International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2020): 7.803

Effect of Potassium Levels and Potassium Solubilizing Bacteria on Growth and Yield of Maize (*Zea mays* L.)

Sunkari Priyavardhini[1], Shikha Singh[2], Tarence Thomas[3], Vijay. J[4]

[1]M. Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, 211 007, India
E- Mail: *priyavardhinirao[at]gmail.com*

[2]Assistant professor, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, 211 007, India

[3]Professor, Department of Soil Sciences, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, 211 007, India

[4]Scientist, KVK, Prakasam Krishi Vigyan Kendra, Jayaprakash Nagar, Jammikunta, Karimnagar, Telangana, 505 122, India

Abstract: ***A field experiment was conducted during kharif 2020 at, Prakasam Krishi Vigyan Kendra (KVK), Jayaprakash Nagar, Jammikunta, Karimnagar District – 505 122, Telangana State. To study the effect of potassium and potassium solubilizing bacteria on growth and yield of maize (Zea mays L.). The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice. It was observed that T6 - K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) 80 DAS was found to be the best treatment for obtaining growth and yield attributes such as Plant height (243.33 cm), Dry matter production (358.33 g/plant), No. cobs per plant (1.77), No. of grains per row (36.67), No. of rows per cob (16.00), No. grains per cob (586.72), Seed index (44.00 g), Grain yield (5.78 t/ha).***

Keywords: Maize, Potassium, Potassium Solubilizing Bacteria, Soil application, Seed inoculation

1. Introduction

Maize (*Zea mays L.*) belongs to family Poaceae and is a highly cross - pollinated crop (95%), it is one of the most versatile emerging crops having wider adaptability under varied agro - climatic conditions, globally and maize is known as "*Queen of Cereals*" because it has the highest genetic yield potential among the cereals. Nutritionally it contains 60 to 68% starch and 7 to 15% protein; also, it has more riboflavin content then wheat or rice crop and is rich in phosphorus and potash content. Maize protein 'Zein' is deficient in triptophane and lysine, the two essential amino acids. A maize grain has significant quantities of vitamin A, nicotinic acid, riboflavin and vitamin E.

Potassium (K) ranks at third among the essential plant nutrients after nitrogen and phosphorus and seventh among all the elements in the earth's crust (Manning 2010). It is the most essential macronutrient needed for the plant growth to increase crop yields with quality produce (Romheld and Kirk 2010). It activates enzymes, maintains cell turgor, enhances photosynthesis, reduces respiration, helps in transport of sugars and starches, helps in nitrogen uptake, and is essential for protein synthesis. In addition to plant metabolism, potassium improves crop quality because it helps in grain filling, kernel weight, strengthens straw, increases disease resistance and helps the plant better to withstand stress. Without adequate potassium, plants have poorly developed roots, grow slowly, produce small seeds and have lower yields; K deficiency causes marginal burning starting from tips, brown scorching and curling of leaf tips along with chlorosis (yellowing) between leaf veins. Nevertheless, K not only participates in nutrient transportation and uptake but also confers resistance to abiotic and biotic stresses, leading to enhance in crop sustainability. In addition to increasing plant resistance to diseases, pests, and abiotic stresses, K is required to activate over 80 different enzymes responsible for plant and animal processes such as energy metabolism, starch synthesis, nitrate reduction, photosynthesis, and sugar degradation (Almeida *et al.*2015; Hussain *et al.*2016; White and Karley 2010; Yang *et al.*2015). Maize response to applied potassium, however, found to vary considerably across soil types (Csatho 1992), availability of potassium in soils (Kapur *et al.*1984) and season (Prasad and Shrivastava 1992). The available information on maize response to applied potassium suggests for the need to conduct experiments to workout site specific potassium recommendation to maize crop.

KSB can solubilize K - bearing minerals and solubilize insoluble K2O soluble forms of K available to plant uptake. It has general plant growth promoting characters like hormone production, biological nitrogen fixation, root colonization, micro nutrient solubilizing (Zn, Fe), it has biotic and a biotic stress tolerance induction (catalyse activity, antibiotic production, anti - oxidants production) and also produces organic acids. KSB application to the soil get activated and multiply by utilizing the carbon source of soil or excudates of the root and in this process secrete organic acids and enzymes. It provides benefits to plants by forming nodules on host plants roots and fix nitrogen, those that are endophytic and colonize effects in host by competitively plant root surface.

Plant growth by Direct action mechanisms by either providing plants with resources/nutrients regulating hormones levels of plants. Indirectly decreasing effects of

various pathogens on plants as bio - control agents. (KSR) potassium solubilizing rhizobacteria can also solubilize minerals and play important role in weathering of these minerals which results in plant growth promotion leading to enhance and yield production. Potassium solubilizing bacteria microorganisms can be isolated by serial dilution method by using Aleksandrov medium. Field studies to see the effect of potassium and KSB application on maize.

2. Material and Methods

This experiment was carried out during *Kharif* 2020 at KVK, Prakasam Krishi Vigyan Kendra, Jammikunta, Karimnagar Dist, Telangana State, which is located an altitude of 243.4 m above mean sea level on 18º301'301" N latitude and 79º471'478" E longitude, organic carbon (0.62), available nitrogen (197.12 kg/ha), phosphorus (31.2 kg/ha) and potassium (198.71 kg/ha). The climate of the region is semi - arid subtropical.

The experiment was laid out in Randomized Block Design. The treatments consist of Potassium Levels and Potassium Solubilizing Bacteria (Frateuria Aurentia) where two Potassium levels of treatments (20 gm and 40 gm) and two KSB levels of treatments are applied as soil application (20 ml/kg of soil, 30 ml/kg soil) and two KSB levels of treatments are applied as Seed Inoculation (20 ml/kg of seed, 30 ml/kg of seed) was used. The treatments comprised of T1 - K2O 20 gm + Soil application 30 ml of KSB/kg soil, T2 - K2O 40 gm + Soil application 20 ml of KSB/kg soil, T3 - K2O 20 gm + KSB 30 ml/kg soil (SA) + KSB 20 ml/kg seed (SI), T4 - K2O 40 gm + KSB 20 ml/kg soil (SA) + KSB 20 ml/kg seed (SI), T5 - K2O 20 gm + KSB 30 ml/kg soil (SA) + KSB 30 ml/kg seed (SI), T6 - K2O 40 gm + KSB 20 ml/kg soil (SA) + KSB 30 ml/kg seed (SI), T7 - K2O 20 gm + Seed inoculation 20 ml of KSB/kg seed, T8 - K2O 40 gm + Seed inoculation 20 ml of KSB/kg seed, T9 - K2O 20 gm + Seed inoculation 30 ml of KSB/kg seed, T1 - K2O 40 gm + Seed inoculation 30 ml of KSB/kg seed. There are ten treatments replicated thrice during *kharif* season 2020.

Crop management

Maize variety (DHM 117) sown at the rate of 20 kg/ha. This variety is tolerant to lodging. Seed of this variety are flint orange - yellow in colour and are Nutritive response. It is 90 - 100 days duration crop. It is non - lodging with high yielding potential. The recommended dose of fertilizer 150: 60: 40 NPK kg/ha. The nutrient sources were Urea, DAP, MOP, KSB. Whole of phosphorus, potash and half dose of nitrogen were applied as basal at the time of sowing and remaining half dose of nitrogen was top dressed as urea at 30 DAS and KSB 30 ml and 20 ml soil application at the time of sowing. The first irrigation was given after 6 DAS; second irrigation was applied 24 days after first irrigation to ensure better germination. Weeding was done to done to control grass as well as broad leaf weeds from the field in order to check any form of initial crop - weed competition and which also checks the spread of diseases. Hand weeding was done manually with Khurpi after 38 DAS.

Statistical Analysis

The data recorded were different characteristics were subjected to statistical analysis by adopting Fishers the method of Analysis of Variance (ANOVA) as described by Gomez and Gomez (2010). Critical Difference (CD) values were calculated the F test was found significant at 5% level.

3. Results and Discussion

Effect of potassium levels and potassium solubilizing bacteria on Plant height (cm) of Maize

Observation regarding the plant height of maize given in the Table.1 there was an increasing in crop age plant height which was progressively increased with the advancement of crop during the experimentation. The analysis on plant height was found to be significantly higher in all the different growth intervals with the application of plant growth regulators and micronutrient. At harvest, highest and significant plant height (243.33 cm) was recorded with application of T6 – K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) which was significantly superior over all other treatments except K2O 20 gm + KSB 30 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) with (236.33 cm), K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 20 ml/ kg Seed (SI) with (232.00 cm) and K2O 20 gm + Seed inoculation 30 ml of KSB/ kg Seed (226.00 cm) was found to be statistically at par K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI). Archana *et al. (*2008) in maize that KSB is able to solubilize inorganic source of K like muriate of potash and sulphate by means of production of organic acids in order to improve yield leads to an increase of plant height as compared to control in both seasons i. e., *kharif* and *rabi*. The increase in plant height is due to Maurya *et al. (*2014) that KSB can provide beneficial effects of plant growth suppressing pathogens and improving soil nutrients.

Effect of potassium levels and potassium solubilizing bacteria on Dry matter production (g/plant) of Maize

Observations regarding the dry matter accumulation (g/plant) of maize are given in the Table.1 and data showed an increasing tendency from 20 DAS to at harvest. At harvest maximum dry matter production (258.33 g/plant) was recorded with application of K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) which was significantly superior over all other treatments except with application of K2O 20 gm + KSB 30 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) is (350.59 gm) and K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 20 ml/ kg Seed (SI) is (341.67 gm). Which are statistically at par with K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI). Maize dry matter production significantly increased by increasing concentration to increase in growth of maize plant that certain bacteria, weather silicate aluminum and secrete bio - active materials to enhance plant growth. These bacteria are widely used in biological K - fertilizers and biological leaching by Meena *et al. (*2013). There showed significant increase in number of leaves and grain yield, root and shoot dry weight compared to uninoculated control by Prajapati *et al. (*2016) by greater solubilization of mineral form of K.

Effect of potassium levels and Potassium solubilizing bacteria on Days taken to Tasseling and silking of Maize:

Observations regarding the Days taken to Tasseling and Silking of maize are given in the table.2 and data showed an

early maturity from 40 to 60 DAS and thereafter, it decreased. Number of days taken to reach 50 per cent tasseling stage was not significantly affected by the treatment levels. The treatment K2O 40gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) has less number of days (41.17 days) to reach 50 per cent tasseling the treatment K2O 20 gm + Seed inoculation 20 ml of KSB/ kg Seed, taken more number of days (49.27 days) for 50 per cent tasseling stage. The treatment K2O 40 gm + KSB 20ml/kg Soil (SA) + KSB 30ml/kg Seed (SI) has less number of days (47.65days) to reach 50 percent tasseling of treatment K2O 20gm + Seed inoculation 20ml of KSB/kg Seed, taken more number of days (55.80 days) for 50 per cent tasseling stage. days to tasseling and silking delayed by higher rate of application of potassium and KSB levels on maize and by Khadem *et al. (*2010) resulted that tasseling were appeared earlier with the application of potassium while delayed in treatment where low rate of potassium is applied.

Table 1: Effect of potassium levels and potassium solubilizing bacteria on Growth attributes of Maize at different day intervals

Plant height (cm)					Dry matter accumulation (g/m2)				50%	50%
Treatments	20 DAS	40 DAS	60 DAS	80 DAS	20 DAS	40 DAS	60 DAS	80 DAS	Tassel- ing	Silking
K_2O 20 gm + Soil application 30ml of KSB/kg soil	34.00	75.67	161.00	208.33	26.33	130.67	242.67	325.00	43.10	49.03
K2O 40 gm + Soil application 20ml of KSB/kg soil	36.67	83.00	159.33	207.33	23.33	240.33	240.33	318.62	42.90	48.50
K2O 20 gm + KSB 30ml/kg soil (SA) +KSB20ml/kg seed (SI)	31.33	76.33	158.33	221.33	29.33	237.67	237.67	329.59	43.60	48.37
K2O 40 gm + KSB 20ml/kg soil (SA) +KSB20ml/kg seed (SI)	36.33	93.33	167.67	232.00	31.33	254.33	254.33	341.67	42.13	49.00
K2O 20 gm + KSB 30ml/kg soil (SA) +KSB30ml/kg seed (SI)	40.00	88.33	171.00	236.33	32.00	257.33	257.33	350.59	41.53	47.80
K2O 40 gm + KSB 20ml/kg soil (SA) +KSB30ml/kg seed (SI)	41.33	98.67	181.67	243.33	36.00	266.00	266.00	358.33	41.17	47.65
K2O 20 gm + Seed inoculation 20 ml of KSB/kg seed	29.33	75.33	155.00	195.33	18.00	230.67	230.67	310.33	49.27	55.80
K2O 40 gm + Seed inoculation 20 ml of KSB/kg seed	30.00	81.33	161.67	212.73	22.67	234.00	234.00	320.62	49.00	55.33
K2O 20 gm + Seed inoculation 30 ml of KSB/kg seed	32.00	80.33	162.00	226.00	25.00	240.33	240.33	323.26	49.00	55.30
K2O 40 gm + Seed inoculation 30 ml of KSB/kg seed	32.00	79.67	164.33	223.00	24.67	239.33	239.33	326.15	49.20	54.93
SEm (±)	1.92	5.01	6.69	6.69	1.45	4.25	7.07	9.59	2.616	2.762
CD (P=0.05)	5.73	14.89	19.90	19.90	4.31	12.63	21.02	28.40	NS	NS

Blanket application of RDF (150: 60: 40 NPK kg/ha)
NOTE: SA - (SOIL APPLICATION), SI - (SEED INOCULATION)

Performance of plant growth regulators and micronutrients on yield attributes and yield of Maize

The data presented on yield attributes and yield of Maize were statistically analyzed and have been presented in Table.2. The maximum number of cobs per plant (1.77) was recorded with application of K2O 40 gm+ KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI), which was significantly superior over all other treatments except with the application of K2O 20 gm + KSB 30 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) is (1.67) and K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 20 ml/kg Seed (SI) is (1.53). Maximum number of grains per cob (586.72) was recorded with application of K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI), which was significantly superior over all other treatments except with application of K2O 20 gm + KSB 30 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) is (571.01). Maximum No. of grains per row (36.67) was recorded with application of K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) which was statistically significant over all other treatments except with the application of K2O 20 gm + KSB 30 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) is (36.44) and K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 20 ml/ kg Seed (SI) is (34.02). Maximum number of rows per cob (16.00) was recorded with application of K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI), which was significantly superior over all other treatments except with application of K2O 20 gm + KSB 30 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) is (15.67) and K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 20 ml/ kg Seed (SI) is (15.33), which was statistically at par with K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI). Maximum seed index (44.00g) was recorded with application of which was significantly superior over all other treatments except with application of K2O 20 gm + KSB 30 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) is (42.00) and K2O 40 gm + Soil application 20 ml of KSB/ kg Soil is (42.00), which were statistically at par with K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI). Maximum grain yield (5.78 t/ha) was recorded with application of K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI), which was significantly superior over all other treatments except with application of K2O 20 gm + KSB 30 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) is (5.57 t/ha), K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 20 ml/ kg Seed (SI) is (5.41 t/ha) and K2O 20 gm + KSB 30 ml/ kg Soil (SA) + KSB 20 ml/ kg Seed (SI) is (5.39 t/ha) which were statistically at par with K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI).

We observed that application of 45 kg K2O/ha + KSB seed inoculation + KSB soil application (K3) and 45 kg K2O/ha + KSB seed inoculation (K2) over control (K0) by K. P. Ghetiya *et al. (*2018) that treatment was significantly increase number of grain rows/cob, grain weight/cob (78.17 g), 100 grain weight (21.09) at 30 DAS and 60 DAS and KSB enhanced grain yield and saving 25% fertilizer dose of potash. Showed higher number of cobs per plant, grain weight of cobs, shelling percentage of grains was maximum recorded similar observations also recorded by (Panwar and Singh 2000). This can be attributed to higher grain yield and straw yield recorded with comparatively lesser cost than additional income under these treatments.

Table 2: Effect of potassium levels and potassium solubilizing bacteria on yield attributes and yield of Maize

Treatments	Cobs/ plant (No.)	Grains/ cob (No.)	Grains/ row (No.)	Rows/ cob (No.)	Seed index (g)	Grain yield (t/ha)	Stover yield (t/ha)
K2O 20 gm + Soil application 30ml of KSB/kg soil	1.40	454.67	31.07	14.67	38.00	4.87	9.96
K2O 40 gm + Soil application 20ml of KSB/kg soil	1.47	468.67	31.80	14.73	42.00	4.70	9.66
K2O 20 gm + KSB 30 ml/kg soil (SA) + KSB 20 ml/kg seed (SI)	1.33	491.89	32.78	15.00	40.03	5.39	10.62
K2O 40 gm + KSB 20 ml/kg soil (SA) + KSB 20 ml/kg seed (SI)	1.53	533.04	34.02	15.67	40.00	5.41	10.74
K2O 20 gm + KSB 30 ml/kg soil (SA) + KSB 30 ml/kg seed (SI)	1.67	580.04	36.44	15.92	42.00	5.57	12.00
K2O 40 gm + KSB 20 ml/kg soil (SA) + KSB 30 ml/kg seed (SI)	1.77	586.67	36.67	16.00	44.00	5.78	12.03
K2O 20 gm + Seed inoculation 20 ml of KSB/kg seed	1.20	404.27	31.07	13.00	34.00	4.45	9.61
K2O 40 gm + Seed inoculation 20 ml of KSB/kg seed	1.40	440.93	31.51	14.00	36.03	4.76	9.70
K2O 20 gm + Seed inoculation 30 ml of KSB/kg seed	1.27	444.74	31.68	14.05	38.03	4.66	9.89
K2O 40 gm + Seed inoculation 30 ml of KSB/kg seed	1.33	481.43	32.94	14.67	38.00	4.61	9.99
SEm (±)	0.08	17.05	0.96	0.47	1.28	0.29	0.60
CD (P=0.05)	0.24	50.66	2.85	1.14	3.82	0.86	NS
Blanket application of RDF - 150: 60: 40 NPK kg/ha NOTE: SA - (SOIL APPLICATION), SI - (SEED INOCULATION)							

4. Conclusion

On the basis of one season experimentation, it is concluded that treatment with application of T6 – K2O 40 gm + KSB 20 ml/ kg Soil (SA) + KSB 30 ml/ kg Seed (SI) was found to be more productive (5.78 t/ha) for receiving of higher yield of Maize.

5. Acknowledgement

The authors are thankful to (KVK) Prakasam Krishi Vigyan Kendra, Jammikunta, Karimnagar Dist, Telangana – 505 722, India for providing field, necessary facilities and assistance in conducting this research.

References

[1] Archana, D. S., Savalgi, V. P. and Alagawadi, A. R.2008, Effect of potassium solubilizing bacteria on growth and yield of maize. *Soil Biology and Ecoligy*, **28 (**1 - 2): 9 - 18

[2] Bakhshandeh, F., Pirdashti, H. and Lendeh, K. S. (2017). Phosphate and potassium - solubilizing bacteria effect on the growth of rice. *Ecological Engineering*, **103**, 164 - 169.

[3] Basavesha, K. N.2013. Studies on bacteria solubilizing both potassium and phosphorus and their effect on maize (*Zea mays* L.). *M. Sc. Thesis*. UAS, Dharwad.

[4] Basavesha, K. N., Savalgi, V. P., Sreenivasa, M. N. and Manjunatha. H.2016. Impact of bacteria solubilizing both potassium and phosphorus on growth and yield of maize (*Zea mas L.). Research in Environment and life sciences* **9** (4) 464 - 465.

[5] Chishi, K. Y. (2010) Studies on dual inoculation of potassium solubilizing bacteria and phosphorus solubilizing bacteria on growth and yield of maize (*Zea mays* L.) (Doctoral dissertation, UAS, Dharwad).

[6] Gajendra, M. and Bihari, R. M.2017. Potentiality of Potassium Solubilizing Bacteria on Enhancing the Growth, Yield and Nutrient Acquisition on Wheat (*Triticum aestivum*L.). *Internationl Journal of Current Microbiology Applied Science*, **6** (4): 2443 - 2450.

[7] Murugappa, A. M. M.2007. Solubilization of potassium containing minerals by bacteria and their effect on plant growth. *World Journal of Agricultural Sciences*, **3** (3): 350 - 355.

[8] Nayak, B., 2001. Uptake of potash by different plants the use of potash mobilizing bacteria *(Fratueria Aurantia). M. Sc. (Agri.) Thesis*, Univ. Agril. Sci., Bhubaneshwar.

[9] Parmar, K. B.2016. Isolation, characterization and efficacy study of potash solubilizing bacteria in maize (*Zea mays* L.) under south Gujarat conditions. Ph. D. Thesis, Navasari Agricultural University, Navasari, Gujarat.

[10] Savalgi, V. P. (2010) Studies on dual inoculation of potassium solubilizing bacteria and phosphorus solubilizing bacteria on growth and yield of Maize (*Zea mays* L.) M. Sc. (agri.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka (India).

[11] Savaliya, N. V.2014. Response of wheat (*Triticum aestivum L.)* to phoshphate and potash solubilizing bacteria. M. Sc. (Agri.). Thesis, Junagadh Agricultural University, Junagadh, Gujarat.

[12] Sindhu, S. S., Parmar, P., Phour, M. and Sehrawat, A.2016. Potassium - Solubilizing Microorganisms (KSMs) and Its Effect on Plant Growth Improvement. In: Meena, V. S.; Maurya, B. R.; Verma, J. P. and Meena, R. S. (eds) Potassium Solubilizing Microorganisms for Sustainable Agriculture. Springer, New Delhi, pp.171 - 185.

[13] Sugumaran, P. and Janarthanam, B.2007. Solubilization of potassium containing minerals by bacteria and their effect on plant growth. *World Journal of Agricultural Sciences*, **3** (3): 350 - 355.

[14] Supanjani, Han, H. S., Jung, S. J. and Lee, K. D.2006, Rock phosphate, potassium and rock solubilizing bacteria as alternative sustainable fertilizers. *Agronomy for Sustainable Development*, **26** (1): 233 - 240.

[15] Yallappa, M., Savalgi, V. P., Shruthi, P., Arpitha, P. S. and Hullur, N. (2015) Effect of dual inoculation of potassium solubilizing bacteria and phosphorus solubilizing bacteria on micro biological changes, enzyme activity inrhizosphere of maize. *Journal of Pure and Applied Microbiology*, **9** (4), 3125 - 3131.

[16] Yallappa, M., Savalagi, V. P. and Shruthi, P.2016. Effect of Dual Inoculation of Potassium Solubilizing Bacteria and Phosphorus Solubilizing Bacteria on Nutrient Content in Maize Crop. *Trends in bioscience*.8 (16): 4402 - 4405.