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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON SOIL MICROBIAL POPULATION AND BIOMASS CARBON IN SUGARCANE-RATOON CROPPING SYSTEM

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ABSTRACT

A field experiment was executed at research farm of G.B. Pant University of Agriculture and Technology, Pantnagar during spring seasons from 2002-05 to find out the effect of integrated nutrient management on soil microbial population and microbial biomass-C in sugarcane based cropping system. Results indicated that the soil biota in terms of bacterial and fungal population was also rich in T_{10}. At 90 days, the bacterial and fungal populations under T_{10} were 8.52 and 3.60 log CFU g^{-1} soil, respectively against 8.00 and 3.29 log CFU g^{-1} soil, respectively under T_1. The actinomycetes and azotobacter population were also higher under T_{10}, being 4.54 and 5.58 log CFU g^{-1} soil, respectively. Total bacterial, fungus, actinomycetes, azotobacter and PSB population in soil were significantly affected by integration of different nutrient sources at harvest stage of plant and ratoon crops, except actinomycetes population in ratoon crops. In plant crop, plots receiving T_{10} maintained significantly higher microbial population than that of 100% NPK. The variations in soil microbial biomass carbon owing to different treatments were significant at different stages in plant and ratoon crop. At harvest, plot fertilized with T_{10} exhibited significantly higher soil microbial biomass carbon of 306.11 µg g^{-1} soil as against 227.0 µg g^{-1} soil under T_1. At harvest of ratoon crop, plot fertilized with T_{10} maintained significantly higher soil microbial biomass carbon of 305.08 µg g^{-1} soil as against 242.17 µg g^{-1} soil under T_1.

Key words : *Ratoon, Soil microbial biomass-C, Soil microbial population, Sugarcane*.

Sugarcane is very nutrient exhaustive crop requiring external use of inorganic fertilizers for attaining higher productivity but due to inappropriate and injudicious application of fertilizers aggravates the problems of soil fertility deterioration and imbalances in soil microbial population and biomass–C which can lead to sustainability under question. Due to integrated use of various organic nutrient sources like FYM, vermicompost, green manuring, pressmud, trash mulching with culture along with bio-fertilizers in supplementation with chemical sources of nutrients will definitely fulfill the overall requirement of the crop (Mader *et al*., 2002). Sutton *et al*. (1996) observed that there was positive influence of cane trash on the soil microbiota. Integrated use of organic manures and chemical fertilizers can sustain sugarcane productivity (Banger and Sharma, 1997).

Keeping in view all these issues, the present investigation was initiated to find out the effect of integrated use of inorganic and organic nutrient sources on soil microbial counts and soil microbial biomass-C in sugarcane ratoon cropping system.

MATERIALS AND METHODS

An experiment was implemented during 2002-05 at research farm of GBPUA&T, Pantnagar during two consecutive years in spring seasons in sugarcane-ratoon cropping system. The soil of the experiment was silty clay loam in texture, neutral pH, medium in organic carbon, available P_2O_5 and K_2O content with low in available N. Treatments comprised of different nutrient sources as mentioned in tables and imposed in plant and ratoon crops, laid out in randomized block design with four replications. Other agronomical operations for plant and ratoon crops were adopted as per their requirements. Observations were recorded on soil microbial populations i.e. bacterial, fungal, actinomycetes, azotobacter and PSB enumerated in nutrient agar, Martin's rose Bengal, Kenknight's agar, Jensen's medium and Pikovskaya's medium, respectively employing the standard dilution plate techniques as given by Black (1965). The soil samples from the field were collected at 0, 60, 90 DAS and harvest. For determination of soil microbial biomass

Table-1 : Effect of different treatments on population of bacteria and fungus in sugarcane plant and ratoon crop.

Treatments			Bacteria population (log CFU/g soil)								Fungus population (log CFU/g soil)							
			Plant				Ratoon				Plant				Ratoon			
	Plant	Ratoon	0 DAS	60 DAS	90 DAS	Harvest	0 DAR	60 DAR	90 DAR	Harvest	0 DAS	60 DAS	90 DAS	Harvest	0 DAR	60 DAR	90 DAR	Harvest
T_1	100% NPK	100% NPK	7.24	7.83	8.00	7.85	7.89	8.02	8.20	8.12	2.78	3.04	3.29	3.16	3.06	3.16	3.24	3.08
T_2	75% NPK+25% N (FYM)	100% NPK+ trash	7.38	7.88	8.02	7.94	8.12	8.37	8.41	8.30	2.83	3.10	3.36	3.28	3.24	3.32	3.31	3.26
T_3	75% NPK+25% N (CSPM)	100% NPK+ trash	7.54	7.90	8.10	8.09	8.18	8.26	8.28	8.39	2.77	3.11	3.37	3.30	3.21	3.27	3.38	3.06
T_4	100% NPK	75% NPK+ GM	7.36	7.80	7.98	7.80	8.01	8.17	8.24	8.19	2.77	3.05	3.29	3.15	3.29	3.36	3.38	3.31
T_5	75% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	7.86	8.37	8.45	8.35	8.37	8.55	8.69	8.61	2.90	3.32	3.52	3.41	3.38	3.52	3.55	3.45
T_6	75% NPK+25% N (CSPM)+ BF	100% NPK+ trash+ BF	7.87	8.26	8.52	8.39	8.43	8.58	8.65	8.56	2.97	3.35	3.49	3.38	3.42	3.55	3.62	3.49
T_7	50% NPK+25% N (FYM)+ BF	50% NPK+ GM+ BF	7.74	8.07	8.24	8.17	8.28	8.53	8.56	8.51	2.85	3.21	3.43	3.37	3.32	3.41	3.50	3.38
T_8	50% NPK+25% N (CSPM)+ BF	50% NPK+ GM+ BF	7.85	8.14	8.13	8.21	8.24	8.44	8.45	8.46	2.86	3.17	3.42	3.37	3.35	3.38	3.48	3.37
T_9	50% NPK+25% N (VC)+ BF	75% NPK+ 25% N (VC)+ BF	7.57	7.99	8.31	8.17	8.22	8.39	8.47	8.45	2.88	3.28	3.47	3.33	3.38	3.46	3.44	3.39
T_{10}	100% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	7.79	8.39	8.52	8.42	8.45	8.59	8.71	8.62	2.95	3.37	3.60	3.48	3.48	3.62	3.65	3.56
SEm±			0.14	0.08	0.08	0.08	0.06	0.05	0.03	0.04	0.08	0.07	0.04	0.04	0.06	0.04	0.05	0.08
CD (P=0.05)			0.42	0.25	0.24	0.24	0.19	0.15	0.10	0.14	NS	0.20	0.14	0.14	0.17	0.13	0.17	0.23

Table-2 : Effect of different treatments on population of actinomycetes and azotobacter in sugarcane plant and ratoon crop.

Treatments			Actinomycetes population (log CFU/g soil)								Azotobacter population (log CFU/g soil)							
			Plant				Ratoon				Plant				Ratoon			
	Plant	Ratoon	0 DAS	60 DAS	90 DAS	Harvest	0 DAR	60 DAR	90 DAR	Harvest	0 DAS	60 DAS	90 DAS	Harvest	0 DAR	60 DAR	90 DAR	Harvest
T_1	100% NPK	100% NPK	3.89	4.09	4.25	4.18	4.06	4.25	4.28	4.14	4.72	5.08	5.22	5.09	4.93	5.09	5.21	5.10
T_2	75% NPK+25% N (FYM)	100% NPK+ trash	3.97	4.17	4.31	4.23	4.20	4.27	4.35	4.26	4.73	5.12	5.30	5.30	5.02	5.18	5.31	5.20
T_3	75% NPK+25% N (CSPM)	100% NPK+ trash	3.97	4.14	4.36	4.28	4.13	4.29	4.38	4.25	4.76	5.10	5.32	5.24	5.07	5.19	5.33	5.22
T_4	100% NPK	75% NPK+ GM	3.90	4.08	4.21	4.23	4.15	4.22	4.34	4.41	4.72	5.07	5.20	5.10	5.11	5.20	5.37	5.28
T_5	75% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	4.03	4.33	4.43	4.42	4.29	4.40	4.51	4.40	4.79	5.23	5.50	5.43	5.26	5.37	5.50	5.40
T_6	75% NPK+25% N (CSPM)+ BF	100% NPK+ trash+ BF	4.05	4.36	4.45	4.43	4.34	4.42	4.55	4.42	4.83	5.25	5.48	5.41	5.31	5.42	5.53	5.43
T_7	50% NPK+25% N (FYM)+ BF	50% NPK+ GM+ BF	4.00	4.25	4.40	4.32	4.28	4.35	4.47	4.38	4.75	5.13	5.46	5.40	5.22	5.08	5.49	5.40
T_8	50% NPK+25% N (CSPM)+ BF	50% NPK+ GM+ BF	3.98	4.30	4.38	4.39	4.26	4.29	4.41	4.34	4.75	5.16	5.41	5.37	5.18	5.19	5.41	5.37
T_9	50% NPK+25% N (VC)+ BF	75% NPK+ 25% N (VC)+ BF	5.02	4.19	4.38	4.32	4.25	4.33	4.39	4.29	4.81	5.15	5.39	5.31	5.16	5.21	5.46	5.34
T_{10}	100% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	4.08	4.40	4.54	4.47	4.36	4.46	4.56	4.23	4.83	5.27	5.58	5.43	5.38	5.45	5.55	5.46
SEm±			0.30	0.06	0.06	0.04	0.06	0.05	0.04	0.07	0.11	0.07	0.04	0.05	0.04	0.09	0.02	0.04
CD (P=0.05)			NS	0.19	NS	0.11	0.18	0.14	0.12	NS	NS	NS	0.13	0.17	0.12	NS	0.08	0.12

Table-3 : Effect of different treatments on PSB population in soil and soil microbial biomass C in sugarcane plant and ratoon crop.

	Treatments		PSB population (log CFU/g soil)								Soil microbial biomass carbon (µg/g soil)							
			Plant				Ratoon				Plant				Ratoon			
	Plant	Ratoon	0 DAS	60 DAS	90 DAS	Harvest	0 DAR	60 DAR	90 DAR	Harvest	0 DAS	60 DAS	90 DAS	Harvest	0 DAR	60 DAR	90 DAR	Harvest
T_1	100% NPK	100% NPK	4.26	4.53	4.67	4.35	4.21	4.35	4.49	4.41	240.6	245.0	251.7	227.0	238.0	243.2	249.6	242.1
T_2	75% NPK+25% N (FYM)	100% NPK+ trash	4.25	4.58	4.69	4.43	4.25	4.39	4.53	4.35	245.1	252.4	267.1	248.0	241.3	257.6	268.8	246.8
T_3	75% NPK+25% N (CSPM)	100% NPK+ trash	4.28	4.57	4.72	4.46	4.32	4.43	4.56	4.39	248.4	259.8	262.9	239.8	247.3	250.7	260.2	250.5
T_4	100% NPK	75% NPK+ GM	4.26	4.50	4.67	4.39	4.36	4.47	4.59	4.32	244.2	247.9	250.0	229.8	280.7	304.3	320.6	305.0
T_5	75% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	4.31	4.61	4.76	4.54	4.49	4.58	4.72	4.57	257.0	274.0	309.8	301.6	268.6	289.0	297.0	281.9
T_6	75% NPK+25% N (CSPM)+BF	100% NPK+ trash+ BF	4.33	4.62	4.77	4.57	4.52	4.59	4.70	4.54	253.6	280.4	302.5	289.2	274.4	296.7	305.7	287.2
T_7	50% NPK+25% N (FYM)+BF	50% NPK+ GM+ BF	4.29	4.61	4.74	4.52	4.47	4.54	4.67	4.52	250.1	267.8	286.2	280.7	257.1	271.9	284.1	258.9
T_8	50% NPK+25% N (CSPM)+BF	50% NPK+ GM+ BF	4.30	4.58	4.75	4.47	4.43	4.55	4.62	4.49	253.2	262.1	280.1	283.8	260.0	283.1	290.1	274.6
T_9	50% NPK+25% N (VC)+BF	75% NPK+25% N (VC)+BF	4.27	4.59	4.72	4.46	4.40	4.51	4.65	4.44	249.9	269.7	293.7	256.3	253.3	265.2	275.6	260.2
T_{10}	100% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	4.34	4.63	4.83	4.58	4.54	4.62	4.74	4.57	260.2	284.5	318.6	306.1	287.0	308.1	312.3	300.1
SEm±			0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.03	4.7	5.6	5.9	4.9	5.4	6.4	8.4	6.4
CD (P=0.05)			NS	0.07	0.05	0.06	0.07	0.06	0.06	0.09	NS	16.2	17.1	14.4	15.7	18.7	24.4	18.5

carbon, chloroform fumigation extraction method was applied as described by Jenkinson and Powlson (1976).

RESULTS AND DISCUSSION

Effect of different treatments on soil microbial properties in sugarcane plant

Bacterial population : A perusal of data revealed that maximum bacterial population was recorded with T_{10} which was significantly higher than rest of the treatments. However, the crop fertilized with T_1 exhibited minimum bacterial population. The differences in bacterial population between T_2 or T_3 and T_5 or T_6 were also significant where later exhibited higher bacterial population than that of former. The soil fertilized with T_7, T_8 or T_9 recorded more population of bacteria as compared to T_1. Total bacterial population in soil was significantly affected by integration of different nutrient sources. Bacterial population tended to increase upto 90 days and declined at harvest.

Fungal population : Total fungal population in soil was significantly influenced by different treatments, except at 0 day. Soil receiving T_{10} attained significantly higher fungal population, which was at par with T_5 or T_6 and was also at par with T_7 or T_8, except at 90 days. However, soil treated with T_1 significantly exhibited lowest population of fungus which was at par with T_2 or T_3 at all stages.

Actinomycetes population : The data revealed that differences in actinomycetes population owing to different treatments were significant, except at 0 and 90 day. At harvest, crop fertilized with T_{10} exhibited significantly higher population of actinomycetes, being at par with T_5 or T_6 and T_8 but significantly higher than that of other treatments. However, the minimum actinomyctes population was noted from T_1 which was at par with T_2 or T_3.

Azotobacter population : The data showed that azotobacter population varied significantly due to different treatments, except at 0 and 60 day. At harvest, soil receiving T_{10} exhibited significantly higher azotobacter population. However, the lowest azotobacter population was noted under T_1. The differences in azotobacter counts among other treatments were non-significant.

PSB population : The data revealed that different treatments of nutrient sources had significant effect on PSB population, except at 0 day. Soil treated with T_{10}

exhibited significantly higher PSB population than that of rest of the treatments. However, T_1 resulted in significantly lower PSB population than that of T_2 or T_3 and T_5 or T_6. Similar trend was noted at other stages.

Soil microbial biomass carbon : The data indicated that the variations in soil microbial biomass carbon owing to different treatments were significant, except at 0 day. The soil microbial biomass carbon increased upto 90 days and thereafter declined at harvest. At harvest stage, the soil microbial biomass carbon was maximum (306.11 µg g-1 soil) from T_{10}. However, lowest soil microbial biomass carbon (227.0 µg g-1 soil) was observed with T_1.

Effect of different treatments on soil microbial properties in sugarcane ratoon

Bacterial population : Bacterial population in soil was significantly affected due to integrated nutrient supply in ratoon crop. The data showed that the population of bacteria increased upto 90 days after rationing and further declined at harvest. At harvest, maximum bacterial population was observed under T_{10} which was at par with T_5, T_6 and T_7. However, T_1 resulted in the lowest bacterial population. The differences in bacterial population between T_4 and T_9 and T_2 and T_8 were also found significant. Similar trend was observed at other stages of ratoon crop.

Fungal population : Differences in fungal population in soil owing to various treatments were significant at all the stages of ratoon crop. At harvest, highest fungus population was observed under T_{10}, being at par with that of T_6 and T_5. However, lowest fungus population was noted under T_1 which was at par with that of T_3 except at harvest. The differences in fungus population between T_9 and T_4 were not significant at all the stages of ratoon crop.

Actinomycetes population : Differences in actinomycetes population due to different treatments were significant at all the stages of ratoon crop except at harvest stage. However, T_{10} resulted in higher actinomycetes population except at harvest while T_1 exhibited lowest actinomycetes population. Differences between T_6 and T_4 were also significant where former recorded higher actinomycetes population than later.

Azotoobacter population : The data pertaining to azotobacter population in soil showed significant variations in their population owing to different treatments at all the stages of ratoon crop except at 60 days. At harvest, significantly higher azotobacter population was noted under T_{10}. However, T_1 exhibited lowest azotobacter population at all the stages of ratoon crop. The differences in azotobacter population among T_2 and T_3 and T_5 and T_6 were non-significant at all the stages of ratoon crop.

PSB population : Integrated nutrient management system had significant influence on the PSB population at all growth stages of ratoon crop. The highest PSB population was noted under T_{10}, being at par with that of T_5 but significantly higher than that of other treatments. The differences in PSB population in T_6 and T_4 were also significant, where former maintained higher PSB population than that of later. T_1 maintained lowest PSB population at all the stages of growth of ratoon crop, except at harvest, which remained at par with that of T_2.

Soil microbial biomass carbon : The differences in soil microbial biomass carbon in ratoon crop under different treatments were significant. The perusal of data showed that the plot receiving T_{10} exhibited significantly higher soil microbial biomass carbon at 0 and 60 days whereas at 90 days and harvest stage, T_4 resulted in higher soil microbial biomass carbon. The differences in soil microbial biomass carbon between T_1 and T_8 were also significant where former exhibited lower soil microbial biomass carbon than that of later. These findings proved the fact that highly soluble C concentrations stimulate microbial activities, since organic substrates are chief source of energy for microbes. Moreover, concentration of microbes has been more pronounced in low fertile soils (Oliveira *et al*., 2006) as in this case. Microbial biomass, although small, plays a key role in controlling the nutrient recycling and energy flow due to its fast turn over (Li and Chen, 2004 and Singh and Singh, 2002).

It might be concluded that T_{10} sustained soil health in terms of improving soil microbial population and microbial biomass carbon in sugarcane-ratoon cropping system.

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