was lesser than the critical level (1.5%) that should be in a leaf from the tillering stage to panicle initiation. The causes could be infertile sandy regosol soil used and DOA recommended fertilizer amounts were insufficient. A study showed, when the number of foliar applications was increased, only two foliar applications were enough to increase leaf K concentration in olive plants above the sufficiency level. Effectiveness of foliar K application could depend on the leaf age. Younger leaves contain higher K concentration than mature ones (Restrepo-Díaz *et al.*, 2009) [9]. While another study confirms that K application increased the potassium content of the leaves (Yener & Altuntaş, 2021) [14].

Table 3: Effect of different K fertilizer applications on K content in leaf

Treatment	K content in leaf (%)
Control	0.33 ± 0.06 [b]
MOP Application	1.15 ± 0.12 [a]
25% K Solution	0.91 ± 0.05 [a]
50% K Solution	1.15 ± 0.12 [a]
p value	0.000

7500 ppm K solution was used. Values represents mean ± standard error of the six replicates. Mean value having the dissimilar letter(s) indicate significant at 0.05 level of significant by Tukey’sTest.

Dry Weight

Table 4, represents the variation of dry weight of the plant in the four different K fertilizer applications. The results showed that the application of K fertilizer significantly ($p<0.05$) affected the dry weight of the rice plant.

Both MOP application and 25% concentration of 7500 ppm K solution achieved the highest dry weight, where they had shared statistically similar significance between them. The lowest dry weight 14.87 g was gained by the control treatment. Thus, K applied treatments tend to show higher dry weights compared to control treatment.

This may be due to K being an essential nutrient for the physiological processes in plants such as cell expansion, stomatal conductance, photosynthesis and nutrient transportation, ultimately these will enhance the plant growth and increase the biomass. The results of the current study were aligned with the study done on tomato by Amjad *et al.* (2014) [4] which showed that K soil and foliar application positively affected the plant dry weight, and it was significantly increased in response to the levels of potassium application used compared to the control.

Table 4: Effect of different K fertilizer applications on dry weight of rice plant

Treatment	Dry Weight (g)
Control	14.87 ± 0.59 [c]
MOP Application	20.49± 0.69 [a]
25% K Solution	21.46± 0.79 [a]
50% K Solution	17.71± 0.68 [b]
p value	0.000

7500 ppm K solution was used. Values represents mean ± standard error of the six replicates. Mean value having the dissimilar letter(s) indicate significant at 0.05 level of significant by Tukey’sTest.

Number of Spikelets per Panicle

The table 5, indicates the effect of K fertilizer application on the number of spikelets per panicle of the Bg 300 rice variety. The number of spikelets per panicle were significantly ($p<0.05$) affected by the K fertilizer application.

The K applied treatments showed comparatively higher number of spikelets per panicle when compared to the control treatment (T1). Hence, they were statistically significant over the control treatment. The lowest mean number of spikelets per panicle 86.40 was recorded in the control treatment. The K applied treatments were insignificant to one another. Statistically similar effect was given in the MOP soil application as well as in both the concentrations of liquid fertilizer foliar applications. Accordingly, results indicate foliar application was effective and successful.

The reason may be attributable to the effect of potassium in increasing the percentage of flower nodes and then increasing the number of grains in the spike. These results were consistent with the findings of Al-Hassoun and Mohsen (2023) [2] that the number of grains in a spike increased by the application of K and increasing its concentration. Sarwar *et al.* (2020) [10] also confirmed that K have an effect on increasing the number of spikelets per panicle.

Table 5: Effect of different K fertilizer applications on number of spikelets per panicle

Treatment	No. of spikelets/ panicle
Control	86.40± 7.15[b]
MOP Application	146.20±5.39[a]
25% K Solution	130.40±5.99[a]
50% K Solution	138.20±3.18[a]
p value	0.000

7500 ppm K solution was used. Values represents mean ± standard error of the six replicates. Mean value having the dissimilar letter(s) indicate significant at 0.05 level of significant by Tukey’sTest

100 grain weight

The table 6, indicates the effect of K fertilizer application on 100 grain weight of the Bg 300 rice variety. The results showed that there was a significant ($p<0.05$) difference in the 100-grain weight due to the different K fertilizer application.

MOP applied treatment (T2) gave the highest 100 grain weight of 1.54 g compared to the control treatment which gave the lowest 0.84 g. Both 25% and 50% of K liquid fertilizer foliar applications gave statistically similar effects on the 100-grain weight, yet it was significantly lower than the MOP applied treatment and higher than the control treatment. The reason for the higher grain weights in the K applied plants may be due to K plays a vital role in the formation of sugars, proteins and starches and this is reflected positively in the increase in grain weight. The results were consented with Sarwar *et al.* (2020) [10] study on K effect on rice and supported the idea that K application positively affects the 1000-grain weight.

Table 6: Effect of different K fertilizer applications on 100 grain weight

Treatment	100 grain weight (g)
Control	0.84± 0.05 c
MOP Application	1.54± 0.04 a
25% K Solution	1.21± 0.05 b
50% K Solution	1.15± 0.05 b
p value	0.000

7500 ppm K solution was used. Values represents mean ± standard error of the six replicates. Mean value having the dissimilar letter(s) indicate significant at 0.05 level of significant by Tukey'sTest.

Conclusion

The most prominent results were given by the MOP applied treatment (T2) and the 25% of 7500 ppm K solution (T3) foliar sprayed treatment. Both the foliar applications resulted in the MOP fertilization on plant height, chlorophyll content, leaf K content, length of flag leaf, fresh weight, panicle length and number of spikelets in a panicle. However, the leaf K contents achieved by all the K-applied treatments were lower than the critical value that needs to be at the maturity level of rice leaves. 25% of K solution was superior over 50% foliar application in regards to the leaf length, leaf area, tiller number and dry weight. Meanwhile, root length and root volume showed no significance between the K-applied treatments and the control treatment. Thus, MOP showed statistically the highest 100 grain weight and it was statistically significant over foliar applications.

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