

GREENHOUSE GAS EMISSIONS FROM POTATO CROP

Preeti Singh^{1*}, Arti Bhatia², N. Subhash³, V. K Dua¹, Sanjay Rawal⁴, Manoj Kumar⁴, Jagdev Sharma¹, Santosh Kumar⁵, Paresh Chaukhande¹ and Pooja Mankar⁴

Human-produced gases including carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) contribute to the natural greenhouse effect. The Intergovernmental Panel on Climate Change (IPCC) has concluded that immediate action is required to mitigate the severe risk of human-induced climate change posed by these gases. According to the IPCC (2001) report, agriculture contributes approximately 4% of global carbon emissions from energy use. Agriculture produces emissions through a variety of processes, including enteric fermentation and animal waste disposal and fermentation, anaerobic process during rice cultivation, nitrification and de-nitrification linked to fertilisation, as well as land clearing, the burning of biomass, fuel wood, and agricultural waste.

The Ministry of Environment and Forests (MoEF, 2010) estimated that approximately 13 percent of Indian agricultural GHG emissions are attributable to N₂O. In addition to being a greenhouse gas, N₂O also contributes to the depletion of ozone (O₃) (Knowles, 1982). Nitrogen is often the most important and limiting nutrient for agricultural production. The world's nitrogen

fertiliser consumption increased from 12 Tg in 1960 to 113 Tg in 2010. (Fagodiya *et al.*, 2017). In addition, the nitrogen cycle includes nitrification, assimilation, ammonification, and denitrification (Kumar and Sharma, 2017b). N₂O production in agricultural settings is predominantly the outcome of microbial denitrification and nitrification processes. In humid and subhumid regions, denitrification is the primary contributor to N₂O production from agricultural soils (Li *et al.*, 2016). There are both direct and indirect impacts of reactive nitrogen (Nr) on soil N₂O emissions. Due to their prolonged air lifetime (approximately 116 years), maximum capacity for global warming (310 times that of CO₂), and significant potential for global climate change (290 on a 100-year basis), N₂O emissions are of great concern (Fagodiya *et al.*, 2020a). Direct and indirect N₂O emissions might come from the addition of nitrogen fertiliser to the soil. Direct emissions are the additional application of nitrogen fertilisers to the same soil (Holka and Bienkowski, 2020). Indirect N₂O emissions are those that originate from non-soil sources and should not be regulated, such as N₂O produced by water and NO₃ leaching into the soil (IPCC,

¹ICAR-Central Potato Research Institute, Shimla - 171 001, Himachal Pradesh, India

²ICAR-Indian Agricultural Research Institute, New Delhi, India

³Present address: ICAR-Indian Agricultural Research Institute, Gauria Karma, Hazaribag, Jharkhand, India

⁴ICAR-Central Potato Research Institute, Regional Station, Modipuram, Meerut - 250110, Uttar Pradesh, India

⁵ICAR-Indian Institute of Farming System Research, Modipuram, Uttar Pradesh, India

^{*}Present address: ICAR-Indian Agricultural Research Institute, Gauria Karma, Hazaribag, Jharkhand, India

*Corresponding author; email: singh.preeti8888@gmail.com

2006). Agriculture and horticulture are responsible for around 8% of CO₂ emissions. N₂O and CH₄ are major greenhouse gases that contribute 57% and 35%, respectively, to global warming (FAS, 2014). N₂O is an extremely potent greenhouse gas that contributes directly to global warming. Due to its long atmospheric residence time (114 years), global climate change potential (290 times that of CO₂), and global warming potential, N₂O emissions over a 100-year period were more sensitive than those of other greenhouse gases (265 times higher than CO₂). After CO₂ and CH₄, these gases are the third most abundant greenhouse gas. In 2014, about 18.09 percent of all greenhouse gases and 73.29 percent of all N₂O were emitted by the agriculture industry in India. A growing population needs the use of nitrogen fertiliser to meet the demand for food production, resulting in an increase in agricultural N₂O emissions.

The potato is the fourth most important food crop in the world, after wheat, rice, and corn, due to its high yield potential and nutritional value (Kumar *et al.*, 2020). In India, the potato is not primarily a rural staple food, but rather a cash crop that provides farmers with substantial money. In order to attain the tuber yield and size distribution required by the potato processing industry, the potato crop often receives 200 kg N ha⁻¹ or more of nitrogen fertiliser (Zebarth *et al.*, 2012). Concerns have been raised about the potential for increased N₂O emissions resulting from these high N inputs. Commonly, soil NO₃⁻ availability, soil aeration, and soil carbon availability are cited as significant factors governing N₂O emissions and denitrification (Gillam *et al.*, 2008).

Fertilizer management, formulation, and placement technologies provide the opportunity to influence the magnitude of

N₂O emissions from fertiliser N sources by regulating the duration and extent of NO₃⁻ accumulation in soil (IPCC, 2001).

Taking this into consideration the present experiment was conducted in ICAR-CPRI, regional station, Modipuram. We studied the effect of nitrogen rates (180 and 270 kg h⁻¹), method of application of nitrogen fertilizers (Broadcast and band placement) and sources of nitrogenous fertilizer (Urea and ammonium sulphate) on N₂O emission from soil in Potato (var. K. Pukhraj). Samples for GHG analysis was collected from potato field, each treatment replicate by placing one box per replicate 1 and 2 day prior to sowing; and on consecutive 15 days after fertilizer application after that once in a week (Figure 1). Estimation of total N₂O emissions during the crop season was done by successive linear interpolation of average



Figure-1-Collection of GHGs samples from field using the closed-chamber method.

emission on the sampling days assuming that emission followed a linear trend during the periods when no sample was taken (Pathak et al. 2002) (Figure-1). Nitrous oxide concentration in the gas samples was estimated by Gas Chromatograph. Cumulative N_2O losses was calculated stepwise for each individual soil-collar area assuming a constant flux rate beginning with the date of each gas sampling until the next gas sampling. The cumulative fluxes at a site was expressed as arithmetic means. Potato yields will be determined from the total plot area. Duncan's Multiple Range Test was carried out to test whether the differences between means statistically significant.

N_2O flux from the treatments showed more or less similar temporal trends with appearance of a peak of N_2O emission one and a half weeks after urea and ammonium sulphate application, however, the magnitude of flux differed. The cumulative emission of N_2O -N from potato treatments varied from 0.34 to 2.04 kg ha⁻¹ (Table 1). Urea and ammonium sulphate additions potentially affect N_2O emissions because they have different nitrification rates and have opposite effects on soil pH. Our results indicate that application of urea led to significant increase

in N_2O emissions over the application of ammonium sulphate. The emission was significantly higher under band placed urea as compared to broadcasting of urea. This may suggest that deep placement of nitrogen fertilizers in light sandy soils might not lead to the mitigation of GHG emissions from the soil. The deep N-fertilizer placement method, however, will be required for better plant nutrition, rather than the possibility of reducing GHG emissions from soil (Sosulski, 2020). However, for ammonium sulphate, N_2O emission from band placed and broadcasting had variable emission. The emission was higher under 270 kg ha⁻¹ application of nitrogen and urea as a source of fertilizer treatments. Overall, N_2O emission was significantly highest for 270 kg ha⁻¹ band placed urea fertilizer. Significant positive correlation was found between doses of fertilizer and N_2O emission. As expected, application of N fertilizer significantly increased total tuber yield and the yield was highest under 270 kg ha⁻¹ broadcasted urea (24.6-ton ha⁻¹), however, higher dose of fertilizers leads to higher emissions. Sun *et al.* (2016) also found that the critical factors for N_2O emission were N fertilizer application rate. Kumar *et al.* (2021) conducted similar study for maize-wheat cropping system and

Table 1. Variations in tuber number, yield and N_2O emission under different treatments in potato.

Treatments	Total tuber number ('000)/ha	Fresh weight of tuber(ton/ha)	N_2O Flux g/ha
T1 (Control)	281.7 ^c	9.97 ^b	339.29 ^h
T2 (180 kg N/ha urea broadcasting)	412.2 ^{ab}	21.99 ^a	1219.27 ^e
T3 (180 kg N/ha ammonium sulphate broadcasting)	392.5 ^{ab}	23.75 ^a	1045.74 ^f
T4 (180 kg N/ha urea band placed)	362.2 ^{abc}	22.94 ^a	1439.38 ^c
T5 (180 kg N/ha ammonium sulphate band placed)	407.8 ^{ab}	24.48 ^a	772.38 ^g
T6 (270 kg N/ha urea broadcasting)	342.8 ^{bc}	24.62 ^a	1324.80 ^d
T7 (270 kg N/ha ammonium sulphate broadcasting)	402.87 ^{ab}	24.10 ^a	1250.08 ^e
T8 (270 kg N/ha urea band placed)	352.5 ^{abc}	22.19 ^a	2041.91 ^a
T9 (270 kg N/ha ammonium sulphate band placed)	430.0 ^a	22.62 ^a	1833.07 ^b

^aMeans with the same letter are not significantly different at (p=0.05).

found that highest N₂O efflux (0.368 kg per ton) was observed at higher dose of nitrogen application (240 kg N per hectare) under wheat crop. He also concluded that direct emission of N₂O was totally dependent on N fertilizers application rate. It was also found that alkaline-forming fertilizers, such as urea tend to produce more N₂O when they are locally concentrated, e.g. in bands, rather than dispersed evenly in the soil. It can be concluded that the emission of N₂O was significantly higher under band placed urea applied at rate of 270 kg ha⁻¹. Therefore, fertilizer N management in potato is very much important in reducing the risk of N₂O emissions from soil.

CONFLICTS OF INTEREST

The authors confirm that this manuscript has no conflicts of interest

LITERATURE CITED

- Bin Feng S, Hong Z, Yi-Zhong L, Fei L, Xiao-ke W (2016) The effects of nitrogen fertilizer application on methane and nitrous oxide emission/uptake in Chinese croplands. *J Integr Agric* 15(2): 440–450.
- Gillam KM, Zebarth BJ, Burton DL (2008) Nitrous oxide emissions from denitrification and the partitioning of gaseous loss as affected by nitrate and carbon addition and soil aeration. *Can J Soil Sci* 88:133–143
- IPCC (2001) Climate change 2001: The scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, & C. A. Johnson (Eds.)]. Cambridge, United Kingdom, & New York: Cambridge University Press.
- Kumar M, Singh P, Nare B, Kumar S (2020) Precision Agriculture in Potato Production. In, *Potato Science and Technology for Sub -Tropics*. NIPA(ed), New Delhi, India.
- Li X, Sørensen P, Olesen JE, Petersen SO (2016) Evidence for denitrification as main source of N₂O emission from residue-amended soil. *Soil Biol Biochem* 92: 153–160. <https://doi.org/10.1016/j.soilbio.2015.10.008>
- Ministry of Environment and Forests, Government of India (2010) India: Green House Gas Emissions 2007, New Delhi, MoEF.
- Pathak H, Bhatia A, Prasad S, Jain MC, Kumar S, Singh S, Kumar U (2002) Emission of nitrous oxide from soil in rice-wheat systems of Indo-Gangetic plains of India. *Environ Monit Assess* 77: 163–178.
- Zebarth BJ, Bélanger G, Cambouris AN, Ziadi N (2012) Nitrogen fertilization strategies in 302 relation to potato tuber yield, quality, and crop N recovery. *Sustainable Potato 303 Production: Global Case Studies*. Springer Netherlands: pp. 165–186
- Kumar R, Karmakar S, Minz A, Singh J, Kumar A, Kumar A (2021) Assessment of Greenhouse Gases Emission in Maize-Wheat Cropping System Under Varied N Fertilizer Application Using Cool Farm Tool. *Front Environ Sci* 355.
- Sosulski T, Stępień W, Wąs A, Szymańska M (2020) N₂O and CO₂ emissions from bare soil: effect of fertilizer management. *Agriculture* 10(12):602.
- Fagodiya RK, Pathak H, Kumar A, Bhatia A, Jain N, Malyan, SK (2020a) Global Warming Impacts of Nitrogen Use in Agriculture: an Assessment for India since 1960. *Carbon Manag* 11 (3): 291–301. doi:10.1080/17583004.2020.1752061.
- Kumar A, Sharma MP, Kumar A (2016b) Greenhouse Gas Emissions from Hydropower Reservoirs: Policy and Challenges. *Int J Renew Energ Res* 6 (2): 472–476.
- Fagodiya RK, Pathak H, Kumar A, Bhatia A, Jain N, Malyan SK (2020a) Global Warming Impacts of Nitrogen Use in Agriculture: an Assessment for India since 1960. *Carbon Manag* 11 (3): 291–301. doi:10.1080/17583004.2020.1752061.
- Holka M, Bienkowski J (2020) Carbon Footprint and Life-Cycle Costs of Maize Production in Conventional and Non-inversion Tillage Systems. *Agronomy* 10: 1877. doi:10.3390/agronomy10121877.
- IPCC (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme*. Editors. Eggleston L, Buendia K, Miwa T, Ngara K. Tanabe. Published: (Japan: IGES).
- FAS (2014) *Reducing Emissions of Greenhouse Gases from Agriculture*. Technical Article. Feb 2014.

MS Received: 17 June, 2022; Accepted: 29 July, 2022