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Soil Microbial Population as Influenced by Different Nutrient Sources under *Desi* Cotton

***V. V. Patil, A. V. Solanke, S. S. Potdar, S. P. Wagh and P. N. Rakhonde**

[1]Department of Agronomy, M.P.K.V., Rahuri, Ahmednagar (MS), India
[2, 3]Associate Professor, SSAC Section, ANCA, Warora, Chandrapur, (MS), India
[4]Plant Pathology Section, ANCA, Warora, Chandrapur, (MS), India

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ABSTRACT

A field investigation on "Nutrient management for organic cotton (*Gossypium arboreum* L.) production" was carried out at All India Coordinated Research Project, Cotton Improvement Project, Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra (India) during *kharif* season of 2017 and 2018. The experiment was carried on the same site and same randomization of treatments during both the years. After these two cycles, the soil microbial properties were significantly influenced due to various combinations of organic nutrient sources treatments. Significantly higher population of bacteria, fungi and actinomycetes was recorded at flowering stage and after harvest due to application of nutrients through FYM based on P equivalent than the rest of the organic nutrient sources treatments at all the stages of observations during both years. Whereas, it was at par with T_9-[($\mathbf{T_4}$- seed treatment with (*Azotobactor* + PSB) + soil application of *Azotobactor* + PSB) and foliar application of PPFM (1% spray at 45 and 65 DAS) + neemcake 250 kg ha^{-1} + raising of sunnhemp between two rows (1:1) incorporation in soil at flowering stage)]. The highest bacteria, fungi and actinomycetes population was observed at flowering stage than initial and at harvest during both the years of experimentation.

***Key words*:** *Desi cotton, Different nutrient sources and Soil microbial population*

Introduction

The organic material in the combination with fertilizers enhance the biological activities and in turn increase the kinetics of CO_2 evaluation, judicious use of organic manure and fertilizers is, thus, essential to maintain soil flora for sustainable agricultural.

The use of organic manures has been the traditional means of maintaining soil fertility. The quality of the fibre may also be affected. Most organic manures provide a balanced source of nutrients for crops. Organic manures have a direct effect on plant growth like any other commercial fertilizer. Organic manures also contain traces of micro-nutrients and also provide food for soil microorganisms. This increases activity of microbes which in turn helps to convert unavailable plant nutrients into available and also fixing atmospheric nitrogen (Manchala *et al*., 2017).

Farm Yard Manure provides essential plant nutrients including micronutrients and it also improves soil physical, chemical and biological environment of soil for favorable crop growth and yield. It is also known to accelerate the respiratory process that increase cell permeability and hormonal growth action or by combination of all these processes. Farm

([1]Head, [2]Associate Professor, [3]Assistant Professor, [4]Assistant Professor)

Yard Manure (FYM) increases organic carbon content in the soil and improves soil physical properties.

Similarly, biofertilizers are commonly called microbial inoculants which are capable of mobilizing important nutritional elements in the soil from non-usable to usable form by the crop plants through their biological processes. Biofertilizers due to its renewable, cheap and eco-friendly nature has gained increasing popularity in the past one decade in the field of agriculture and food production. The use of chemical fertilizers and pesticides has caused tremendous effect to the environment. Biofertilizers will help to solve such problems as increased salinity of soil and chemical run off from the agricultural field. It has been found to minimize the use of chemical fertilizers, improved soil fertility status and enhancing the crop production by their biological activity in the rhizosphere (MeCarty *et al*., 2017).

Materials and Methods

A field investigation on "Nutrient management for organic cotton (*Gossypium arboreum* L.) production" was carried out at All India Coordinated Research Project, Cotton Improvement Project, Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra (India) during *kharif* season of 2017 and 2018. The soil of the experimental field was clayey in texture with low in available nitrogen (180.49 kg ha^{-1}), medium in available phosphorous (20.12 kg ha^{-1}) and high in potassium (348.37 kg ha^{-1}). The soil slightly alkaline in reaction (pH 8.27) with electrical conductivity (0.33 dSm^{-1}) and 0.43 organic carbon content.

The field experiment was laid out in Randomize Block Design and in three replications. The treatment consist of nine treatments for *desi* cotton *viz.*, **T_1-** Absolute control, **T_2-** Application of recommended dose of fertilizer through inorganic (80:40:40 NPK kg ha^{-1}), **T_3-** Application of nutrients through FYM based on P equivalent, **T_4-** Seed treatment with *Azotobactor* + PSB + soil application of *Azotobactor* and PSB + foliar application of PPFM (1% Spray at 45 and 65 DAS), **T_5-** Neem cake @250 kg ha^{-1}, **T_6-** Raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS), **T_7-** T_4 + neem cake @250 kg ha^{-1}, **T_8-** T_4 + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS), **and T_9-** T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS).

The effect of different nutrient sources treatments on soil microorganisms was studied in the experiment field. The soil samples from each plot taken 0-20 cm depth were collected at initial stage, at flowering stage and after harvesting of crop for microbial count. The moist soil sample were collected and stored at 4^0 C until further analysis in Refrigerator. Soil microbial count that is cfu (colony forming unit) g^{-1} of soil bacteria, fungi and actinomycetes were determined by using serial dilution pour plate technique using their respective media (Dhingra and Sinclair, 1995).

Results and Discussion

Bacterial population

The bacterial population in soil was influenced significantly at all the stages of observations during both the years except initial stage during first year. The data presented in Table 2 and 3 revealed that the bacterial population was significantly higher at flowering stage due to application of nutrient through FYM based on P equivalent than the rest of the organic nutrient sources treatments during both

Table 1. Composition of media used for growing actinomycetes, fungi and bacteria

Kenknight's agar medium (Actinomyces)		Potato dextrose agar medium (Fungi)		Nutrient agar medium (Bacteria)	
Glucose	1g	Potato (Peeled)	250g	Peptone	5g
Mono-potassium phosphate (KH_2PO_4)	0.1g	Dextrose	20g	Beef extract	3g
Sodium nitrate ($NaNO_3$)	0.1g	Agar	20g	Sucrose	20g
Potassium chloride (KCL)	0.1g	Distilled water	1000 ml	Agar	20g
Magnesium sulphate ($MgSO_4$)	0.1g	pH	6.0-6.5	Distilled water	1000 ml
Agar	15g	-	-	pH	6.8-7.2
Distilled water	1000 ml	-	-	-	-
pH	7.0-7.2	-	-	-	-

years. However, it was at par with T_9-[(**T_4**- seed treatment with (*Azotobactor* + PSB) + soil application of *Azotobactor* + PSB) and foliar application of PPFM (1% spray at 45 and 65 DAS) + neemcake 250 kg ha^{-1} + raising of sunnhemp between two rows (1:1) incorporation in soil at flowering stage)]. The absolute control treatment and application of recommended dose of fertilizer through inorganic (80:40:40 N, P and K kg ha^{-1}) was observed lowest bacterial population as compared to all organic nutrient sources treatments during both the years of experimentation.

Highest bacterial population was recorded with treatment application of nutrients through FYM based on P equivalent followed by addition of seed treatment with (*Azotobactor* + PSB) + soil application of *Azotobactor* + PSB) and foliar application of PPFM + neemcake + raising of sunnhemp between two rows incorporation in soil at flowering stage. This might be due to organic sources provided sufficient organic matters which act as a substrate and sources of food for bacteria. Whereas application of recommended dose of fertilizer through inorganic (80:40:40 N, P and K kg ha^{-1}) recorded lowest bacterial count as compared to organic sources could be attributed to lack of sufficient organic substrate. The results are in line with findings reported by Badole and More (2001), Jayshree *et al*. (2015) and Kaur *et al*. (2019).

Table 2. Soil microbial population as influenced by different treatment during 2017

Treatment	Soil microbial population								
	Bacteria (cfu x 10^{-4} g^{-1} of soil)			Fungi(cfu x 10^{-6} g^{-1} of soil)			Actinomycetes (cfu x 10^{-5} g^{-1} of soil)		
	Initial	At flowering	After harvest	Initial	At flowering	After harvest	Initial	At flowering	After harvest
T_1- Absolute control	13.71	23.95	19.82	3.59	8.66	5.12	5.70	13.59	8.49
T_2- Application of RDF through inorganic (80:40:40 NPK kg ha^{-1})	15.98	35.52	24.99	4.63	10.54	6.61	6.21	15.67	10.58
T_3- Application of nutrient through FYM based on P equivalent	18.38	110.35	81.66	5.33	20.59	16.26	7.49	30.83	23.14
T_4- ST with (*Azotobactor* + PSB) + SA of (*Azotobactor* + PSB) and FA of PPFM (1% Spray at 45 and 65 DAS)	16.49	78.70	50.00	4.83	13.22	9.74	6.80	20.73	14.46
T_5- Neem cake @250 kg ha^{-1}	16.50	87.91	59.22	4.92	14.70	10.63	7.06	23.05	15.92
T_6- Raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage	16.86	63.61	34.92	4.70	11.73	7.87	6.37	19.45	12.53
T_7- T_4 + neem cake @250 kg ha^{-1}	16.99	94.28	65.58	4.98	15.75	12.12	7.16	24.32	17.49
T_8- T_4 + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage	17.64	100.30	71.60	5.13	17.13	14.33	7.33	27.04	20.35
T_9- T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage	17.99	104.79	76.10	5.11	18.93	15.25	7.16	29.65	22.57
S.Em.(±)	1.14	2.51	2.55	0.34	0.57	0.49	0.61	0.60	0.57
C.D at 5 %	NS	7.54	7.66	NS	1.71	1.47	NS	1.81	1.71
General mean	16.73	77.71	53.77	4.80	14.58	10.88	6.81	22.70	16.17

SA- Soil application, **ST**- Seed treatment, **FA**- Foliar application of **PPFM**-Pink pigmented facultative methylotrophs

Fungi population

Fungi populations in soil as influenced by different treatments are presented in Table 2 and 3. The data revealed that the fungi population in soil was influenced significantly at all the stages of observations during both the years, except initial stage during first year.

Application of nutrient through FYM based on P equivalent basis was recorded significantly highest fungi population at all the stages of observations than rest of the organic nutrient sources treatments during both years. However, it was at par with T_9-[(**T_4**- seed treatment with (*Azotobactor* + PSB) + soil application of *Azotobactor* + PSB) and foliar application of PPFM (1% spray at 45 and 65 DAS) + neemcake 250 kg ha^{-1} + raising of sunnhemp between two rows (1:1) incorporation in soil at flowering stage)]. The maximum fungi population was observed at flowering stage than initial and at harvest during both the years of experimentation. Application of recommended dose of fertilizer through inorganic (80:40:40 N, P and K kg ha^{-1}) was observed lowest fungi population at all stages of observations as compared to all organic treatments during both the years of experimentation.

Fungal population significantly influenced with treatment application of nutrients through FYM based on P equivalent and treatment T_9-(**T_4**-seed treatment with (*Azotobactor* + PSB) + soil application of *Azotobactor* + PSB) and foliar application of PPFM (1% spray at 45 and 65 DAS) + neemcake 250 kg ha^{-1} + raising of sunnhemp between two rows (1:1) incorporation in soil at flowering stage) and significant higher fungi population over other organic as well as inorganic nutrient sources treatments might be due to performance of farmyard manure which stimulate fungi growth because of dead food material available from farmyard manure and decomposition of green manuring crop addition of *Azotobactor*, phosphate solubilizers bacteria, neemcake, foliar application pink pigmented

Table 3. Soil microbial population as influenced by different treatment during 2018

Treatment	Soil microbial population								
	Bacteria (cfu x 10^{-4} g^{-1} of soil)			Fungi (cfu x 10^{-6} g^{-1} of soil)			Actinomycetes (cfu x 10^{-5} g^{-1} of soil)		
	Initial	At flowering	After harvest	Initial	At flowering	After harvest	Initial	At flowering	After harvest
T_1- Absolute control	22.43	36.71	21.85	3.94	8.73	5.05	5.64	13.69	7.85
T_2- Application of RDF through inorganic (80:40:40 NPK kg ha^{-1})	28.41	48.29	30.45	5.40	14.34	8.34	7.06	17.98	12.52
T_3- Application of nutrient through FYM based on P equivalent	45.04	123.12	97.65	8.46	26.59	18.03	11.23	37.26	26.55
T_4- ST with (*Azotobactor* + PSB) + SA of (*Azotobactor* + PSB) and FA of PPFM (1% Spray at 45 and 65 DAS)	28.92	91.46	65.99	5.97	15.60	11.02	8.23	26.81	17.31
T_5- Neem cake @250 kg ha^{-1}	29.60	100.68	75.21	6.69	17.80	13.01	8.83	24.50	18.63
T_6- Raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage	26.30	76.38	50.90	5.47	14.50	8.08	7.62	21.89	14.86
T_7- T_4 + neem cake @250 kg ha^{-1}	31.75	106.04	80.57	6.75	19.17	13.89	8.92	28.09	20.17
T_8- T_4 + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage	37.37	111.40	85.92	7.40	22.55	15.77	9.21	33.14	22.49
T_9- T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage	42.02	117.56	92.09	7.69	25.53	17.02	10.93	36.41	25.09
S.Em.(±)	1.23	2.62	2.81	0.34	0.76	0.43	0.34	0.80	0.57
C.D at 5 %	3.68	7.85	8.42	1.02	2.27	1.29	1.02	2.41	1.72
General mean	32.43	90.18	66.74	6.42	18.31	12.25	8.63	26.64	18.38

SA- Soil application, **ST**- Seed treatment, **FA**- Foliar application of **PPFM**-Pink pigmented facultative methylotrophs

facultative methylotrophs increases the availability of adequate amount of food for fungi.

Application of fertilizer through inorganic sources and absolute control treatment showed significantly lower fungi population than organic nutrient sources treatments due to lack of organic substrate for the growth of fungi. Similar results were also reported by Chandramohan (2002), Gudadhe *et al*. (2015) and Kaur *et al*. (2019).

Actinomycetes population

Actinomycetes populations in soil as influenced by different treatments are presented in Table 2 and 3. The data revealed that the actinomycetes population in soil was influenced significantly due to different treatments at all the stages of observations during both the years, except initial stage during first year. Application of nutrients through FYM based on P equivalent registered significantly maximum population of actinomycetes at all the stages of observations than the other organic nutrient sources treatments during both years. However, it was at par with T_9-[(**T_4**- seed treatment with (*Azotobactor* + PSB) + soil application of *Azotobactor* + PSB) and foliar application of PPFM (1% spray at 45 and 65 DAS) + neemcake 250 kg ha^{-1} + raising of sunnhemp between two rows (1:1) incorporation in soil at flowering stage)]. The highest actinomycetes population was observed at flowering stage than initial and after harvest of crop during both the years of experimentation.

The absolute control treatment and was observed significantly lowest actinomycetes population followed by inorganic sources as compared to all organic treatments during both the years of experimentation.

Results of significant improvement in the microbial population in rhizosphere of cotton at initial, flowering and after harvesting stage due to use of organic nutrient sources viz., FYM, seed treatment as well as soil application of *Azotobactor* + phosphate solubilizers bacteria, neemcake, foliar application pink pigmented facultative methylotrophs and in-situ green manuring it serve as food and energy for actinomycetes it increase their colonies and which was decreased as reduction in the quantity of food material after harvest of crop. Lowest actinomycetes population was found under the application of inorganic source of fertilizer and absolute control treatment due to lack of food material available to the effective microbes. These results were in agreement with the finding of Badole and More (2001), Halemani *et al*. (2004) and Gudadhe *et al*. (2015).

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