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INFLUENCE OF NATURAL SAFEROCK MINERAL ON SOIL MICRO-BILOGICAL PARAMETERS UNDER RICE-WHEAT CROPPING SYSTEM

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Abstract

A field experiment was conducted to study the effect of SafeRock Minerals (SRM) application on soil microbiological parameters in rice-wheat cropping system. The experiments consisted of two methods of rice and wheat establishment and six different levels of crop nutrition including SRM with mineral fertilizers and organic manure (FYM). The rice was grown in *kharif* (June to October) season through aerobic direct seeded condition and flooded transplanted system. During *rabi* (October to April) season wheat was cultivated by two establishment methods *viz*. system of wheat intensification (SWI) and conventional wheat. The high yielding varieties of *Basmati* rice (*Pusa Basmati* 1509) and wheat (HD 2967) were used in the experiment. The results revealed that the soils of rice and wheat crops showed significant improvement in available N, P and K and soil microbial parameters (enzymatic activities and microbial biomass carbon) due to the integrated application of 250 kg/ha SRM + 100% recommended dose of fertilizer (RDF) and 250 kg/ha SRM + 50% RDF (chemical) + 25% RDF (organic) and 250 kg/ha SRM + 50% organic-FYM (10.0 t/ha) over the sole SRM application under both the methods of stand establishment of rice as well as wheat.

Introduction

Rice and wheat are the world's two most important cereal crops, contributing 45% of the digestible energy and 30% of total protein in the human diet (Alam *et al.* 2014). In South Asia, rice-wheat crop sequence is the largest agriculture production system and occupies about 13.5 million hectares area including 10.5 million hectares in India, extending from Indo-Gangetic plain to Himalayan foothills (Singh and Kaur 2012, Sister *et al.* 2013). In spite of such a vital significance of rice-wheat cropping system in providing food security and livelihood to hundreds of millions of people around the globe the questions have arisen regarding the sustainability of the system due to various environmental, economic and management problems encountered in areas following this production system (Upadhyay *et al.* 2014).

SafeRock mineral is a natural mineral resource which can be used to reduce dependence on chemical fertilizers, as it contains many of the minerals (P 0.5%, K 5.5%) and trace elements (Si 21%, Ca 1.2%, Mg 1.3%, Al 4.5%, Fe 2.2%, Na 1.6%) essential for healthy crops and livestock. It has been recently discovered in the United Kingdom. SafeRock Minerals are reported to provide a natural holistic solution to help to mitigate the global crisis of soil degradation and water scarcity. It has shown to be agronomically effective, slow-release fertilizers that can provide many macro- and micronutrients to enhance soil fertility and restore soil fertility in the long-term. It has the greatest affinity for ammonium and potassium but when a plant is taking up the ammonium or potassium off the SRM, it attracts calcium from the phosphorus mineral apatite, such as rock phosphate, or locked up phosphorus in soil to balance the SRM, negative charge. This is reported to be achieved through its unique balance of nutrients and clay minerals, which also increases microbial and earthworm activity and builds long term soil fertility (www.saferockminerals.com).

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Soil microorganisms play an important role in the soil environment. They are the critical factors that determine soil organic matter decomposition, nutrient cycling, soil degradation and bioremediation of soil pollution (Larkin 2003, Li *et al.* 2012). Some studies have documented that fertilization has had significant impacts on the population, composition and function of soil microorganisms, and that organic and inorganic fertilizer amendments have increased the soil microorganisms' activity (Mandal *et al.* 2007, Ge *et al.* 2008). However, other studies have demonstrated that inorganic and organic fertilizers have had relatively little or no effect on soil microbial diversity and activities (Treseder 2008, Kabirigi *et al.* 2017). Long-term fertilization experiments can be controlled so as to modify soils in a particular manner and so can contribute significantly to existing knowledge about the evolution of soil fertility, the effects of fertilization, nutrient cycling in croplands, as well as soil biogeochemical cycles (Kstjasteinauer *et al.* 2015). Thus, research on soil microorganism communities under long-term fertilizer management has been one of the foci of soil ecological research in recent years (Yamaguchi *et al*. 2009, Wen Yi Dong *et al.* 2014). Geiseller and Scow (2014) published a meta-analysis based on 107 datasets from 64 long-term experiments from around the world and revealed that mineral fertilizer application led to a significant increase (15.1%) in the microbial biomass above levels in the unfertilized control treatments (Rebecca *et al.* 2017). With the above background, an experiment was conducted to study the effects of SRM application on microbiological parameters of soil in rice-wheat cropping system.

Materials and Methods

The field and laboratory experiments were conducted during 2016-17 and 2017-18 at the research farm of ICAR-Indian Agricultural Research Institute, New Delhi, India. The institute farm is located at a latitude of 28^o40’ N and longitude of 77^o12’ E with an altitude of 228.6 meters above the mean sea level (Arabian Sea). Before beginning of experiments composite soil sample of same field was having 144.6 kg/ha alkaline permanganate oxidizable N (Subbiah and Asija 1956), 14.7 kg/ha available P (Olsen *et al*. 1954), 261.5 kg 1 N ammonium acetate exchangeable K. The pH of soil was 7.8 (1 : 2.5 soil and water ratio).

The experiment was laid out in randomized block design (RBD) with six treatments and replicated thrice which were statistically analyzed using the F-test following Gomez and Gomez (1984). LSD values at p = 0.05 were used to determine the significance of difference between treatment means. The following six treatments were included:

- No SafeRock Minerals (SRM) application +100 % RDF* ($N_{120}P_{60}K_{60}$) - control
- Only SRM application @ 250 kg/ha
- SRM application @ 250 kg/ha + 50 % RDF($N_{60}P_{30}K_{30}$)
- SRM application @ 250 kg/ha + 100 % RDF
- SRM application @ 250 kg/ha + 50 % RDF (Chemical)+ 25 % RDF (Organic-FYM 10 t/ha)
- SRM application @ 250 kg/ha + 50 % RDF (Organic-FYM)

*Recommended dose of fertilizer

Basmati (aromatic) rice variety ‘*Pusa Basmati* 1509’ and wheat variety ‘HD 2967’ were taken in rice and wheat crops, respectively. Rice was grown under direct sown aerobic and puddled transplanted conditions whereas, wheat was grown under conventional and system of wheat intensification (SWI) condition. In transplanted rice 21 days old seedlings were transplanted after land preparation through puddling. Two seedlings were transplanted per hill. General recommendations for the crop were followed for performing all other agronomic practices excluding the treatments.

For analysis of microbial biomass carbon (MBC) the method described by Nunan *et al.* (1998) was followed. Enzyme analyses were carried out by using following method described by Tabatabai and Bremner (1969). Dehydrogenase was estimated by the method given by Klein *et al.* (1971). Fluorescein diacetate (FDA) enzyme was analysed by the method given by Green *et al.* (2006).

Results and Discussion

Status of microbial biomass carbon (MBC) in soil at 30, 60 DAS/DAT and crop maturity stage was significantly influenced due to the integrated application of SafeRock mineral with mineral and organic sources of nutrients (Table 1). MBC in soil was lowest with sole application of SRM and higher with SRM + 100% RDF and integrated application of organic and mineral nutrient sources. Application or organic sources also enhanced the MBC in general. MBC was found to vary between 167.10 and 215.12 and 222.24 to 238.66 µg MBC/g soils in aerobic rice and 188.11 to 220.45 and 228.22 to 274.43 µg MBC/g soils in transplanted rice and 169.43 to 208.66 and 224.13 to 260.66 µg MBC/g soils in conventional wheat and 182.33 to 211.66 and 230.32 to 261.18 µg MBC/g soils in system of wheat intensification 30 DAS and 60 DAS and crop maturity stage, respectively. The highest MBC (274.43 µg MBC/g soil) in rice and MBC (261.18 µg MBC/g soils) in wheat were recorded with 250 kg SRM + 100% RDF and it was statistically different from rest of the treatment. The treatment with sole SRM recorded lowest MBC as compared to other treatment under aerobic as well as transplanted and conventional as well as system of wheat intensification conditions. MBC content further increased due to combined application of SRM with organic material (FYM) compared to their sole application mineral fertilizer. Soil MBC declined at crop harvest stage while it was highest at 60 DAS/DAT. Similar results were reported by Geiseller and Scow (2014) who published a meta-analysis based on 107 data sets from 64 long-term experiments from around the world and revealed that mineral fertilizer application led to a significant increase (15.1%) in the microbial biomass above levels in the unfertilized control treatments.

Alkaline phosphatase enzyme activity in soil at 30 and 60 DAS/DAT and crop harvest stage of rice and wheat were significantly influenced due to the application of SRM with mineral fertilizers and organic sources as compared to sole SRM application (Table 2). Alkaline phosphatase enzyme activity was significantly higher at 250 kg/ha SRM + 100% RDF ($N_{120}P_{60}K_{60}$) than other treatments while lowest activity was recorded at only SRM application. Alkaline phosphatase enzyme activity with 250 kg/ha SRM + 100% RDF was highest and it was significantly higher over sole 250 kg/ha SRM application. Alkaline phosphatase enzyme activity through SRM + 100 RDF was at par with integrated application of mineral fertilizers and organic manure. Treatment having combined application of SRM and organic manure showed higher alkaline phosphatase enzyme activity than sole application of mineral fertilizers in most of the observations. Alkaline phosphatase enzyme was declined at crop harvest stage while it was highest at 60 DAS/DAT. Nath *et al.* (2011) also reported increased phosphatase activity in rice due to the application of rock phosphate.

Like alkaline phosphatase enzyme activity and dehydrogenase enzyme activity in soil at 30 and 60 DAS/DAT and crop harvest stage of rice and wheat crop increased significantly due to the integrated application of 250 kg/ha SRM with other mineral fertilizers and organic manures over the sole SRM application (Table 3). Dehydrogenase enzyme activity was significantly highest at 250 kg P/ha through SRM + 100% RDF while lowest activity was recorded at sole SRM application. Dehydrogenase enzyme activity with 250 kg/ha SRM + 100% RDF was significantly higher over 250 kg P/ha SRM, 250 kg/ha SRM + 50% RDF and found at par with No SRM +100%

Table 1. Effect of SafeRock minerals application on microbial biomass carbon (MBC) of rice and wheat soil in rice-wheat cropping system.

Treatment	Microbial biomass carbon (µg c/g soil)											
	Rice						Wheat					
	Aerobic			Transplanted			Conventional			SWI		
	30 DAS	60 DAS	At harvest	30 DAT	60 DAT	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
No SRM + 100% RDF	198.1	236.1	222.1	210.2	250.3	224.0	196.1	256.3	221.5	201.7	258.6	224.2
Only SRM 250 kg/ha	167.1	222.2	205.2	188.1	228.2	210.1	169.4	224.1	201.3	182.3	230.3	204.2
SRM + 50% RDF	183.2	225.5	215.0	197.1	236.3	218.4	186.3	251.3	214.2	196.4	252.2	219.3
SRM + 100% RDF	215.1	238.7	227.1	220.5	274.4	234.2	208.7	260.7	224.1	211.7	261.2	226.7
SRM + 50% RDF (chemical) + 25%RDF (organic)	196.1	231.3	221.1	200.3	249.1	222.2	191.7	254.5	220.3	198.1	256.6	222.3
SRM + 50% RDF (organic)	186.5	228.1	220.4	190.1	238.1	220.2	190.6	253.2	219.2	197.7	255.3	221.3
SEm±	4.4	5.8	4.0	4.9	5.8	5.0	5.7	6.1	5.7	6.1	6.2	5.8
LSD (p = 0.05)	14.4	16.7	13.9	14.9	17.0	15.3	17.8	20.2	18.7	17.9	20.7	18.9

RDF: Recommended dose of fertilizer; SRM: SafeRock Mineral; DAS: Days after sowing; DAT: Days after transplanting and SWI: System of wheat intensification.

Table 2. Effect of SafeRock Minerals application on alkaline phosphatase activity in soils of rice and wheat.

Treatment	Alkaline phosphatase activity (µg PNP/g soil/hr)											
	Rice						Wheat					
	Aerobic			Transplanted			Conventional			SWI		
	30 DAS	60 DAS	At harvest	30 DAT	60 DAT	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
No SRM + 100% RDF	60.6	66.8	62.0	62.2	68.5	63.1	43.4	66.9	62.0	44.2	67.3	63.1
Only SRM 250 kg/ha	45.4	52.7	46.3	49.6	58.9	47.7	30.7	53.8	49.3	31.7	54.1	50.7
SRM + 50% RDF	56.8	58.4	52.0	57.5	63.4	50.6	36.9	59.8	55.1	37.6	60.6	56.6
SRM + 100% RDF	66.5	72.9	64.4	68.7	78.6	71.9	44.6	67.5	62.4	45.7	68.5	64.9
SRM + 50% RDF (chemical) + 25%RDF (organic)	58.3	65.6	60.3	61.6	66.9	64.5	41.5	64.1	59.4	42.6	65.6	58.5
SRM + 50% RDF (organic)	57.9	64.8	58.3	58.6	65.8	62.6	38.0	61.3	57.3	38.6	62.7	57.6
SEm±	2.2	2.9	2.22	2.7	2.9	2.7	0.8	1.7	1.4	1.0	1.8	1.5
LSD (p = 0.05)	6.48	7.9	6.6	7.0	8.1	7.4	2.9	5.1	4.3	3.1	5.2	4.6

Table 3. Effect of SafeRock Minerals application on dehydrogenase activity in rice and wheat soil.

Treatment	Dehydrogenase activity (µgTPF/g soil/d)											
	Rice						Wheat					
	Aerobic			Transplanted			Conventional			SWI		
	30 DAS	60 DAS	At harvest	30 DAT	60 DAT	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
No SRM + 100% RDF	14.5	30.8	18.8	18.5	38.3	21.5	52.3	70.9	63.9	53.7	71.8	64.8
Only SRM 250 kg/ha	9.7	20.1	14.8	10.0	25.3	15.8	41.7	59.3	52.8	42.7	60.9	53.8
SRM + 50% RDF	11.6	21.2	15.6	13.5	34.2	17.5	45.5	63.2	56.5	47.0	64.6	57.9
SRM + 100% RDF	20.3	33.8	20.6	21.1	44.7	24.3	53.1	71.7	64.3	54.7	72.9	65.8
SRM + 50% RDF (chemical) + 25%RDF (organic)	13.9	26.2	17.6	18.2	37.2	19.3	51.2	69.2	62.3	52.8	70.7	63.1
SRM + 50% RDF (organic)	12.1	22.2	16.5	15.3	36.0	18.1	48.3	67.0	59.1	49.9	67.5	60.4
SEm±	0.3	1.3	0.5	0.4	0.9	0.6	1.3	1.7	1.6	1.4	1.9	1.8
LSD (P=0.05)	1.1	2.4	1.3	1.1	1.9	1.6	4.1	5.1	5.0	4.1	5.8	5.1

Table 4. Effect of SafeRock minerals application on fluorescein diacetate (FDA) in rice and wheat soil.

Treatment	FDA activity (µg fluoresceince/g soil/hr)											
	Rice						Wheat					
	Aerobic			Transplanted			Conventional			SWI		
	30 DAS	60 DAS	At harvest	30 DAT	60 DAT	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
No SRM + 100% RDF	1.22	1.87	1.33	1.27	1.88	1.38	2.56	7.34	6.45	2.64	7.43	6.58
Only SRM 250 kg/ha	0.69	1.08	0.75	0.86	0.98	0.86	1.58	6.34	5.45	1.59	6.48	5.56
SRM + 50% RDF	0.95	1.56	1.23	1.17	1.78	1.25	1.95	6.83	5.92	2.08	6.96	6.03
SRM + 100% RDF	1.28	1.96	1.42	1.31	2.30	1.48	2.67	7.48	6.59	2.77	7.56	6.67
SRM + 50% RDF (chemical) + 25% RDF (organic)	1.16	1.73	1.31	1.19	1.87	1.36	2.45	7.21	6.32	2.56	7.34	6.43
SRM + 50% RDF (organic)	0.89	1.66	1.26	1.18	1.81	1.28	2.21	6.97	6.12	2.31	7.09	6.23
SEm±	0.13	0.22	0.15	0.14	0.19	0.16	0.04	0.21	0.16	0.03	0.22	0.18
LSD (p = 0.05)	1.22	1.87	1.33	1.27	1.88	1.38	0.14	0.62	0.53	0.15	0.64	0.57

RDF and SRM+ 50% RDF (chemical) + 25% RDF (organic). Treatment having integrated application of SRM with FYM showed higher dehydrogenase enzyme activity than sole mineral fertilizer application. Dehydrogenase enzyme activity declined at crop harvest stage while it was highest at 60 DAS/DAT. Nath *et al.* (2011) also reported increased dehydrogenase activity in rice due to the application of rock phosphate.

Fluorescein diacetate (FDA) enzyme activity recorded in rice soil at 30 and 60 DAS/DAT and crop harvest stage of rice and wheat crop were found to increase significantly due to the integrated application of SRM with mineral fertilizer and organic manure over sole SRM application (Table 4). FDA enzyme activity was significantly higher than 250 kg/ha SRM + 100% RDF than other treatments while lowest activity was recorded at only SRM. FDA enzyme activity with 250 kg/ha through SRM + 100% RDF was significantly higher over 250 kg/ha SRM, SRM + 50% RDF and were found to be at par with no SRM + 100% RDF and SRM + 50% RDF (chemical) + 25% RDF (organic). Treatment having combined application of SRM showed higher FDA enzyme activity than sole application. FDA enzyme activity was found to decline at crop harvest stage while it was highest at 60 DAS/DAT.

In the present study, MBC and other parameters of rice and wheat were positively influenced by the integrated application of SRM in both the years. Integrated inoculation of 250 kg/ha SRM + 50% organic-FYM (10 t/ha) was found to be suitable combination for enhancing the microbial activities in soils of rice and wheat. This treatment was significantly better than the application of only SRM 250 kg/ha. Thus, integrated application of 250 kg/ha SRM + 50% organic-FYM (10 t/ha) may be appropriate dose for rice-wheat cropping system and therefore may be recommended for rice-wheat system in Indo-gangatic plains of south Asia.

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