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Response of Lentil to Application of Potassium and Potash Solubilizing Bacteria

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ABSTRACT

A study was conducted to estimate the effect of potassium and KSB on the growth and yield of lentil at SKUAST-K during rabi 2019 and 2020. The experiment was laid out in randomized complete block design with eight treatments (Control, 10 kg K/ha, 20 kg K/ha, 30 kg K/ha, KSB, 10 kg K/ha + KSB, 20 kg K/ha + KSB and 30 kg K/ha + KSB) replicated thrice. Application of potassium alone or in combination with KSB had a significant effect on growth and yield of lentil. The combined application of 30 kg K/ha + KSB recorded highest the plant height (28.55 cm), pods per plant (49.93) and seeds per pod (1.87) but statistically at par with application of potassium at 30 kg/ha alone. The lowest value of growth and yield attributes was recorded in control treatment. The highest grain yield of 6.81 q/ha was observed with combined application of 30 kg K/ha + KSB which was at par with potassium application @ 30 kg/ha alone with the lowest yield recorded in control treatment. The experiment indicated that potassium application alone or in combination was found to have a significant impact on lentil growth and yield.

Keywords
Inoculation, Lentil, KSB, Potassium, Yield

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INTRODUCTION

Pulses are popular as a protein source among vegetarians and play an important role in the dietary habits of Indian population. They are considered as a core component of sustainable agriculture and have a remarkable influence on soil health (Laishram *et al*, 2020). In the Indian subcontinent, lentil is an important food source among various pulses for human population**.** In India, lentil (*Lens culinaris* L.) is an essential rabi crop that is cultivated for being a good source of protein and for improving the soil fertility due to biological N fixation. As a legume, it occupies a prime place in crop rotation in several parts of the country like Madhya Pradesh, Uttar Pradesh, Bihar etc. Lentil contains around 24-26% protein, 57-60% carbohydrates besides calcium, fat, iron and phosphorous. In addition to this lentil is also a rich source of vitamin A and vitamin C (Devesh *et al*, 2017). Potassium is the most significant primary nutrients for growth and development of plants after nitrogen and phosphorus. The potassium application is necessary at the flowering and pod setting phase of legumes and plays a significant role in plant metabolic activities, activating the most key enzymes associated with plant physiology, enhances biological nitrogen fixation and increases protein content of pulses (Srinivasarao *et al*, 2003). Potassium deficiency has a negative impact on plant physiology, resulting in stunted growth and decreased productivity. Potassium application not only increases pulses pest resistance but also boosts the yield and quality of the seeds (Srinivasarao *et al*, 2003). Potassium deficiency weakens the immune system of plants, making plants more susceptible to disease and pest infestation (Armengaud *et al*, 2010). Most of the potassium in soils is locked up as insoluble K minerals that can't be taken up by plants, making it difficult for them to use. A significant amount of potassium is depleted in intensive cropping systems, which need to be addressed. Potassium is made available from unavailable forms due to some biological processes in the presence of certain microorganisms. A promising approach to increasing soil K availability is the use of potassium solubilizing bacteria (KSB), which contribute significantly in crop production in K deficient soils (Ahmad *et al*, 2016).Build on this idea, the present study was conducted with an aim to investigate the response of lentil in terms of growth and yield to selected amounts of potassium fertilizer and efficient mineral potassium solubilizing (recommended dose is 20 kg K/ha) bacteria under temperate conditions of Kashmir.

MATERIALS AND METHODS

An experiment was carried out on the Agronomy Research Farm at the SKUAST-K, Regional Research Station, Wadura, Sopore, during the 2019 and 2020 rabi seasons, to investigate the response of lentil to potassium and KSB under temperate conditions of Kashmir. The climatic data during the period of experiment revealed that weekly maximum temperatures of 27.5 and 29 °C and minimum temperature of -7 and-10 °C,

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during the rabi season of 2019 and 2020 respectively. The total rainfall received during the crop growing season was 935.8 and 722mm, during2019 and 2020 respectively. The experimental soil textural class was clay loam. The pH was neutral with medium in available nitrogen (312 kg/ha), phosphorus (17.20 kg/ha) and potassium (181.5 kg/ha). The experiment was laid out in Randomized Complete Block Design with eight treatments (Control, 10 kg K ha^{-1}, 20 kg K ha^{-1}, 30 kg K ha^{-1}, KSB, 10 kg K ha^{-1} + KSB, 20 kg K ha^{-1} + KSB and 30 kg K ha^{-1} + KSB) replicated thrice. Lentil variety Shalimar massor-1 was line sown with a spacing of 30 cm x10 cm and plant to plant spacing was maintained by thinning. The crop was raised as per standard package of practices recommended. The crop was fertilized with basal dose of 20 kg N ha^{-1} and 60 kg P ha^{-1}through DAP. Potassium as per treatment was applied in the form of muriate of potash (58% K) at the time of sowing. KSB was inoculated with seeds one hour prior to sowing and then dried in a shade. The data for growth, yield attributes and yield was recorded at maturity. Data of all parameters was statistically analysed by using the technique of analysis of variance (ANOVA) subjected to RCBD using SPSS software.

RESULTS AND DISCUSSIONS

Growth and yield attributes

Results of pooled data indicated that application of potassium and potassium solubilizing bacteria (KSB) alone or in combination were capable to increase growth and yield parameters of lentil as presented in Table 1 . Application of potassium at 30 kg ha^{-1}+ potassium solubilizing bacteria (KSB), plant height increased (28.55 cm) significantly over their sole application but was at par with potassium at 30kg/ha which recorded plant height of 28.04 cm when applied alone as sole treatment, whereas the lowest plant height of 25.35 cm was observed in control. Potassium solubilizing bacteria had significant growth promoting effect on plant height than control, which serves an index that these bacteria provided potassium to the plant which is among the important nutrients for plant development as it enhances cell size, quality, rapid growth, quickens maturity of crop and enhances development of seed. Besides, potassium is required for metabolic processes of the plant cells and for the purpose of stimulating enzyme activity and assisting in the synthesis and transport of carbohydrates (Archana *et al*, 2013). Solubilisation of minerals is primarily accomplished through organic acid production through these bacteria, which led to acidification of the soil ecosystems and endorse the potassium solubilisation from minerals, which aftermath's paves a way for substantial escalation of available potassium in soil solution, thereby enhancing its accessibility to plants. Mineral dissolution improves plant growth by making nutrients more readily available resulting in an increase in plant height. Soluble compounds, soil organic matter decomposition and nutrient mobilisation are all assisted by bacteria. This results in increased height. Many growth-promoting traits, such as root colonisation, chitinase activity and nutrient mineralization, have been found in these bacteria. Potassium's role as a catalyst in the activation of several enzymes and the synthesis of peptide bonds, as well as its improved tolerance to water stress, may have led to the enhancement in plant growth characteristics and, as a result, to the increase in plant height. These findings are in agreement with those of Tiwari *et al* (2018). Table 1 demonstrates that potassium solubilizing bacteria (KSB) seed treatment together with application of potassium at 30 kg ha^{-1} increased the number of pods per plant (49.93) as well as the number of seeds per pod (1.87) significantly and were statistically at par with potassium application alone at 30 kg ha^{-1}, that recorded 48.87 pods per plant and 1.75 seeds per pod, respectively. Moreover, the various treatments did not significantly affect the 1000 seed weight. Moreover, the control treatment recorded lowest values for number of pods per plant (40.03) and seeds per pod (1.28). The easy access to the solubilized potassium due to KSB might have played a positive role in increasing the sugar translocation resulting in higher yield attributes. Potassium may be the reason for the increase in the yield attributing characters. It serves as a catalyst for a variety of enzymes and in the synthesis of peptide bonds. Due to fewer flower drop and more efficient transfer of photosynthates from source to sink, the number of pods per plant increases as potassium and KSB levels increase. These findings are in agreement with those of (Ea and Mahmoud, 2013) . Intervention of potassium in numerous biochemical functions in plants, such as photosynthesis, enzyme activation, as well as cell division, may have resulted in the increase in the number of seeds per pod. These findings are also supported by the studies of Sahay *et al* (2013). Moreover, there was non- significant yield increase by KSB with 30 kg K/ha in comparison to 30 kg K/ha but this on the other hand would have reduced the depletion of K in soil and could have maintained the exchangeable K in soil solution.

Seed Yield

The pooled data of two years showed significant improvement in the seed yield of lentil with application of potassium and potassium solubilizing bacteria (Table 1). The analysis of results indicated that highest seed yield (6.81 qha^{-1}) was observed in 30kg ha^{-1}+ KSB treatment which was statistically at par with solo application of potassium @30kgha^{-1} which recorded seed yield of 6.02 qha^{-1}, however, the lowest yield of 3.70 $qha^{1}$was observed in control treatment. KSB's ability to dissolve and release potassium through organic acids leads to promotion of plant growth and ultimately leading to enhanced grain yield. Mineralization increases crop productivity by making nutrients more readily available (Laishram *et al*, 2020). The application of potassium exhibited a positive effect on yield enhancement, owing it to the alleviation of oxidative damage in plants and physiological index which reflects the mobilization percentage of assimilates from vegetative part of plant to reproductive part (grain).

Table 1: Effect of Potassium and KSB on growth and yield of lentil (Pooled data of 2019 and 2020)

Treatments	Plant height (cm)	Pod plant^{-1}	Seeds pod^{-1}	1000 seed weight (g)	Seed yield (kg ha^{-1})
Control	25.35	40.03	1.28	22.25	370
10 kg K/ha	26.02	44.84	1.44	22.50	455
20 kg K/ha	26.89	45.41	1.55	22.79	514
30 kg K/ha	28.04	48.87	1.75	23.01	602
KSB	25.94	44.57	1.46	22.42	450
10 kg K/ha+ KSB	26.43	45.10	1.50	22.59	460
20 kg K/ha+ KSB	27.18	46.69	1.62	22.90	540
30 kg K/ha+ KSB	28.55	49.93	1.87	23.10	615
Sem±	0.22	0.53	0.06	0.38	17.22
C.D(P≤0.05)	0.61	1.52	0.14	NS	52.13

Moreover, potassium also provides resistance to crops against pest and disease infestation, which in turn increased the yield. These findings are also supported by the studies of Thesiya *et al* (2013).

Path coefficient analysis

The interaction effect of various yield attributes final decide the seed yield. The relationships determined by path analysis among the examined characteristics in the research are shown in Figure 1 . In the present study, 1000 seed weight exhibited the highest magnitude of direct effects on seed yield whereas the lowest magnitude on seed yield was due to direct effect of plant height. The direct effect of characteristics on seed yield with YC variable created to combine relation between 1000 seed weight and seeds per pod (1.59 and 1.00), whereas EA variable created to combine relation between pods per plant and plant height (2.70 and 1.00), direct effect with YC and EA with seed yield was 2.97 and 0.29 which indicates upper pair is having more influence to govern seed yield than other pair. These results are supported by the findings of Thanki and Sawargaonkar (2010) and Singh *et al* (2013).

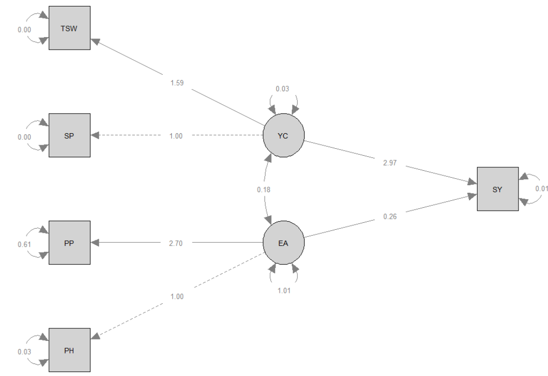

Fig. 1: Path Coefficient diagram depicting direct and indirect relationship between yield attributes and yield. (TSW is 1000 seed weight; SP is seeds pod^{-1}; PP is pods plant^{-1} ; PH is plant height)

Correlation and regression studies

The correlation and regression analysis of yield with growth and yield attributes is presented in Table 2 and Figure 2. The data indicated that seed yield exhibited a strong and positive correlation with plant height (0.946**), pods plant^{-1}(0.990**), seeds pod^{-1} (0.980**) and 1000 seed weight (0.984**), respectively. The enhanced value of growth and yield characters significantly contribute to the final seed yield as also reported by Tauseef *et al* (2013) and Abo-Hegazy *et al* (2012). The coefficient of determination varied from 0.94 to 0.97 indicating the response of seed yield with yield promoting characters (Figure 2). The variability in seed yield exhibited by plant height, pods plant^{-1}, seeds pod^{-1} and 1000 seed weight is 97%, 94%, 96% and 97 %, respectively. This precisely shows the magnitude of positive association between yield attributes and yield. Similar results were observed by Parisa *et al* (2012).

Table 2: Pearson Correlation Matrix between growth and yield attributes with seed yield

Parameters	Plant height	Pods plant^{-1}	Seeds pod^{-1}	Test weight	Seed yield
Plant height	1.000	0.946**	0.990**	0.980**	0.984**
Pods plant^{-1}		1.000	0.973**	0.936**	0.970**
Seeds pod^{-1}			1.000	0.964**	0.983**
Test weight				1.000	0.984**
Seed yield					1.000

** is significance at 0.05

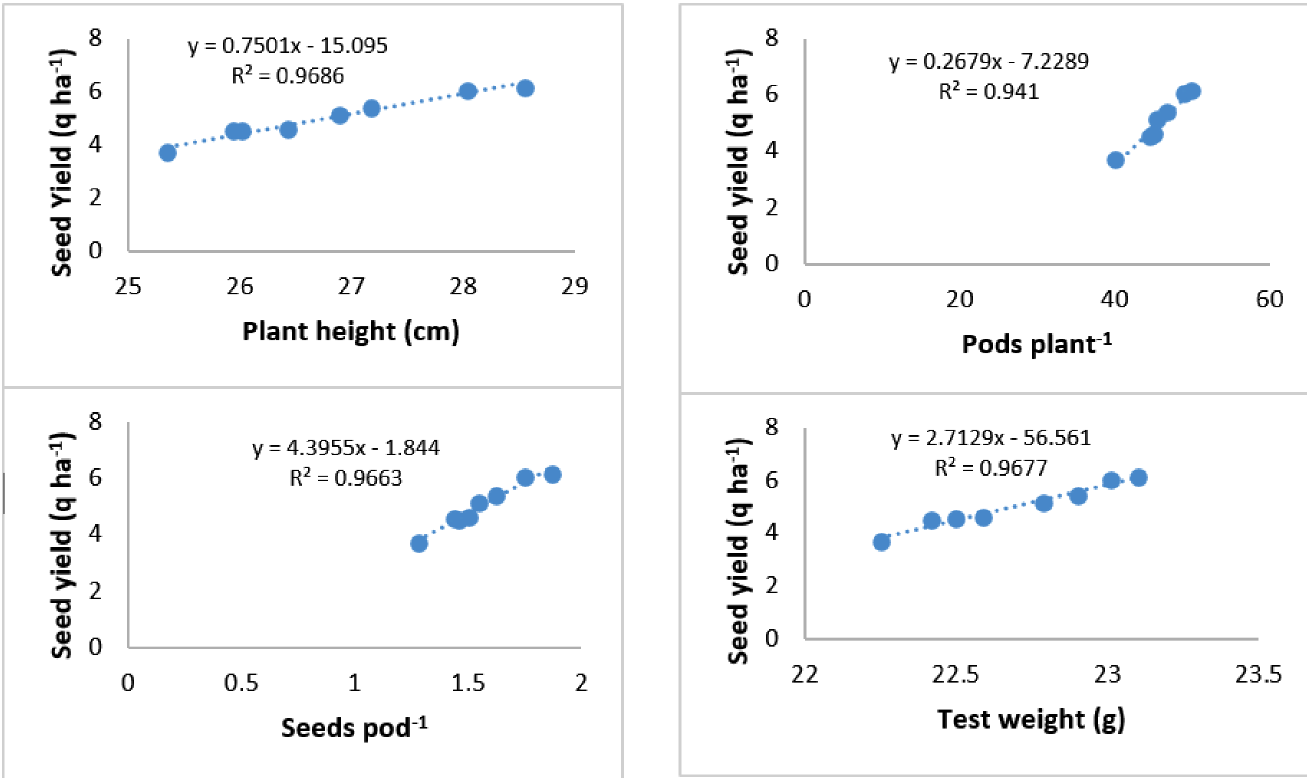

Fig. 2: Regression equation between growth and yield attributes with seed yield

Relative Economics of different treatments

The results from the pooled data (Table 3) revealed that application of potassium @ 30 kg/ha in combination with potassium solubilizing bacteria (KSB) exhibited highest gross returns (₹62460 ha^{-1}), Net returns (₹39228 ha^{-1}) and B.C ratio of 1.68 whereas the control was least economical among all the treatments with B.C ratio of 0.73 as lowest net returns (₹15970) and gross returns (₹37870), respectively. The constructive effects of potassium application @ 30 kg/ha along with potassium solubilizing bacteria (KSB)was witnessed on productivity of lentil and increased the economic returns and fetched good market prices and resulted more favourable economics. Hence, could be the viable future strategy in terms of economics. These findings coincide with studies of Meena *et al* (2018) and Zahan *et al* (2009).

CONCLUSION

From the experiment, it is concluded that application of potassium resulted in enhanced growth and yield of lentil, combined application of 30 kg K ha^{-1} + KSB exhibited the highest value of yield attributes, yield, and economic returns, however was at par with 30 kg K ha^{-1}alone, but the application of KSB might influence the fixed potassium in soil and will increase the exchangeable K without depletion. Therefore the 30 kg K ha^{-1} + KSB would be effectively used to enhance lentil productivity under Kashmir's temperate climate.

Table 3: Economic analysis different treatments Pooled data of 2019 and 2020)

Treatments	Cost of Cultivation (₹)	Gross Returns (₹)	Net Returns (₹)	B:C Ratio
Control	21900	37870	15970	0.73
10kg/ha	22227	46415	24188	1.09
20kg/ha	22555	52324	29769	1.32
30kg/ha	22882	61142	38260	1.67
KSB	22100	45897	23797	1.08
10kg/ha+ KSB	22577	46927	24350	1.07
20kg/ha+ KSB	22905	54936	32031	1.39
30kg/ha+ KSB	23232	62460	39228	1.68

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