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Improving beneficial microflora population in soils of predominant crop sequences through *Parthenium* utilization

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ABSTRACT

Congress grass (Parthenium hysterophorus L.) is rapidly spreading in many countries around the world. The weed has become a serious threat to nature as well as managed ecosystems. An experiment was conducted during summer, kharif and rabi seasons of 2008-09 and 2009-10 at the Viswavidyalaya "C" Block Farm, Kalyani, Nadia, West Bengal to determine the suitability of Parthenium utilization either as green manure or as mulch along with recommended dose of fertilizers (RDF) in improving crop productivity and soil health rather than eradication or control of the weed. The results revealed that either green manuring or mulching of Parthenium @ 5 t ha^{-1} along with recommended dose of NPK would have the ability for enhancing productivity potentials of important crop sequences by improving soil microflora status possibly due to addition of weed biomass which resulted in better aeration and improved soil physical condition.

Keywords: *Parthenium*, green manure, mulch, soil microflora

Congress grass (*Parthenium hysterophorus* L.) is an exotic, poisonous, allergic and aggressive weed having tremendous potential for biomass production both under cropped and non-cropped situations. Proper utilization of the weed biomass through composting may have the potential to improve soil fertility and crop productivity (Shanmugasundaram, 2003). Its invasion in cultivated fields has been causing alarming signals in almost all the states of India as it grows everywhere and is almost associated with every crop. There are some reports about its utilization owing to its potential nutrient status as a source of organic manure either as compost (before or after flowering) or as green manure (before flowering), effective use in combination with graded levels of fertilizers for reducing the dose of chemical fertilizers and improving the soil health (Anudhekar and Gore, 2009; Ghosh *et al*., 2009), and also as mulch for the purpose of crop production and soil reclamation (Barman and Varshney, 2009). Thus, there is a need to investigate the potential of *Parthenium* biomass in improving beneficial microflora population in soil. Hence, the present study was taken up.

A field experiment was conducted at the Viswavidyalaya "C" Block Farm, Kalyani, Nadia, West Bengal during summer, *kharif* and *rabi* seasons of 2008-09 and 2009-10. The experimental site was situated at 23^0 N latitude and 89^0 E longitude with an altitude of 9.75 m above mean sea level and the land topography was medium. The experimental soil was new alluvium (Inceptisol) with sandy clay loam in texture, good irrigation-cum-drainage facility and medium soil fertility status, having soil pH 6.87, organic carbon 0.58%, available N 180.72 kg ha^{-1}, available P_2O_5 12.9 kg ha^{-1} and available K_2O 130.2 kg ha^{-1}. The experimental field was divided into 3 blocks and subdivided further into 9 plots of 4 x 5 m size. Irrigation channel of 1 m width was kept in between the blocks. Three nutrient management treatments *viz*. recommended dose of fertilizer (RDF) + green manuring (GM) with *Parthenium* @ 5 t ha^{-1}, RDF + mulching with *Parthenium* @ 5 t ha^{-1} and subsequent incorporation, and control (only RDF) were evaluated in three predominant crop sequences (black gram-transplanted paddy-onion, sesame-transplanted paddy-bengal gram, and okra-transplanted paddy-rapeseed in a sequence of summer-*kharif*-*rabi* season), following randomized block design with three replications. The C : N ratio of the applied *Parthenium* biomass was 21:1.

Soil samples were collected from the rhizosphere of various crop sequences before green manuring and mulching of *Parthenium* with RDF incorporated into the soil and after application for all the treatments at harvest. In case of GM @ 5 t ha^{-1} + RDF, soil samples were taken after GM application. The samples were properly tagged, sealed and carried out from the field to the laboratory for isolation of soil micro flora. The enumeration of microbial population was done on agar plates containing appropriate media following serial dilution technique and pour plate method, and plates were incubated at 30^{0}C. The counts were taken at 5th day

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of incubation. The results were reported as number of colony-forming units (CFUs) g^{-1} of soil.

For counting total number of viable bacteria, Thornton's agar medium was used and pH of the medium was adjusted at 7.4 and sterilized at 15 lbs pressure for 20 minutes. Martin's rose Bengal streptomycin agar medium was used for counting total fungi. Sterile streptomycin was added to the medium just prior to planting. A stock solution was prepared by dissolving 10.0 mg of streptomycin in 2.0 ml distilled water. Approximately 0.1 ml of this stock solution was added to each plate containing about 15 ml of the medium. Medium containing all the ingredients except streptomycin was sterilized at 15 lbs steam pressure for 20 minutes. Medium for actinomycetes was used for counting the number of total actinomycetes. pH of the medium was adjusted at 6.5-6.6 and the medium was sterilized at 15 lbs steam pressure for 20 minutes (Table 1).

The statistical analysis of the recorded data was done by the analysis of variance method (Gomez and Gomez, 1984). The significance of different sources of variations was tested by Error Mean Square by Fisher and Snedecor's 'F'-test at probability level of 0.05. For the determination of least significant difference at 5% level of significance, Fisher and Yates' tables were consulted.

Effect on total bacterial population

Total bacterial population (Table 5), as recorded under different treatments, revealed that population of total bacteria (35.00-38.67 CFU x 10^6 g^{-1}) did not differ significantly with the treatments before application of nutrients during summer season of 2008. Significant differences were observed among the treatments thereafter at initial and at harvest of each crop sequences from *kharif* season of 2008. In all the three seasons, similar trends were recorded regarding total bacterial population and finally the highest population (182.00 CFU x 10^6 g^{-1}) was found in case of application of NPK + GM of *Parthenium* @ 5 t ha^{-1}, followed by NPK (RDF) + mulching of *Parthenium* along with subsequent incorporation @ 5 t ha^{-1} and the lowest (170.00 CFU x 10^6 g^{-1}) from the only NPK (RDF) application.

The populations of total bacteria were non-significant in the first year of summer season, compared to the observation before applying nutrient (initial) and then increased after applying nutrient. The decrease in bacterial population was due to competitive influence and toxic effect of RDF + GM, RDF + mulching and only NPK (RDF) in soil. On the other hand, the increase might be due to the commensalic or protocooperative influence of various micro-organisms on total bacteria in the rhizosphere soil of various crop sequences. Shanmugasundaram (2003) was of the opinion that the utilization of *Parthenium* biomass for composting might have the potential to improve soil fertility.

Effect on population of fungi

Two-year data on fungal population (Table 6) showed that population of fungi, ranging from 53.33 to 57.00 CFU x 10^4 g^{-1}, did not differ significantly with the treatments before nutrient application (at initial). Trends regarding fungal population were similar during summer, *kharif* and *rabi* seasons. Finally highest population (139.67 CFU x 10^4 g^{-1}) was recorded under the application of NPK + GM of *Parthenium* @ 5 t ha^{-1} and was followed by NPK (RDF) + mulching of *Parthenium* along with subsequent incorporation @ 5 t ha^{-1} (136.00 CFU x 10^4 g^{-1}). The treatment having only NPK (RDF) application recorded comparatively lower population of fungi (126.67 CFU x 10^4 g^{-1}).

As per observation before applying nutrient, it showed that the population of fungi remained non-significant in the first year of summer season initially and then it increased after applying nutrients. The decrease in fungal population was due to competitive influence and toxic effect of RDF + GM, RDF + mulching and only NPK (RDF) in soil.

Effect on population of actinomycetes

The actinomycetes population as recorded under different treatments (Table 4) during 2008-09 and 2009-10 revealed that before applying nutrient, population of actinomycetes did not differ significantly with the treatments (22.15-24.32 CFU x 10^5 g^{-1}). In summer, *kharif* and *rabi* seasons, similar trends were recorded regarding actinomycetes population. Highest actinomycetes population (99.71 CFU x 10^5 g^{-1}) was recorded under the application of NPK + GM of *Parthenium* @ 5 t ha^{-1} followed by NPK (RDF) + mulching of *Parthenium* along with subsequent incorporation @ 5 t ha^{-1} (89.93 CFU x 10^5 g^{-1}). The NPK (RDF) application recorded the lowest population of (64.60 CFU x 10^5 g^{-1}).

The population of actinomycetes remained non-significant in the first year of summer season initially and then increased after application of nutrient. The decrease in the actinomycetes population was due to competitive influence and toxic effect of RDF + GM, RDF + mulching and only NPK (RDF) in soil. On the other hand, the increase was due to the commensalic or protocooperative influence of various micro-organisms

Table 1 : Different media used for the experiment

Name of medium	Composition	Reference
Thornton's agar	Dipotassium hydrogen phosphate [K_2HPO_4]: 1.0 g Calcium chloride [$CaCl_2$]: 0.1 g Magnesium sulphate [$MgSO_4$, $7H_2O$]: 0.2 g Sodium chloride [NaCl]: 0.1 g Ferric chloride [$FeCl_3$, $6H_2O$]: 0.002 g Potassium nitrate [KNO_3]: 0.5 g Asparagine [$C_4H_8N_2O_4$]: 0.5 g Mannitol [C_6H_8 $(OH)_6$]: 1.0 g Agar : 15.0 gDistilled water: 1000 ml	Thornton (1922)
Martin's rose bengal streptomycin agar	Potassium dihydrogen phosphate [KH_2PO_4]: 1.0 g Magnesium sulphate [$MgSO_4$, $7H_2O$]: 0.5 g Dextrose [$C_6H_{12}O_6$]: 10.0 g Peptone : 5.0 g Agar : 10.0 g Rose Bengal (1:300 aq) : 10.0 ml Distilled water : 1000 ml Streptomycin : 30 µg ml^{-2}	Martin (1950)
Jensen's agar	Dextrose [$C_6H_{12}O_6$]: 2.0 g Casein [dissolved in 10 ml of 0.1 (N) [NaOH] : 5.0 g Dipotassium hydrogen phosphate [K_2HPO_4]: 0.2 g Magnesium sulphate [$MgSO_4$, $7H_2O$]: 0.2 g Yeast extract : 0.5gPotassium chloride [KCl]: 0.2g Ferrous sulphate [$FeSO_4$ $2H_2O$]: TraceAgar : 15.0 g Distilled water : 1000 ml	Jensen (1930)

Table 2 : Effect of treatments on the population of total bacteria (CFUx10^6 g^{-1}) in soil

Treatment	2008-09						2009-10					
	Summer		*Kharif*		*Rabi*		Summer		*Kharif*		*Rabi*	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
N_1CS_1	37.00	90.33	88.02	103.00	102.33	128.67	127.33	142.67	141.33	164.33	163.67	181.00
N_2CS_1	37.67	83.67	82.67	96.33	94.67	122.00	121.67	136.00	135.67	157.67	156.00	174.33
N_3CS_1	37.33	80.00	80.50	92.67	93.00	118.33	118.50	132.33	133.00	154.00	154.33	170.67
N_1CS_2	36.00	91.33	90.31	104.00	102.33	129.67	128.33	143.67	142.33	165.33	164.67	182.00
N_2CS_2	37.00	83.67	82.67	96.33	95.67	122.00	121.67	136.00	135.67	157.67	156.00	174.33
N_3CS_2	35.00	79.33	80.05	92.00	92.33	117.67	118.33	131.67	132.33	153.33	153.67	170.00
N_1CS_3	38.67	89.67	88.55	102.33	101.67	128.00	127.67	142.00	141.67	163.67	162.00	180.33
N_2CS_3	38.00	84.00	83.09	96.67	95.00	122.33	122.00	136.33	135.00	158.00	157.33	174.67
N_3CS_3	38.33	81.33	81.83	94.00	94.33	119.67	120.33	133.67	132.33	155.33	156.67	172.00
SEm(±)	**0.94**	**0.35**	**0.30**	**0.52**	**0.49**	**0.15**	**0.15**	**0.40**	**0.32**	**0.35**	**0.33**	**0.39**
LSD (0.05)	**NS**	**1.04**	**0.96**	**1.56**	**1.47**	**0.46**	**0.45**	**1.19**	**1.15**	**1.06**	**1.00**	**1.16**

Table 3 : Effect of treatments on fungal population (CFUx10^4 g^{-1}) in soil

Treatment	2008-09						2009-10					
	Summer		*Kharif*		*Rabi*		Summer		*Kharif*		*Rabi*	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
N_1CS_1	57.00	69.00	68.33	73.67	73.00	85.33	84.00	100.67	100.00	121.00	120.67	137.33
N_2CS_1	55.00	63.67	62.00	68.33	67.67	80.00	79.67	95.33	94.67	115.67	113.33	132.00
N_3CS_1	56.33	58.33	58.67	63.00	64.33	74.67	75.33	90.00	90.33	110.33	111.00	126.67
N_1CS_2	53.33	69.67	68.00	74.33	73.67	86.00	85.67	101.33	100.67	121.67	120.33	138.00
N_2CS_2	56.33	61.00	60.33	65.67	64.00	77.33	76.00	92.67	92.00	113.00	112.67	129.33
N_3CS_2	55.67	59.33	59.67	64.00	65.33	75.67	75.83	91.00	91.33	111.33	112.00	127.67
N_1CS_3	55.67	71.33	70.67	76.00	75.33	87.67	86.33	103.00	101.33	123.33	122.00	139.67
N_2CS_3	56.00	67.67	66.00	72.33	71.67	84.00	83.67	99.33	93.67	119.67	119.33	136.00
N_3CS_3	56.33	59.00	60.33	63.67	64.00	75.33	76.00	82.67	83.00	103.00	105.67	119.33
SEm(±)	**1.25**	**0.47**	**0.41**	**0.65**	**0.55**	**0.28**	**0.25**	**0.52**	**0.51**	**0.48**	**0.45**	**0.51**
LSD (0.05)	**NS**	**1.42**	**1.00**	**1.93**	**1.82**	**0.83**	**0.78**	**1.57**	**1.53**	**1.43**	**1.42**	**1.53**

Note : *N: Nutrient level; CS: Crop sequence; Initial: Microflora population in soil before sowing; Final:Microflora population in post-harvest soil*

Table 4 : Effect of treatments on the population of Actinomycetes (CFUx10^5 g^{-1}) in soil

Treatment	2008-09						2009-10					
	Summer		*Kharif*		*Rabi*		Summer		*Kharif*		*Rabi*	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
N_1CS_1	22.21	34.21	33.21	42.21	41.21	52.21	51.22	68.21	67.96	84.96	83.71	99.71
N_2CS_1	24.32	33.32	33.05	41.78	41.01	50.24	50.07	63.47	62.77	76.70	75.93	89.93
N_3CS_1	23.58	26.58	26.87	35.16	35.45	43.74	44.03	51.03	51.32	58.32	58.61	65.61
N_1CS_2	24.32	35.32	34.44	45.56	44.68	55.80	54.92	71.92	70.04	88.04	87.16	98.16
N_2CS_2	22.89	29.89	29.05	40.11	39.22	51.33	50.44	63.44	62.55	75.55	74.66	87.66
N_3CS_2	24.11	28.11	28.47	36.83	37.19	42.55	42.91	50.91	51.27	59.27	59.63	67.63
N_1CS_3	22.15	34.15	33.22	42.25	42.03	52.35	51.04	68.40	67.45	84.45	83.50	97.50
N_2CS_3	23.65	30.65	30.30	39.95	38.76	49.25	48.09	60.90	59.55	72.55	71.20	84.20
N_3CS_3	24.25	26.25	27.03	36.35	36.84	43.45	44.25	50.50	51.55	57.55	57.60	64.60
Sem(±)	**0.94**	**0.45**	**0.38**	**0.62**	**0.59**	**0.25**	**0.25**	**0.50**	**0.32**	**0.45**	**0.42**	**0.49**
LSD (0.05)	**NS**	**1.34**	**0.95**	**1.86**	**1.76**	**0.75**	**0.67**	**1.49**	**0.95**	**1.35**	**1.34**	**1.46**

on actinomycetes in the rhizosphere soil of various crop sequences. Shanmugasundaram (2003) reported that the utilization of *Parthenium* biomass for composting might have the potential to improve soil fertility. Bera and Ghosh (2013) reported better soil physical and chemical environment development with the application of weed compost and neem cake which helped to enhance the availability and absorption of macro and micronutrients, thereby increased crop yields.

Thus, the study indicated that although the population of initial soil microflora was less, it increased subsequently after applying nutrients through *Parthenium* utilization either as green manure or as compost, besides applying recommended dose of NPK. Such improvement in soil microflora status would have special bearing on increased nutrient availability to crop plants in a particular crop sequence that might finally enhance productivity potentials.

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