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# IMPACT OF POTASSIUM APPLICATION ON THE GROWTH AND YIELD ENHANCEMENT OF COTTON

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**ABSTRACT**

*The field study to evaluate the growth and yield of cotton variety Sindh-1 under the influence of potassium application rates was undertaken at Crop Sciences Research Institute, Agriculture Research Centre, Tandojam during Kharif, 2022. The experiment was laid out in a three replicated randomized complete block design. The experiment consisted of six treatments i.e. Control (without potassium), Potassium @ 25.0 kg ha$^{-1}$ (50% < recommended), Potassium @ 37.5 kg ha$^{-1}$ (25% < recommended), Potassium @ 50.0 kg ha$^{-1}$ (recommended), Potassium @ 62.5 kg ha$^{-1}$ (25% > recommended) and Potassium @ 75.0 kg ha$^{-1}$ (50% > recommended). The analysis of variance of data suggested that application of potassium at different rates exhibited statistically significant (P<0.05) effect on the growth, yield and yield contributing attributes of cotton variety Sindh-1 as compared to Control (without potassium). The results of experiment illustrated that highest traits i.e. plant height (cm), sympodial branches plant$^{-1}$, opened bolls plant$^{-1}$, single boll weight (g), seedcotton weight plant$^{-1}$ (g), and seedcotton yield (kg ha$^{-1}$) were observed when potassium was applied at 75.0 kg ha$^{-1}$ (50% > recommended). Potassium @ 62.5 kg ha$^{-1}$ (25% > recommended) followed almost in all growth and yield traits particularly, seedcotton yield (kg ha$^{-1}$). Similarly, Potassium @ 50.0 kg ha$^{-1}$ (recommended) ranked 3$^{rd}$ in all growth and yield traits particularly seedcotton yield (kg ha$^{-1}$). Furthermore, Potassium @ 37.5 kg ha$^{-1}$ (25% < recommended) and Potassium @ 25.0 kg ha$^{-1}$ (50% < recommended) ranked 4$^{th}$ and 5$^{th}$ in all growth and yield traits especially seedcotton yield (kg ha$^{-1}$). However, minimum attributes of cotton variety Sindh-1 such as plant height (cm), sympodial branches plant$^{-1}$, opened bolls plant$^{-1}$, single boll weight (g), seedcotton weight plant$^{-1}$ (g), and seedcotton yield (kg ha$^{-1}$) were documented in control plots where potassium was not applied. It is worth mentioning that Potassium @ 62.5 kg ha$^{-1}$ (25% > recommended) was found optimum level due to having non-significant statistical differences in all growth and yield traits particularly, seedcotton yield (kg ha$^{-1}$) with highest dose of Potassium @ 75.0 kg ha$^{-1}$ (50% > recommended). Hence, it is conferred from the afore mentioned results that*

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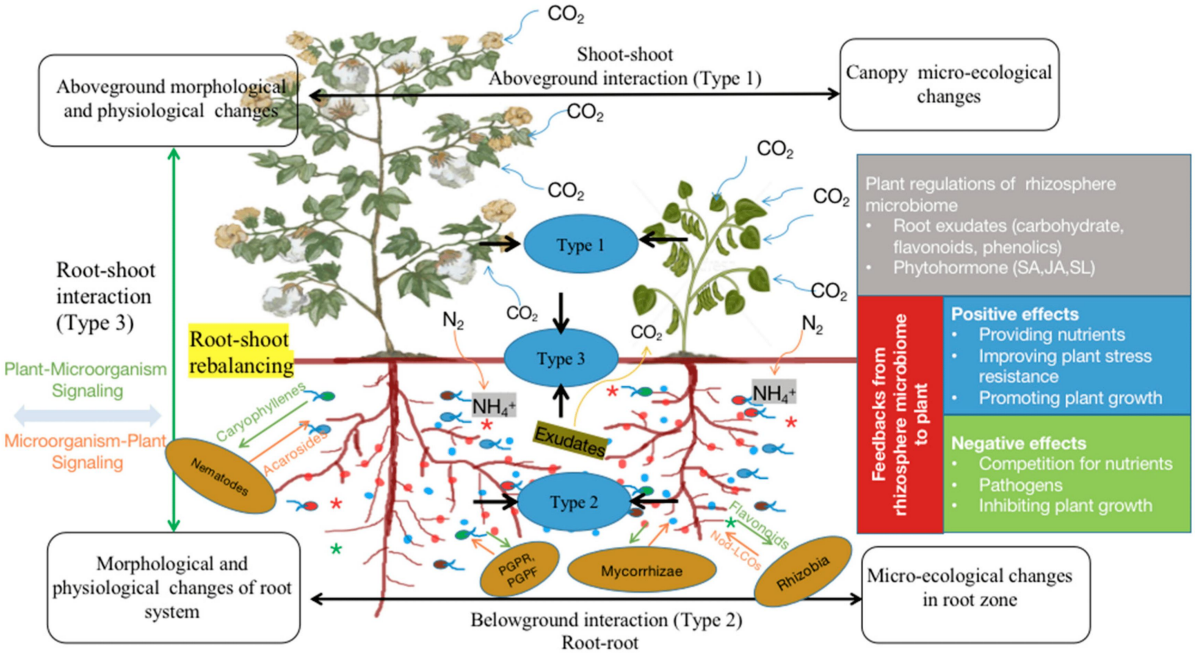
*potassium should be applied @ 62.5 kg ha$^{-1}$ for obtaining optimum seedcotton yield of cotton variety Sindh-1 under agro-ecological conditions of Tandojam.*
***Keywords:*** *Cotton, Growth, Yield.*

## INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is known as the "white gold" of Pakistan (Akhtar et al., 2022). It is cultivated in tropical and subtropical regions of more than 60 countries (Feng et al., 2017). Its widespread use is largely due to the ease with which its fibres are spun into yarns. Cotton's strength, absorbency, and capacity to be washed and dyed also make it adaptable to a considerable variety of textile products. The plant has certainly been grown and used in Indo-Pak subcontinent for at least 5000 years and probably for much longer. Cotton was used also by the ancient Chinese, Egyptians, and North and South Americans (Echer et al., 2020). Cotton is a major fiber crop and is estimated to account for approximately 25% of the world's fiber usage (Schumacher et al., 2020). It is the most important cash crop of Pakistan and earns a good income for the country in the form of foreign exchange. Pakistan is the 5$^{th}$ largest producer of cotton in the world. It contributes the around 0.6% to GDP and 2.4% of the value added in the agriculture. Cotton plays a significant role in agriculture, industrial development, employment, financial stability and economic viability ever since the country attained the independence (Aslam et al., 2020).




Cotton is the main source of foreign exchange and it provides raw material to the textile sector. Being a tropical crop, cotton production requires an average temperature from 20 to 30 °C during its growth and development (Reddy et al., 2017). Cotton is the most important renewable natural textile fiber worldwide and the world's sixth-largest source of vegetable oil (Zhao et al., 2020). Therefore, optimizing crop productivity is important for sustainable food, feed, fuel, and fiber supplies for the growing human population (Watts et al., 2017). Pakistani soils are specifically becoming deficient in plant available potassium because of intensive cropping without application of potassic fertilizers (Wakeel et al., 2017). The low productivity of cotton due to imbalanced use of fertilizers, erratic rainfall and periodic dry spells are major among constraints. Among many factors which contribute toward low production of cotton in Pakistan are nutritional in-balance, insufficient use of fertilizer, low soil organic matter contents, inadequate plant density, weeds problem, scarce water supply, selection of unsuitable varieties and insect pest attack (Tahir et al., 2008). Presence of nutrients like nitrogen, phosphorus, potassium and magnesium in well-

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adjusted forms is necessary for plant growth, development and final yield. Balanced nutrition is an imperative feature which shows a main function in achieving quality production of cotton (Zahoor et al., 2017). Cotton plants are often naturally subjected to potassium deficiency resulting in developmental hindrances and further yield loss. Fortunately, plants have developed certain mechanisms to tolerate this stress through post-transcriptional regulation. Potassium is a macronutrient that is essential for many physiological and biochemical processes pertaining to plant growth, development, and nutrient uptake (Fontana et al., 2020).

In Pakistan most soils contain relatively large amounts of total K as component of relatively insoluble minerals. However, only a small fraction is present in available form to plants. Most of the soils have <150 mg kg of exchangeable K, which is considered a critical limit for soil K deficiency (Chen et al., 2023). Presently, potassium levels in our soils are going to be depleted day by day as it is used by extensive cropping and cultivation of high yielding crop varieties, so far there is no natural source to replenish it into the soil, however due to its low levels in soils negative effects on crop yield and quality are seen in some parts of the country. In the prevailing conditions when the release is not enough to fulfill the requirement of crops, the small available quantity has to be supplemented with commercial fertilizers (Daniels et al., 2023). Nevertheless, in climate change scenario, cotton productivity is threatened by abiotic stresses especially drought stress. Droughts as an intermittent climate disturbance play an important role in the earth systems and are predicted to increase under global warming conditions (Denton et al., 2022).

## MATERIAL AND METHOD

The field experiment was carried out at the Cotton Research Institute (CRI) Tandojam, to determine the lines with local variety of cotton for higher growth and yield. The experiment followed a completely randomized block design with a net plot size of 6 m x 5 m (30 $m^2$). The land preparation methods recommended for Cotton plantations were implemented. The study focused on the local variety Sindh-1 and was replicated three times.

### Culture Practices

A good seed bed was prepared by two dry plowings and leveling the land. The recommended dose of potassium was applied to all treatments during the sowing time. The agronomical traits of the plants were observed by selecting five plants in each plot at five-day intervals during the initial 10 days following crop formation.

1. $T_1$ = Without potassium (control)
2. $T_2$ = Potassium @ 25.0 kg $ha^{-1}$ (50% < recommended)
3. $T_3$ = Potassium @ 37.5 kg $ha^{-1}$ (25% < recommended)
4. $T_4$ = Potassium @ 50.0 kg $ha^{-1}$ (recommended)

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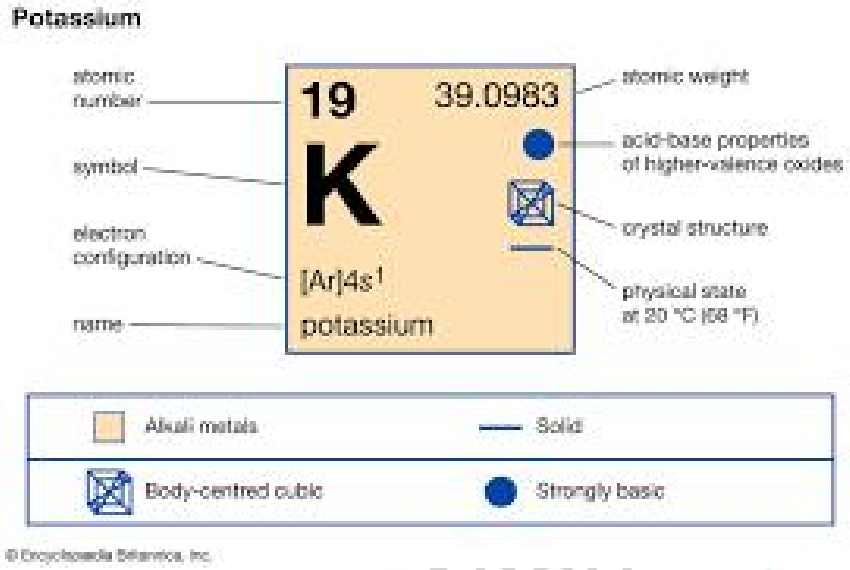
5. $T_5$ = Potassium @ 62.5 kg $ha^{-1}$ (25% > recommended)
6. $T_6$ = Potassium @ 75.0 kg $ha^{-1}$ (50% > recommended)

During the maturity stage, 15 plants were sampled from each experimental unit to measure their Plant height (cm) with help of measuring tap, Sympodial branches $plant^{-1}$, Opened bolls $plant^{-1}$, Single boll weight (g), Seedcotton weight $plant^{-1}$ (g), Seedcotton yield (kg $ha^{-1}$) were recorded.

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**Statistical analysis**

Statistical analysis was performed on the collected data through ANOVA via Statistix-8.1 Computer Software (Statistix, 2006). In cases where it remained deemed necessary, the LSD test was utilized to compare the superiority of different treatments.

## RESULTS

**Plant height (cm)**

The results regarding plant height (cm) of cotton under the influence of different potassium levels are shown in Table 4.1 and their analysis of variance as Appendix 1. It is evident from the analysis of variance different levels of potassium affected significantly (P<0.05) on plant height (cm) of cotton variety Sindh-1. The tallest (104.3 cm) plants were observed under potassium application @ 75.0 kg ha$^{-1}$ (50% > recommended) followed by potassium application @ 62.5 kg ha$^{-1}$ (25% > recommended) with 103.7 cm. The LSD (4.7091) indicated that plant height was statistically non-significant (P<0.05) between potassium application of 75.0 and 62.5 kg ha$^{-1}$.

**Sympodial branches plant$^{-1}$**

The data pertaining to sympodial branches plant$^{-1}$ of cotton variety Sindh-1 as affected by different levels of potassium are presented in Table 4.2 and its analysis of variance as Appendix 2. The analysis of variance indicated that influence of different levels of potassium on sympodial branches plant$^{-1}$ of cotton variety Sindh-1 was significant (P<0.05). Highest (23.0) number of sympodial branches plant$^{-1}$ of cotton variety Sindh-1 was achieved when potassium was applied @ 75.0 kg ha$^{-1}$ (50% > recommended) seconded by potassium application @ 62.5 kg ha$^{-1}$ (25% > recommended) with 22.7 sympodial branches plant$^{-1}$. Potassium application @ 50.0 kg ha$^{-1}$ (recommended) and 37.5 kg ha$^{-1}$ (25% < recommended) ranked 3$^{rd}$ and 4$^{th}$ in performance by producing 21.3 and 19.7 sympodial branches plant$^{-1}$.

**Opened bolls plant$^{-1}$**

The results regarding opened bolls plant$^{-1}$ of cotton under the influence of different potassium levels are shown in Table 4.3 and their analysis of variance as Appendix 3. It is obvious from the analysis of variance different levels of potassium affected significantly (P<0.05) on opened bolls plant$^{-1}$ of cotton variety Sindh-1. The maximum (75.7) number of opened bolls plant$^{-1}$ was seen under potassium application @ 75.0 kg ha$^{-1}$ (50% > recommended) followed by potassium application @ 62.5 kg ha$^{-1}$ (25% > recommended) with 71.3 opened bolls plant$^{-1}$.

| Treatments | Plant height (cm) | Sympodial branches plant$^{-1}$ | Opened bolls plant$^{-1}$ |
|---|---|---|---|
| $T_1$ = Without potassium (control) | 85.3 c | 16.0 b | 55.7 d |
| $T_2$ = Potassium @ 25.0 kg ha$^{-1}$ (50% < recommended) | 92.3 b | 17.3 b | 59.0 d |
| $T_3$ = Potassium @ 37.5 kg ha$^{-1}$ (25% < recommended) | 95.7 b | 19.7 ab | 65.3 c |
| $T_4$ = Potassium @ 50.0 kg ha$^{-1}$ (recommended) | 96.7 b | 21.3 a | 67.3 bc |
| $T_5$ = Potassium @ 62.5 kg ha$^{-1}$ (25% > recommended) | 103.7 a | 22.7 a | 71.3 ab |

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| | | | |
|---|---|---|---|
| $T_6$ = Potassium @ 75.0 kg $ha^{-1}$ (50% > recommended) | 104.3 a | 23.0 a | 75.7 a |
| S.E | 2.1134 | 1.6799 | 2.6275 |
| LSD 0.05 | 4.7091 | 3.7432 | 5.8544 |
| P-value | 0.0000 | 0.0089 | 0.0002 |

**Single boll weight (g)**

The data pertaining to single boll weight (g) of cotton variety Sindh-1 as affected by different levels of potassium are presented in Table 4.4 and its analysis of variance as Appendix 4. The analysis of variance indicated that influence of different levels of potassium on single boll weight (g) of cotton variety Sindh-1 was significant ($P<0.05$). Greatest (3.8 g) single boll weight of cotton variety Sindh-1 was obtained when potassium was applied @ 75.0 kg $ha^{-1}$ (50% > recommended) trailed by potassium application @ 62.5 kg $ha^{-1}$ (25% > recommended) with 3.4 g single boll weight.

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**Seedcotton weight plant$^{-1}$ (g)**

The results regarding seedcotton weight plant$^{-1}$ (g) of cotton under the influence of different potassium levels are shown in Table 4.5 and their analysis of variance as Appendix 5. It is clear from the analysis of variance different levels of potassium affected significantly (P<0.05) on seedcotton weight plant$^{-1}$ (g) of cotton variety Sindh-1. The maximum (220.5 g) seedcotton weight plant$^{-1}$ was observed under potassium application @ 75.0 kg ha$^{-1}$ (50% > recommended) followed by potassium application @ 62.5 kg ha$^{-1}$ (25% > recommended) with 217.9 g seedcotton weight plant$^{-1}$. The LSD (12.105) value indicated that seedcotton weight plant$^{-1}$ was statistically non-significant (P<0.05) between potassium application of 75.0 and 62.5 kg ha$^{-1}$. The potassium application @ 50.0 kg ha$^{-1}$ (recommended), 37.5 kg ha$^{-1}$ (25% < recommended) and 25 kg ha$^{-1}$ (50% < recommended) ranked 3$^{rd}$, 4$^{th}$ and 5$^{th}$ with regard to seedcotton weight plant$^{-1}$ resulting in 202.8, 200.3 and 193.0 g, respectively. However, minimum (173.3 g) seedcotton weight plant$^{-1}$ was noted in control plots where potassium was not applied.

**Seedcotton yield (kg ha$^{-1}$)**

The analysis of variance indicated that influence of different levels of potassium on seedcotton yield (kg ha$^{-1}$) of cotton variety Sindh-1 was significant (P<0.05). Numerically greatest (3693 kg ha$^{-1}$) seedcotton yield of cotton variety Sindh-1 was obtained when potassium was applied @ 75.0 kg ha$^{-1}$ (50% > recommended) trailed by potassium application @ 62.5 kg ha$^{-1}$ (25% > recommended) with 3501 kg ha$^{-1}$ seedcotton yield. It is pertinent to mention that seedcotton yield of cotton variety Sindh-1 was found statistically non-significant between Potassium @ 75.0 kg ha$^{-1}$ (50% > recommended) and Potassium @ 62.5 kg ha$^{-1}$ (25% > recommended). Potassium application @ 50.0 kg ha$^{-1}$ (recommended), 37.5 kg ha$^{-1}$ (25% < recommended) and 25.0 kg ha$^{-1}$ (50% < recommended) ranked 3$^{rd}$, 4$^{th}$ and 5$^{th}$ in performance by producing seedcotton yield of 3264, 3129 and 2473 kg ha$^{-1}$, respectively. Nevertheless, least (2148 kg ha$^{-1}$) single boll weight was observed under control (without potassium) treatment.

| Treatments | Single boll weight (g) | Seedcotton weight plant$^{-1}$ (g) | Seedcotton yield (kg ha$^{-1}$) |
|---|---|---|---|
| $T_1$ = Without potassium (control) | 1.9 d | 173.3 c | 2148 e |
| $T_2$ = Potassium @ 25.0 kg ha$^{-1}$ (50% < recommended) | 2.1 d | 193.0 b | 2473 d |
| $T_3$ = Potassium @ 37.5 kg ha$^{-1}$ (25% < recommended) | 2.8 c | 200.3 b | 3129 c |
| $T_4$ = Potassium @ 50.0 kg ha$^{-1}$ (recommended) | 3.0 bc | 202.8 b | 3264 bc |
| $T_5$ = Potassium @ 62.5 kg ha$^{-1}$ (25% > recommended) | 3.4 ab | 217.9 ab | 3501 a |
| $T_6$ = Potassium @ 75.0 kg ha$^{-1}$ (50% > recommended) | 3.8 a | 220.5 a | 3693 a |
| S.E | 0.2503 | 11.267 | 90.863 |
| LSD 0.05 | 0.5578 | 12.105 | 202.45 |
| P-value | 0.0001 | 0.0179 | 0.0000 |

## DISCUSSION

Potassium is a macronutrient that is essential for many physiological and biochemical processes pertaining to plant growth, development, and nutrient uptake (Rawat et al., 2022). Presently, potassium levels in our soils are going to be depleted day by day as it is used by extensive cropping and cultivation of high yielding crop varieties, so far there is no natural source to replenish it into the soil, however due to its low levels in soils negative effects on crop yield and quality are seen in some parts of the country. In the prevailing conditions when the release is not enough to fulfill the requirement of crops, the small available quantity has to be supplemented with commercial fertilizers (Yu et al., 2023).

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Potassium is an essential nutrient for plant growth and needed by plants in larger quantity. In Pakistan most soils contain relatively large amounts of total K as component of relatively insoluble minerals. However, only a small fraction is present in available form to plants. Most of the soils have <150 mg kg of exchangeable K, which is considered a critical limit for soil K deficiency (Ahmed et al., 2020). The findings of this research indicated that growth, yield and yield contributing traits of cotton variety Sindh-1 were significantly ($P< 0.05$) affected by application of different levels of potassium as compared to control (without potassium). It is envisaged from the results of present experiment that highest traits i.e. plant height (cm), sympodial branches plant$^{-1}$, opened bolls plant$^{-1}$, single boll weight (g), seedcotton weight plant$^{-1}$ (g), and seedcotton yield (kg ha$^{-1}$) were observed when potassium was applied at 75.0 kg ha$^{-1}$ (50% > recommended), followed by potassium application at 62.5 kg ha$^{-1}$ (25% > recommended) almost in all growth and yield traits. Potassium @ 50.0 kg ha$^{-1}$ (recommended) ranked 3$^{rd}$ in all growth and yield traits particularly seedcotton yield (kg ha$^{-1}$). Furthermore, Potassium @ 37.5 kg ha$^{-1}$ (25% < recommended) and Potassium @ 25.0 kg ha$^{-1}$ (50% < recommended) ranked 4$^{th}$ and 5$^{th}$ in all growth and yield traits especially seedcotton yield (kg ha$^{-1}$). However, minimum attributes of cotton variety Sindh-1 such as plant height (cm), sympodial branches plant$^{-1}$, opened bolls plant$^{-1}$, single boll weight (g), seedcotton weight plant$^{-1}$ (g), and seedcotton yield (kg ha$^{-1}$) were documented in control plots where potassium was not applied. It is worth mentioning that due to having statistically similar values between potassium application @ 75.0 kg ha$^{-1}$ (50% > recommended) and potassium application @ 62.5 kg ha$^{-1}$ (25% > recommended) for almost all studied growth and yield traits particularly, seedcotton yield (kg ha$^{-1}$) potassium application @ 62.5 kg ha$^{-1}$ (25% > recommended) was found as optimum level because saving of capital incurred on 12.5 kg more potassium and having no statistical differences with each other. The results of this study are in line with the findings of Hussain et al. (2021) who revealed that potassium application alone and in different combinations significantly improved the plant morphology, seed cotton yield, boll characteristics and potassium concentrations in various plant parts. The potassium concentration in vegetative and boll components was improved with the higher potassium application rate. Moreover, potassium improves the overall yield of cotton. It also helps plant to regulate the movement of stomata (Geng et al., 2020). Similarly, reported that for improved yield of cotton, potassium acts as a potential osmolytes which is capable of producing tolerance against drought stress at reproductive phase. The results also in accordance with those of Qayyum et al. (2002) who disclosed that cotton lint yield increased linearly with band application of potassium only in a relatively dry growing season possibly due to enhanced potassium uptake especially early in the season. Combination of band and broadcast application of potassium fertilizer was more effective in increasing cotton lint yield than either method alone. Maximum lint yield was obtained with the application of potassium at 34 kg ha$^{-1}$ banded plus potassium at 136 kg ha$^{-1}$ broadcast. This combined treatment resulted in greater leaf potassium concentration and total potassium uptake than either broadcast or band application alone. A linear increase in petiole and leaf potassium at early flowering resulted from broadcast incorporated potassium rates. Similarly, Shahzad et al. (2019) revealed that potassium application has impact on boll setting as well as seed cotton yield. Considering the best benefit cost ratio under water deficiency, it is concluded that potassium should be applied at the time of seedbed preparation for economical seedcotton yield of cotton.

## Conclusions

The results of this experiment concluded that various levels of potassium demonstrated significant positive effects on growth and yield of cotton variety Sindh-1. Maximum growth and yield attributes particularly seedcotton yield (3693 kg ha$^{-1}$) was recorded when potassium was applied @ 75.0 kg ha$^{-1}$ (50% > recommended) but potassium @ 62.5 kg ha$^{-1}$ (25% > recommended) was found optimum (3501 kg ha$^{-1}$) because non-significant statistical differences with each other.

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