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Phosphate solubilizing rhizospheric bacterial communities of different crops of Korea District of Chhattisgarh, India

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Occurrence of Phosphate Solubilizing Bacteria (PSB) in the rhizospheric soil of different crops of Korea District of Chhattisgarh, India was studied. Phosphate solubilizing bacteria colonize the plant roots, affect plant growth positively and add nutrients to the soil. A good number of PSB were isolated, purified and identified from twenty-five different representative soil samples collected from five blocks of Korea District of Chhattisgarh, India. The bacterial species were *Pseudomonas alcaligenes, Pseudomonas syringae* and *Bacillus subtilis*. The total rhizospheric bacterial (TRBP) population indicated that bacterial population in the rhizospheric soil of Korea District of Chhattisgarh ranged from 3.03×10^6 to 4.92×10^6 cfu. TRBP was affected greatly by different physico-chemical properties of soil (nitrogen, phosphorus, potassium, organic carbon %, pH and electrical conductivity = EC). All the parameters studied showed positive correlation with TRBP except EC that showed negative correlation. On the basis of correlation co-efficient values, positive significant values are grouped in three. Example – strong (r = >0.5), medium (r = < 0.4 but greater than 0.1) and weak (r < 0.1). The present study indicates 100% distribution of phosphate solubilizing bacteria in soil of Korea district of Chhattisgarh, India, indicating only 14% occurrence of *Pseudomonas* spp. while 86% bacterial inhabitants belong to genus *Bacillus*. P (Phosphorus) had strong positive significant correlation with TRBP. N, K & OC% had medium correlation and pH had weak positive significant correlation with TRBP.

Key words: Correlation, PSB, *Pseudomonas* spp., physicochemical property of soil, Rhizospheric bacteria, egression.

INTRODUCTION

Rhizospheric bacterial inhabitants have marked impact on soil ecosystem. Plant root exudates are good nutrient source available for microorganisms in soil that supports their rapid proliferation in the rhizosphere (Marilley and Aragno, 1999). The composition of microbial community is affected by the amount and composition of root exudates which in turn influences nutrient availability of soil. The variation in total rhizospheric bacterial population in near vanity of roots may be due to organic carbon substrates supplied from the roots exudates, dead organic matter (Baudoin et al., 2001) and plant variety (Dunfield and Germida, 2001). Bacterial count is higher

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in rhizosphere, considered as hot spot of bacterial diversity (Botelho et al., 2006; Kumar et al., 2011). Bacteria in rhizhosphere are beneficial to plants, have ability to colonize the roots and exert plant growth promotion, thus called as plant growth promoting rhizobacteria (PGPR). Strains with PGPR activity, belongs to genera *Azoarcus, Azospirillum, Azotobacter, Arthrobacter, Bacillus, Clostridium, Enterobacter, Gluconacetobacter, Pseudomonas* and *Serratia.* Also the root nodules of leguminous plants are the habitat of many species of bacteria like *Bacillus megaterium, Bacillus aerophilus, Microbacterium laevaniformans* and *Staphylococcus xylosus* (Singha and Sharma, 2013). Among these, species of *Pseudomonas* and *Bacillus* predominates in the rhizhosphere and are most extensively studied (Sutra et al., 2000; Widawati, 2011; Kumar et al., 2011; Keneni et al., 2012; Sharma et al., 2014). The bacterial community in rhizosphere act as both biofertilizers and microbial antagonists. The principal mechanisms of growth promotion include production of growth stimulating phytohormones, solubilization and mobilization of phosphate, production of siderophore and antibiotics, inhibition of plant ethylene synthesis, and induction of plant systemic resistance to pathogens (Kumar et al., 2011). The phosphate solubilizing bacteria is present in all the soil types and their population is higher in the rhizosphere as compared to the non-rhizosphere. The solubilization of mineral phosphate is attributed by the production and release of organic acids and acid phosphatases that play a major role in the mineralization of organic phosphorous in soil with simultaneous decrease in pH (Park et al., 2009). The phosphate solubilizing ability of PGPR is greatly affected by various environmental parameters such as Temperature, ph, carbon and nitrogen sources (Mujahid et al., 2015). Also diversity in the phosphate solubilizing bacterial community is impacted by physico-chemical parameters of different soil samples such as high concentrations of sodium, alkaline ph and high Electrical Conductivity (Mohan and Menon, 2015). In present study; data on comparative population of phosphate solubilizing rhizospheric bacteria in the agricultural soil of Korea District of Chhattisgarh, India has been depicted and correlation-regression between physico-chemical property and total rhizospheric microbial population of soil has been studied.

MATERIALS AND METHODS

Soil sampling

The present study was conducted on agricultural land of Korea District of Chhattisgarh India, one of the four major districts of northern hilly zones of Chhattisgarh State with area of 5978 Km^2. The climate is ideal with a beautiful monsoon, a mild summer and a bearable winter. Average temperature ranges from maximum 32°C to minimum17°C, 59.03% land area is covered with forest, average rainfall is 1410.9 mm (http://korea.gov.in/glaonce.htm) , soil type is red-yellow and major crop is paddy (http://korea.gov.in/). District Korea is divided into 5 blocks: Baikunthpur, Manendragarh, Khadgawan, Sonhat and Janakpur. (http://korea.gov.in/).

In the present investigation soil samples were collected from randomly selected 05 locations of 05 agricultural fields from each blocks of Korea District of Chhattisgarh, India (Walworth, 2004**)**. A total of 25 composite soil samples were collected to a depth of about 6 to 8 inches from 05 blocks of agro based areas of Korea District of Chhattisgarh, five soil samples from each blocks (Baikunthpur, Manendragarh, Khadgawan, Sonhat, Janakpur), during the month of May - June, 2009, all these were drawn from post harvested fields (Venkateswarlu et al., 1984). Each sample weighing 200 g were obtained as representative samples of crop fields and analyzed for its physical and chemical properties and the occurrence of phosphate solubilizing bacteria.

Representative soil samples were air-dried at room temperature to reduce moisture content. Each sample was then analyzed for microbial content and tested for organic matter, potassium, phosphorous and nitrogen contents, pH and EC, for which the desired sample amount, 100 g was taken to laboratory for microbiological analysis (isolation of rhizospheric PSB) and another 100 g was used for physic-chemical analysis at Biotech Lab and Training Centre, Collectorate campus, Ambikapur (Surguja). Rest quantity of the soil samples, were stored in dry place for future use if needed.

Isolation of phosphate solubilizing soil bacteria

The isolation of Phosphate solubilizing rhizospheric bacteria was carried out by serial 10-fold dilutions technique (Pandey et al., 2006) and pour-plate method on Pikovskaya (PVK) agar (Pikovskaya, 1948) and Modified Pikovskaya media (Gupta et al., 1994; Dave and Patel, 1999) at Plant Pathology Laboratory, RMD College of Agriculture and Research Station, Ambikapur (Chhattisgarh), India. Phosphate solubilizing bacteria was screened by selecting the microorganisms which are capable of producing a clear zone on plate.

Enumeration and purification of phosphate solubilizing bacterial isolates

The population of individual phosphate solubilizing rhizospheric bacterial isolates was enumerated on basis of per gram of soil using following formula (Schmidt and Caldwell, 1967; Tripathi et al., 2013).

Number of bacteria per gram soil = No. of colony forming units × dilution / Dry weight of 1 g soil × aliquot taken

Different colonies showing clear zone around the line of growth on each plates were aseptically transferred on the surface of Nutrient agar media and Pseudomonas Agar base media to obtain pure sub cultures of each primary culture. The prepared pure cultures were then preserved in refrigerator at low temperature (4°C) in the Department of Plant Pathology, RMDCARS IGKVV Ambikapur for longevity of bacterial isolates for their further use.

Physiological markers tests like growth behavior in medium, color change on Modified Pikovskaya medium along with biochemical markers like gram staining reaction, starch hydrolysis test (Sharma et al., 2007) were carried out for the primary identification of the bacterium *Pseudomonas*. After primary identification, cultures were sent to Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, Pusa campus, New Delhi, India - 12, for their molecular identification based on 16s rRNA and 16s rDNA gene sequencing (Kanimozhi and Panneerselvam, 2010; Singha

Table 1. Physico-chemical Property and total rhizospheric microbial population of soil of Korea District (Chhattisgarh).

S/No.	Field area	Crops	Soil parameters							Blocks
			N	P	K	OC %	pH	EC	TRBP cfu (10^6)	
1.	Cheetajhor	*Oryza sativa*	166.6	34.9	250.2	0.67	6.5	0.11	3.58	Khadgawan block
2.	Banjaridand	*Oryza sativa*	126.4	37.1	277.6	0.86	6.3	0.19	3.69	
3.	Akhradand	*Oryza sativa*	153.2	23.1	303.5	0.39	6.1	0.8	3.03	
4.	Dubchhola	*Oryza sativa*	255.6	14.9	211.2	0.28	6.4	0.9	3.08	
5.	Bhukbhukii	*Oryza sativa*	277.8	40.9	207.5	0.76	6.2	0.4	3.81	
6.	Navgayi	*Oryza sativa*	126.2	37.1	297.1	0.67	6.3	0.18	3.69	Sonhat block
7.	Katgodi	*Abelmoschus esculentus*	126.3	42	336.2	0.79	5.95	0.7	4.01	
8.	Kachardand	*Oryza sativa*	161.1	47	266.1	0.61	6.3	0.1	4.8	
9.	Ghughra	*Oryza sativa*	171.5	31	259.4	0.44	6.2	0.3	4.09	
10.	Kailashpur	*Oryza sativa*	144.5	41	216.5	0.69	6.7	0.7	4.05	
11.	Barbaspur	*Abelmoschus esculentus*	129.5	39.6	325.5	0.66	6.4	0.11	4.3	Manendragarh block
12.	Sarbhoka	*Triticum aestivum*	162.2	48.9	232.4	0.45	6.8	0.21	3.65	
13.	Pahad hanswahi	*Triticum aestivum*	278.2	41	291	0.68	6.9	0.4	4.92	
14.	Kachhod	*Oryza sativa*	126.4	33.9	255.2	0.86	6.3	0.18	3.17	
15.	Belbehra	*Oryza sativa*	229.5	33.7	248.1	0.66	6.2	0.5	3.81	
16.	Kharwat	*Triticum aestivum*	163.2	43.5	336.2	0.36	5.95	0.3	3.99	Baikunthpur block
17.	Tendua	*Triticum aestivum*	129.1	32.9	243.1	0.64	6.01	0.7	3.03	
18.	Bisunpur	*Oryza sativa*	220.2	31	297.2	0.66	6.1	0.12	3.07	
19.	Dumaria	*Lycopersicum esculentum*	169.1	40.5	257.2	0.8	5.87	0.13	4.83	
20.	Nagar	*Cajanus cajan*	144.2	39.6	226.2	0.64	5.9	0.8	3.57	
21.	Khetawli	*Oryza sativa*	148.1	33.7	325.5	0.49	6.7	0.4	3.87	Janakpur block
22.	Barel	*Oryza sativa*	163.2	30	294.4	0.36	6.1	0.1	3.59	
23.	Dhobataal	*Oryza sativa*	146.5	24	211.2	0.49	6.5	0.7	3.06	
24.	Chutki	*Lagenaria vulgaris*	175.6	37.2	297	0.73	6.1	0.18	3.87	
25.	Umarwaah	*Oryza sativa*	254.6	53.1	330.2	0.89	5.86	0.3	4.2	

NPK (Kg/ha), EC (mmol/cm), OM-Organic matter, TRBP- Total rhizospheric bacterial population.

and Sharma, 2013).

RESULTS

Soil analysis

Soil testing refers to the chemical analysis of soil and is well recognized as a scientific means for quick characterization of the fertility status of soils and predicting the nutrient requirement of crops. It also includes testing of soils for other properties like texture, structure, pH, cation exchange capacity, water holding capacity, electrical conductivity, phosphorus (P), potassium (K), organic matter, sulfur (S), boron (B), zinc (Zn), and other micronutrients. Total 25 soil samples collected from Korea District were analyzed for N, P, K, EC, organic matter (Organic Carbon %), pH and total rhizospheric bacterial population (TRBP).

Results depicted in Table 1, indicates that nitrogen content of soil samples ranges from 126.2- 278.2 Kg/ha, phosphorus content is 14-55 Kg/ ha and potassium analysis indicates that 11 soils samples of the District belongs to high category of potash (> 280 Kg/ha) while rest of the 14 samples have potash in the medium range (110-280 Kg/ha). Table 1 also indicates the result data on EC, OC% and pH of soil. EC of all the samples from the district were less than 1 milimole cm^{-2} organic carbon percentage (OC%) of 6 soil samples were low (<0.5), other 6 samples have high OC% (>0.75) and rest samples are in the range of medium OC% (0.5-0.75). pH values of the soil ranged from 5.86-6.9 indicating soils are acidic to neutral suitable for cultivation.

Studies on the total rhizospheric bacterial (TRBP) population indicates that bacterial population in the rhizospheric soil of Korea District of C.G. ranged from 3.03 x 10^6 to 4.92 x 10^6 cfu. Highest rhizospheric bacterial population (4.92 x 10^6 cfu) was recorded from rhizospheric soil of *Triticum aestivum* (Pahadhanswahi, Sonhat block), followed by 4.83 x 10^6 cfu from rhizospheric soil of *Lycopersicum esculentum* (Dumaria, Baikunthpur block), 4.80 x 10^6 cfu from rhizospheric soil of *Oryza sativa* (Kachardand, Sonhat block) 4.30 x 10^6 cfu from rhizospheric soil of *Abelmoschus esculentus* (Barbaspur, Manendragarh Block) 4.20 x 10^6 cfu from rhizospheric soil of *Oryza sativa* (Umarvah, Janakpur

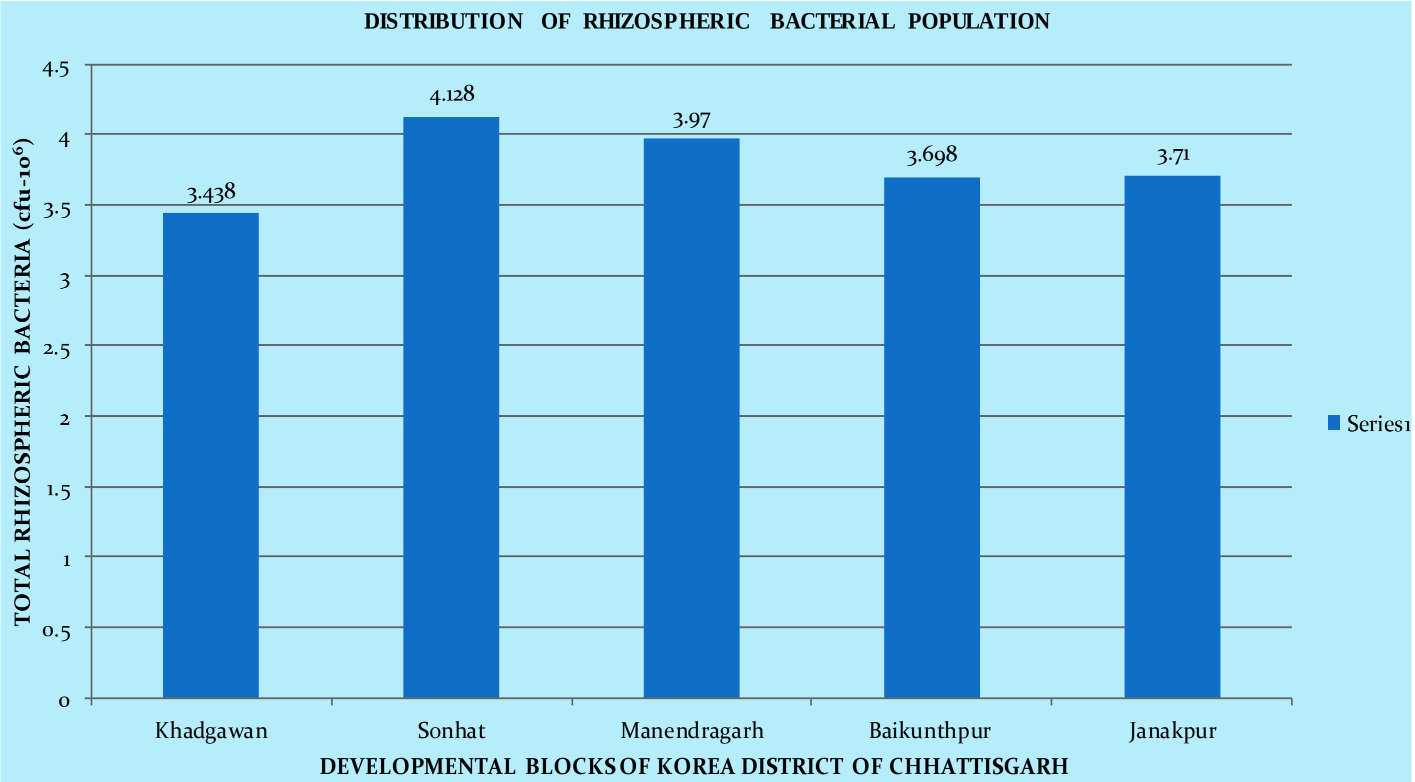

Figure 1. Distribution of total rhizospheric bacterial population in five blocks of Korea District of Chhattisgarh, India.

Block) 4.09 x 10^6 cfu from rhizospheric soil of *Oryza sativa* (Ghughra, Sonhat Block) 4.05 x 10^6 cfu from rhizospheric soil of *Oryza sativa* (Kailashpur, Sonhat Block) 4.01 x 10^6 cfu from rhizospheric soil of *Abelmoschus esculentus* (Katgodi, Sonhat Block). Lowest rhizospheric bacteria population 3.03 x 10^6 cfu was recorded from rhizospheric soil of *Oryza sativa* (Akhradand, Khadgawan Block).

Figure 1 depicts the Distribution of Total Rhizospheric Bacterial population in five Blocks of District Korea. The occurrence of maximum TRBP is found in Sonhat followed by Manenedragarh and Janakpur, respectively. The lowest TRBP exists in Khadgawan followed by Baikunthpur, therefore according to the occurrence of TRBP the whole Korea District is grouped into two Zonal Blocks that is, First Zonal Block comprising of blocks Sonhat, Manendragarh, Janakpur and Baikunthpur with TRBP > cfu 3.5 × 10^6 and Second Zonal Block comprising of Block Kadgawan withTRBP < cfu 3.5 × 10^6. Data recorded in the present investigation indicates the highest Rhizospheric population (> cfu 3.5 × 10^6) is present in First Zonal Blocks- Sonhat, Manendragarh, Janakpur and Baikunthpur where OC% is also high. The Total rhizospheric population is usually influenced by organic carbon substrates supplied from the roots exudates and dead organic matter in near vanity of roots (Baudoin et al., 2001).

Correlation and regression studies between physico-chemical property and total rhizospheric microbial population of soil of Korea District (Chhattisgarh)

The present study of correlation and regression (Table 2) between physico-chemical property and total rhizospheric bacterial population of soil of Korea District (Chhattisgarh), indicates that the TRBP is affected greatly by different physico-chemical property of soil that is, N, P, K, OC%, pH and EC. All the parameters studied showed positive correlation with TRBP except EC that showed negative correlation. N, P, K, OC% and PH values have positive significant correlation with TRBP but EC have negative correlation with TRBP. On the basis of correlation co-efficient values, positive significant values are grouped in three. Example – strong (r = >0.5), medium (r = < 0.4 but greater than 0.1) and weak (r < 0.1). Thus the present study reveals that P has strong positive significant correlation with TRBP. N, K & OC% have medium correlation and pH has weak positive significant correlation with TRBP.

Isolation of Phosphate solubilizing bacteria from Rhizosphere of Korea District of Chhattisgarh

Total of 28 phosphate solubilizing bacteria were isolated

Table 2. Correlation and Regression studies between physico-chemical property and total rhizospheric microbial population of soil of Korea District (Chhattisgarh)

S/No.	Independent Character	Dependent Character	Correlation (r)	Calculated t- value	Regression Equation
1.	N	TRBP	0.184942	0.903*	**Y=** .002 **X=+**3.427
2.	P	TRBP	0.655487	4.163*	**Y=**.044 **X=+**2.201
3.	K	TRBP	0.21609	1.395*	**Y=**.004 **X=**+2.787
4.	OC%	TRBP	0.29935	1.505*	**Y=**.970 **X=+**3.188
5.	pH	TRBP	0.091674	0.442*	**Y=** .173 **X=+**2.706
6.	EC	TRBP	-0.38674	-2.011**	**Y**= -.807 **X**=+4.097

Significant (p=>0.05) = *Non-Significant(p< 0.05) =**

on Pikovskaya and Modified Pikovskaya medium from 25 soil samples (Table 3), collected from five blocks of Korea District of Chhattisgarh. Four bacterial isolates were identified as *Pseudomonas* spp. out of 28 bacterial cultures from division of plant pathology, IARI, Delhi and rest were identified as *Bacillus subtillis*.

DISCUSSION

Soil sampling and analysis

Soil is a medium that provides physical support to plants and supply plants with mineral nutrients that are essential for their growth and reproduction. Highly fertile soil contains >0.75% organic carbon, > 560 Kg/ha nitrogen, >55 Kg/ha phosphorus and > 280 Kg/ha potassium (Arora, 2002) and pH values between 6 and 7.5 and electrical conductivity values between 0 and 0.8 dS/m are optimal for crop growth (Arias et al., 2005). Sampling depth depends on the crop, cultural practices, tillage depth, and the nutrients to be analyzed. Because the greatest abundance of plant roots, greatest biological activity, and highest nutrient levels occur in the surface layers, the upper 12 inches of soil are used for most analyses. The analyses run on the surface sample include soil reaction (pH), phosphorus (P), potassium (K), organic matter, sulfur (S), boron (B), zinc (Zn), and other micronutrients. Sampling depth is especially critical for nonmobile nutrients such as P and K. The recommended sampling depth for nonmobile nutrients is 12 inches. The tillage zone, typically 6 to 8 inches deep, usually contains a relatively uniform, high concentration of nonmobile nutrients. Below the tillage zone the concentration is usually lower. Therefore, a sample from the tillage zone will usually have a higher content of nonmobile nutrients than a sample from the desired 0- to 12-inch sample depth.

The soil fertility levels influences plant growth and microbial population that itself is affected by tillage and nutrient mobility. A total of 25 soil samples, each weighing 200 g were obtained as representative samples (Mahler and Tindal, 1994) from 5 blocks of Korea District of Chhattisgarh, from rhizosphere region of crop fields and analyzed for Physico-chemical property at Biotech Lab Training and Demostration Center, Collectorate, Ambikapur (Chhattisgarh). Our results on the different parameters indicate that soils of Korea District of Chhattisgarh has pH (5.86-6.9), EC (0.1- 0.9 mmol/cm) and contained organic carbon (0.28-0.89%), N (126.2-278.2 Kg/ha), P (14.9-48.9 Kg/ha) and K (207.5-336.2 Kg/ha). The above soil test results are as per fertility rating interpreted by Arora, (2002) and Arias et al. (2005) suitable for cultivation of crops except nitrogen and phosphorus that were slightly less than optimum range.

Total rhizospheric bacterial population (TRBP)

The rhizosphere is a hot spot of soil organisms: microbial activity is stimulated by nutrient content of soil. Rhizosphere microorganisms have marked effect on plant performance in agricultural and marginal soils by influencing growth and development of root and improving nutrient availability in the rhizosphere.

Our results on the total rhizospheric bacterial (TRBP) population indicates that bacterial population in the rhizospheric soil of Korea District of C.G. ranged from minimum 3.03 × 10^6 to maximum 4.92 × 10^6 cfu. Highest rhizospheric bacterial population (4.92 × 10^6) was recorded from rhizospheric soil of *Triticum aestivum* (Pahadhanswahi, Sonhat block), followed by 4.83 × 10^6 from rhizospheric soil of *L. esculentum* (Dumaria, Baikunthpur block) and lowest rhizospheric bacterial population 3.03 × 10^6 was recorded from rhizospheric soil of *Oryza sativa* (Akhradand, Khadgawan Block). Marilley and Aragno (1999) reported that plant root exudates are good nutrient source for microorganisms that allow some microbial species to proliferate rapidly in the rhizosphere especially those with high growth rates and relatively high nutrient requirements such as pseudomonads. The composition of microbial community is affected by the amount and composition of root exudates which in turn influences nutrient availability of soil. The variation in total rhizospheric bacterial population in near vanity of roots may be due to organic carbon substrates supplied from

Table 3. Occurrence of Phosphate solubilizing bacteria in Rhizospheric soil of Korea District of Chhattisgarh.

S/No.	Blocks	Field	Crops	Bacterial genus identified from Rhizospheric soil	Presence (+) or absence (-) of PSB
1.	Khadgawan Block	Cheetajhor	*Oryza sativa*	*Bacillus subtilis*	(+)
		Banjaridand	*Oryza sativa*	*Bacillus subtilis*	(+)
		Akhradand	*Oryza sativa*	*Bacillus subtilis*	(+)
		Dubchhola	*Oryza sativa*	*Bacillus subtilis*	(+)
		Bhukbhukii	*Oryza sativa*	*Bacillus subtilis*	(+)
2.	Sonhat Block	Navgayi	*Oryza sativa*	*Bacillus subtilis*	(+)
		Katgodi	*Abelmoschus eculentus*	*Bacillus subtilis*	(+)
		Kachardand	*Oryza sativa*	*Bacillus subtilis*	(+)
		Ghughra	*Oryza sativa*	*Bacillus subtilis*	(+)
		Kailashpur	*Oryza sativa*	*Pseudomonas syringae*	(+)
3.	Manendragarh Block	Barbaspur	*Abelmoschus eculentus*	*Pseudomonas syringae*	(+)
		Sarbhoka	*Triticum aestivum*	*Bacillus subtilis*	(+)
		Pahadhanswahi	*Triticum aestivum*	*Bacillus subtilis*	(+)
		Kachhod	*Oryza sativa*	*Bacillus subtilis*	(+)
		Belbehra	*Oryza sativa*	*Bacillus subtilis*	(+)
4.	Baikunthpur Block	Kharwat	*Triticum aestivum*	*Bacillus subtilis*	(+)
		Tendua	*Triticum aestivum*	*Bacillus subtilis*	(+)
		Bisunpur	*Oryza sativa*	*Bacillus subtilis*	(+)
		Dumaria	*Lycopersicon esculentum*	*Bacillus subtilis* , *Pseudomonas alcaligenes*	(+)
		Nagar	*Cajanus cajan*	*Bacillus subtilis*	(+)
5.	Janakpur Block	Khetawli	*Oryza sativa*	*Bacillus subtilis*	(+)
		Barel	*Oryza sativa*	*Bacillus subtilis*	(+)
		Dhobataal	*Oryza sativa*	*Bacillus subtilis*	(+)
		Chutki	*Lagenaria vulgaris*	*Bacillus subtilis*	(+)
		Umarwaah	*Oryza sativa*	*Pseudomonas alcaligenes*	(+)

the roots exudates and dead organic matter (Baudoin et al., 2001). Rhizosphere soil of different plant species shows differential composition and abundance of microbial populations (Ponmurugan and Gopi, 2006).

Correlation and Regression studies between physico-chemical property of soil and total rhizospheric microbial population of soil of Korea District (Chhattisgarh)

Our result on the present study of correlation and regression between physico-chemical properties and total rhizospheric bacterial population (TRBP) of soil of Korea District (Chhattisgarh), indicates that the TRBP is affected greatly by N, P, K, OC%, pH of soil and showed positive significant correlation except EC, which showed negative correlation. Ross and Tate (1993) reported that microbial biomass and activities are coordinated by many soil and environmental factors such as soil organic matter quality, physic-chemical characteristics of soil. Pereira et al. (2006) observed that low pH values and high metal contents negatively affected the size and activity of soil microbial biomass. Also the soil external parameters such as water content, temperature, pH, soil types (texture, organic matter, microaggregate stability, presence of key nutrients such as N, P, K, and Fe), composition of root exudates, presence of other microorganisms and plant species are major determinant of overall microbial diversity (Grayston et al., 1998; Dakora and Philipps, 2002). Plants grown with deficient or sufficient nutrient supply generaly have different microbial communities in the rhizosphere (Marschner et al., 2004; Marschner et al., 2005b; 2006; 2007). Rengel and Marschner (2005) told that nutrient deficiency can influence rhizosphere microorganisms. Microbial community composition is also influenced by soil properties as well as P addition (Marschner et al., 2006) and other management factors (Steenwerth et al., 2003; Marschner et al., 2005b; Steenwerth et al., 2008), with agricultural intensification resulting in decreased microbial diversity and lowering of ecosystem function (Steenwerth et al., 2005).

Isolation of phosphate solubilizing bacteria from rhizosphere of Korea District of C. G.

Occurrence of phosphate solubilizing bacteria in rhizospheric soil of Korea District of Chhattisgarh depicted in Table 3. Our result on isolation of phosphate solubilizing *Pseudomonas* spp. from soil of Korea District of Chhattisgarh indicates 100% success for best distribution of phosphate solubilizing bacteria but poor distribution of *Pseudomonas* spp. indicating only 14% occurrence while 86% bacterial inhabitants belong to genus *Bacillus*. The number and type of bacterial inhabitants of rhizospheric soil is determined by the nutrient content of soil. The report of Glandorf et al. (1993) supported our findings that the occurrence and composition of *Pseudomonas* population differed between crops. Rhizosphere soil of different plant species shows differential composition and abundance of microbial populations (Ponmurugan and Gopi, 2006). Species of bacterial genus *Pseudomonas* and *Bacillus* predominates in the rhizhosphere are most extensively studied (Kumar et al., 2011).

In the present research work we were able to isolate phosphate solubilizing bacteria from agricultural soil of Korea District of Chhattisgarh, India. Korea District of Chhattisgarh is known for coal mines and mining is the main occupation of local residents. Nutrient status of agricultural land is poor and agricultural people generally depend upon single season crop. The information generated through the present investigation will help for the future study of the nutrient quality of soil, effect of soil pollution by pollutants in mining area and consequently for the maintenance of indigenous microorganisms in the soil through the correction of above studied soil parameters; however further research is needed to explore other potentials of these isolates and environmental parameters of Korea District of Chhattisgarh.

Conflict of interests

The author(s) did not declare any conflict of interest.

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