www.ThePharmaJournal.com
The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 382-386

www.thepharmajournal.com
Received: 20-02-2023
Accepted: 25-03-2023

Kavya V
Department of Soil Science and Agricultural Chemistry, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shimoga, Karnataka, India

Jayaprakash R
Department of Soil Science and Agricultural Chemistry, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shimoga, Karnataka, India

Shankar M
Department of Agricultural Engineering, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shimoga, Karnataka, India

Dileep R
Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Raichur, Karnataka, India

Corresponding Author:
Dileep R
Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Raichur, Karnataka, India

Effect of potassium solubilizing bacteria and foliar application of potassium on growth and yield of paddy (*Oryza sativa*) in coastal acid soils of Karnataka

Kavya V, Jayaprakash R, Shankar M and Dileep R

Abstract
A field experiment was conducted to study the "effect of potassium solubilizing bacteria (KSB) and foliar application of potassium on growth and yield of paddy (*Oryza sativa*) in coastal acid soils of Karnataka" during the *Kharif* 2021 at Zonal Agricultural and Horticultural Research Station (ZAHRS), Brahmavar, Udupi, KSNUAHS, Shivamogga. The experiment was laid out in Randomized Complete Block Design with eleven treatments replicated thrice. Among the eleven treatments, the treatment received with recommended dose of N and P_2O_5 + 75% K_2O + soil application of KSB @ 5 kg per ha + 2% KCl @ 30 and 60 DAT (T_{10}) has significantly recorded higher growth and yield parameters at harvest *i.e*., plant height (102.10 cm), number of tillers hill^{-1} (22.90), total dry matter production (84.61 g hill^{-1}), panicle length (22.71 cm), panicle weight (4.23 g), number of filled grains panicle^{-1} (119), total number of grains panicle^{-1} (129), test weight (26.14 g), grain yield (5436 Kg ha^{-1}) and straw yield (7079 kg ha^{-1}) and the significantly lower values was recorded in recommended dose of fertilizer (60:30:60 kg ha^{-1}) + FYM @ 5 t ha^{-1}. The experiment demonstrates that the use of chemical fertilizers along with biofertilizers *i.e*., potassium solubilizing bacteria (KSB) has potential to save substantial amounts of inorganic fertilizers and significantly increase growth and yield of paddy under suitable management practices.

Keywords: Potassium solubilizing bacteria, farm yard manure and coastal acid soils

Introduction
Rice is one of the oldest domesticated grain crop (10,000 years) and is the important energy source for more than 2.5 billion people worldwide. It provides 15 percent of global human per capita protein and 21 percent per capita energy. It is grown in majority of the countries, with a total harvested area of about 162.05 m ha, with an annual production of 755.47 m t (USDA, 2019) [14]. Nearly 65 percent of the population living in India depend on rice as staple food and is being cultivated in an area of 43.79 m ha with an annual production of 118.87 m t and productivity of 2434 kg ha^{-1}. In Karnataka, rice is cultivated in an area of 1.45 m ha with the annual production of 3.72 m t and productivity of 2637 kg ha^{-1} varying with district and agro climatic zones (GOI, 2019) [2].

In acidic soils less availability of nutrients (N, P, K, Ca, Mg and S) besides inadequate organic matter. Paddy is an exhaustive crop and removes a large amount of macro and micronutrients from the soil. None of the sources of nutrients alone can meet the total plant nutrients from chemical, organic, bio-fertilizer is the most efficient way to supply plant nutrients for sustained crop productivity and improved soil fertility (Singh *et al*. 2011) [11]. As a source of K_2O, MOP (KCl) is generally used both in basal as well as in foliar spray especially in acidic soil. When KCl is used, it not only adds K_2O but also chloride ions to plants and soil. Due to intensive cropping intensity & rapid plant growth, potassium deficiency occurs as the plant root cannot absorb a sufficient amount of K_2O from the soil. In the soil where water holding capacity is less, moisture stress conditions may occur during a dry spell or in between the application of two irrigation. Under this situation, foliar application of potassium plays important role in the osmotic regulation of the leaf due to climate change, more urbanization, vagaries of monsoon, depletion of the ground underwater table, etc. the rice-growing areas in India are decreasing day by day. Now-a-days most of the farmers use injudicious application of chemical fertilizers for achieving maximum productivity. However, the KSB are most important biofertilizers for solubilizing fixed form of K in soil system. The KSB are an indigenous rhizospheric microorganism which show effective interaction between soil-plant systems. The main mechanism of KSB is acidolysis, chelation, exchange reactions, complexolysis and production of organic acid.

The potassium solubilizing microorganisms (KSMs) are rhizospheric microorganism which solubilize the insoluble potassium (K) to soluble forms of K for plant growth and yield. K-solubilization is carried out by a large number of saprophytic bacteria (*Bacillus mucilaginosus*, *B. edaphicus*, *B. circulans, Acidothiobacillus ferrooxidans, Paenibacillus spp*.) and fungal strains (*Aspergillus spp. and Aspergillus terreus*). Major amounts of K containing minerals (muscovite, orthoclase, biotite, feldspar, illite) are present in the soil as a fixed form which is not directly taken up by the plant. These potassium solubilizing bacteria (KSB) were found to dissolve potassium, silicon and aluminium from insoluble K-bearing minerals such as micas, illite and orthoclases, by excreting organic acids which either directly dissolved rock K or chelated silicon ions to bring K into the solution (Maheta *et al*. 2020) [6]. Moreover, due to imbalanced fertilizer application, potassium deficiency is becoming one of the major constraints in crop production. This emphasized the search to find an alternative indigenous source of K for plant uptake and to maintain K status in soils for sustaining crop production. Hence, research efforts are required to find out the ideal combination of potassium solubilising biofertilizer and different levels of potassium (inorganic) to satisfy the overall nutrient requirement of paddy crop without impairing soil health.

Material and Method

The experiment was conducted at Seed Farm, Zonal Agricultural and Horticultural Research Station, Brahmavar, Udupi district, Karnataka. The experimental site is situated between 130 25' N latitude and 740 45' E longitude with an altitude of 10 meters above mean sea level. It comes under the coastal zone (agro-climatic zone 10) of Karnataka. Composite soil samples were drawn at a depth of 0 to 15 cm soil layer and a representative sample was obtained by standard procedures. The soil was analyzed for its chemical properties *viz*., pH, EC, organic carbon, available nitrogen, phosphorus and potassium and for biological properties *viz*., Bacteria, Fungi, Actinomycetes and K-solubilizers. The results of the analysis are given in Table 1. Experimental design is RCBD with eleven treatment and three replication. The cropping season is *kharif* with spacing 20 ×10 cm, seed rate 25 kg acre^{-1} and variety MO-4. Treatment details are T_1: Recommended dose of nutrients (60: 30: 60 kg per ha) + 5 tonnes of FYM, T_2: T_1 + soil application of KSB @ 5 kg per ha, T_3: T_1+ 2% KCl @ 30 and 60 DAT, T_4: T_1 + soil application of KSB @ 5 kg per ha + 2% KCl @ 30 and 60 DAT, T_5: Recommended dose of N and P_2O_5 + 50% K_2O + soil application of KSB @ 5 kg per ha, T_6: Recommended dose of N and P_2O_5 + 50% K_2O + 2% KCl @ 30 and 60 DAT, T_7: Recommended dose of N and P_2O_5 + 50% K_2O + soil application of KSB @ 5 kg per ha +2%KCl @ 30 and 60 DAT, T_8: Recommended dose of N and P_2O_5 + 75% K_2O + KSB @ 5 kg per ha, T_9: Recommended dose of N and P_2O_5 + 75% K_2O + 2% KCl @ 30 and 60 DAT, T_{10}: Recommended dose of N and P_2O_5 + 75% K_2O + soil application of KSB @ 5 kg per ha + 2% KCl @ 30 and 60 DAT and T_{11}: Absolute control. Note: FYM: Farm yard manure, KSB: Potassium solubilizing bacteria, KCl: Muriate of potash, Urea, rock phosphate and muriate of potash were used as inorganic source of N, P and K fertilizers. Five hills were selected randomly from the net plot and labeled for recording the observations in each treatment. Fisher's method of analysis of variance was applied for analysis and interpretation of data as given by Panse and Sukhatme (1967). The level of significance used in 'F' and 't' tests was P=0.05. Critical difference values were calculated wherever the 'F' test was significant.

Results and Discussion

Growth parameters

Plant height

At 30, 60, 90 DAT and at harvest the plant height was found significantly higher in T_{10} treatment (35.46, 76.86, 98.46 and 102.10 cm respectively) which was on par with treatment T_8 (35.35, 74.38, 94.25 and 97.37 cm respectively). Significantly lower plant height was observed with treatment T_1 (33.10, 70.19, 81.86 and 84.22 cm respectively). Increase in the number of nodes in the plant stem due to increase in the levels of inorganic potassium application might have resulted in increased plant heights. The results were in conformity with the findings of Tsai and Huber (1996) [13], Normohammadi *et al*. (2001) [8] and Grazia *et al*. (2003) [3] who expressed plant height can be increased by increasing levels of potash application (Table 2).

Number of tillers per hill

Significantly higher number of tillers per hill was observed at 30, 60, 90 DAT and harvest with a treatment, T_{10} (12.60, 21.44, 24.84 and 22.90 respectively) which was on par with treatments, T_8 (12.53, 20.26, 23.74 and 21.72). Significantly lower number of tillers per hill was observed with treatment T_1 (8.91, 12.91, 15.37and 14.52 at 30, 60, 90 DAT and at harvest, respectively) (Table 2).

Total dry matter production (g hill^{-1})

Total dry matter production of paddy recorded at different stages as influenced by potassium solubilizing microorganisms and foliar application of 2 percent KCl varied significantly among the treatments. The total dry matter production was significantly higher at T_{10} treatment (3.35, 25.24, 59.98 and 84.61 g hill^{-1} at 30, 60, 90 DAS and at harvest, respectively). However, all treatments registered significantly higher total dry matter production over T_1 (2.43, 16.78, 37.63 and 52.19 g hill^{-1} at 30, 60, 90 DAT and at harvest, respectively) (Table 2). Higher dry matter production obtained in the treatment *i.e*., T_{10} is because of synergetic effect of potassium solubilizing bacteria and muriate of potash. Greater solubilization of mineral form of K (Prajapati, 2016) [10]. According to the Jothi *et al*., 2019 [5] application of potassium either soil or foliar spray had significantly influenced growth parameters of paddy. Significantly taller plants, more number of tillers per hill, higher LAI and dry matter production were recorded with soil application of potassium at 50 kg ha^{-1} than other treatments. Foliar spray of 2% KCl was the best treatment. Increment in growth parameters of rice under soil application of potassium in four equal splits was mainly due to that potassium plays an essential role in plant physiological functions, needed for osmoregulation, enzyme activation, regulation of cellular pH, cellular cation-anion balance, regulation of transpiration by stomata opening and closing, and the transport of the products of photosynthesis and ultimately increased the growth parameters of rice Zaman *et al*. (2015) [15].

Yield parameters

Yield parameters of paddy showed in Table 3. The data regarding the panicle length was considerably higher in treatments, T_{10} (22.71 cm) and it was on par with T_8 (21.52 cm) as compare to treatment, T_1 (17.11 cm). Significantly, higher panicle weight were observed in T_{10} treatment (4.23 gm). This was closely followed by T_8 (3.96 gm) as compare to treatment, T_1 (2.90 gm). Significantly, higher numbers of filled grains per panicle were observed in T_{10} treatment (119), followed by T_8 (114) as compare to treatment, T_1 (93). The number of unfilled grains per panicle varied significantly in absolute control (24) relative to other treatments. Treatment T_{10} (129) significantly recorded higher total number of grains per panicle, which was on par with treatment, T_8 (125). Significantly, lower total number of grains per panicle was observed with treatment T_1 (106). The test weight was not affected significantly by the various treatments. The highest test weight might be due to supplementation of K in balanced dose resulting in better grain filling due to increased photosynthetic activity of larger leaf area and higher dry matter production.

Grain and straw yield

Treatment, T_{10} (5436 and 7079 kg ha^{-1} kg ha^{-1}) significantly recorded higher grain and straw yield, followed by T_8 (5379 and 6904 kg ha^{-1}) as compared to treatment, T_1 (4685 and 5788 kg ha^{-1}) and rest of the treatments were on par with each other (Table 4). Among the treatments there is no significant difference observed in the harvest index. The higher percent of grain yield (16.03%) was noticed in T_{10} when compared to RDF (T_1) as shown in Fig. 1. Integration of biofertilizers with inorganic sources helped in more absorption of nutrients from deeper layer of soil resulting into significant increase in dry matter and grain yield. These findings were in agreement with the results reported by Gill *et al*. (1994) [1] and Grewal *et al*. (1982) [4]. The increased grain yield by the application of K fertilizer was due to the continuous supply of K during crop growth period which might be due to increased total number of tillers, dry mater accumulation, effective tillers, number and weight of filled grains and fertilizer use efficiency. These findings were in close conformity with those of Surekha *et al*. (2003) [12]. Application of chemical fertilizers along with biofertilizer had increased the straw yield, this result is in agreement with Negessa *et al*., (2002) [7] this is due to increased N uptake which will result in the increase of grain yield and stover yield.

Table 1: Initial soil properties

Chemical properties of soil	
pH (1:2.5)	5.62
EC (1:2) (dS m^{-1}) at 25 °C	0.058
Organic carbon (percent)	1.14
Available nitrogen (kg ha^{-1})	272.00
Available P_2O_5 (kg ha^{-1})	60.30
Available K_2O (kg ha^{-1})	110.25
DTPA Fe (mg kg^{-1})	14.31
DTPA Mn (mg kg^{-1})	4.12
DTPA Zn (mg kg^{-1})	1.45
DTPA Cu (mg kg^{-1})	1.92
Biological properties of soil	
Bacteria (cfu $\times 10^5$ g^{-1} of soil)	13.15
Fungi (cfu $\times 10^4$ g^{-1} of soil)	18.72
Actinomycetes (cfu $\times 10^2$ g^{-1} of soil)	12.45
K Solubilizers (cfu $\times 10^2$ g^{-1} of soil)	4

Table 2: Effect of potassium solubilizing bacteria and foliar application of potassium on growth parameters of the paddy

Treatments	Plant height (cm)				Number of tillers per hill				Total dry matter (g $hill^{-1}$)			
	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	Harvest
T_1	33.10	70.19	81.86	84.22	8.91	12.91	15.37	14.52	2.43	16.78	37.63	52.19
T_2	30.80	74.18	93.68	96.83	12.40	19.64	21.71	20.51	2.79	21.35	54.10	75.25
T_3	31.48	71.98	84.22	87.37	9.77	14.85	17.47	16.50	2.44	18.26	40.03	53.76
T_4	32.05	72.10	86.60	89.19	10.32	15.64	18.04	17.04	2.40	17.36	41.35	54.54
T_5	31.94	73.41	91.42	93.34	12.29	18.06	20.74	19.59	2.91	20.31	51.77	68.71
T_6	31.94	72.87	90.39	93.08	10.82	17.54	19.52	18.44	2.68	19.44	46.50	63.47
T_7	32.71	73.54	93.17	95.84	11.25	18.71	21.15	19.98	3.34	23.10	53.30	71.73
T_8	35.35	74.38	94.25	97.37	12.53	20.26	23.74	21.72	2.60	24.31	56.00	80.39
T_9	35.46	72.25	88.58	91.05	10.580	16.61	18.85	17.81	2.47	18.21	44.13	60.94
T_{10}	33.36	76.86	98.46	102.10	12.60	21.44	24.84	22.90	3.35	25.24	59.98	84.61
T_{11}	26.45	45.06	58.35	62.47	5.16	9.19	9.88	8.64	1.86	9.79	21.23	30.44
S.Em.±	0.83	1.41	2.43	2.65	0.99	1.27	1.77	1.74	0.23	2.38	5.98	7.91
C.D. at 5%	2.49	4.22	7.26	7.91	2.95	3.81	5.29	5.21	0.71	7.11	17.84	23.57

Table 3: Effect of potassium solubilizing bacteria and foliar application of potassium on yield parameters of the paddy

Treatments	Panicle length (cm)	Panicle weight (g)	Filled grains $panicle^{-1}$	Unfilled grains $panicle^{-1}$	Total number of grains $panicle^{-1}$	Test weight (g)
T_1	17.11	2.90	93	13	106	24.10
T_2	21.12	3.92	110	11	121	25.48
T_3	17.71	3.08	96	13	109	24.84
T_4	18.55	3.31	98	12	110	24.37
T_5	19.63	3.57	104	11	115	25.04
T_6	18.93	3.38	98	11	109	24.92
T_7	20.42	3.85	108	10	118	25.06
T_8	21.52	3.96	114	11	125	25.57
T_9	18.75	3.56	100	11	111	24.35
T_{10}	22.71	4.23	119	10	129	26.14
T_{11}	9.87	1.35	59	24	83	21.71

S.Em.±	1.14	0.22	5.11	1.51	6.30	1.24
C.D. at 5%	3.41	0.68	15.23	4.52	18.79	NS

Table 4: Grain yield, straw yield and harvest index of paddy as influenced by soil application of potassium solubilizing bacteria and foliar application of potassium

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
T_1	4685	5788	0.447
T_2	5189	6713	0.436
T_3	4761	5886	0.447
T_4	4826	5987	0.446
T_5	4971	6377	0.438
T_6	4944	6198	0.444
T_7	5082	6500	0.439
T_8	5379	6904	0.438
T_9	4864	6111	0.443
T_{10}	5436	7079	0.434
T_{11}	2335	3014	0.437
S.Em.±	229	320	0.016
C.D. at 5%	681	953	NS

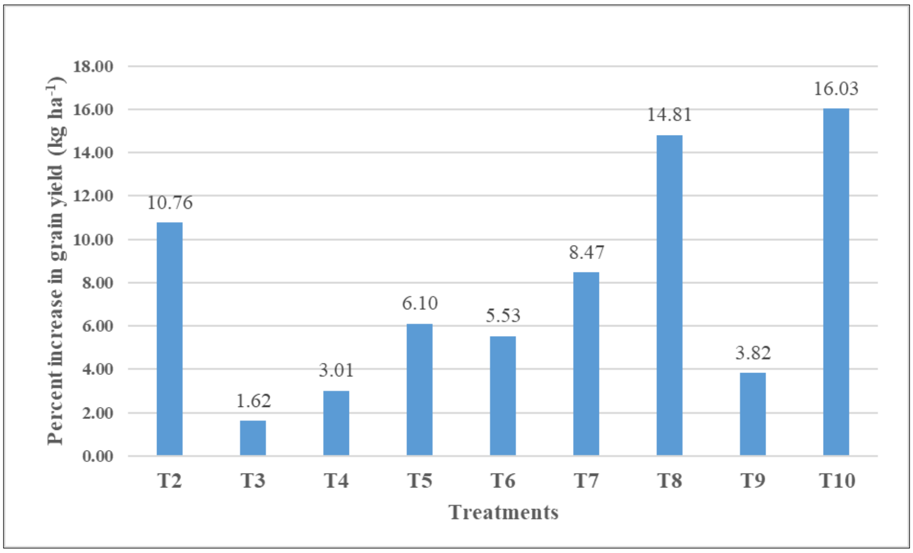

Fig 1: Percent increase in grain yield as influenced by soil application of potassium solubilizing bacteria and foliar application of potassium over control

Conclusion

From the present investigation, it can be inferred that soil application of potassium solubilizing bacteria in addition to the supply of recommended dose of N and P_2O_5 + 75% K_2O and foliar application of two percent KCl to paddy resulted in 16.03 and 12.30 percent higher grain and straw yield over RDF alone with better soil potassium availability and uptake of nutrients along with improvements in the microbial population. KSB being a biofertilizer helped in solubilization of unavailable or bound forms to available forms thereby, increasing the soil availability of macro and micronutrients in soils and nutrient concentrations in plants. This leads to increase in the growth and yield parameter of paddy crop. F.

References

1. Gill MS, Singh Tarlok, Rana DS, Bhandari AL. Response of maize and wheat to different levels of fertilization. Indian J Agron. 1994;39(1):168-170.
2. GOI [Government of India, Ministry of Agriculture and Farmers' Welfare]. Annual Report 2019-2020. Government of India, Ministry of Agriculture and Farmer's Welfare, Krishibhavan, New Delhi, 2019, 194.
3. Grazia J, Tittonell PA, Germinara D, Chiesa A. Short communication: Potassium and nitrogen fertilization in sweet corn (*Zea mays* L. var. *saccharata* Bailey). Spanish J Agril. Res. 2003;1(2):103-107.
4. Grewal SS, Sud AD, Mittal SP, Singh Kehur A. Effect of FYM and chemical fertilizers on yield of rainfed maize in Shivalik foot hills. Indian J Agron. 1982;27(3):282-283.
5. Jothi M, Keerthana P, GomathI S, Priya B, Ramesh T, Rathika S. Effect of foliar spray of potassium on rice under sodic soil. The Pharma Innovation J. 2019;8(8):244-247.
6. Maheta AA, Vaghani JJ, Bavaliya AH, Gajera KC. Effect of Potassium (K) And Potassium Solubilizing Bacteria (KSB) Growth, Yield, Quality Parameters and Nutrient Uptake by Wheat (*Triticum Aestivum* L.), Int. J Chem. Studies. 2020;8(5):1736-1740.
7. Negessa W, Negisho K, Friesen DK, Ransom J, Yadessa A. Determination of optimum farm yard manure and NP fertilizers for maize under the farmers conditions. 7th East and South African Regional Maize Conference, 11-15th Feb, Nairobi, Kenya; c2002. p. 387-393.
8. Normohammadi G, Siadat A, Kashani A. Agronomy

(Cereal) First Education. Ahvaz, Iran, Shahid Chamran University publication; c2001. p. 468.
9. Panse BG, Sukhatme PV. Statistical methods for agricultural workers. ICAR, New Delhi; c1967. p. 162-174.
10. Prajapati K. Impact of potassium solubilizing bacteria on growth and yield of Mungbean (*Vigna radiata*). Indian J App. Res. 2016;6(2):2249-555.
11. Singh JS, Pandey VC, Singh DP. Efficient Soil Microorganisms: A New Dimension for Sustainable Agriculture and Environmental Development. Agric Ecosyst Environ. 2011;140:339-353.
12. Surekha K, Reddy MN, Balasubramanian V. Effect of potassium application on yield and nutrient use efficiency of rice hybrids and conventional varieties. J Potassium Res. 2003;19:55-60.
13. Tsai CY, Huber DM. Genetic variation of maize hybrids in grain yield response to potassium and inhibiting nitrification. Journal of Science of Food & Agriculture. 1996;7:263-270.
14. USDA [United States Department of Agriculture]. World: Rice Area, yield and production [online], 2019. Available: http://apps.fas.usda.gov/psdoline/reportHandlr. ashx?
15. Zaman UZ, Ahmad M, Farooq S, Saeed M, Ahmad Wakeel A. Potassium Fertilization May Improve Stem Strength and Yield of Basmati Rice Grown on Nitrogen Fertilized Soils. Pak. J Agric. Sci. 2015, 52.