Plant Archives Vol. 26, Supplement 1, 2026 pp. 1635-1640 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-1.220

ENHANCING POTASSIUM USE EFFICIENCY IN RABI SWEET CORN (*ZEA MAYS* L. *VAR.* SACCHARATA) THROUGH KSB INOCULATION AND BSF FRASS AMENDMENT

Ch. Siva Naga Raju[1]*, Sudhanshu S. Kasbe[2], K. Suresh[3] and G. Kiran Reddy[4]
[1]Department of Agronomy, College of Agriculture, Rajendranagar, PJTAU, Hyderabad–500030,Telangana, India
[2]Department of Agronomy, Agricultural College, Adilabad, PJTAU, Telangana–504002, India
[3]Principal Scientist (WMU, C-NARE), Department of Agronomy ,PJTAU, Rajendranagar, Hyderabad–500030, Telangana, India
[4]Department of Soil Science and Agricultural Chemistry, Agricultural College, Jagtial, PJTAU, Telangana, India
*Corresponding author E-mail: rajchennuboina8@gmail.com
(Date of Receiving : 30-09-2025; Date of Acceptance : 06-12-2025)

ABSTRACT

The study titled "Evaluation of black soldier fly larval frass as a bio-resource for potassium management in Rabi sweet corn (*zea mays* L. var. saccharata)" conducted during the Rabi season (2024-25), aimed to address issues related to the lack of potassium, limited sources of organic manure and dependency on imported chemical K fertilizers. The treatments consisted of integrating different proportions of the recommended dose of potassium (RDK) with various potassium sources such as BSF larval frass, poultry manure and farmyard manure, applied through broadcasting or band placement, in combination with potassium-solubilizing bacteria. The results revealed that among different fractions of soil K i.e, water soluble-K, exchangeable-K and available-K were found significantly higher in T_8: 50% RDK + 50% RDK through BSFL Frass (Band application) + KSB and it was comparable with T_4: 100% RDK through BSFL Frass (Band application) + KSB. Whereas lowest fractions of soil k were recorded in T_1: 0% RDK (Control).
***Keywords* :** Black soldier fly larval frass, KSB, Potassium dynamics.

Introduction

Maize *(Zea mays* L.) is one of the most important cereal crops in the world because of its excellent adaptability to varied agro-climatic conditions. In India, it occupies an area of 107.44 lakh hectares and contributes to the national production with 380.85 lakh tonnes at an average productivity level of 3545 kg ha^{-1}. In Telangana, maize is grown on 5.15 lakh hectares, producing 28.62 lakh tonnes with a productivity of 5557 kg ha^{-1}.

Specialty sweet corn, *Zea mays* var. saccharata, is a type of maize characterized by its naturally higher sugar content due to a recessive mutation that interferes with the conversion of sugars into starch within the kernel endosperm (Tracy, 1993). Nutritionally, raw yellow sweet corn contains 3.43 g glucose, 1.94 g fructose, and 0.89 g sucrose per 100 g (USDA, 2025).

BSF larvae have demonstrated outstanding waste-degradation efficiencies, ranging between 66 and 79% according to Diener *et al.* (2011). They are also capable of pathogen suppression in organic streams of waste, according to Lalander *et al.* (2015). This provides an explanation for why BSF larvae is a highly effective biological agent of nutrient recycling. The application of BSF frass as organic manure would be a rapid and efficient form of recycling the nutrients contained in organic waste to improve soil fertility. Several researchers also reported its richness, containing macro-nutrients like nitrogen and potassium (Kubay, 2022).

The seventh most abundant element in the Earth's crust is potassium, mostly in forms unavailable to plants. About 98% of the total soil K remains unavailable (Hoeft *et al*., 2000). This fixed K is transformed very slowly into plant-available forms to meet crop demands during the growing season. Soil microorganisms play an important role in the solubilization of potassium by releasing organic acids and enzymes that mobilize K from mineral sources (Maurya *et al*., 2014), therefore contributing substantially to plant nutrition and soil health.

In the recent few years, potassium has emerged as one of the prime limiting macronutrients in the restraint of crop productivity (Rajawat *et al*., 2016). The dependency on imported potassium fertilizers, mainly muriate of potash and sulfate of potash, because of the absence of indigenous Indian reserves of high-grade K-bearing minerals, calls for searching out alternative and sustainable K sources.

Materials and Methods

The present investigation was conducted during the rabi season of 2023–2024 in plot B10 of the College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad (Telangana, India). The site is situated at 17° 32' 21" N latitude and 78° 41' 04" E longitude, at an elevation of 559 m above mean sea level. The study area falls within the Southern Telangana agro-climatic zone and is characterized as a semi-arid tropical (SAT) region according to Troll’s climatic classification. Prior to initiating the experiment, a composite soil sample was collected from the field and analyzed for its physico-chemical characteristics.The soil was sandy loam with neutral pH (7.21), EC (0.22ds/m). Soil had 175.6 kg/ha available N (Subbiah and Asija, 1956), 26.7 kg ha^{-1} available P (Olsen *et al.,* 1954), 185.7 kg ha^{-1} available K (Jackson, 1967), 0.41 % organic carbon (Walkley and Black, 1934), 26.2 mg kg^{-1} water soluble K, 164.3 mg kg^{-1} exchangeable K, 522.3 mg kg^{-1} non-exhangeable K. Research was laid out in Randomized block design with the 8 following treatments.

T_1:0% RDK (Control), T_2: 100% RDK + KSB (Potassium Solubilizing Bacteria), T_3: 100% RDK through BSFL Frass (Broadcasting) + KSB, T_4: 100% RDK through BSFL Frass (Band application) + KSB, T_5: 75% RDK + 25% RDK through BSFL Frass (Band application) + KSB, T_6: 75% RDK + 25% RDK through Poultry Manure (Band application) + KSB, T_7: 75% RDK + 25% RDK through Farmyard Manure (Band application) + KSB and T_8: 50% RDK + 50% RDK through BSFL Frass (Band application) + KSB. For seed treatment and soil soaking, PJTAU's Biofertilizer Production Unit provided liquid biofertilizer KSB (*Bacillus amyloliquefaciens*) was used. The band application of organic manures like poultry manure and BSFL frass are applied after mixing the manure with soil in 1: 4 ratio to reduce scorching effect and for better germination (Banoth *et al*., 2024). The KSB solution was combined with the jaggery solution at a rate of 10 ml kg^{-1} sprinkled over the seed and thoroughly mixed to ensure that the KSB solution adhered to the seed surface. The treated seeds were then dried in shade. While soil drenching, KSB @ 2.5 ml L^{-1} water poured near to the plant stem by loosening the nozzle of a battery-operated sprayer. About 20 ml of solution was drenched per plant at knee high stage.The treatments were randomly allocated to different plots using random number table of Fisher and Yates. (1938), in a randomized block design with 3 replicates.

Recommended doses of nitrogen, phosphorus and potassium (200:60:50 kg ha^{-1}) were applied through urea, SSP, MOP. Five centimetres below the seed row, a third of the nitrogen and the whole quantity of phosphorous were administered as a basal treatment. For all treatments, the remaining two thirds of the nitrogen was top-dressed in two equal splits at the knee height stage and at the tasseling stage. MOP was used in accordance with dosages and treatment allocation.

Sugar 75 was sown on November 7, 2024 and harvested on February 7, 2025. The soil samples were taken from all treatments at a depth of 0 to 15 cm .They were transported to the lab in HDPE plastic bags. In order to analyse potassium fractions, soil samples were also taken at various crop stages, such as 15 DAS, knee height, tasseling and harvest. After being pounded with a pestle and mortar and allowed to dry in the shade, the soil samples were sieved through a 2 mm sieve (for soil organic carbon 0.2 mm) sieve The accessible soil K fractions were all measured in the processed soil samples.

The experimental data was statistically analysed by applying "Analysis of Variance" technique for randomized block design. Standard error of mean (SEm±) and Critical difference (CD) at 5% significance level was worked out for each observation as per the method suggested by (Gomez and Gomez, 1984).

Results and Discussion

Water soluble K

Water soluble K is the least amount of soil K. In other words, it is a component of the available-K. Plants only uptake potassium from water sol K that are put back into soil by exchangeable-K and non-exchangeable-K pool (Meena *et al*., 2016).Water soluble-K in soil was found to be significantly differed due to different management practices. At 15 DAS, knee height stage, tasseling stage and at harvest, water-soluble K was significantly higher in T4: 100% RDK through BSFL Frass (Band application) + KSB (17.1, 30.3, 28.8, 24.5 mg kg^{-1}) , however it was on par with T5: 75% RDK + 25% RDK through BSFL Frass (Band application) + KSB (15.9, 29.1, 26.9, 23.1 mg kg^{-1}), T6: 75% RDK + 25% RDK through Poultry Manure (Band application)+ KSB (16.6, 29.4, 27.5, 23.4 mg kg^{-1}), T7: 75% RDK + 25% RDK through Farmyard Manure (Band application) + KSB (15.5, 28.7, 26.3, 23.0 mg $kg^{-1)}$ and T8: 50% RDK + 50% RDK through BSFL Frass (Band application) + KSB (16.7, 29.8, 28.6, 24.3 mg kg $^{-1}$). The lowest water Soluble-K was recorded with T_1 0% RDK (10.5, 22.5, 20.1, 18.8 mg kg^{-1}). This might be because band application concentrates inorganic nutrients and frass derived soluble K in root zone which results in increased water soluble K and also KSB helps in accelerate release of K from frass and soil mineral pools into soil solution (Figure 1).

Exchangeable K

Exchangeable-K is the major fraction of available-K. When water soluble- K content increased, to maintain dynamic equilibrium, some of the water soluble- K get fixed into exchangeable site and vice-versa. At 15DAS, knee height stage, tasseling stage and at harvest, highest Exchangeable-K was recorded with T_8: 50% RDK + 50% RDK through BSFL Frass (Band application) + KSB (107.9, 179.2, 145.7, 137.6 mg kg^{-1}) and it was on par with T_5: 75% RDK + 25% RDK through BSFL Frass (Band application) + KSB (101.2, 177.6, 125.9, 119.9 mg kg^{-1}), T6: 75% RDK + 25% RDK through Poultry Manure (Band application) + KSB (106.3, 178.4, 145.1, 137.1 mg kg^{-1}), T7: 75% RDK + 25% RDK through Farmyard Manure (Band application) + KSB(99.3, 1766.2, 125.2, 119.4 mg kg^{-1}) and T4: 100% RDK through BSFL Frass (Band application) + KSB (98, 175.8, 124.8, 119.1 mg kg^{-1}). This might be due to combined input of organic and inorganic fertilizers which raises quantity of K adsorbed on exchange sites near roots. Organic matter in frass might increase soil exchange complex activity, resulting in raising exchangeable K. Because of high crop uptake, leaching and dynamic equilibrium between water soluble K and exchangeable-K, a decreasing trend of exchangeable-K pool was found from knee height stage to harvest.These findings were in accordance with Gnanasundari *et al.* (2020) and Saritha *et al.* (2021) where exchangeable-K also followed the similar trend of water soluble-K (Figure 2).

Non-Exchangeable K

The experimental data on non-exchangeable-K in soil did not significantly vary due to different organic manures and KSB management practices at different growth stages of the crop. The non-exchangeable-K pool is the reserve and unavailable soil-K pool. The non-exchangeable-K pool can replenish the available-K pool in response to depletion of the available-K pool in soil. The non-exchangeable-K content was numerically higher in sole application of different doses of chemical K-fertilizer compared to the specific chemical fertilizer treatment in addition to KSB. This implied KSB facilitated the solubilization of the unavailable soil-K pool and diminished the conversion of available-K to non-exchangeable-K.

Ahmad *et al.* (2020), Gnanasundari *et al.* (2020), Saritha *et al.* (2021) and Bhattacharyya *et al.* (2018) observed depletion of the non-exchangeable-K pool in soil with increase in crop growth regardless of chemical fertilizer dose, however, greater depletion was in the control plot (without K). Ding *et al.* (2021) stated non-exchangeable-K was significantly less in the KSB treated plot compared to KSB treated only with 100% RDK (Figure 3).

Available potassium (mg kg^{-1})

Available-K is the resultant of summation of water soluble-K and exchangeable-K. Soil available K was found to be significantly influenced by different management practices. Decreasing trend of soil available K was observed from knee height stage to harvesting stage. At 15DAS, knee height stage, tasseling stage and at harvest, highest Available-K was recorded with T8: 50% RDK + 50% RDK through BSFL Frass (Band application) + KSB (118.3, 196.4, 174.1, 179.4 kg ha^{-1}) and it was on par with T5: 75% RDK + 25% RDK through BSFL Frass (Band application) + KSB (113.8, 193.6, 172.6, 174.8 kg ha^{-1}), T6: 75% RDK + 25% RDK through Poultry Manure (Band application) + KSB (115.2, 195.9, 173.2, 178.5 kg ha^{-1}), T7: 75% RDK + 25% RDK through Farmyard Manure (Band application) + KSB (111.7, 190.2, 170.2, 173.2 kg ha^{-1}) and T4: 100% RDK through BSFL Frass (Band application) + KSB (110.3, 189.3, 169.9, 184.7 kg ha^{-1}).

These findings are consistent with the observations of Bhattacharyya *et al.* (2018), who reported that in maize grown under adequate moisture conditions, both available-K and water-soluble K declined steadily from 40 DAS to 90 DAS, irrespective of the level of potassium applied. Similarly, Ding *et al.* (2021) noted that plots treated with KSB + 100% RDK recorded significantly higher concentrations of water-soluble and exchangeable K compared to those receiving only 100% RDK (Figure 4).

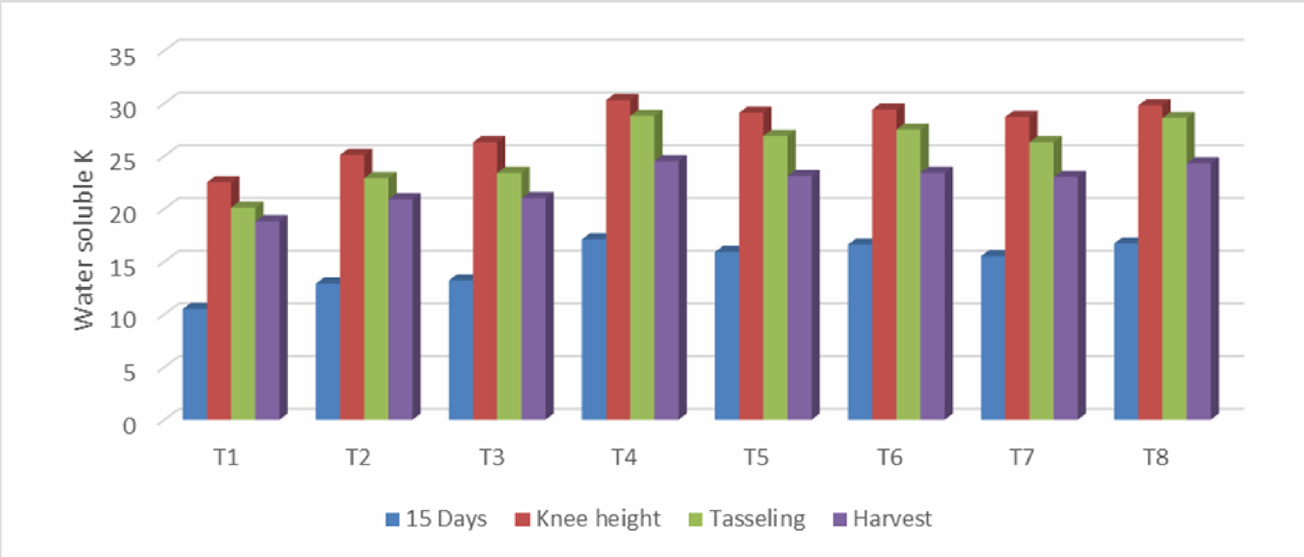

Fig. 1: Impact of BSFL Frass on Soil K dynamics i.e. K_2O in soil (Water soluble K) at 15 DAS, knee high stage and tasselling and at harvest

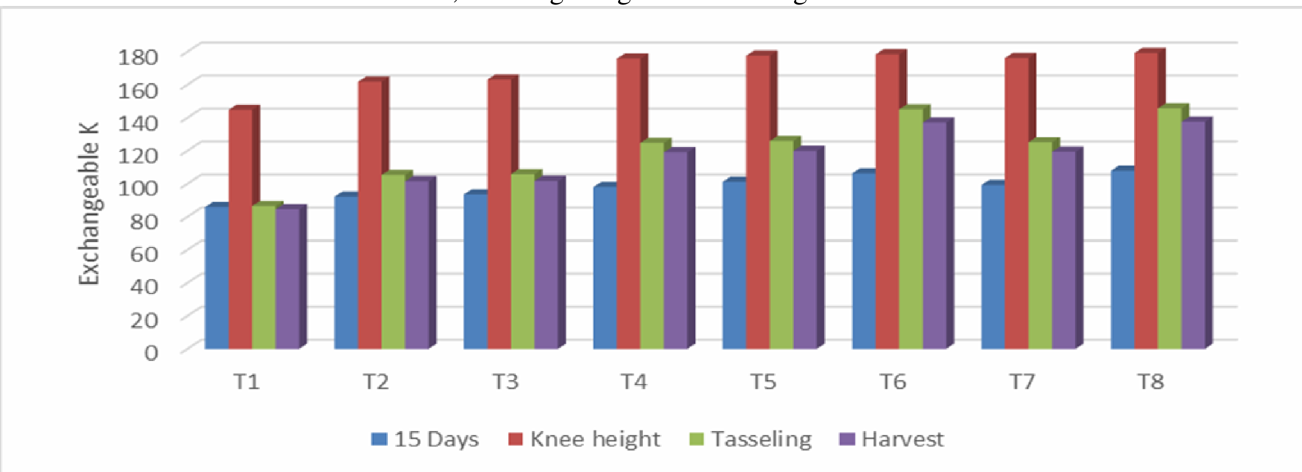

Fig. 2: Impact of BSFL Frass on Soil K dynamics i.e. K_2O in soil (Exchangeable K) at 15 DAS, knee high stage and tasselling and at harvest)

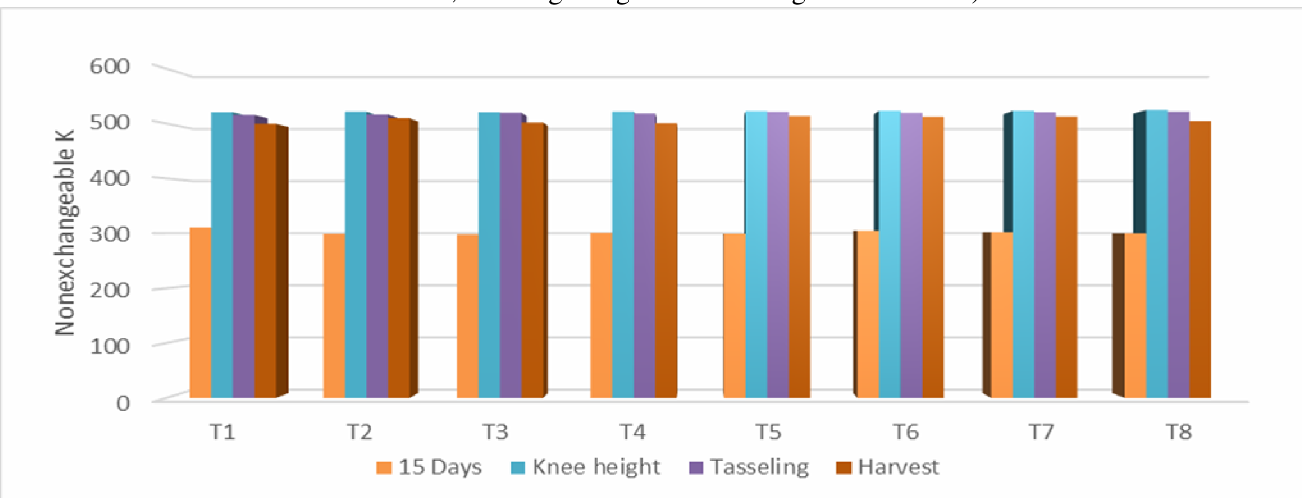

Fig. 3: Impact of BSFL Frass on Soil K dynamics i.e. K_2O in soil (Non-Exchangeable K) at 15 DAS, knee high stage and tasselling and at harvest)

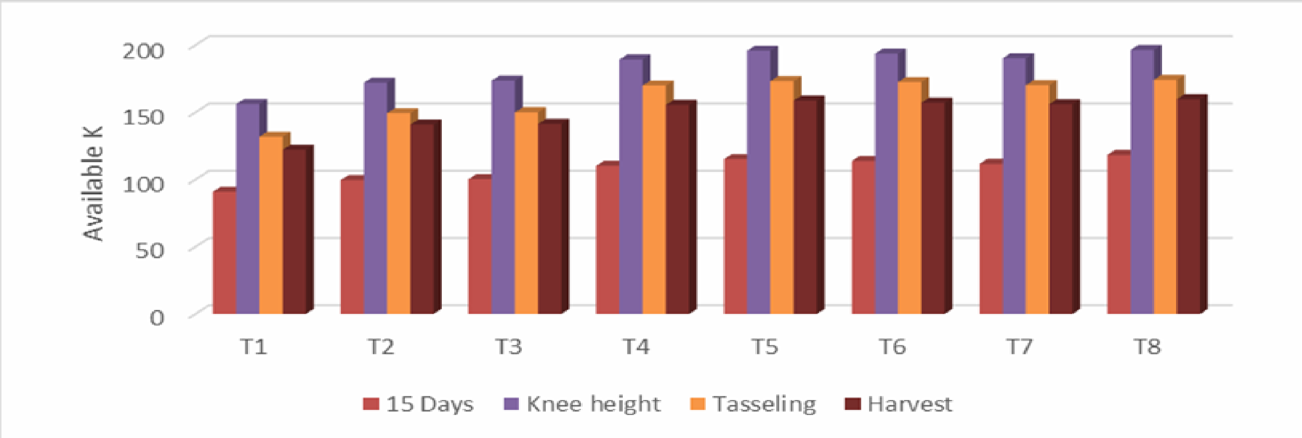

Fig. 4: Impact of BSFL Frass on Soil K dynamics i.e. K_2O in soil (Available K) at 15 DAS, knee high stage and tasselling and at harvest)

Conclusion

Among different fractions of soil K, water soluble-K, exchangeable-K and available-K were found significantly higher in T8: 50% RDK + 50% RDK through BSFL Frass (Band application) + KSB however it was found to be onpar with T5: 75% RDK + 25% RDK through BSFL Frass (Band application) + KSB, T6: 75% RDK + 25% RDK through Poultry Manure (Band application) + KSB, T7: 75% RDK + 25% RDK through Farmyard Manure (Band application) + KSB and T4: 100% RDK through BSFL Frass (Band application) + KSB. This might be because Band application keeps the nutrients close to the plant roots, so plants get more water-soluble and exchangeable potassium than with broadcasting. Adding inorganic RDK gives an immediate supply of K. Organic manures like BSFL frass, poultry manure, and FYM release potassium quickly and slowly over time and also improve the soil's ability to hold K. KSB further helps by converting unavailable forms of potassium into forms that plants can easily absorb. Whereas, non-exchangeable-K was found to be unaffected due to the different nutrient management practices at all the crop stages. In all fractions of K, a decreasing trend was observed from knee height stage to harvest irrespective of treatments.

References

Ahmad, A., Chattopadhyay, N., Mandal, J., Mandal, N and Ghosh, M. (2020). Effect of potassium solubilizing bacteria and waste mica on potassium uptake and dynamics in maize rhizosphere. *Journal of the Indian Society of Soil Science*, **68**(4): 431-442.

Banoth, S.K., Kasbe, S.S., Ramanjaneyulu, A.V and Madhavi, A. (2025). Effect of different application methods of various organic manures on plant population and growth attributes of *rabi* sweetcorn. *Plant Archives*, **25**(1): 282-287.

Bhattacharyya, K., Das, T., Ray, K., Dutta, S., Majumdar, K., Pari, A and Banerjee, H. (2018). Yield of and nutrient-water use by maize exposed to moisture stress and K fertilizers in an inceptisol of West Bengal, India. *Agricultural Water Management*. **206**: 31-41.

Diener, S., Studt Solano, N.M., Roa Gutiérrez, F., Zurbrugg, C and Tockner, K. (2011). Biological treatment of municipal organic waste using black soldier fly larvae. *Waste and Biomass Valorization*. 2: 357-363.

Ding, Z., Ali, E.F., Almaroai, Y.A., Eissa, M.A and Abeed, A.H. (2021). Effect of potassium solubilizing bacteria and humic acid on faba bean (*Vicia faba* L.) plants grown on sandy loam soils. *Journal of Soil Science and Plant Nutrition*. **21**(1): 791-800.

Fisher, R. A., & Yates, F. (1938). Statistical Tables for Biological, Agricultural and Medical Research.

Gnanasundari, R., Sellamuthu, K.M and Malathi, P. (2020). Distribution and variation of potassium in black soil at different stages of crop growth in maize (*Zea mays*). *Asian Journal of Physical and Chemical Sciences*. **8**(4): 14-21.

Gomez, K.A and Gomez, A.A. (1984). Statistical procedures for agricultural research. John wiley & sons. Department of Statistics The International Rice Research Institute Los Banos, Laguna, Philippines; 1984.

Hoeft, R.G., E.D. Nafziger, R.R. Johnson and Aldrich, S.R. (2000). Modern Corn and Soybean Production. MCSP Publications. Champaign, IL. 353.

Kubayi, C. (2022). Frass from black soldier flies as a valuable fertilizer and biopesticide for crops.

Lalander, C.H., Fidjeland, J., Diener, S., Eriksson, S and Vinneras, B. (2015). High waste-to-biomass conversion and efficient *Salmonella* spp. reduction using black soldier fly for waste recycling. *Agronomy for Sustainable Development*. **35**: 261-271.

Maurya, B.R., Meena, V.S and Meena, O.P. (2014). Influence of inceptisol and alfisol's potassium solubilizing bacteria (KSB) isolates on release of K from waste mica. *Vegetos*. **27**(1): 181–187.

Meena, V.S., Bahadur, I., Maurya, B.R., Kumar, A., Meena, R.K., Meena, S.K and Verma, J.P. (2016). Potassium-solubilizing microorganism in evergreen agriculture: an overview. *Potassium solubilizing microorganisms for sustainable agriculture*. 1-20.

Rawat, J., Sanwal, P and Saxena, J. (2016). Potassium and its role in sustainable agriculture. In *Potassium solubilizing microorganisms for sustainable agriculture* (235-253). New Delhi: Springer India.

Saritha, J.D., Sridevi, S., Ramprakash, T., Ramana, M.V and Chary, D.S. (2021). Fractions of Soil Potassium and their Depthwise Distribution under Long-Term Nutrient Management Practices in Semiarid *Alfisols* in India. *International Journal of Environment and Climate Change*. **11**(12): 403-416.

Tracy, W.F. (1993). Sweet corn: *Zea mays* L. In *Genetic improvement of vegetable crops* (777-807). Pergamon.

U.S. Department of Agriculture, Agricultural Research Service, Beltsville Human Nutrition Research