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Effect of different potassium solubilizing microbial inoculants on chemical properties of soil

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Abstract
Increasing cost of the fertilizers with lesser nutrient use efficiency necessitates alternate means to fertilizers. Soil microorganisms play a significant role in number of chemical transformations of soils and thus, influence the availability of macro- and micronutrients. The efficacy of different microbial strains for improving plant nutrient availability in soil was tested in this study. Treatments including nine microbial strains along with recommended dose of fertilizers and one control in three replications were used. Results indicated that inoculation with *Pseudomonas* sp (KSB-PD-1-A) along with RDF of NPK followed by *Pseudomonas* sp (KSB-M-1) were found considerably effective in enhancing soil chemical properties.

Keywords: Soil chemical properties, microbial inoculants, KSB

Introduction
Among the three major essential nutrient required by plants, one of them is potassium. It is involved in numerous biochemical and physiological processes in plants like stomatal regulation for plants depend upon K to regulate the opening and closing of stomata. The activation of enzymes by potassium and its involvement in adenosine tri phosphate (ATP) production is important in regulating the rate of photosynthesis; sugars produced in photosynthesis must be transported through the phloem to other parts of the plants for utilization and storage. The plants transport system uses energy in the form of ATP if K is inadequate, less ATP is available, transport system breaks down. The enzyme responsible for synthesis of starch is activated by K, hence it plays crucial role in water and nutrient transport (Pettigrew, 2008) [10].

K is present in several forms in the soil, including mineral K, non-exchangeable K, exchangeable K, and solution K. Interrelationships of various forms of soil K are shown in Figure 1. Depending on soil type, from 90 to 98% of soil K is mineral K and most of this K is unavailable for plant uptake (Sparks and Huang, 1985) [15]. Minerals containing K are feldspar (orthoclase and microcline) and mica (Biotite and muscovite). The non-exchangeable form of K makes up approximately 1 to 10% of soil K and is trapped between the layers or sheets of certain kinds of clay minerals (Sparks, 1987) [14]. Solution K is the form of K that directly and readily is taken up by plants and microbes in soil. In addition, this form is most subject to leaching in soils. The concentration of soil solution K varies from 2 to 5 mg l–1 for normal agricultural soils (Sparks and Huang, 1985) [15].

It is proven that microbial soil community is able to influence soil fertility through soil processes *viz*. decomposition, mineralization, and storage / release of nutrients (Parmar and Sindhu, 2013) [9]. It was reported that some beneficial soil microorganisms, a wide range of saprophytic bacteria, fungal strains and actinomycetes, could solubilize the insoluble K to soluble forms of K by various mechanisms including production of inorganic and organic acids, acidolysis, polysaccharides, complexolysis, chelation, polysaccharides, and exchange reactions.

Among these microorganisms, K solubilizing bacteria (KSB) have attracted the attention of agriculturists as soil inoculum to promote the plant growth and yield. The KSB are effective in releasing K from inorganic and insoluble pools of total soil K through solubilization (Zeng *et al*., 2012; Zhang *et al*., 2013) [18, 19].

Materials and Methods
One pot culture soil experiment was carried out to study Potassium solubilization potential of

different microorganisms. For this purpose potassium deficient soil was used in pot culture experiment, brinjal used as test crop. Experiment consists of ten treatments in which microbial cultures and recommended dose of NPK was given as per treatments given below.
T_1: Only RDF (50:50:50 NPK kg ha^{-1})
T_2: RDF + KSB-W1 (*Bacillus* sps)
T_3: RDF + KSB-PD-3-A (*Bacillus* sps)
T_4: RDF +KSB-NP-3 (*Bacillus* sps)
T_5: RDF +KSB-PD-1-A (*Pseudomonas* sps)
T_6: RDF + KSB-M-1(*Pseudomonas* sps)
T_7: RDF +KSB-M-2 (*Pseudomonas* sps)
T_8: RDF + KSB-PD (*Sinorhizobium metallidans*)
T_9: RDF + KSB-PD-1-B (*Sinorhizobium metallidans*)
T_{10}: RDF + KSB-M-3 (*Sinorhizobium metallidans*)

Collection and preparation of soil samples
Soil samples were collected from each pot at fruit development and harvesting stage. The collected soil samples were thoroughly mixed and brought to the laboratory, air dried and sieved through 2 mm sieve, for analyzing pH, EC, organic carbon, calcium carbonate, available N, P, K and micronutrients (Zn, Fe, Cu and Mn). The sieved samples were stored in polythene bags with proper labeling for subsequent analysis. All the precaution was followed in the estimations such as use of A.R. grade chemicals, uncontaminated glass wares and use of double distilled water as suggested by Jackson (1973) [5].

Chemical analysis of soil
Soil pH
Hydrogen ion activity expressed as pH was measured on digital pH meter using 1:2.5 (soil: water) suspension (Jackson, 1973) [5].

Electrical conductivity
The clear supernatant obtained from the suspension used for pH was utilized for the EC measurement using digital electrical conductivity meter (Jackson, 1973) [5].

Organic carbon
Organic carbon in soil was estimated by Walkley and Black's rapid titration method as described by Piper (1966) [11].

Calcium carbonate
Rapid titration method was used to determine the calcium carbonate content in soil as described by Jackson (1973) [5].

Available nitrogen
It was estimated using alkaline permanganate method as suggested by Subbiah and Asija (1956) [16].

Available phosphorus
It was determined by using 0.5 M sodium bicarbonate as an extractant as outlined by Olsen *et al*., (1954) [8].

Available potassium
It was determined by using neutral normal ammonium acetate as an extractant and measured on flame photometer (Piper, 1966) [11].

Available micronutrients (Zn, Fe, Mn, Cu)
DTPA extractable zinc, iron, manganese and copper in soil were estimated as per procedure described by Lindsay and Norvell (1978) [6] on Atomic Absorption Spectrophotometer (AAS) at different specified wavelengths.

Results and Discussion
Soil pH
There was a marginal decline in rhizosphere soil pH with different potassium solubilizing microbial strains as compared to uninoculated control in brinjal crop. Periodical changes in soil pH were noticed after sowing till harvest. Soil pH was declined from 90 days till to the harvest. Among the KS microbial strains, *Pseudomonas sp* (KSB-PD-1-A) (7.79) and *Pseudomonas sp* (KSB-M-1) (7.81) acidify the rhizosphere soil to a greater extent and significantly declined pH as compared to other KS strains and uninoculated control (7.92). Soil pH was significantly decreased at harvest while the effect was not significant. Similar decline in rhizosphere pH with the inoculation of potassium solubilizing strains was previously reported by Zhang and Kong (2014) [20] who noticed that inoculation with KSB decreased soil pH value and increased the available K content. Whereas, Sangeeth *et al*., (2012) [13] also proposed that the pH of inoculated mixture with addition of ash was low, the K content was high. This may be due to the secretion of organic acids by the bacterial strains, there by enhanced the plant growth and nutrient uptake (Basak and Biswas, 2010) [4].

Electrical conductivity of soil
Electrical conductivity indicates total soluble salts in the soil solution (Table 1). There was only slight variation in the EC due to potassium solubilizing microbial inoculation and crop growth. Electrical conductivity was slightly increased with increasing age of crop till harvest (0.249-0.259 dSm^{-1}). Electrical Conductivity of soil ranged from 0.223–0.280 dSm^{-1} and 0.240 – 0.280 dSm^{-1} at flowering and harvest stage of crop, respectively. The electrical conductivity was found statistically non-significant at all the sampling stages.

Table 1: Effect of potassium solubilizing microbial inoculants on soil pH and EC

Treatment	Soil pH		EC (dSm^{-1})	
	90 DAT	150 DAT	90 DAT	150 DAT
T_1: Uninoculated control	7.92	7.89	0.25	0.26
T_2: RDF + *Bacillus sp* (KSB-W1)	7.89	7.88	0.25	0.26
T_3: RDF + *Bacillus sp* (KSB-PD-3-A)	7.84	7.83	0.23	0.24
T_4: RDF + *Bacillus sp* (KSB-NP-3)	7.88	7.87	0.24	0.26
T_5: RDF + *Pseudomonas sp* (KSB-PD-1-A)	7.79	7.78	0.25	0.25
T_6: RDF + *Pseudomonas sp*(KSB-M-1)	7.82	7.81	0.28	0.28
T_7: RDF + *Pseudomonas sp* (KSB-M-2)	7.84	7.83	0.25	0.27
T_8: RDF + *Sinorhizobium metallidans* (KSB-PD)	7.87	7.87	0.26	0.27
T_9: RDF + *Sinorhizobium metallidans* (KSB-1-B)	7.86	7.85	0.26	0.27
T_{10}: RDF + *Sinorhizobium metallidans* (KSB-M-3)	7.87	7.87	0.22	0.26
GM	7.68	7.85	0.24	0.26

SE+	0.020	0.020	0.010	0.007
CD at 5%	NS	NS	NS	NS
CV %	0.52	0.48	8.14	6.10
Initial	7.98		0.245	

Organic carbon content in soil

There was an increase in the organic carbon content in the KS microbial inoculated rhizosphere soil (Table 2). Organic carbon content in soil increased with increasing crop growth (5.38 to 5.50 g kg^{-1}). At flowering and harvesting stage of crop, organic carbon content in soil was ranged from 4.43-6 g kg^{-1}, and 4.63-6.2 g kg^{-1}. Significantly highest value of organic carbon was obtained with potassium solubilizing *Pseudomonas sp* (KSB-PD-1-A) *viz.*, 6.00 and 6.20 g kg^{-1} in soil at different intervals and it is on par with *Pseudomonas sp*(KSB-M-1) (5.87 and 6.1 g kg^{-1}), *Pseudomonas sp* (KSB-M-2) (5.67 and 5.90 g kg^{-1}), *Bacillus sp* (KSB-PD-3-A) (5.63 and 5.73 g kg^{-1}) and *Sinorhizobium metallidans* (KSB-1-B) (5.47 and 5.73 g kg^{-1}) Whereas, minimum value was noticed in uninoculated treatment 4.43 and 4.63 g kg^{-1} at various sampling stages. Our results also shows that due to inoculation of microbial cultures, there was increasing organic carbon content in respective treatments as compared to initial values over the control. It might be due to creation of favorable condition for the growth of soil micro-organisms, root biomass *etc*. Experimental results are in agreement with the findings of Bagyalakshmi *et al.*, (2012) [3] who observed that soil organic carbon values were increased from 5.2% (Control) to 8.2% (inoculated with KSB).

Table 2: Effect of different potassium solubilizing microbial inoculants on organic carbon and calcium carbonate content in soil

Treatment	Organic Carbon(g kg^{-1})		Calcium Carbonate(g kg^{-1})	
	90 DAT	150 DAT	90 DAT	150 DAT
T_1: Uninoculated control	4.43	4.63	54.33	54.67
T_2: RDF + *Bacillus sp* (KSB-W1)	4.83	4.93	53.33	54.00
T_3: RDF + *Bacillus sp* (KSB-PD-3-A)	5.63	5.73	48.67	48.67
T_4: RDF + *Bacillus sp* (KSB-NP-3)	5.23	5.17	53.00	54.33
T_5: RDF + *Pseudomonas sp* (KSB-PD-1-A)	6.00	6.20	47.33	48.33
T_6: RDF + *Pseudomonas sp*(KSB-M-1)	5.86	6.10	48.67	49.33
T_7: RDF + *Pseudomonas sp* (KSB-M-2)	5.67	5.90	49.00	50.33
T_8: RDF + *Sinorhizobium metallidans* (KSB-PD)	5.37	5.37	52.00	51.00
T_9: RDF + *Sinorhizobium metallidans* (KSB-1-B)	5.47	5.73	51	52.67
T_{10}: RDF + *Sinorhizobium metallidans* (KSB- M-3)	5.37	5.27	52.33	53.00
GM	5.38	5.50	50.97	51.63
SE+	0.17	0.14	1.36	1.35
CD at 5%	0.57	0.43	NS	NS
CV %	6.27	5.24	5.34	5.24
Initial	4.23		54.60	

Calcium carbonate content in soil

Calcium carbonate content in soil was significantly influenced by the application of different potassium solubilizing microbial strains (Table 2). Calcium carbonate content values in soil were varied from 47.33-54.33g kg^{-1} and 48.33-54.67 g kg^{-1} at flowering and harvesting stage respectively. The highest $CaCO_3$ content was found in treatment T_1 (54.33 and 54.67 g kg^{-1}) in uninoculated control. Whereas, lowest was recorded in treatment T_5 (47.33 g kg^{-1}) at 90 DAT and T_5 (48.33 g kg^{-1}) at harvest stage of crop. Non-significant differences were found at flowering and harvesting stage of crop.

Available nitrogen content in soil

The available N content in soil was decreased from flowering (0.091 g kg^{-1}) to harvesting stage (0.089 g kg^{-1}) of crop (Table 3). Available N content in soil at 90 and harvest stage was varied from 0.080 – 0.100 and 0.081 – 0.097 g kg^{-1}, respectively. At different sampling intervals, KSB *Pseudomonas sp* (KSB-PD-1-A) treated soil noticed significantly highest N content in soil (0.1003and 0.097 g kg^{-1}) followed by *Pseudomonas sp* (KSB-M-1) (0.099 and 0.095 g kg^{-1}), *Pseudomonas sp* (KSB-M-2) (0.097and 0.094 g kg^{-1}) and *Bacillus sp* (KSB-PD-3-A) (0.096 and 0.091) and treatments were found to be at par with each other. Whereas, minimum available N content (0.080 g kg^{-1} and 0.0.081 g kg^{-1}) was found in uninoculated control at various sampling intervals.

The availability of mineral N in the soil at a particular time during crop growth may be affected by many factors, including crop growth itself. Experimental results are corroborated with the findings of Bagyalakshmi *et al.*, (2012) [3] they reported that soil from the potassium solubilizing microbe's inoculated treatment shows highest nitrogen content over control.

Available phosphorus content in soil

Inoculation of different potassium solubilizing microbial strains enhanced available P content in soil as compared to control (Table 3). Periodical changes in available P content in soil were recorded. P content in soil was decreased from flowering to harvesting stage (0.0049-0.0048 g kg^{-1}) of crop. The maximum build-up of available P was obtained with the inoculation of *Bacillus sp* (KSB-PD-3-A) treated soil (0.0054 and 0.0053 g kg^{-1}) followed by *Pseudomonas sp* (KSB-PD-1-A) (0.0052 and 0.0051 g kg^{-1}) and *Pseudomonas sp* (KSB-M-2) (0.0052and 0.0050 g kg^{-1}) and treatments were found to be at par with each other and minimum available P content was recorded with uninoculated control (0.0037 and 0.0036 g kg^{-1}).

Table 3: Effect of different potassium solubilizing microbial inoculants on macro nutrient availability in soil

Treatments	Available N (g kg^{-1})		Available P_2O_5 (g kg^{-1})		Available K_2O (g kg^{-1})	
	90 DAT	150 DAT	90 DAT	150 DAT	90 DAT	150 DAT
T_1: Uninoculated control	0.080	0.081	0.0037	0.0036	0.306	0.302
T_2: RDF + *Bacillus sp* (KSB-W1)	0.085	0.084	0.0048	0.0046	0.309	0.308
T_3: RDF + *Bacillus sp* (KSB-PD-3-A)	0.096	0.091	0.0054	0.0053	0.367	0.365
T_4: RDF + *Bacillus sp* (KSB-NP-3)	0.086	0.083	0.0048	0.0047	0.326	0.324
T_5: RDF + *Pseudomonas sp* (KSB- PD-1-A)	0.100	0.097	0.0052	0.0051	0.375	0.371
T_6: RDF + *Pseudomonas sp* (KSB-M-1)	0.099	0.095	0.0050	0.0049	0.373	0.370
T_7: RDF + *Pseudomonas sp* (KSB-M-2)	0.097	0.094	0.0052	0.0050	0.372	0.369
T_8: RDF + *Sinorhizobium metallidans* (KSB-PD)	0.089	0.087	0.0049	0.0048	0.355	0.341
T_9: RDF + *Sinorhizobium metallidans* (KSB-1-B)	0.096	0.090	0.0050	0.0049	0.357	0.352
T_{10}: RDF + *Sinorhizobium metallidans* (KSB-M-3)	0.086	0.086	0.0048	0.0047	0.326	0.326
GM	0.091	0.089	0.0049	0.0048	0.346	0.343
SE±	0.001	0.001	0.0001	0.0004	0.004	0.003
CD at 5%	0.004	0.003	0.0005	0.0012	0.013	0.011
CV %	2.807	1.950	5.9764	5.8445	2.363	2.056
Initial	0.079		0.0037		0.297	

The increased availability of P with microbes could be ascribed to their solubilizing effect on the native insoluble P fractions through release of various organic acids, thus resulting into a significant improvement in available P status of the soil. Our results are also in consonance with the reports of Maity *et al*., (2014) [7] as they reported that the increase in K and P uptake by pomegranate plants might be attributed to the mobilization of insoluble sources of K and P in soil by the inoculated fungal strain in response to addition of K- feldspar which was reflected by the enhancement of soil available K and P content. Higher dehydrogenase, alkaline and acid phosphatase activity in inoculated soil might have contributed to greater mobilization of K and P than un-inoculated soil. Sugumaran and Janardhanam (2007) [17] also reported that available phosphorus content were more in bacteria inoculated plots than control.

Available potassium content in soil

Perusal of the data on available K content in soil (Table 3) indicated increase in available K in potassium solubilizing microbial inoculated treatments as compared to uninoculated control. K availability in soil seems to be decreased from 90 DAT (0.346-0.343 g kg^{-1}) till harvest. Available K content in soil was ranged between 0.306-375 and 0.302-0.371 g kg^{-1} at 90 and harvest stage, respectively. The maximum build-up of available K was obtained with the inoculation of *Pseudomonas sp* (KSB-PD-1-A) treated soil (0.375 and 0.371 g kg^{-1}) followed by *Pseudomonas sp*(KSB-M-1) (0.373 and 0.370 g kg^{-1}), *Pseudomonas sp* (KSB-M-2) (0.372 and 0.369 g kg^{-1}) and *Bacillus sp* (KSB-PD-3-A)(0.367 and 0.365) and treatments were found to be at par with each other and minimum available K content was recorded with uninoculated control (0.306 and 0.302 g kg^{-1}). *Pseudomonas sp* (KSB-PD-1-A) treated soil recorded 22.85% higher K content over uninoculated soil.

Our results are also confirmed with the findings of Sheng *et al*., (2005) [21], they reported that due to inoculation of effective strains *Bacillus edaphicus* have significantly increased the K content in rhizosphere soil. Further, Zhang and Kong (2014) [20] concluded that inoculation with KSB decreased soil pH value and increased available K content in soil. The most possible reason is that the inoculation of silicate dissolving bacteria accelerated the transformation of non-available forms of K into an available one (Badr *et al*., 2006) [2]. Badr *et al*., (2006) [2] also reported that water soluble and exchangeable K increased significantly when mica was inoculated with *Bacillus mucilaginosus* strain, which can be attributed to solubilization of non-exchangeable and structural K by the microbe through production of organic acids. Coinoculation of PSB and KSB strains synergistically solubilized the rock P and K materials which were added into the soil and made them more available to the plant. This led to the promotion of their uptake and plant growth (Han and Lee, 2005) [22].

DTPA zinc availability of soil

Different potassium solubilizing microbial inoculants had their significant effect on soil DTPA Zn over control which was analysed periodically (Table 4). DTPA Zn in soil was found to be decreased from 90 DAT to harvest (0.89-0.85 mg kg^{-1}) stage of crop. The highest build-up of soil DTPA Zn was noticed under *Pseudomonas sp* (KSB-PD-1-A) (1.15 and 1.00 g kg^{-1}) and followed by *Pseudomonas sp* (KSB-M-1) (1.03 and 0.96 mg kg^{-1}), *Pseudomonas sp* (KSB-M-2) (0.97 and 0.95 mg kg^{-1}) at various sampling stages. While lowest Zn was obtained with uninoculated control (0.84 and 0.83 mg kg^{-1}) treatment. Our results are confirmed with the findings of Ramesh *et al*., (2014) [12] who observed that the inoculation of *B. aryabhattai* strains significantly increased exchangeable Zn, Mn oxide bound zinc, amorphous and crystalline sesquioxide bound Zn pools in rhizosphere soil of soybean as well as wheat crops over un-inoculated control.

DTPA iron availability in soil

Inoculation of potassium solubilizing microbial inoculants enhanced the iron content in soil as compared to initial value and control (Table 4). DTPA extractable Fe was decreased slightly from 90 DAT to harvest stage of crop (6.03-5.98 mg kg^{-1}). The highest build-up of soil DTPA Fe was noticed under *Pseudomonas sp* (KSB-PD-1-A) (6.94 and 6.89 g kg^{-1}) and followed by *Pseudomonas sp* (KSB-M-1) (6.81 and 6.78 mg kg^{-1}), *Pseudomonas sp* (KSB-M-2) (6.66 and 6.44 mg kg^{-1}) at various sampling stages. While lowest Fe was obtained with uninoculated control (5.00 and 4.92 mg kg^{-1}) treatment. Similarly, Adak *et al*., (2014) [1] reported that the three was continuous build-up of available Fe in the soil due to various treatment of bio inoculants which may be attributed to release from the organic sources because of increased microbial activities in the soil.

DTPA copper availability in soils

The copper content in soil showed significant increase under

all the KSB microbial treatments as compared to control (Table 4). DTPA copper in soil was found to be decreased with increasing growth period from flowering to harvesting (1.68 to 1.79 mg kg^{-1}). DTPA Cu was varied from 1.14-2.39 and 1.11 – 2.24 mg kg^{-1} at various growth stages.
The results shows that highest build-up of soil DTPA Cu was noticed under *Pseudomonas sp* (KSB-PD-1-A) (2.39 and 2.24 g kg^{-1}) and followed by *Pseudomonas sp* (KSB-M-1) (2.04 and 1.96 mg kg^{-1}), *Pseudomonas sp* (KSB-M-2) (1.89 and 1.77 mg kg^{-1}) at various sampling stages. While, the lowest Cu *content* values (1.14 and 1.11 mg kg^{-1}) were found in uninoculated control. Similarly, Adak *et al*., (2014) [1] reported DTPA Cu in soil increased significantly with the application of microbial inoculants.

DTPA manganese availability in soil
Data given in Table 4reveal significant build-up of DTPA manganese in soil due to addition of potassium solubilizing microorganisms. DTPA Mn in soil was decreased with increasing age of crop from 90 days (8.02 mg kg^{-1}) to harvest stage (7.85 mg kg^{-1}) of brinjal crop. All these potassium solubilising microbial strains registered increase in Mn availability in soil over control. Among KSB strains, highest build-up of soil DTPA Mn was noticed under *Pseudomonas sp* (KSB-PD-1-A) (9.04 and 8.91 g kg^{-1}) and followed by *Pseudomonas sp* (KSB-M-1) (8.90 and 8.72 mg kg^{-1}), *Pseudomonas sp* (KSB-M-2) (8.72 and 8.53 mg kg^{-1}) at various sampling stages. While lowest Fe was obtained with uninoculated control (6.57 and 6.41 mg kg^{-1}). Our results are in agreement with the findings of Adak *et al*., (2014) [1], they reported that DTPA Mn increased significantly with application of inorganic sources of NPK along with Azotobacter and *Trichoderma harzianum* + organic mulching because the microbes and organic sources played significant role in nutrient acquisition and availability in the soil which is clearly evident for the dehydrogenase activity in the soil.

Table 4: Effect of different potassium solubilizing microbial inoculants on micro nutrient availability in soil.

Treatments	DTPA Zn (mg kg^{-1})		DTPA Fe (mg kg^{-1})		DTPA Cu (mg kg^{-1})		DTPA Mn (mg kg^{-1})	
	90 DAT	150 DAT	90 DAT	150 DAT	90 DAT	150 DAT	90 DAT	150 DAT
T_1: Uninoculated control	0.84	0.83	5.00	4.92	1.14	1.11	6.57	6.41
T_2: RDF + *Bacillus sp* (KSB-W1)	0.84	0.82	5.29	5.29	1.23	1.21	6.96	6.83
T_3: RDF + *Bacillus sp* (KSB-PD-3-A)	0.93	0.90	6.49	6.42	1.76	3.33	8.57	8.48
T_4: RDF + *Bacillus sp* (KSB-NP-3)	0.85	0.83	5.46	5.38	1.42	1.39	7.27	7.11
T_5: RDF + *Pseudomonas sp* (KSB-PD-1-A)	1.15	1.00	6.94	6.89	2.39	2.24	9.04	8.91
T_6: RDF + *Pseudomonas sp* (KSB-M-1)	1.03	0.96	6.81	6.78	2.04	1.96	8.90	8.72
T_7: RDF + *Pseudomonas sp* (KSB-M-2)	0.97	0.95	6.66	6.44	1.89	1.77	8.72	8.53
T_8: RDF + *Sinorhizobium metallidans* (KSB-PD)	0.77	0.75	5.87	6.07	1.63	1.52	7.88	7.68
T_9: RDF + *Sinorhizobium metallidans* (KSB-1-B)	0.81	0.78	6.22	6.17	1.70	1.84	8.40	8.28
T_{10}: RDF + *Sinorhizobium metallidans* (KSB-M-3)	0.70	0.68	5.55	5.49	1.54	1.47	7.83	7.51
GM	0.89	0.85	6.03	5.98	1.68	1.79	8.02	7.85
SE±	0.02	0.006	0.03	0.12	0.017	0.02	0.04	0.05
CD at 5%	0.05	0.019	0.12	0.42	0.06	0.06	0.15	0.16
CV %	3.11	1.32	1.16	4.13	2.04	1.89	1.14	1.21
Initial	0.83		4.85		1.12		5.6	

Conclusion
Decline in rhizosphere soil pH with the inoculation of different potassium solubilizing microbial strains was observed as compared to initial value and control. Electrical conductivity was slightly increased with application of different potassium solubilizing strains over initial and control pot but not to the level of significance. Soil organic carbon content was increased with inoculation of microbial cultures and highest was found with treatment *Pseudomonas sp* (KSB-PD-1-A) followed by *Pseudomonas sp* (KSB-M-1), *Pseudomonas sp* (KSB-M-2), *Bacillus sp* (KSB-PD-3-A) and *Sinorhizobium metallidans* (KSB-1-B) and lowest organic carbon was observed in uninoculated pot. Whereas, calcium carbonate content in soil was found to be increased due to application of different KSB strains as compared to initial values over control.
Potassium solubilizing microbial cultures improved the soil health and nutrient availability as compared to control. 6. Available N, P, K, Zn Cu, Mn and Fe in soil were found more in treatment *Pseudomonas* sp (KSB-PD-1-A) over control.

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