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Analysis of Soil N_2O Emission under Drip Irrigation Technology

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Abstract

Under drip irrigation, there is a strong alternation of wetting and drying, which affects the process of soil nitrification and denitrification, and consequently affects the emission of soil N_2O. Therefore, it is very important to analyze and summarize the research progress of soil N_2O emission under drip irrigation conditions by different scholars at home and abroad. This paper summarized the development status of drip irrigation technology, analyzed the research progress of soil N_2O emission under drip irrigation, including the effects of temperature, humidity, soil texture and other factors on N_2O emissions under drip irrigation conditions, pointed out the main research directions in China in the future.

Keywords

Drip Irrigation, N_2O, Emissions

1. Introduction

Global warming has become an important challenge threatening human survival. The main reason for climate warming is that human beings use fossil fuels or other greenhouse gases generated by living activities, including carbon dioxide, nitrous oxide, methane, etc. These greenhouse gases can prevent the release of heat from the earth and cause the warming of the earth, that is, the greenhouse effect. Nitrous oxide contributes little to the greenhouse effect, but its warming effect is nearly 100 times that of the other two gases, and its concentration in the atmosphere reaches 324 ppb (part per billion, microgram/liter) (IPCC, 2013). Therefore, more and more attention has been paid to the research of nitrous oxide emissions.

Agricultural production is one of the important causes of N_2O emission. Irrigation, fertilization and other operations in agricultural production will affect

N_2O emissions. With the advancement of agricultural modernization, drip irrigation technology has been more and more applied to agricultural irrigation. Drip irrigation technology has a strong drying and wetting process after irrigation. This drastic change of soil moisture will inevitably affect the process of nitrification and denitrification, and then affect the discharge of soil N_2O. Therefore, it is of great significance to summarize the research progress of soil N_2O emission under drip irrigation.

2. Development Status of Drip Irrigation Technology

Drip irrigation technology, as an advanced irrigation technology, has obvious water saving and yield increasing benefits, and has been widely used in various countries in the world. Drip irrigation is an irrigation method that transfers water with a certain pressure to the field through pipeline and drips into the soil with a small amount of flow by using drippers installed on the pipeline. China introduced drip irrigation technology from Mexico in the 1970s, and began to use it in practice in the 1980s. At first, it was mainly used in drip irrigation of fruit trees. Drip irrigation technology was introduced from Mexico in 1974, and its initial use began in the early 1980s. At present, drip irrigation technology has been widely applied in China. The State has also issued the National Agricultural Water Saving Program (2012-2020). It clearly points out that the effective irrigation area of farmland in China will reach 1 billion hectares by 2020, and the irrigation area of newly added drip irrigation projects will reach 300 million hectares.

Micro-irrigation technology, mainly drip irrigation, was mainly used in flowers and fruit trees in the past. Now it has been widely used in the field. It has also been applied from small-area decentralized application in the past to large-area intensive application. In terms of development goals, the economic goals of saving water and increasing production in the past have gradually changed to the comprehensive goals of paying equal attention to economic, social and ecological benefits. Drip irrigation technology is developed in the northern region to reduce the exploitation of groundwater through water saving, and then to protect the ecological environment. In the southern region, water saving and emission reduction are used to protect the ecological environment.

Drip irrigation can save more than 30% of water than sprinkler irrigation, save more than 85% of energy, and increase production by 20% to 30%. The research of drip irrigation water quota is mostly concentrated on soil such as sand soil, loam soil and clay. The PH value of drip irrigation water quality should generally be in the range of 5.5 - 8, and the total salt content should not exceed 2000 ppm. The irrigation design guarantee rate of drip irrigation is generally not less than 85%. The drip irrigation design soil moisture ratio is generally 25% - 30%, the vegetable is 60% - 90%, the design water-consuming intensity fruit tree is 3 - 5 mm/d, and the vegetable (protected area) 2 - 3 mm/d.

3. Research Status of N_2O Soil Emission under Drip Irrigation

3.1. Study on Soil Water Transport under Drip Irrigation

When drip irrigation is used, irrigation water seeps vertically and diffuses laterally, forming a certain shape of soil wet zone near the emitter. In the process of irrigation, if the vertical depth is too deep, it will lead to deep leakage loss and affect the environment; if the horizontal wetting area is too large, it will waste water resources. The distribution of soil moisture in soil is mainly affected by soil bulk density, initial soil moisture content, dripper discharge and irrigation quota. Therefore, most of the studies on the distribution of irrigation soil moisture are carried out by indoor simulation experiments (Wang & Li, 2011; Fu et al., 2013; Medinazizi et al., 2013). A certain number of wooden soil containers are made indoors, and the soil to be studied is loaded into the containers to control different soil bulk density and moisture content. Then the spatial distribution of soil moisture under different emitter discharge and irrigation quota is studied by simulating the infiltration of emitters.

Some scholars (Sun & Li, 2013) established mathematical models to study the distribution of soil moisture under drip irrigation. Some scholars (Lu & Wang, 2012) pointed out the power function relationship between the spatial distribution of soil moisture front and infiltration time by establishing mathematical functions. There are also studies (Zhang et al., 2010) that the vertical distribution of soil moisture decreases with the increase of dripper discharge (2 L/s to 6 L/s). At present, the law of soil moisture distribution and movement under drip irrigation has been fully studied, and the basic law has been found out.

3.2. Effect of Drip Irrigation on N_2O Emission from Soil

Drip irrigation process will bring strong alternation of dry and wet soil. Under the combined influence of nitrogen fertilizer and temperature, the number of denitrifying bacteria in soil increase (Qin, 2012). The increase of soil water content during irrigation results in poor soil air permeability and easy formation of anaerobic environment in the soil, which enhances soil denitrification, and the alternation of soil moisture during drip irrigation is more obvious.

Therefore, N_2O emissions are intense in a short time (Laura et al., 2008). Drip irrigation is mostly used in greenhouse agricultural system, large amount of fertilizer, abundant nitrogen resources in the soil, and intense nitrification and denitrification in the soil, which leads to the increase of N_2O emissions. Wang, Mao, & Yan (2014) studied N_2O emission from vegetable plots in facilities by static box method. It was found that N_2O emission flux under drip irrigation was 27.90% higher than that under conventional irrigation, and drip irrigation promoted N_2O emission.

Yu, Wang, & Zhu (2012) found that the emission flux of N_2O from non-nitrogenous purple soil is (50.7 ± 13.3) $\mu g \cdot m^{-2} \cdot h^{-1}$, and the emission coefficient of N_2O caused by nitrogen (N150 kg/hm^2) is 1.86%.

However, there are also studies (Maraseni, Mushtaq, & Reardon-Smith, 2012).

Under drip irrigation, the amount of irrigation is less than that under conventional irrigation, which is conducive to the occurrence of nitrification, reduces the rate of denitrification, and reduces the N_2O emission of soil by 70%, N_2O emissions from nitrogen application accounted for 0.38% of nitrogen application.

At the same time, some studies (Verge, DeKimpe, & Desjardins, 2007) showed that 30 per cent reduction of N_2O emission under drip irrigation with organic fertilizer. Whether drip irrigation promotes N_2O emission from soils is still uncertain and needs further study.

Under drip irrigation conditions, the environmental factors affecting soil N_2O emissions mainly include soil physical and chemical characteristics, water and heat conditions, climatic factors and microbiological activities. Soil N_2O emissions generally increase with the increase of temperature, and the maximum value generally occurs at about 13:00 noon. When the soil temperature is within 20˚C to 40˚C, soil N_2O emissions increase with the increase of temperature. The soil texture of drip irrigation has a certain influence on N_2O emissions. Nitrification is the main effect in loam soil, and denitrification is the main influence in clay.

The water content of the drip irrigation soil (80% - 90% of the water held in the field) was positively correlated with the emissions of N_2O. Soil N_2O emissions from drip irrigation generally occur within 7 days after irrigation and peak at 3 - 5 days. The water content of farmland soil increases suddenly after irrigation or rainfall. When the water holding rate in the field reaches or exceeds the water holding rate, the emissions of N_2O will appear to be low, and the soil water content will drop to about 75% of the saturated water content (Mosier & Kroeze, 1999).

Six years of emission data from several German observation points showed significant differences in N_2O emission factors according to factors such as precipitation, soil, crop type and nitrogen fertilizer type, ranging from 0.33 to 15.58 per cent. Bouwman et al. (2002) estimates the N_2O emission factor for fertilizers at an average of 0.9 per cent based on global observations of farm land.

4. Conclusion and Perspective

Agricultural production activities, especially soil nitrogen emissions caused by drip irrigation, have aroused widespread concern. It is very important to develop effective drip irrigation technology to effectively reduce soil nitrogen emissions. This paper reviews the development of drip irrigation technology in China, reviews the research on soil nitrogen emissions from drip irrigation at home and abroad, and provides an important reference for future research. Some scholars have proposed that the use of drip irrigation has reduced N_2O emissions, while others have proposed that drip irrigation has increased N_2O emissions; some scholars also pointed out that drip irrigation fertilization is the most critical factor affecting soil N_2O emissions, but at present, the research on the influence mechanism and regulatory measures of soil moisture and nitrogen fertilizer on soil N_2O emissions under drip irrigation conditions is not yet in-depth.

As a large agricultural country, drip irrigation technology has developed rapidly and is widely used. It is of great practical significance to study the emission mechanism and control measures of soil N_2O under drip irrigation in China to improve the greenhouse gas emission theory and improve the sustainable development level of agriculture in China.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

Bouwman, A. F., Boumans, L. J. M., & Batjes, N. H. (2002). Modeling Global Annual N_2O and NO Emissions from Fertilized Fields. *Global Biogeochemical Cycles, 16,* 1080-1088. https://doi.org/10.1029/2001GB001812

Fu, J. P., Lan, Z. P., Sun, S. W. et al. (2013). Study on the Law of Soil Moisture Change of Poplar Plantation under Drip Irrigation. *Journal of Beijing Forestry University, 35,* 61-66.

IPCC (2013). *Climate Change 2013: Working Group I Contribution to the IPCC Fifth Assessment Report, The Physical Science Basis Summary for Policymakers.*

Laura, S. M., Vallejo, A., Dick, J. et al. (2008). The Influence of Soluble Carbon and Fertilizer Nitrogen on Nitric Oxide and Nitrous Oxide Emissions from Two Contrasting Agricultural Soils. *Soil Biology and Biochemistry, 40,* 142-151. https://doi.org/10.1016/j.soilbio.2007.07.016

Lu, J. H., & Wang, Y. K. (2012). Study on the Characteristics of Soil Wetting Body under Drip Irrigation. *Rural Water Conservancy and Hydropower in China, 3,* 1-6.

Maraseni, T. N., Mushtaq, S., & Reardon-Smith, K. (2012). Integrated Analysis for a Carbon- and Water-Constrained Future: An Assessment of Drip Irrigation in a Lettuce Production System in Eastern Australia. *Journal of Environmental Management, 111,* 220-226. https://doi.org/10.1016/j.jenvman.2012.07.020

Metriniazi, N., Zheng, X. H., Bartel, B. et al. (2011). Analysis of Soil Water and Salt Transport Characteristics after Drip Irrigation in Arid Saline-Alkali Land. *Journal of Shandong Agricultural University, 42,* 551-554.

Mosier, A. R., & Kroeze, C. (1999) Contribution of Agroecosystems to the Global Atmospheric N_2O Budget. In R. L. Desjardins, J. C. Keng, & K. Haugenkozyra (Eds.), *Proceedings of International Workshop on Reducing N_2O Emissions from Agro-Ecosystems* (pp. 3-15). Banff, Canada.

Qin, Y. M. (2012). *Study on Greenhouse Gas (CH_4 and N_2O) Emissions from Paddy and Vegetable Fields under Conventional and Organic Production Methods.* Nanjing: Nanjing Agricultural University.

Sun, H. Y., & Li, X. B. (2013). Identification and Optimization of Soil Water Transport

Model under Drip Irrigation. *Science and Technology and Engineering, 13,* 5459-5463.

Verge, X. P. C., DeKimpe, C., & Desjardins, R. L. (2007). Agricultural Production, Greenhouse Gas Emissions and Mitigation Potential. *Agricultural and Forest Meteorology, 142,* 255-269. https://doi.org/10.1016/j.agrformet.2006.06.011

Wang, C., & Li, Y. N. (2011). Experimental Study on Wetting Body Characteristics under Subsurface Drip Irrigation. Ru*ral Water Resources and Hydropower in China, 3,* 38-40.

Wang, W. H., Mao, Q., & Yan, A. L. (2014). Study on N_2O Emission from Green Pepper Fields under Drip Irrigation. *Rural Water Resources and Hydropower in China, 7,* 31-34.

Yu, Y. J., Wang, X. G., & Zhu, B. (2012). Soil N_2O Emission from Purple Soil Vegetable Ecosystem and Its Main Influencing Factors. *Journal of Ecology, 32,* 6.

Zhang, J. F., Zhu, M., Liang, Z. et al. (2010). Effects of Drip Irrigation on Soil Water Transport in Jujube Orchards and Jujube Leaves. *Xinjiang Agricultural Science, 47,* 2283-2287.