International Journal of Tropical Agriculture
Volume 41, Numbers (1-2) • 2023 : pp. 161-166
ISSN: 0254-8755

Effect of Microbial consortium (Azotobacter and Mycorhiza) on Nitrogen losses and yield in Wheat (*Triticum Aestivum L.*)

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Abstract: Nitrogen is one of the most vital nutrients required for wheat growth and production. Nitrogen losses from the agroecosystem lower soil fertility, crop yield and disturb the environment. Nitrogen losses in agroecosystem majorly occur through ammonia volatilization and denitrification. Therefore, the need of the hour is to explore various microbial consortium approach to improve nutrient supply along with reducing the nitrogen losses and synchronise with nutrient demand of crop. Under this research 4 different treatment had been taken those are Control (unfertilized, Tc), Azotobacter (Ta), Mycorrhiza (Tm), Azotobacter + Mycorrhiza (Tam). Tam showed highest available soil nutrient such as P, and K and also showed vigorous root growth, which increase the uptake of soil available nutrients. The cumulative emission from ammonia flux in plot receiving microbial consortium treatment from 5.84 to 6.25 kg ha^{-1} and denitrification losses varied from 3.6 to 3.9 kg ha^{-1}, while it was recorded minimum in the plot treated with Tc. The yield obtained under Tam plot recorded as 5.34 t ha^{-1}, which is higher as compared to plot receiving treatment Tc i.e., 2.73 t ha^{-1}. Thus, using microbial consortium as nutrient practices proved to be reducing nitrogen losses as well as increases crop yield.

Keywords: Ammonium volatization loss, Azotobacter, Mycorrhiza, Denitirification loss, Root traits

INTRODUCTION

Wheat (*Triticum Aestivum* L.) is considered to be most cultivated crop across the world. The reason behind it is the adaptability of wheat to a wide range of environment. It contributes to be the essential component of human diet. Out of global wheat production (760 MT) 65% is used towards human food production while remaining for livestock feed and food industry (FAO-AMIS, 2020) and the primary source of calories for the world population is wheat (Braun *et al.* 2019). However, the global rate of yield gain has been constantly dropping, and yields seem to be stagnant in many major wheat producing regions (Fischer and Edmeades, 2020) and prime reason behind it is climate change and vigorous chemical usage on soil which will vary the growing condition of wheat and thus hamper wheat production and sustainable intensification. Hence sustaining and securing future wheat production is the need of hour and it can be done through two major ways. Firstly, sustainable intensification of wheat systems to conciliate rising food demand and, secondly, the influences of future climate on wheat yields (Lobell *et al*. 2011 and Asseng *et al.* 2011). Nitrogen (N) is one of the vital nutrient elements which mainly involve in plant growth and development (Kant 2018). Human caused activities led to dramatically increased the volume of reactive nitrogen (Nr) present in the biosphere and atmosphere, generating

Article History: Received: 09 May 2023; Revised: 28 May 2023; Accepted: 08 June 2023; Published: 20 June 2023

a sequence of environmental consequences, such as eutrophication, acidification, water pollution and air pollution (Fowler *et al.* 2013). (Shi *et al.* 2012) reported that additionally, N loss through various ways such as runoff, ammonia volatilization, denitrification and leaching causes groundwater pollution, water eutrophication, and the greenhouse effect, and the release of N oxides which in turn causes O_3 degradation in the stratosphere. Ammonia volatilization is the process of depletion of nitrogen in the form of free ammonia (NH_3) gas and one of major ways of nitrogen losses from agroecosystem. Moreover, from agricultural systems denitrification is an important process of fertilizer N loss (Bouwman *et al.* 2013), as it converts nitrate and nitrite into nitric oxide (NO), nitrous oxide (N_2O), and N_2. N_2 release when soil condition is completely submerged or in alternately wetting and drying condition of soil. (Ciais *et al.* 2014) stated that terrestrial denitrification transforms 30%–60% of the Nr back into nitrogen gas (N_2). Previous studies have shown that in rice paddy fields or wetlands the N loss is mainly via denitrification (Wang *et al.* 2017). To ensure high crop yield application N fertiliser is one of the important measures but haphazard use led to a common problematic practice in agricultural production. Shi et al. reported that the removal of N by wheat is also govern by the active soil N content, root distribution, N transport rate and the capability of nutrients to be absorbed and utilized. (Raiver *et al.* 2017) found that there has been increase in yield, protein content and N use efficiency in wheat due to initial N deficiencies. The increase in yield may be due to change in root growth at seedling stage under low- N condition. Thus, it is very important to introduce N fertilisation strategies through various option available for fertiliser rather restrict to only inorganic fertiliser application and increase nitrogen use efficiency. Root elongation and growth of wheat seedling are sluggish at early stages of growth stages. Thus, N absorption capacity is weak due immature root, which in turn increase retention or loss of significant amount of N, and finally reduce N use efficiency (Jiang *et al.* 2017). (Hu *et al.* 2018) found that for N uptake root morphology and functioning is important. Root morphology mainly determine by root length, surface area and branching. Absorption of nutrient facilitated by upper root (Tian *et al.* 2018). No doubt countries are becoming self reliant in terms of agricultural production, but at the cost of massive use of chemical fertiliser which in turn affect soil nutrient status as well as soil biota. Considering all these adverse effect of chemical fertiliser, use of microbial consortium as nutrient source emerges out to be potential substitutive area in terms of the growing demand of crop production supply, sustainability and growing concerns regarding environmental pollution. Microbial consortium are nothing but mass of living microorganisms applied to soil, plant or incorporated with seeds before sowing, which promotes plant growth by increasing supply of nutrient to the plant (Malusa *et al.* 2014)

MATERIAL AND METHODS

The field experiment was carried out at the research farm of Indian Agricultural Research Institute (IARI), New Delhi during rabi season of 2018-19. The wheat cv. "HD 3086" was sown in third week of November on sandy loam soil which was medium in organic carbon (0.45%), medium in nitrogen (347.7 kg/ha), medium in phosphorus (21 kg/ha) and potassium (68.4 kg/ha), with soil pH of 8.2 and electrical conductivity of 0.42 dS/m. The mean minimum and maximum temperature during the trial from November to April were 9.18 °C and 25.57 °C respectively, recorded from metrological observatory of IARI, New Delhi. The climate of New Delhi is continental, sub tropical, and semi arid type and the annual average precipitation of this sight was 650 mm, from which approximately 80% is due to south-west monsoon. Field experiment was carried out using Randomised block design with three replications by growing wheat variety (HD 3086) with 4 treatments in plot during rabi season. All the 4 treatments were Tc- (No Fertiliser), Ta-Azotobacter, Tm-Mycorrhiza, Tam-Azotobacter + Mycorrhiza. Biofertiliser treatment were Mycorrhiza treatment- 10 kg ha^{-1} and Azotobacter- Seed treatment 20 kg ha^{-1}. Fresh soil samples taken from 0-30 cm layer of soil at three different locations from each treatment were collected by using a tube auger.

Three soil samples from each treatment were collected during tillering, flowering, grain-filling and physiological maturity of the crop. Analysis of the different soil properties were done by using standard procedures mentioned below. Total nitrogen content in soil was determined by Kjeldahl method (Kjeldahl, 1883). Ammonical form nitrogen in soil was determined by using Continuous flow analyzer (Keeney and Nelson 1982). Nitrate content in soil was estimated by using continuous flow analyzer (Keeney and Nelson,1982). Available soil phosphorus soil was determined using Olsen's method (Olsen *et al*. 1954). Available soil potassium was determined by using Ammonium acetate method (Hanway and Heidel 1952). Soil Organic Carbon was determined by using Walkley and Black Method (Walkley and Black 1934). Plant nitrogen content was estimated using Kjeldahl method. Ammonia Volatilization estimated using Force air graft method (Stumpe *et al.* 1984). A closed-chambers measuring 20 cm × 20 cm × 50 cm size made of 6 mm acrylic sheets would be placed in field. The volatilized ammonia gas from soil surface under different treatments will be collected in 2% Boric acid solution containing mixed indicator (methyl red and bromocresol green). The air inside the chamber will be collected into boric acid traps using vacuum pump having a flow rate of 3 L/min. The boric acid traps will be changed after every 24 hr. Denitrification potential of soils can be determined using the acetylene inhibition method (Ryden *et al.* 1979). The harvesting was done in fourth week of April, 2019. The yield and yield contributing characteristics *viz.* number of effective tillers and number of grains/spike, grain and straw yield were recorded. The data collected on various parameters under study were statistically analyzed and means were compared at 5% level of significance.

RESULTS AND DISCUSSION

Effect of Microbial Consortium on Soil nutrient status

The result showed that total N content varied significantly among the treatment ranging from 0.02% to 0.03%. Tram showed the highest total nitrogen content in soil i.e., 0.036% which may be attributed due to application of Azotobacter and Mycorrhiza which result in the slight enhancement of total nitrogen content of soil. The finding reported here are in good agreement with (Karad *et al.* 2016) while working on effect of biofertiliser on nitrogen dynamics under groundnut-wheat system of typic haplustepts in long term fertilizer experiment. The available P significantly varied from 20.4 kg ha^{-1} to 26.98 kg ha^{-1} with most available P content in the Tam. The available K content was 48.9 kg ha^{-1} to 66.56 kg ha^{-1}. Tram recorded the highest K content in soil. Therefore, it is evident from the results that biofertilizer mycorrhiza in combination with application of Azotobacter improved the soil fertility status which help to obtain sustainable crop yield of wheat. (Joshi *et al.* 2018) also reported similar result while working on soil nutrient studies under various microbial treatment in baby corn (*Zea mays* L.). A significant improvement of soil organic carbon under various treatments was observed by regular addition of biofertilizer in combination. The soil organic carbon content varied from 0.47% to 0.50%. The greatest soil organic carbon content was recorded under treatment Tam i.e., 0.50 %. This increase in organic carbon content in Tam could be due to enhanced soil microbial diversity of wheat crop. (Kaur *et al*. 2018) also found similar result while working on Soil organic matter dynamics as affected by long-term use of organic and inorganic fertilizers under maize–wheat cropping system.

Table 1: Effect of Microbial Consortium on Soil nutrient status

Treatments	*Total Nitrogen (%)*	*Phosphorus (kg/ha)*	*Potassium (kg/ha)*	*Organic Carbon (%)*
Tc	0.028	20.42	48.96	0.47
Ta	0.031	24.52	60.48	0.49
Tm	0.032	25.13	61.60	0.49
Tam	0.036	26.98	66.56	0.50
CD	0.02	1.38	4.89	0.02
sEM±	0.008	0.70	1.61	0.008

Effect of Microbial Consortium on Nitrogen losses

This study revealed that there is significant less ammonium volatisation losses and denitrification losses in plot receiving azotobacter and mycorrhiza. The least loss was observed in Tc i.e., 3.8 N kg ha^{-1} whereas the Tam showed 6.2 N kg ha^{-1}. Ta and Tm also showed decrease in ammonium volatisation loss. Statistically at par value was observed in Tam, Tr and Ta. Identical results were observed by (Prasad & Singh 2017) Cumulative Volatilization Loss of Ammonia from Rice Field under Integrated Nutrient Management. Similarly for denitrification losses, the data depict that highest denitrification loss observed in Tam i.e., 3.9 N kg ha^{-1} and lowest denitrification losses was observed in Tc i.e., 1.05 N kg ha^{-1}. Ta and Tm showed twofold decrease in denitrification losses. Ta and Tm showed statistically at par value in denitrification losses. It might be due increased soil available nitrogen, vigorous root growth and increased nutrient use efficiency hence uptake of nitrogen will be more and making it less susceptible for nitrogen losses. The denitrification losses less in integrated fertiliser treatment compare to inorganic fertiliser treatment and the results are in close conformity with (Aulakh 2020) Use of biofertiliser for sustainable crop production, improving crop quality and soil health, and minimizing environmental pollution

Effect of microbial consortium on yield attributes of wheat crop

Azotobacter and Mycorrhiza significantly influenced wheat yield, straw yield, test weight, no. of grains per ear, no. of spikelet per ear and are presented in table 2 and their analysis of variance are given in respectively. The highest grain yield was observed in Tam i.e., 4.3 t ha^{-1} which significantly higher compared to Tr and Ta. Tam showed a percentage increase of 4.7% in grain yield compare to Tr and Ta. Tam showed highest test weight i.e., 37.9 g which is 5.9% percentage higher compare to Tc. Test weight shown by Tr and Ta are statistically at par. Number of grains per ear and number of spikelet's per ear was also recorded highest in Tra i.e., 40.2 and 13.8 respectively. Harvesting Index recorded to be highest in Tra i.e., 37.1% which significantly higher compare to Tr and Tc. Harvesting index recorded by Ta and Tr showed statistically at par value. It was observed that there is significant difference in yield in treatment receiving biofertiliser treatment compare to unfertilised control. Similar result was reported by (Soleimanzadeh and Gooshchi, 2018) while working on effects of Azotobacter and nitrogen chemical fertilizer on yield and yield components of wheat. The increase in grain and straw yield might be due to sufficient quantities and balanced fraction of plant nutrient delivered to the crop as per need during the growth period resulting in final increase in yield attributing character. Integrated use of fertilizers with bio-fertilizers increased the dry matter accumulation, number of effective tillers, grains spike and the test weight. The enhanced

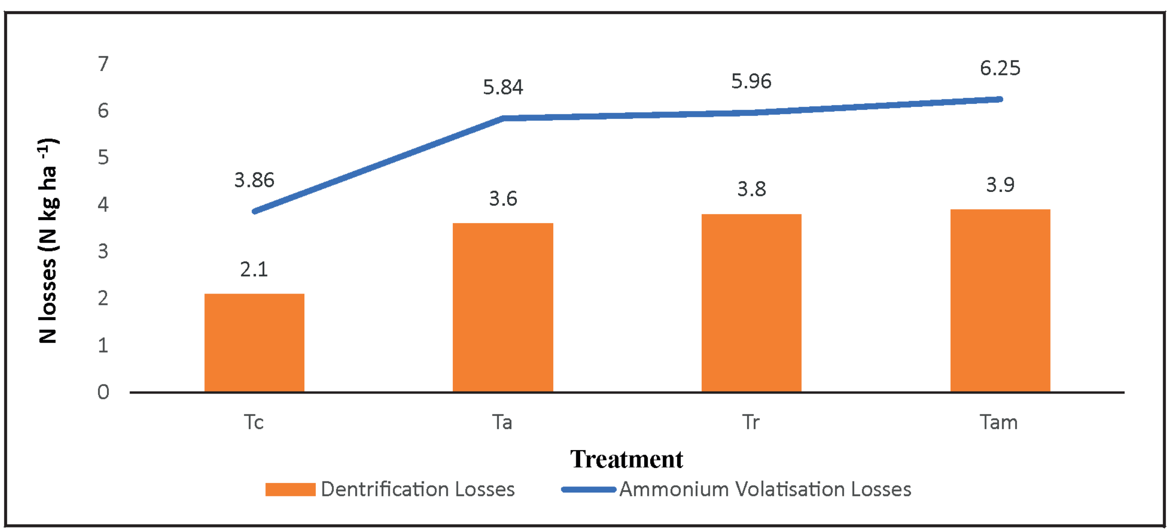

Figure 1: Effect of Microbial Consortium on Nitrogen losses

Ammonium volatisation and Denitrification losses (kg N ha^{-1}). Bar represent denitrification losses whereas line represent ammonia volatisation losses. Tc- (No Fertiliser), Ta-Azotobacter, Tm-Mycorrhiza, Tam-Azotobacter + Mycorrhiza.

Table 2: Effect of microbial consortium on yield attributes of wheat crop

Treatment no.	*Wheat Yield ($t\ ha^{-1}$)*	*Straw yield ($t\ ha^{-1}$)*	*Biological yield ($t\ ha^{-1}$)*	*Test weight (g)*	*No. of grains per ear*	*No. of spikelet per ear*	*Harvesting index (%)*
T_C	2.7	5.2	8	36.8	38.1	11.9	34
Ta	3.7	6.4	10.1	37.6	39.8	12.6	36.4
Tc	3.4	6.1	9.6	36.9	38.6	12.7	36.1
Tam	4.3	7.2	11.5	37.9	40.2	13.8	37.1
sEM±	**0.11**	**0.19**	**0.34**	**0.6**	**0.7**	**0.26**	**0.98**
CD	**0.35**	**0.57**	**1.04**	**1.85**	**2.12**	**0.79**	2.98

early vegetative growth in terms of vigorous root system resulted in more spikes which consequently increased the number of spikes bearing tillers significantly. (Devi *et al.* 2019) also reported similar results while working on effect of microbial consortium on growth and yield of wheat. It might be due to stimulated vegetative growth of wheat on account of sufficient and prolonged supply of essential nutrients.

CONCLUSION

The present study showed that the application of biofertilizer increased the soil available nutrient pool which in turn makes the available nutrient more available for uptake. It also improved nitrogen use efficiency makes the soil less susceptible for nitrogen losses either in the form of volatisation losses or denitrification losses which is observed in the rate of ammonia volatilization and denitrification loss was decreased with the usage of azotobacter and mycorrhiza treatment to the wheat crop. The study also showed that increase in yield attributes of wheat under the supply azotobacter and mycorrhiza results in agronomically possible, economically viable and environmentally sound sustainable crop production systems by enhancing soil fertility and reducing N losses by using both sources of nutrients optimizes fertilizer input, increases the use efficiency by crops and then lessens their losses.

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