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Effect of different nutrient practices and Methanotrophs on growth of rice under submerged condition

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Abstract
An investigation entitled, "Bioremediation of methane emission using methanotrophic bacteria in paddy" was undertaken during *kharif*, 2022-23 at experimental farm, department of Soil Science and Agricultural Chemistry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli, Dist. Ratnagiri. The field experiment was laid out in the factorial complete randomized design, consisting 16 treatment combinations comprising two factors i.e. four different nutrient source *viz*, control, recommended dose through chemical fertilizer, recommended dose through konkan Annapurna briquette and gliricidia application and four different methanotrophic consortium *viz*, control, type I, type II, and type Ib which were replicated three time to study the effect of different nutrient source and methanotrophic bacteria on growth parameters. The significantly highest growth attributes *viz*. number of tillers, plant height and number of panicles were recorded highest in the treatment were recommended dose of fertilizer 100:50:50 N: P_2O_5:K_2O kg ha^{-1} was applied using straight fertilizer.

Keywords: Rice, nutrient source, methanotrophic consortium

Introduction

Rice is the staple food for more than 60 percent of world's population and mainly in South-East Asia. About 90 percent of rice grown in the world is produced and consumed in Asia. Nearly half of the world population consumed rice as staple food source. India is the second largest producer of rice in the world after China. In India, rice occupies the first position among the cereals in respect to both area and production. The area of 46.27 million hectares is under rice, with the production of 129.47 million ton and 35.25q ha^{-1} productivity (Anonymous, 2022) [1-2]. In Maharashtra rice is cultivated in about 1.65 million hectares area with annual production of 3.59 ton with productive of 29.95 q ha^{-1}and in Konkan it occupies 0.39 M ha area with production of 2.90 MT and productivity of 25.54 q ha^{-1} (Anonymous, 2022) [1-2].

The demand of rice increasing year to year with increasing population. To obtain high yield, requires the fulfillment of nutrients through application of different nutrient source. The fertilizer as a source of nutrients plays important role in improving rice productivity due to their easily availability which can meet the nutrient requirement of plant but in field condition low availability due to leaching losses by means of easy solubility leads to low yield. Therefore, the application of briquette fertilizers enhance yield due to their slow-release pattern under submerged condition (Jagtap *et al*., 2018) [4]. The strategic use of inorganic fertilizers and organic manures is a crucial agronomic practice for enhancing rice production per unit area. But the increasing methane emission from rice field by following these practices which is second most serious dilemma.

Rice cultivation contributes 10 percent towards methane emission from all natural and manmade sources (Nazaries *et al*., 2017) [6]. The concentration of methane in the atmosphere is rising approximately 1 percent per year and thus sharing 15-20 percent of the total greenhouse gas effect amongst all greenhouse gases (Anonymous, 2022) [1-2]. Methane exhibit '28 times' more potential for global warming than the carbon dioxide (Liu *et al*., 2015) [5] and thus considered second most significant greenhouse gas after CO_2 causing 20-30 percent of global warming effects.

Methane is the utmost firm carbon compound in anaerobiotic environments and it is a most important intermediate in the reactions that eventually lead to the mineralization of organic matter.

When methanotrophs not oxidize methane, it outflows to the atmosphere from anaerobic environment. The increased concentration of methane emission in the environment results to the increased rate of global warming and also variation in chemical composition of the atmosphere. Sohngen. (1906) [9] standardised that, methane was produced in huge amounts and suggested that its low concentration in atmosphere due to its microbial oxidation. Sohngen. (1906) [9] isolated methane oxidizing bacteria first time and named *Bacillus methanicus*. The methane oxidation is nowadays recognized to occur in both aerobic and anaerobic environments. Methane is the furthermost abundant organic gas in the atmosphere. The molar ratio of carbon dioxide and methane is around 27 at present-day, and these ratios will diminution to 7.5 in 100 years according to a recent assessment. Although the present concentration of methane is much lower than the concentration of carbon dioxide in the atmosphere, methane absorbs global radiation in the 4 to 100-nm region (infrared irradiation) more effectively than carbon dioxide, and reemission of the absorbed radiant energy causes global warming.

Methanogenesis and Methanotrophy are the fundamental processes in relation to production, emission and mitigation of methane from rice field (Nazaries *et al*., 2013) [6]. Methane is produced by methanogens by a complex process in strictly anaerobic environment known as "Methanogenesis" performed by a specific group of archaea that is methanogens.

Potential methanotrophic bacteria have great application purposes for environment friendly and sustainable agriculture system. These microbes play an important role in reducing the amount of methane released from paddy fields into the atmosphere. It was also noticed that isolated *Methylocysti spalvus* BGM 3 and *Methylococcus capsulatus* BGM 9 known to have *nif H* and *nif D* genes these play a role in the nitrogen fixation (Bintarti *et al*., 2014) [3].

Rice cultivation facing two challenges simultaneously one is declining productivity and another is mitigation of methane emission. In Maharashtra, as well as Konkan region large area is cultivated rice under submerged condition, thus the present investigation was undertaken with premier objectives. Hence, the methanotrophs was applied as the source of methane mitigation to get benefits for suppression of methane emission and organic and inorganic nutrient source was applied the in combination (in that recommended dose of fertilizer through straight chemical fertilizer, Konkan Annapurna Briquette as slow released fertilizers and glyricidia as organic manure was applied) to improve yield and growth of rice.

Materials and Methods

The pot culture experiment was carried out at the experimental farm of Department of Soil Science and Agricultural Chemistry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, during the *Kharif* season 2022-23. Selection of the place for arranging the pot culture experiment was done on the basis of availability of resources like irrigation water, protection from the wild animals, suitability for the supervision and recording observations. The soil used for the pot culture experiment was lateritic in type and classified as Alfisol. The area receives very high rainfall which leaches all the bases from the soil and become dominant in Fe and Al oxides. Due to high P fixing ability, soil is low in available phosphorous.

Experimental Details

Rice (*Oryza sativa* L.) variety Karjat-3 was selected for the experiment during the *Kharif* season of the year, 2022-23 under Konkan conditions of Maharashtra state. The experiment comprised total sixteen treatment combinations with three replications and laid out in Factorial Randomized Block Design where two factors include nutrient sources and methanotrophic consortium to reduce the methane emission. The recommended dose of fertilizer *i.e.*, 100: 50: 50 N: P_2O_5: K_2O kg ha^{-1} through chemical fertilizers *viz*. urea, single super phosphate and muriate of potash respectively, Konkan Annapurna Briquette containing 34:14:06% N:P_2O_5:K_2O, and fresh glyricidia leaves collected and add the time of transplanting and denoted by symbols N_0 N_1, N_2 and N_3. While second factor (different methanotrophic consortium) denoted by symbols control, M_0 M_1, M_2 and M_3 were methanotrophic consortium control, Type I, Type II and Type Ib to reduce methane emission applied at the time of tillering and panicle initiation stage. All the fertilizers and organic amendments used in the experiment were analyzed for determination of the nutrient content, respectively.

Estimation of the effect of nutrient management practices and methanotrophs on growth parameters

The biometric observations such as the number of tillers, number of effective tillers (numbers of panicles) and plant height were recorded for each plant and the mean was calculated for each treatment.

Statistical analysis

The data are analyzed by using the methods suggested by Panse and Sukhatme (1985) [7].

Results and Discussion

Plant Height

The range of combined effect of Nutrient source and Methanotrophic consortium on the height of rice plant during 30 DAT was from 46.83 to 55.50 cm which was mentioned in the Table 1. The result indicate that different nutrient source had significant effect on plant height at 30 DAT. The maximum plant height of rice (54.29 cm) was found in the N_1 treatment receiving the recommended dose of fertilizer 100: 50:50 N:P_2O_5:K_2O kg ha^{-1} compare to other treatment which found at par with N_0 treatment *i.e.,* control where nutrient source was not applied. Regarding the effect of methanotrophic consortium and interaction effect found non-significant on plant height of rice at 30 DAT. But numerically the maximum plant height of rice (51.85cm) was recorded in the M_0 treatment in which methanotrophic consortium was not applied. Similar results were obtained at 60 DAT in relation to plant height. It revealed that only different sources of nutrient found significant effect. The maximum plant height (84.44cm) of rice was recorded in the treatment N_1 were recommended dose of fertilizer 100: 50:50 N:P_2O_5:K_2O kg ha^{-1} was applied which was found at par with treatment N_2 application of recommended dose of nutrient through Konkan Annapurna Briquette (KAB). The split application of urea at the time of tillering and panicle initiation stage were responsible for the easy solubility of urea and restricted leaching losses in the pots which increase the available nitrogen which plays direct role in photosynthesis which might be responsible for the increment in the plant height by the chemical fertilizer's application. The effect of Methanotrophic consortium showed non-significant result on plant height of rice at 60 DAT. The maximum plant height (83.31cm) of rice was recorded in the M_3 treatment receiving methanotrophic consortium Type Ib (5ml Type Ib diluted with 50ml of water), which was found highest result over rest of all methanotrophic consortium treatments. The results of the data depicted that at Harvest, the maximum plant height (86.44cm) of rice was found in the treatment N_1 where there was application recommended dose of fertilizer 100: 50:50 $N:P_2O_5:K_2O$ kg ha^{-1} and found significant results over rest of treatments. Where nutrient source for treatment N_2 application *i.e.,* Recommended dose of nutrient through Konkan Annapurna Briquette (KAB) and N_0 control was found to be at par with N_1. This could be attributed to the higher nitrogen application which might have increased the chlorophyll formation and improved photosynthesis and there by increased the plant height. Increase in nitrogen might have assisted in greater photosynthesis. Nitrogen, a basic constituent of protoplasm and chloroplast might have stimulated meristematic growth and thus increased the various growth parameters of semi-dry rice (Rao *et al*., 2014) [8]. The data related Methanotrophic consortium not exhibited the significant results where methanotrophic consortium Type Ib (5ml Type Ib diluted with 50ml of water) showed the maximum plant height (84.71cm) of rice which was found highest value.

Number of tillers

The combined effect of different nutrient sources and methanotrophic consortium on number of tillers of rice at tillering stage varied from 7.33 to 4.00 (Table 1). The result revealed that different nutrient sources effect on number of tillers at 30 DAT showed statistically significant results in that the maximum number of tillers (7.31) was noticed in treatment N_1 receiving the Recommended dose of fertilizer 100:50:50 N: P_2O_5: K_2O kg ha^{-1} which showed at par results with treatment N_0 *i.e.,* control. The data regarding effect of methanotrophic consortium on number of tillers found non-significant results with respect to other treatments. But numerically the maximum plant tillers of rice (6.23) were recorded in the M_0 treatment in which methanotrophic consortium not applied. It was recorded that the application of different nutrient source showed significant effect on number of tillers at 60 DAT. The treatment N_1 receiving the recommended dose of fertilizer 100: 50:50 $N:P_2O_5:K_2O$ kg ha^{-1} which found maximum number of tillers of rice (15.81), whereas the treatment N_2 *i.e.,* application recommended dose of nutrient through Konkan Annapurna Briquette (KAB) showed at par results. The similar results were found by Derrick *et al*. (2017) [4] that was might be due to the split application of urea at tillering and panicle initiation stage gives the effective results. The effect of methanotrophic consortium and interaction of different nutrient source and methanotrophic consortium on number of tillers was noticed non-significant results statistically. But numerically the maximum tillers (14.48) were recorded in the M_1 treatment in which methanotrophic consortium type I (5ml of type I methanotrophic consortium diluted with 50ml of water added into per pot) was applied. The application of different nutrient source at harvest, the maximum plant tillers of rice (16.10) was found in the N_1 treatment receiving the recommended dose of fertilizer 100: 50:50 $N:P_2O_5:K_2O$ kg ha^{-1} which found at par with treatment N_2 i.e., application recommended dose of nutrient through Konkan Annapurna Briquette (KAB) and showed significant results. Considering the effect of methanotrophic consortium and effect of different nutrient sources with methanotrophic consortium combination showed statistically non-significant results, but according to numerical data, the maximum number of tillers (14.75) were recorded in treatment M_1.

Number of panicles

The application of different nutrient sources at 60 DAT, influenced number of panicles which showed non-significant results. The maximum number of panicles of rice (8.88) was found in the N_1 treatment receiving the recommended dose of fertilizer 100: 50:50 $N:P_2O_5:K_2O$ kg ha^{-1} over rest of treatment. Regarding the effect of methanotrophic consortium, the number of panicles not showed significant result with respect to other treatment. But numerically the maximum number of panicles (8.40) were recorded in the treatment M_0 were methanotrophic consortium was not applied. The data showed significant result regarding number of panicles due to the application of different nutrient source at harvest, were the maximum number of panicles of rice (15.00) was found in the N_1 treatment receiving the recommended dose of fertilizer 100: 50:50 $N:P_2O_5:K_2O$ kg ha^{-1} which was found at par with treatment N_2 i.e., application Recommended dose of nutrient through Konkan Annapurna Briquette (KAB). The data obtained in respect of the different type of methanotrophic consortium indicate that, the number of panicles noted non-significant result. The maximum number of panicles (13.60) were recorded in the M_1 treatment in which methanotrophic consortium type I (5ml diluted with 50ml of water added into per pot) was applied.

Table 1: Effect of different Nutrient sources and Methanotrophic consortium on plant growth parameters

Treatment Details	Plant Height (cm)			Tillers			Panicle	
	At 30 DAT	At 60 DAT	At Harvest	At 30 DAT	At 60 DAT	At Harvest	At 60 DAT	At Harvest
N_0	51.35	80.58	83.98	5.79	12.85	12.81	6.81	11.98
N_1	54.29	84.44	86.44	7.31	15.81	16.10	8.88	15.00
N_2	47.75	83.75	85.33	4.98	14.75	14.96	6.92	14.50
N_3	49.19	80.15	79.88	5.35	11.44	11.98	7.42	11.19
Sem	1.15	1.21	0.92	0.56	0.71	0.66	1.00	0.53
CD	3.32	3.47	2.65	1.63	2.05	1.91	2.89	1.54
M_0	51.85	82.15	82.92	6.23	13.19	13.10	8.40	12.79
M_1	50.71	81.50	83.77	5.65	14.48	14.75	6.88	13.60
M_2	49.92	81.96	84.71	5.90	13.69	14.06	7.67	13.44
M_3	50.10	83.31	84.23	5.67	13.50	13.94	7.08	12.83
Sem	1.15	1.21	0.92	0.56	0.71	0.66	1.00	0.53
CD	3.32	3.47	2.65	1.63	2.05	1.91	2.89	1.54

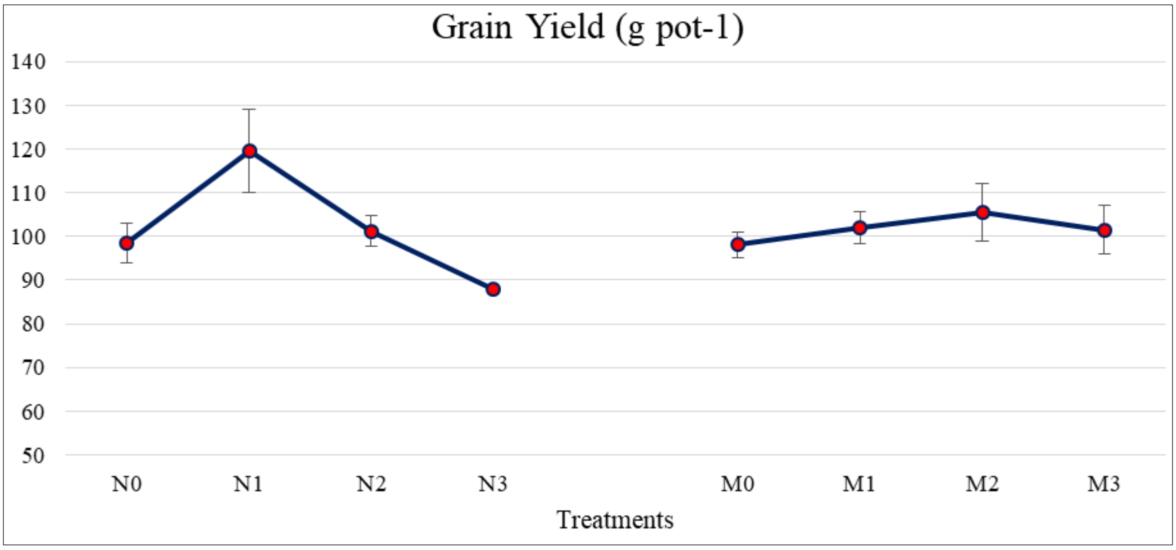

Fig 1: Effect of different Nutrient sources and Methanotrophic consortium on grain yield (g pot-1).

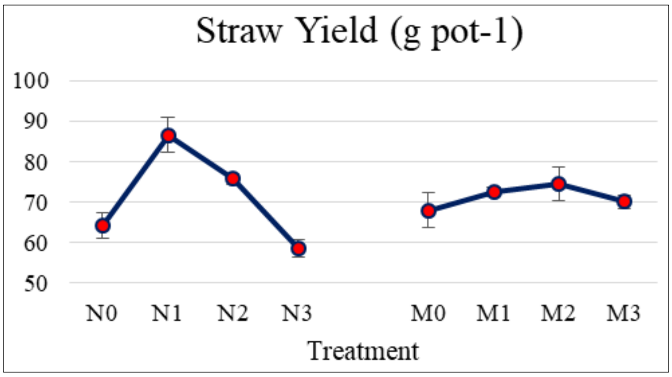

Fig 2: Effect of different Nutrient sources and Methanotrophic consortium on Straw Yield (g pot-1)

Conclusion

The conclusion from this experiment can be drawn that The significant maximum growth parameters *viz.* number of tillers, plant height and number of panicles were recorded in the treatment recommended dose of fertilizer 100:50:50 $N:P_2O_5:K_2O$ kg ha^{-1} through chemicals fertilizer was applied.

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