EFFECT OF POTASSIUM SOLUBILIZING BACTERIA ON GROWTH AND YIELD OF BRINJAL (*Solanum melogina*)

R.Thuvaraka[1*], K.K.K.Nawaratna[2], A.G.B. Aruggoda[1], S.Kohombange[2]

[1]*Department of Agriculture and Plantation Engineering, Open University of Sri Lanka*

[2]*Soil Microbiology unit, Horticulture Crop Research and Development Institute Gannoruwa, Peradheniya*

Abstract

Potassium-solubilizing bacteria (KSB) based bio fertilizer is a sustainable approach to increase K availability in soil for crops. The present study was conducted to assess the ability of potassium solubilizing bacteria inoculum (KSB) to enhance the growth and yield of brinjal under plant-house condition. The KSB was isolated from soil samples which were collected from six (06) different locations in Sri Lanka: Matale Alfisol, Artisol, Jaffna Oxisol, Ultisol and Gannoruwa Ultisols. Matale Alfisol and Jaffna Ultisol soils were identified having more KSB naturally. Six (06) treatments were applied: nitrogen (N), phosphorous (P), potassium (K), NP+K inoculum, NP+ 50%K+K inoculum, NP+75%K + K inoculum, NP only and no fertilizer. Growth and yield parameters were assessed. Plant height, number of flowers per plant and number of leaves per plant were increased significantly ($p<0.05$) with both KSB inoculum and K inorganic fertilizer application. Shoot and root biomass was increased significantly ($p<0.05$) with KSB application. However, the highest growth was observed in NP+75%K + K inoculum treatment. Number of fruits per plant and fruit dry weight was increased significantly ($p<0.05$) with both KSB inoculum and K inorganic fertilizer application. The highest yield was observed in trial treated with both KSB and 75% K chemical fertilizer. The results indicated that KSB application increased soil available K. The best growth and yield promotion of brinjal was achieved by applying 75% Potassium, Nitrogen and Phosphorus chemical fertilizer along with Potassium solubizing bacteria

Keywords: Bio fertilizer, potassium solubilizing bacteria, inoculum, Alfisol, Ultisols, Artisols, Oxisols

[*] *Corresponding Author: thuvaraveendranath@gmail.com*

EFFECT OF POTASSIUM SOLUBILIZING BACTERIA ON GROWTH AND YIELD OF BRINJAL (*Solanum melogina*)

R.Thuvaraka[1*], K.K.K.Nawaratna[2], A.G.B. Aruggoda[1], S.Kohombange[2]

[1]*Department of Agriculture and Plantation Engineering, Open University of Sri Lanka*

[2]*Soil Microbiology unit, Horticulture Crop Research and Development Institute Gannoruwa, Peradheniya*

INTRODUCTION

Potassium (K) is one of the important components required for plant growth, metabolism and development. Potassium deficiency in the soil leads to slow plant growth and low yield. Feldspar and Mica are the common potassium supplement to the soil. The major amounts of K in the soil are in the form of fixed K (non-available to plant directly). K deficiency has been reported in most of the crop plants. Since cost of K-fertilizers is increasing every year (Meena *et al*., 2014) and also the use of these fertilizers has harmful effects on the environment, it is necessary to find an alternative indigenous source of K. Soil microorganisms helps to break down complex minerals present in soil either by secreting acid or base and convert it into a simple form which helps to maintain the soil fertility and Iron cycle in soil (Verma *et al*.,2016). The use of bio fertilizers is a safe alternative to chemical inputs minimizing environmental disturbance for managing K nutrient availability in soil (Mahanty 2017). Need of investigating the suitability of bio fertilizer concept for vegetable cultivation systems including brinjal is important to reduce the dependence on importing chemical fertilizers to Sri Lanka. The main purpose of this research study was to determine the effect of potassium solubilizing bacteria on growth and yield of brinjal. The specific objectives were to determine effect of potassium solubilizing bacteria along with different rate of inorganic fertilizer on growth and yield parameter of brinjal and to evaluate the potassium solubilizing bacteria content in six different soils from three districts and one of the most specific objectives is to evaluate the effect of potassium solubilizing bacteria inoculum on abundance of potassium solubilizing bacteria in soil.

METHODOLOGY

Determining the effect of KSB with different rates of inorganic fertilizer on growth and yield parameter of brinjal

The experiment was conducted at the Division of Soil Microbiology, Horticulture Crop Research and Development Institute (HORDI), Gannoruwa, Peradheniya for a period of six months under a controlled environmental condition in a plant house. Six soil samples were collected from Matale (Alfisol, Artisol), Jaffna (Oxisol, Ultisol) and Kandy (Ultisol) and potassium solubilizing bacteria was isolated. Aleksandrow media is a selective growth media for KSB. Glucose1g, Ca $(PO_4)_3$ 2 g, $MgSO_4.7H_2O$ 2 g, $FeCl_3$ 0.006 g, $CaCO_3$ 0.1 g, Insoluble mica powder/ wood ash 3 g and distill water 1000ml were used to prepare k solubilizing media (Sangeeth *et al*., 2012). Isolation from the fresh soil samples were done using the dilution plate technique in the Aleksandrow media. The plates were incubated at 30°C for 72 hours. The potassium solubilizing bacteria colony count was estimated in each plate after 72hrs.

The isolated colonies were grown in Aleksandrow broth for 72 hours (Sangeeth *et al*, 2012). Cultured broth was cross streaked in Aleksandrow media and incubated for 72 hours to obtain the pure colonies. The Soil (ultisols) was collected from the research field in HORDI, Gannoruwa and sieved well before filling the pots (each pot was filled with 5kg of soil). Random soil samples were taken from collected soil, initially investigated the pH, EC, Exchangeable K and organic matter separately from the sample.

Commercially available seeds of brinjal (variety; HORDI Lena Iri) was used as planting material four (04) weeks old healthy, vigorous and grown seedlings were transplanted into pots applying six (06) treatments with five (05) replicates.

Table 1: Treatment combinations

Treatments	Notation
T1	NPK*
T2	NP+Inoculum (50 ml) (K)
T3	NP+50%K+Inoculum(50ml) (K)
T4	NP+75%K+Inoculum(50ml) (K)
T5	NP
T6	No fertilizer

N – nitrogen source (urea), P – phosphorus source (TSP), K – potassium source (MOP)

Potassium solubilizing bacteria inoculum was inoculated to brinjal plants two (02) days after transplanting. T2, T3 and T4 were inoculated with 50ml of inoculum containing approximately 2.7-3.0×10^{11} CFU/ml colony count. Inoculation was repeated in every month on the same date until four (04) months. Inorganic fertilizer was applied to the treatments as recommended by the Department of Agriculture (DOA). Completely Randomized Designed (CRD) was applied as the statistical design. Growth and yield parameter data were recorded once a month from all the treatments. Soil samples were collected from each treatment separately at the 1st month of the trial and the end of the trial. Collected soil samples were serially diluted 5 times and plated in Aleksandraw media. Cultures were incubated and colony counts were estimated after 72 hrs. All the statistical analysis was carried out using Analysis of variance (ANOVA) and the significance of the difference among the treatment combinations means were estimated by applying Duncan's Multiple Range Test (DMRT) at $P<0.05$ level of probability using SPSS 26 statistical package.

RESULTS AND DISCUSSION

Estimating the potassium solubilizing bacteria in 6 different soils from 3 districts

The soil pH of the studied soil was 6.7 ± 0.04, thus soil pH was within the neutral range. The exchangeable K of studied soil was low (117.64 ± 0.2 ppm). Further, organic matter content and the electrical conductivity were appeared to be low 3.7 ± 0.2% and 102.3 ± 0.8 ds/m respectively. Thus, it is non saline soil (Mapa *et al*., 1999). The highest amount of potassium solubilizing bacteria was reported in Palapatwala (5.4×10^4 CFU/ml) [Alfisols (Sandy Regols)] and Point Pedro soil (6.9 ×10^4 CFU/ml) [Ultisols (Red yellow latasols)]. The nature of the ultisols soil was clay and not sticky which contain 20% organic matter having high range of exchangeable K^+ and with soil acid, soil organic acid and exchangeable K^+ ion influence more on the potassium bacteria solubilizing effect. (Meena *et al.,* 2014) Alfisols soil has a high concentration of nutrient cation K^+ and it contains $CaCO_3$ (Meena *et al*., 2014). High K^+ cation influence more Potassium Bacteria solubilizing effect and calcium carbonate induces more potassium solubilization (Sheng *et al*., 2002)

Table 2: Potassium solubilizing bacteria content in 6 different soils

Location	USDA soil classification	Colony count (CFU/ml)
Matale	Artisols	0.2×10^4
Marthanarmadam	Oxisols	0.7×10^4
Point petro	Ultisols	6.9 ×10^4
Palapathwala	Alfisols	5.4×10^4
HORDI Gannoruwa	Ultisols	1.2×10^4
HORDI organic field Gannoruwa	Ultisols	1.4×10^4

Determining the effect of KSB with different rates of inorganic fertilizer on growth and yield parameter of brinjal

Table 3: Effect of KSB and inorganic fertilizer on plant growth parameter

Treatments	Mean plant height (cm)	Mean number of leaves	Mean numbers of buds	Mean number of flowers
T1- NPK	36.30±4.2[ab]	22±1[bc]	4.2±0.83[ab]	1.4±1.1[bc]
T2- NP+ K ino	37.10±6.5[ab]	23.4±5.7[ab]	5.6±2.7[a]	2.2±0.83[ab]
T3-NP+50%K+K ino	37.44±6.9[ab]	26±7.2[ab]	6±2[a]	2.6±1.14[ab]
T4-NP+75%K+K ino	39.88±3.3[a]	30±5.2[a]	5.8±1.61[a]	3.8±1.9[a]
T5- NP	31.80±3.5[b]	21±5.3[bc]	2.6±0.54[b]	1.4±1.14[bc]
T6 – No fertilizer	24.38±3.9[c]	14.6±5.7[c]	4±2.23[ab]	0.6±0.5[c]

There was no significant difference in plant height among treatments T1, T2, T3 and T4. However, the highest plant height was observed in the trial treated with both KSB and 75% K chemical fertilizer. According to the findings of Han and Lee (2005), chemical K fertilizer application did not significantly increase the plant growth. An increase in plant growth occurred in the combined treatment; soil inoculated with K Bacteria and K chemical fertilizer. The plant growth promoting effects and nutrient uptake level was influenced by potassium solubilizers (sheng *et al*., 2002). Similarly, the application K solubilizing bacteria on brinjal increases the plant height as well as the K uptake (Ramerethinam and Chandra, 2006**.** The highest number of leaves and buds were observed in treatment T4 which was treated with 75% inorganic K fertilizer along with K inoculum. T4 was statistically identical to T2 and T3. Potassium bacteria inoculum which influences the increased leaf and bud rate, enhanced the early growth in plants and further increased the already increased photosynthesis. (Han and Lee 2005). The number of flowers was significantly higher in treatment T4 when compared with un-inoculated treatments (T1, T5 and T6). Plant flowering and the early flowering rates were influenced by the potassium solubilizing bacteria (Nayak, 2001).

Effect of KSB and inorganic fertilizer on dry biomass

Dry biomass was significantly higher ($p<0.05$) in all inoculated treatments compared to un-inoculated treatments. Nayak (2001) investigated the effect of K mobilizer on brinjal and recorded increased K uptake and increased plant biomass in mobilizer treated plant as compared to un-inoculated.

Table 4: Effect of KSB and inorganic fertilizer on dry biomass of brinjal

Treatments	Mean root dry weight(g)	Mean shoot dry weight(g)	Mean dry biomass(g)
T1- NPK	4.2804±1.1[a]	9.7102 ±_1.31[ab]	11.7256±2.29[b]
T2- NP+ K ino	5.4072±1.38[a]	12.481 ±2.4[a]	17.8882±3.47[a]
T3-NP+50%K+K ino	5.6734±1.31[a]	13.1522 ±1.7[a]	18.8256±2.74[a]
T4-NP+75%K+K ino	5.1068±1.5[a]	12.481 ±3.3[a]	17.5878±2.7[a]
T5- NP	2.4430±0.9[b]	7.8686 ±1.297[b]	10.3116±2.07[b]
T6 – No fertilizer	2.2424±1.04[b]	6.7742 ±1.9[b]	9.0166±2.87[b]

Ino-inoculum, N-nitrogen, P-phosporus, K-potassium

Effect of KSB and inorganic fertilizer on plant yield parameters

Table 5: Effect of KSB and inorganic fertilizer on yield parameters

Treatments	Mean number of fruits(g)	Mean fruit fresh weight(g)	Mean fruit dry weight(g)
T1- NPK	1±0.707[bc]	28.051±6.39[c]	2.481±1.6[b]
T2- NP+ K ino	1.4±1.14[bc]	33.077±3.04[bc]	4.556±3.1[b]
T3-NP+50%K+K ino	2±0.707[a]	54.836±4.50[ab]	8.028±2.4[a]
T4-NP+75%K+K ino	2.4±1.14[a]	70.138±11.5[a]	8.78±2.8[a]

T5- NP	0.6±0.54[c]	22.733±12.4[c]	2.172±2.01[b]
T6 – No fertilizer	0.6±0.54[c]	16.384±8.72[c]	2.041±1.93[b]

The number of fruits per plant was significantly higher ($p<0.05$) in treatment T3 (2 ± 0.7) and T4 (2.6 ± 1.1) which was treated with KSB bacteria as well as K inorganic fertilizer. Studies on the effect of K solubilizing bacteria *Frateuria aurantia* on brinjal showed a significant increase in yield and K uptake as per the Ramarethinam and Chandra in 2006. The inoculation of KSB along with chemical K fertilizer into the soil increased K uptake, photosynthesis and the yield of eggplant grown on K limited soils. (Sangeeth *et al*., 2012). The highest fresh weight of the fruits was observed from treatment T4 (70.177 ± 7.78 g) which was statistically identical to the T3 (54.83 ± 4.5 g). Dry weight of the fruit was significantly high in T3 (8.02 ± 2.4 g) and T4 (8.78 ± 2.8 g) which was treated with both K chemical fertilizer and K inoculum. NPK - applied treatment was shown approximately the same fruit growth compared to K inoculum and NP applied treatment. According to the Archana *et al*., (2013), the K-solubilizing bacteria showed an increase yield in maize. That indicates the KSMs significantly increased yield, plant growth and nutrient uptake component over absolute fertilizer control. The application of KSB with K minerals on sorghum enhanced the dry matter yield by 48 % and 65 % respectively (Badr *et al.,*2006).

Abundance of potassium solubilizing bacteria in soil

T4 (5.4×10^7) soil contained high potassium solubilizing bacteria a month after the transplanting. However, at the end of the experiment, the abundance of potassium solubilizing bacteria was increased by 79.54.% compared to abundance of bacteria during its first month. Inoculated treatments T2, T3 and T4 soil induced higher bacteria abundance at the end of the trial compared to the bacteria abundance during its first month. According to the findings of Hu, Chen and Guo (2006), the continuous application of inoculum increased the sustainability of bacteria in soil. Studies showed that inoculating soil with KSB boosts the growth of rye and its absorption of N and K (Basak and Biswas, 2012). KSB was found to dissolve slow-release K compounds which increased the concentration of available K in the soil, further facilitating the plant growth. Correlation analysis showed that the tobacco biomass and K content were positively correlated with soil K ion content (Zhang and Kong 2014).

Table 6: Abundance of potassium solubilizing bacteria in soil

Treatments	**Initial (CFU/ml)**	**1st month after transplanting (CFU/ml)**	**End of the experiment (CFU/ml)**
T1	0.2×10^7	0.4×10^7	0.6×10^7
T2	0.2×10^7	2.9×10^7	0.3×10^9
T3	0.2×10^7	5.0×10^7	2.94×10^8
T4	0.2×10^7	5.4×10^7	2.64×10^8
T5	0.2×10^7	0.1×10^7	0.1×10^7
T6	0.2×10^7	0.2×10^7	0

CONCLUSION

As per the results of the present study, the highest natural abundance of potassium solubilizing bacteria was observed in the soils of Matale Alfisol and Jaffna Ultisol. The highest growth and yield promotion of brinjal was achieved by the application of 75% potassium chemical fertilizer and nitrogen, phosphorus chemical fertilizer along with the potassium solubilizing bacteria inoculum. Further, inoculum applied treatment showed high plant dry biomass than the uninoculated treatments.

AKNOWLEDGEMENT

The authors greatly acknowledge the financial support provided by the Ministry of Agriculture for the research plan project, "Development of Environmentally found sustainable plant protection and nutrient management technologies in vegetable to minimum use of agro chemicals".

REFERENCE

Archana D. S, Nandish M.S, Savalagi V.P., Alagawadi A.R., 2013. Characterization of potassium solubilizing bacteria (KSB) from rhizosphere soil. Bioinfolet 10:248–257

Badr, M.A., Shafei, A.M., Sharaf El-Deen, S.H., 2006. The dissolution of K and P-bearing minerals by silicate dissolving bacteria and their effect on sorghum growth. Res. J. Agri. Biol. Sci. 2, 5-11.

Basak, B., Biswas, D., 2012. Modification of waste mica for alternative source of potassium: evaluation of potassium release in soil from waste mica treated with potassium solubilizing bacteria (KSB). LAMBERT Academic Publishing, Germany. ISBN 978-3659298424

Han, H.S., and Lee, K.D., 2005. Phosphate and Potassium solubilizing bacteria effect on mineral uptake, soil availability and growth of eggplant, research journal of Agriculture and biological sciences1(2); 176-180,2005

Hu X., Chen J., Guo J., 2006. Two phosphate- and potassium-solubilizing bacteria isolated from Tianmu Mountain, Zhejiang, China. World J Microbiol Biotechnol. 22: 983–990

Nayak, B., 2001. 'Uptake of potash by different plants with the use of potash mobiliz- ing bacteria Frateuria aurantia.' Ph.D. the- sis submitted to Orissa University of Agricultural Science and Technology, Bhubaneswar, India.

Mahanty, T.,2017. 'Biofertilizers: a potential approach for sustainable agriculture development', *Environmental Science and Pollution Research,* 24(4), pp. 3315–3335. doi: 10.1007/s11356-016-8104-0

Mapa, R.B., Kumaragamage, D., Gunarathne, W.D.L., and Dassanayake, A.R., 1999, August. Land use in Sri Lanka: past, present and future. In Proceedings of the 17th world congress of Social Science (WCSS), Bangkok,Thailand(pp.14-21)

Meena, V.S., Maurya, B.R., Verma, J.P., 2014. A rhizospheric microorganism enhance K+ availability in agricultural soils? Microb. Res. 2015; 169:337-347.

Ramarethinam, S., Chandra, K., 2006. Studies on the effect of potash solubilizing bacteria Frateuria aurantia (Symbion-K- liquid formulation) on Brinjal (*Solanum melongena* L.) growth and yield. Pestology 11:35–39

Sangeeth, K. P., Rosa-Magri M .M., Avansini, S.H., Lopes-Assad, M.L., , Bhai, R.S., Srinivasan V., 2012. Paenibacillus glucanolyticus, a promising potassium solubilizing bacterium isolated from black pepper (Piper nigrum L.) rhizosphere. J Spices Aromat Crop 21:118–112

Sheng, X.F., L.Y. He and Huang, W.Y., 2002. The conditions of releasing potassium by a silicate dissolving bacterial strain NBT. Agri. Sci. in China, 1: 662-666.

Verma, A., Patidar, Y. and Vaishampayan, A., 2016. Isolation and purification of potassium solubilizing bacteria from different regions of India and its effect on crop's yield. *Indian J Microbiol Res*, *3*(4), pp.483-8.

Zhang, C., Kong, F., 2014. Isolation and identification of potassium-solubilizing bacteria from tobacco rhizospheric soil and their effect on tobacco plants. Appl Soil Ecol 82:18–25