

Original Research Article

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Potentiality of Potassium Solubilizing Bacteria on Enhancing the Growth, Yield and Nutrient Acquisition on Wheat (*Triticum aestivum* L.)

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ABSTRACT

Keywords

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Soil potassium supplementation relies heavily on the use of chemical fertilizer, which has a considerable negative impact on the environment. There is a growing need to turn back to nature or sustainable agents that promote evergreen agriculture. Among such natural bio-agents, the potassium solubilizing bacteria (KSB), which solubilize fixed forms of potassium (K) and increase growth, yield and nutrient uptake of wheat plant and hence Soil fertility can be restored effectively through adopting concept of integrated soil fertility management (ISFM). A pot experiment conducted to study the effect of KSB isolates in wheat plant. Soil and leaf samples were drawn from the respective plots and they were subjected for the analysis of various parameters related to nutrients and quality aspects. Plants treated with different KSB isolate without potassium fertilizer. Among various treatments five isolates were in order of KSB 107 > KSB 37> KSB 54>KSB 48>KSB 1008-4 found positive effect on growth and yield of wheat crop as well as gave better nutrient uptake.

Introduction

Potassium is one of 17 vital nutrients required for the growth and reproduction of plant. Potassium is one of the mass nutrients essential for wheat growth and development. Most of the K in soil exists in various insoluble rocks, minerals, and sedimentary materials (Goldstein, 1994). Excessive usage of fertilizers leads to the leaching of nutrients from the soil and contributes to environmental pollution, without corresponding increases in yield. In contrast, insufficient fertilizer application in countries where resources are limited results suboptimal yields. Bio-fertilizer is an alternative path to meet mineral to crop requirement, especially in case of potassium mineral because it fixed with in

soil and not easily meet to crop Although most agricultural soils have large amounts of K, these are immobilized and mostly become unavailable. Hence, very limited concentration of K is available to plants due to K deficient in soils The amount of potassium present in the soil solution is often smaller than the wheat crop requirement for potassium. With the use of K-solubilizing microbes the concentration of available K ions can be increase in the soil which may further reduce K deficiency (Barker *et al.*, 1998). There is many research has done in previous year on KSB and their working mechanism. The use of KSB as a biological fertilizer is a hotspot for the study of

agriculture and environmental conservation (Deng *et al.*, 2003). The application of organo-minerals with the combination of silicate bacteria for enhancing plant growth and yield of maize and wheat was first reported by Aleksandrov (1967). Therefore, the use of KSB in agricultural practice would not only offset the high cost of manufacturing potassic fertilizers but would also mobilize insoluble fertilizers in the soils to which they are applied. Use of phosphate bio-fertilizers decreases the detrimental effects of phosphate fertilizers on crop and soil health. Xie (1998), Archana *et al.*, (2008) reported that the KSMs was isolated from rock and rhizosphere soils of green gram (*Vigna radiata*) reported that these KSMs enhanced the solubilisation of K in acid leached soil as well as increased seedling growth and yield of green gram.

Potassium solubilizing microorganisms and their occurrence

Different bacterial species like silicate bacteria were found to dissolve potassium, silicates and aluminium from insoluble minerals (Aleksandrov, 1967) Muentz reported the first evidence of microbial involvement in solubilization of rock potassium (Muentz, 1890). Microorganisms like *Bacillus mucilaginosus*, *Aspergillus niger*, *Bacillus extroquens* and *Clostridium pasteurianum* were found to grow on muscovite, biotite, orthoclase microclase and mica *in vitro* (Archana, 2013).

Materials and Methods

KSB strain for pot application

The indigenous potassium solubilizing bacteria strain obtained from soil microbiology laboratory of Institute of Agriculture science BHU, India was selected based on prior knowledge of their higher potassium solubilization rate and production

of phytohormones (Bagyalakshmi *et al.*, 2009). The selected KSB strain was formulated using jagary as priming application and seed shown directly up to 5 cm depth in pot.

Bacterial strains

KSB isolated from potassium mining. The BHU farm soil used in this study and put in clay pot without any potassic synthetic fertilizers had been used during experiment Nitrogenous and phosphoric fertilizer used to maintain the soil fertility. Bacterial strains were cultivated on Aleksandrov medium (Hu *et al.*, 2006). The composition of Aleksandrov medium 5.0 g glucose, 0.005 magnesium sulphate ($MgSO_4 \cdot 7H_2O$), 0.1 g ferric chloride ($FeCl_3$), 2.0 g calcium carbonate, 3.0 g potassium mineral Mica (biotite), 2.0 g calcium phosphate, 20 g Agar-agar in 1000 mL of Distilled water Pot experiment. A one-year pot experiment was conducted in the Net house of institute of agriculture science of Banaras Hindu University. This site was situated at between 25^o18' North latitude and 80^o36' East longitude.

Efficiency of Potassium Solubilizing Bacteria (KSB) on Nutrient uptake, growth and yield parameters of Wheat plants under Net house

A pot culture experiment was conducted using fifteen efficient potassium solubilizing bacterial isolates which were used with recommended dose N:P:K (120:60:40) fertilizers in combination to study their effect on growth, yield, K content of Wheat as detailed below. Experiment design was CRD (Complete Randomized Design) with 15 Number of isolates with three replication in 45 pots and 3 control. Fertilizer applies in ratio of 120:60 for N and P₂O₅ respectively. Malviya 234 (HUW-234) crop variety takes in *rabi* season of 2015- 16. The isolates used

for pot culture experiment are presented in table 1.

Yield assessment

Number of leaves per plant counted and recorded by manually at 30, 45 and 60 day after sowing Plant height of wheat crop measured by meter scale from base of plant at 30, 45, 60, 75, and 90 Day after sowing. Plant chlorophyll determine by chlorophyll meter SPAD-502 MINOLTA at 30, 45 and 60 Day after sowing.

In Yield parameters Tillers which produced spike were counted manually. Spike length was measured with the help of meter scale manually after harvesting the crop. Number of spike was counted and recorded manually. Total 100 grains were randomly selected from each pot and their weight was recorded and expressed in grams. Test weight was measured with the help of electrical balance and recorded and expressed in g/plant. At maturity, plant in each pot was harvested and weighted with the help of balance and recorded total biological yield. Grains were separated by beating the ears by wooden rods and weight using electrical balance and expressed in g plant⁻¹. Straw weight was recorded with the help of electrical balance and expressed in g plant⁻¹ Harvest index was calculated with the help of formula as below;

$$\text{Harvest Index} = \frac{\text{Economic Yield}}{\text{Total Yield}} \times 100$$

Statistical analysis and interpretation of data

The raw data generated during the whole experiment were subjected to statistical analysis by following the Complete Randomized Design (CRD) with the appropriate ANOVA table. Overall significance of treatments was tested by F-test

and further comparisons were made with the critical difference (CD) at 5% degree of significance to draw the valid differences among the treatments.

Results and Discussion

Effect of potassium solubilizing bacteria on the growth and yield wheat crop

In the background of unstable fertilization, lower potash application results in a major depletion of soil potash reserves, yield loss and higher economic risk for farmers. KSB isolates that are able to dissolve potassium from mineral and rocks have influence on plant growth and have both economic and environmental advantage. Tables 2 and 3 summarize effect of potassium solubilizing bacteria on growth and yield on wheat crop under Net House condition respectively.

Maximum and significantly higher SPAD value was recorded with KSB 36 (39.76) followed by KSB 31 (39.59) compared to control. KSB 107 caused significantly higher 64.39 cm plant height than control. Plant height increased from 60 DAI to 75 DAI. KSB 37 caused significantly higher leaves plant⁻¹ than control and it was at par with 3 KSB isolates. Plant height increased with about 11 per cent increase compare to control. Out of 15 KSB isolates 11 KSB isolates showed significant superiority in number of tillers over control. KSB107 showed significantly higher number of effective tillers (2.60) than control.

Maximum spike length was recorded with KSB 48 followed by KSB 22 which is increased by 8 per cent. Number of grains per pot was significantly more than all isolates. KSB 107 produces maximum 189.33 grains pot⁻¹ which increased with about 73 per cent compare with control. KSB 36 showed maximum value of grains spike⁻¹ which is

increased by 40 per cent compares to control. KSB 107 gave highest and significant by more grain yield pot^{-1} over all isolates which was 33% more than control. Maximum straw

yields and total biomass were recorded with isolates KSB 107. Content of K in grain, straw and in soil at harvest were influenced by KSB isolates.

Table.1 Isolates detail

S.No.	Isolates	S.No.	Isolates
1	KSB 40	9	KSB 19
2	KSB 28	10	KSB 31
3	KSB 111	11	KSB 1008-4
4	KSB 9	12	KSB 48
5	KSB 15	13	KSB100
6	KSB 54	14	KSB 107
7	KSB 37	15	KSB 22
8	KSB 36		

Table.2 effect of KSB isolates on growth attributes of wheat crops

KSB isolates	Chlorophyll SPAD value	plant height in cm	Number of leaves per plant	Tillers per plant
Control	38.4	57.02	9.01	1.48
KSB 40	39.21	59.35	9.66	2.13
KSB 28	36.47	58.12	9.85	1.66
KSB 111	39.68	63.24	9.94	1.8
KSB 9	38.71	61.28	9.87	2.03
KSB 15	38.48	62.15	9.26	2.26
KSB 54	38.62	59.38	9.41	2.33
KSB 37	38.61	63.56	10.89	2.16
KSB 36	39.76	61.51	10.01	2.38
KSB 19	39.18	61.66	10.27	2.23
KSB 31	39.59	60.88	9.86	2.17
KSB 1008-4	37.31	62.95	9.87	2.21
KSB 48	37.69	62.18	10.68	2.46
KSB100	37.02	62.44	10.22	2.08
KSB 107	37.51	64.39	9.6	2.19
KSB 22	38.08	60.6	10.06	2.36

Table.3 Effect of KSB isolates on yield attributes of wheat crop

KSB isolates	Effective tillers plant⁻¹	Spike length (cm)	Grains pot⁻¹	Grains spike	Grain yield pot⁻¹ (g)	Straw yield pot⁻¹ (g)	Total biomass pot⁻¹ (g)	harvest index in per cent
Control	1.59	11.66	50	16.68	2.63	3.11	5.75	46
KSB 40	2.23	12.02	82	20.5	3.97	5.01	8.98	44
KSB 28	1.78	11.86	99.33	24.2	5.07	6.31	11.37	45
KSB 111	2.1	12.33	42.67	20.77	4.83	7.88	12.71	38
KSB 9	2.1	12.28	69.33	20.41	2.63	3.5	6.13	43
KSB 15	2.42	11.47	82.33	20.62	3.9	5.01	8.91	44
KSB 54	2.54	11.84	110.33	22.29	5.67	6.98	12.64	45
KSB 37	2.15	12.31	163	25.12	7.01	8.7	15.71	45
KSB 36	2.57	10.7	89.33	27.82	4.73	6.47	11.21	42
KSB 19	2.35	12.34	84.67	25.18	5.41	7.03	12.44	43
KSB 31	2.23	11.07	67.33	23.43	4.03	5.05	9.08	44
KSB 1008-4	2.38	11.96	148	22.5	4.83	8.65	13.48	36
KSB 48	2.55	12.7	121.33	23.79	6.4	8	14.4	44
KSB100	2.38	12.31	126	25.59	5.07	6.47	11.54	44
KSB 107	2.6	12.09	189.33	27.08	7.87	10.42	18.29	43
KSB 22	2.29	12.64	105.33	26.14	5.17	6.37	11.54	45

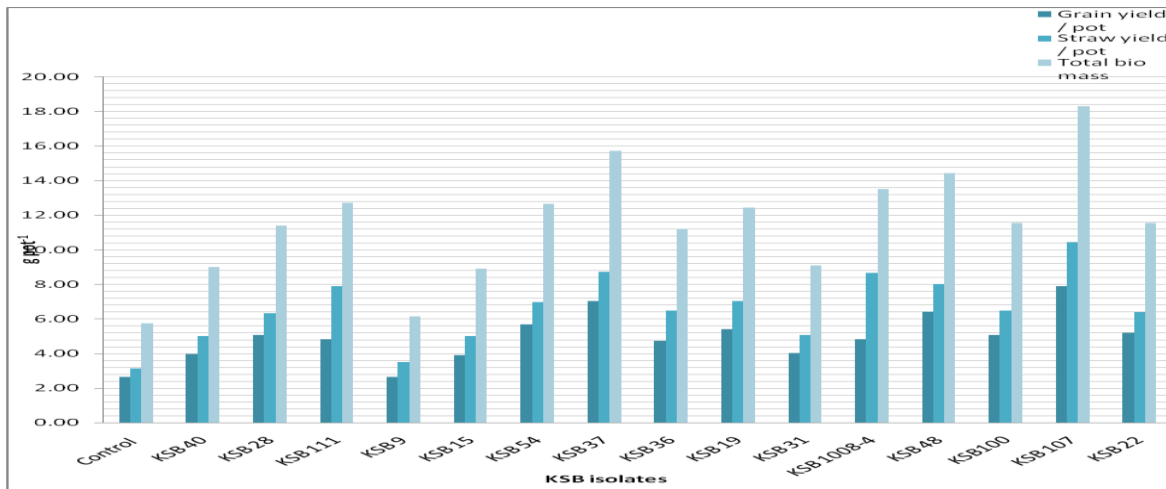
Table.4 Effect of KSB isolates on per cent content of P in straw and grain wheat crop

KSB isolates	Content of K (%)		Content of N (%)		Content of P (%)	
	Straw	Grain	Straw	Grain	Straw	Grain
Control	1.08	0.27	0.31	1.44	0.03	0.24
KSB 40	1.43	0.42	0.39	1.63	0.04	0.33
KSB 28	1.62	0.49	0.33	1.67	0.05	0.41
KSB 111	1.41	0.38	0.44	1.72	0.04	0.37
KSB 9	1.52	0.42	0.41	1.53	0.04	0.35
KSB 15	1.61	0.46	0.41	1.62	0.04	0.3
KSB 54	1.35	0.38	0.39	1.74	0.05	0.38
KSB 37	1.55	0.35	0.42	1.51	0.05	0.37
KSB 36	1.6	0.5	0.41	1.97	0.07	0.35
KSB 19	1.49	0.46	0.43	1.96	0.05	0.34
KSB 31	1.58	0.47	0.39	1.83	0.06	0.37
KSB 1008-4	1.53	0.45	0.41	1.75	0.04	0.27
KSB 48	1.52	0.44	0.39	1.83	0.07	0.47
KSB100	1.42	0.41	0.39	1.78	0.06	0.3
KSB 107	1.64	0.51	0.44	1.99	0.08	0.44
KSB 22	1.4	0.39	0.38	1.81	0.05	0.32

Table.5 Effect of KSB isolates on uptake of nutrient (mg pot^{-1}) of wheat crop

KSB isolates	Uptake of N (mg pot^{-1})			Uptake of P (mg pot^{-1})			Uptake of K (mg pot^{-1})		
	by straw	by grain	Total uptake	by straw	by grain	Total uptake	by straw	by grain	Total uptake
Control	9.7	38.2	47.9	1.04	6.39	7.43	33.48	7.17	40.65
KSB 40	19.7	64.4	84.1	1.84	13	14.84	71.43	16.82	88.25
KSB 28	21	84.4	105.4	4.19	21.02	25.21	102.32	24.73	127.05
KSB 111	34.5	83.2	117.7	3.67	18.16	21.83	110.61	18.16	128.77
KSB 9	14.4	40.4	54.8	1.52	9.1	10.62	53.16	10.98	64.14
KSB 15	20.8	63	83.8	2.5	17.04	19.54	80.6	18.05	98.65
KSB 54	27.5	98.7	126.2	3.23	21.17	24.4	94.4	21.34	115.74
KSB 37	36.9	105.7	142.6	4.08	26.59	30.67	134.45	24.77	159.22
KSB 36	26.7	94.7	121.4	4.53	15.57	20.1	103.87	23.7	127.57
KSB 19	29.5	108.5	138	3.52	18.4	21.92	116.09	27.52	143.61
KSB 31	22.2	76.4	98.6	3.17	14.82	17.99	79.69	19.09	98.78
KSB 1008-4	35.7	85.4	121.1	3.46	13.2	16.66	131.67	21.88	153.55
KSB 48	31.7	116.5	148.2	6.19	29.96	36.15	122.11	28.2	150.31
KSB100	25.4	90.2	115.6	3.88	15.19	19.07	91.59	20.55	112.14
KSB 107	40.6	154.8	195.4	5.21	23.62	28.83	155.43	36.37	191.8
KSB 22	24.1	94.3	118.4	3.19	16.45	19.64	89.74	19.88	109.62

Figure.1 Effect of KSB isolates on grain, straw and total bio mass of wheat crop at harvest



Effect of potassium solubilizing bacteria on content and uptake of primary nutrient in wheat

There was 65% increase in potassium content in straw due to inoculation of KSB 107 than un-inoculated. Maximum K content in straw

was recorded with isolates KSB 107 (1.64%) which was significantly superior to 10 KSB isolates. Increase in potassium content in grain also influenced by KSB isolates. Isolates KSB 107 was recorded for maximum K content in grain (0.51%) followed by KSB 28 and KSB 36.

Out of 15 KSB isolates, 7 isolates showed significant superiority in N % of plant over the control. Nitrogen per cent was more in grain than straw. Highest N % in grain was recorded with KSB 107 (1.99%). Maximum N content in straw was recorded equally in KSB 107 and KSB 111 (0.44%) which is increased by 29 per cent compare to control showed in table 4.

Maximum phosphorus content was observed with KSB 37 (0.145%). Phosphorus content in grain and straw was significantly influenced by various KSB isolates. KSB 107 caused maximum P content in straw which was insignificantly greater than KSB 36 and KSB 48. Isolate KSB 48 gave maximum P content in grain which was insignificantly higher than KSB 107 and KSB 28. Out of 15 KSB isolates, 12 KSB isolates were significantly superior to control. KSB 107 gave 54.5 % more phosphorus in grain than control.

KSB 107 appeared to be the effective isolates is causing greater N uptake in grain and straw than other treatments. Maximum N uptake by straw was recorded with KSB 107 (40 mg pot⁻¹) which was at par with 3 KSB isolates. All the KSB isolates were significantly superior to control except isolate KSB 9. Out of 15 KSB isolates, 13 KSB isolates showed significant superiority of N uptake in grain over control. KSB 9 and KSB 15 were caused non-significantly more N uptake than control showed in table 5. Phosphorus up take by straw and grain was significantly influenced by various KSB isolates. KSB 48 gave highest (6.2 mg pot⁻¹) and significantly more P uptake by straw than control and insignificantly greater than KSB 107 (5.4 mg pot⁻¹). Thirteen KSB isolates were significantly superior to control. KSB 48 gave highest (30 mg pot⁻¹) P uptake by grain which was at par with KSB 37 and KSB 107. Twelve KSB isolates showed their significant

superiority over control. Potassium uptake in straw and grain was significantly influenced by various KSB isolates. Isolate KSB 107 caused maximum (155 g pot⁻¹) and significant K uptake by straw than the all isolates. Out of 15 KSB isolates, 14 KSB isolates were significantly superior in K uptake to control. KSB 9 gave insignificantly lower K uptake in straw than control. KSB 107 showed maximum and significantly greater K uptake value grain in-comparison to other KSB isolates. All the KSB isolates caused control

In conclusion application of KSB on soil-plant system can be a valuable tool for increased crop productivity. Therefore it has been examined the potentiality of KSBs on yield, growth and nutrient uptake attributes. Maximum straw yields and total biomass were recorded with isolates KSB 107 and also plant height significantly higher (64.39 cm) as well as maximum K content in grain (0.51%) by KSB107. Finally it can be concluded that seed inoculation of KSB influenced growth and yields of wheat crop. Increase in K-content in wheat plant and increase nutrient uptake at harvest in crop showed significance of K-solubilizers in supply of potassium to crop and enrichment of soil with potassium.

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References

- Aleksandrov, V.G., Blagodyr, R.N. and Iiiev, I.P. 1967. Liberation of phosphoric acid from apatite by silicate bacteria. *Mikrobiyol Zh. (Kiev)*. 29: 111-114.
- Archana, D.S., Nandish, M.S., Savalagi, V.P. and Alagawadi, A.R. 2013.

- Characterization of potassium solubilizing bacteria (KSB) from rhizosphere soil. *Bioinfolet*. 10: 248-257.
- Archana, D.S.; Savalgi, V.P. and Alagawadi, A.R. 2008. Effect of potassium solubilizing bacteria on growth and yield of maize. *Soil Biol. Ecol.* 28(1-2): 9-18.
- Bagyalakshmi B, Nithya B, Ponmurugan P. 2009. Studies on potassium solubilizing bacteria from Southern Indian tea soils, in: P.Ponmurugan, B.Nithya (Eds.), Guidelines for Entrepreneurship development programme to biotechnology graduates, Excel India Publishers, New Delhi, pp. 71–76.
- Barker, W.W., Welch, S.A., Chu, S. and Banfield, F. 1998. Experimental observations of the effects of bacteria on aluminosilicates weathering. *Amer. Mineral.* 83: 1551 – 1563.
- Deng, S.B., Bai, R.B., Hu X.M., and Luo Q. 2003. Characteristics of a bioflocculant produced by *Bacillus mucilaginosus* and its use in starch wastewater treatment. *Applied Microbiology and Biotechnology*. 60: 588–593
- Goldstein, A.H. 1994.. Involvement of the quino protein glucose dehydrogenase in the solubilization of exogeneous mineral phosphates by gram negative bacteria. In phosphate in micro-organisms: cellular and molecular biology. *Cell. Mol. Biol., Eds.* 197-203
- Hu, X.F., Chen, J. and Guo, J.F. 2006. Two phosphate and potassium solubilizing bacteria isolated from Tiannu mountain, Zhejiang, China. *World J. Micro. Biotech.* 22: 983 – 990.
- Muentz, A. 1890 Surla decomposition des roches et la formation de la terre arable. *C. R. Acad Sci.* 110:1370-1372.
- Xie, J.C. 1998. Present situation and prospects for the world's fertilizer use. *Plant Nutrition and Fertility Science* 4: 321-330.

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