

Original Research Article

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Effect of Irrigation and Nutrient Management on Microbial Population in Soil after Cultivation of Indian Mustard (*Brassica juncea*) and Direct-Seeded Autumn Rice (*Oryza sativa*)

Bollaveni Sathish Kumar^{1*}, J.C. Das² and A. Sarma³

Dept. of Agronomy, Assam Agricultural University (AAU), Jorhat, India

*Corresponding author

ABSTRACT

Keywords

Bacteria, Direct seeded rice, Fungus and Indian mustard

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An experiment was conducted at the Instructional-cum- Research Farm, Assam Agricultural University, Jorhat, during two consecutive *rabi* (Oct-Feb) followed by summer (Feb-June) seasons of 2016-2017 and 2017-2018. The experiment was laid out in a split-plot design with 3 replications to evaluate the performance of Indian mustard and direct-seeded rice under irrigation and nutrient management practices. Among the 4 irrigation regimes, IW:CPE =1.60 and among the 5 nutrient management practices, 50 % RDF(N) + 50 % N as FYM + Bio-fertilizers resulted in superior fungal and bacterial population in soil after harvesting of Indian mustard and direct-seeded autumn rice in both the years.

Introduction

Modern agricultural practices largely depended on high range of mineral fertilizers inputs to high yields. These excessive mineral fertilizer practices are now being reevaluated and are coming under scrutiny as our awareness of potential health and environmental consequences. Applications of mineral fertilizers can result in groundwater contamination, greenhouse effect and alteration in the ozone layer. This new approach to farming with bio-fertilizers, often referred to as sustainable agriculture, seeks to

introduce agricultural practices that are more friendly to the environment, earth and that maintain the long – term ecological balance of the soil ecosystem.

Biofertilizers are organic preparations containing microorganisms that are beneficial to crops in terms of nutrient supply particularly concerning nitrogen and phosphorous. Microorganisms in soil are important to the maintenance of soil function in agricultural soils because of microorganisms involvement in such key processes as soil structure formation, organic

matter decomposition, cycling of carbon and essential nutrients (Van Elsas and Trevors, 1997). Besides, microorganisms play key roles in promoting plant growth and in changes in vegetation. Microorganisms derive food from the organic matter present in the soil and root exudates and fix atmospheric N through the process of biological nitrogen fixation (BNF), solubilize plant nutrients like phosphates, and stimulate plant growth through synthesis of growth-promoting substances (*auxins*, *gibberellins* and *antibiotics*) and have C: N ratio 20:1 indicating the stability of the biofertilizer (Doran *et al.*, 1996).

Both the *rabi* (Nov- Feb) and early summer (March-April) of Assam are characterized by prolonged drought with very low and erratic average rainfall (about 40 mm and 60 mm during *rabi* and early summer, respectively) with high evapo-transpirational demand of the crops. As such, both the crops are likely to suffer from moisture deficit and may respond well to irrigations. An intensive cropping system that is not only productive and profitable but also stable over time and maintains soil fertility is of great importance in the present scenario. Reports indicated that continuous application of high amounts of only inorganic fertilizers had deleterious effects leading to a decline in productivity due to the limitation of one or more micronutrients (Nambiar and Abrol, 1989). Thus, lack of adequate irrigation facilities, poor soil fertility, imbalanced and indiscriminate use of fertilizers with improper management practices have been considered to be major constraints in achieving the higher microbial activity in soil and productivity of both Indian mustard and direct-seeded rice in different agro-climatic conditions (Schloter *et al.*, 2003 and Dini-Andreote *et al.*, 2015).

Considering the above facts present study was conducted to evaluate the changes in soil

microbial population (bacteria and fungi) in soil after cultivation of Indian mustard and direct-seeded autumn rice under different irrigation and nutrient management practices.

Materials and Methods

The experiment was conducted at the Instructional-cum - Research Farm, Assam Agricultural University, Jorhat, during two consecutive *rabi* (Oct- Feb) followed by summer (Feb-June) seasons of 2016-2017 and 2017-2018. The experiment was laid out in a split-plot design with 3 replications. The entire experimental field was divided into as many numbers of main plots as per treatments of four irrigations in each replication and allocated randomly. Each main plot was subdivided into five sub-plots as per five treatments of nutrient management practices which were also allocated randomly. The main plot treatments were I₀- Rain-fed, I₁- IW: CPE =1.20, I₂- IW: CPE =1.40 and I₃ - IW: CPE =1.60. The subplot treatments were N₁- Recommended dose of fertilizers (RDF), N₂ - RDF + FYM @ 5t/ha, N₃ -75 % RDF(N) + 25% N through FYM, N₄- 50 % RDF(N) + 50% N through FYM and N₅- 50 % RDF(N) + 50 % N as FYM + Bio-fertilizers (Consortium of *Azotobacter* and PSB). All the organic manures were applied once as a basal dose and incorporated in the soil 15 days before sowing. The seed of Indian mustard and DSR under N₅- 50 % RDF (N) + 50 % N as FYM + Bio-fertilizers (Consortium of *Azotobacter* and PSB) treatment were mixed with a slurry of the consortium before sowing.

To evaluate the effect of different treatments on microbial population in soil, serial dilutions were made. Soil samples collected after harvesting of every crop for microbial studies were processed for serial dilution by suspending 10 gm of the soil sample in 90 ml. Sterilized distilled water in flasks and was shaken on a horizontal shaker for 20 min.

Subsequent serial dilution was made up to 10^4 , and 10^6 dilution and was used to calculate the presence of fungal and bacterial population in the soil dilution. The observations were made by using standard procedures and the data were analyzed as per the statistical methods are given by Panse and Sukhatme (1995).

Results and Discussion

Effect of irrigation

The effect of different irrigation levels on the microbial population in soil after harvest of Indian mustard and direct-seeded autumn rice was found to be significant during both the year. Results revealed that the fungal population increased with the increasing levels of irrigation from IW:CPE ratio 1.20 to IW:CPE ratio 1.60 in soil after harvesting of both Indian mustard and direct seeded autumn rice. The effect of the irrigation regimes IW:CPE ratio 1.60 (6.13×10^4 cfu g^{-1} soil and 6.09×10^4 cfu g^{-1} soil) and IW:CPE ratio 1.4 (6.08×10^4 cfu g^{-1} soil and 6.04×10^4 cfu g^{-1} soil) on fungal population was at par, in both the year of Indian mustard. In direct seeded autumn rice the irrigation regimes IW:CPE ratio 1.60 (6.19×10^4 cfu g^{-1} soil and 6.15×10^4 cfu g^{-1} soil) and IW:CPE ratio 1.40 produced similar values of fungal population and both were significantly superior to IW:CPE ratio 1.20 and rainfed, in 2017 (Table 1).

However, in 2018, results revealed that each of the higher irrigation regime resulted in significantly higher values of the fungal population over the respective lower irrigation regime and the lowest values were observed under rainfed control. Like wise, bacterial population also increased with increasing of irrigation regimes. In this respect the irrigation regime IW:CPE ratio 1.60 (7.63×10^6 cfu g^{-1} soil and 7.53×10^6 cfu g^{-1} soil) produced similar results with the irrigation

regime IW:CPE ratio 1.40 (7.57×10^6 cfu g^{-1} soil and 7.52×10^6 cfu g^{-1} soil) and both these two treatments resulted in higher values over rainfed, in both the years of Indian mustard. The irrigation regime IW:CPE ratio 1.60 (7.91×10^6 cfu g^{-1} soil and 7.81×10^6 cfu g^{-1} soil) produced significantly higher bacterial population over the rest of the treatments in both the year of direct-seeded autumn rice. This was followed by the irrigation regimes IW:CPE ratio 1.40 and IW:CPE ratio 1.20, the effect of which was at par and resulted in significantly higher values of bacterial population over the rainfed treatment. The higher values of microbial population (fungal and bacterial population) observed under the irrigation regimes IW:CPE ratio 1.60 and IW:CPE ratio 1.40 may be due to adequate water availability that enhances the microbial activity by increasing the intercellular water potential and thus increase the hydration and activity of enzymes over the drier regime IW:CPE ratio 1.20 and rainfed.

Higher water content in soil may also increase the microbial activity by making more substrate supply to the microbes for energy (Stark and Mary, 1995). The adequate substrate supply to the microbes for energy and increased carbon input to soils due to intensive irrigation regimes (Entry *et al.*, 2002 and Follett, 2001) might have increased the microbial population under the said treatments. Reports also indicated that optimum moisture availability may provide a favorable environment for soil habituating microbes (Jedidi *et al.*, 2004).

Effect of nutrient management

Significantly the highest fungal population was observed under the treatment 50% RDF (N) + 50% N through FYM + Bio-fertilizers (6.14×10^4 cfu g^{-1} soil and 6.08×10^4 cfu g^{-1} soil) over rest of the treatments in both the year of Indian mustard (Table 2).

Table.1 Effect of irrigation and nutrient management on microbial population of soil after harvest of Indian mustard

Treatments	Microbial population			
	Fungal population (10^4 *cfu g ⁻¹ soil)		Bacterial population (10^6 *cfu g ⁻¹ soil)	
Irrigation (I)	2016-17	2017-18	2016-17	2017-18
Rainfed	5.948	5.88	7.40	7.33
IW:CPE = 1.20	6.024	5.96	7.47	7.39
IW:CPE = 1.40	6.085	6.04	7.57	7.52
IW:CPE = 1.60	6.135	6.09	7.63	7.53
S.Ed \pm	0.022	0.03	0.05	0.04
CD: (P=0.05)	0.054	0.09	0.14	0.11
Nutrient Management (N)				
Recommended dose of fertilizer (RDF)	5.931	5.89	7.04	6.99
RDF + FYM @ 5t/ha	6.076	6.00	7.71	7.61
75% RDF(N) + 25%N through FYM	5.994	5.95	7.43	7.35
50% RDF(N) + 50% N through FYM	6.088	6.03	7.56	7.51
50% RDF(N) + 50% N through FYM + Bio-fertilizers	6.14	6.08	7.83	7.75
S.Ed \pm	0.009	0.03	0.03	0.04
CD: (P=0.05)	0.019	0.07	0.06	0.09
Interaction (I x N)	N.S	N.S	N.S	N.S

N.S: Non-significant

Table.2 Effect of irrigation and nutrient management on microbial population of soil after harvest of direct seeded autumn rice

Treatments	Microbial population			
	Fungal population (10^4 *cfu g ⁻¹ soil)		Bacterial population (10^6 *cfu g ⁻¹ soil)	
Irrigation (I)	2017	2018	2017	2018
Rainfed	5.96	5.95	7.53	7.39
IW:CPE = 1.20	6.04	6.01	7.66	7.52
IW:CPE = 1.40	6.10	6.05	7.67	7.53
IW:CPE = 1.60	6.19	6.15	7.91	7.81
S.Ed±	0.03	0.01	0.04	0.11
CD: (P=0.05)	0.09	0.03	0.11	0.27
Nutrient Management (N)				
Recommended dose of fertilizer (RDF)	5.98	5.92	7.36	7.16
RDF + FYM @ 5t/ha	6.09	6.07	7.82	7.70
75% RDF(N) + 25%N through FYM	6.03	6.01	7.58	7.49
50% RDF(N) + 50% N through FYM	6.12	6.09	7.75	7.63
50% RDF(N) + 50% N through FYM + Bio-fertilizers	6.15	6.11	7.95	7.84
S.Ed±	0.03	0.04	0.05	0.04
CD: (P=0.05)	0.06	0.08	0.11	0.08
Interaction (I x N)	N.S	N.S	N.S	N.S

N.S: Non-significant

In direct seeded autumn rice the highest fungal population was observed under the treatment 50% RDF (N) + 50% N through FYM + Bio-fertilizers which was at par in effect with the treatments 50% RDF (N) + 50% N through FYM and RDF + FYM @ 5t/ha and all being proved significantly superior to 75% RDF (N) + 25% N through FYM and RDF alone in both the year. The later two treatments resulted in similar values of fungal population with the lowest under RDF alone. 50% RDF (N) + 50% N through FYM + Bio-fertilizers (7.83×10^6 cfu g⁻¹ soil and 7.75×10^6 cfu g⁻¹ soil) resulted in significantly the highest bacterial population over rest of the treatments in both the year. The lowest value of bacterial population was also recorded under RDF alone (7.04×10^6 cfu g⁻¹ soil and 6.99×10^6 cfu g⁻¹ soil). As in case of effect of fungal population the treatments 50% RDF (N) + 50% N through FYM + Bio-fertilizers (7.95×10^6 cfu g⁻¹ soil and 7.84×10^6 cfu g⁻¹ soil) resulted in significantly higher bacterial population in soil over rest of the treatments in direct-seeded autumn rice. The lowest values were recorded under RDF alone (7.36×10^6 cfu g⁻¹ soil and 7.16×10^6 cfu g⁻¹ soil) in both the year. Such increase in microbial population with the application of bio-fertilizers might be due to enhanced availability of carbonaceous materials and substrates such as sugars, amino acids and organic acids to the soil from the decomposing materials and decay of roots for supplying energy for the microbial population (Arya *et al.*, 2007). This might be due to an increase in porosity and organic carbon, humic substances and better aggregation of soil which increased physicochemical properties of soil (Kumari *et al.*, 2013). Such, beneficial effects of the treatments 50% RDF (N) + 50% N through FYM + Bio-fertilizers and RDF + FYM@ 5t/ha might have positive influence on availability of macro and micronutrients that reflected in resulting higher fungal and bacterial population after

harvest of the crop, over rest of the treatments in both the year. Moreover, addition of FYM or bio-fertilizers with chemical fertilizers might have created environment conducive for formation of humic acid, stimulated the activity of microorganisms (Singh *et al.*, 2015) and provided a steady source of organic carbon to support the microbial community and organic residues that contain the microbes in addition to substrate carbon, which stimulates the indigenous soil microbiota (Vanaja and Raju, 2002, Chesti *et al.*, 2015 and Bhandari *et al.*, 1992).

In conclusion, Indian mustard and direct-seeded rice are mostly cultivated as a rainfed crops in Assam and there is a need for irrigation and nutrient management practices for better growth and yield. From the present experiment, It was concluded that, the application of irrigation regimes at IW:CPE ratio 1.60 showed superior results on fungal and bacterial populations in soil after harvesting of both the crops. The nutrient management practice 50% RDF (N) + 50% N through FYM + Bio-fertilizers resulted in superior values of fungal and bacterial population in soil after harvesting of both the crops.

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