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Green house gas emission potentiality of wheat as influenced by microclimate and ambient sunshine under varied climatic conditions

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ABSTRACT

Nitrous oxide (N_2O) emissions from winter wheat field were measured using closed chamber technique during 2012-2013 and 2013-2014 at Bidhan Chandra Krishi Viswavidyalaya farm (22°572 N latitude, 88°202 E longitude). Experiment was conducted taking two winter wheat varieties (K0307 and KRL-288) with two dates of sowing (15th November and 30th November) and two nutritional traits (100% inorganic and 50% organic + 50% Inorganic). The aim of the experiment was to evaluate the effect of crop eco- climate and sunshine hours on nitrous oxide emission rate from wheat field. Experimental results showed that canopy temperature and sunshine hours directly affect N_2O efflux at different phenophases of wheat under different treatment combinations. Whereas during active vegetative stage variety-K0307 responded positive relation for N_2O emission with canopy temperature and sunshine hours. But for both nutritional approaches similar response was observed during active vegetative stage as well as advance reproductive stage. Results imply that 1st sowing with K0307 and 100% inorganic and 50% organic + 50% inorganic fertilization had some effective responses towards microclimatic variation as well as ambient sunshine hours. Moreover, wheat productivity had some association with N_2O emission rate.

Keywords: *Canopy temperature, nitrous oxide flux, phenophase, productivity, sunshine hours*

Nitrous oxide a trace gas contributing to green house effect and depletion in stratospheric ozone layer and becomes an important climate change indicator. Its abundance in atmosphere is less than 1,100 times than carbon dioxide but its activity is 250 times greater than carbon di oxide. According to IPCC 2007 report nitrous oxide concentration in atmosphere is in increasing trend from pre industrial period (270ppb) to 2005 (319ppb) and still increasing at a rate of approximately 0.26% per year. Mosier *et al.,* (1998) and Kroeze *et al.* (1999) reported that 78% of gaseous nitrous oxide in atmosphere resulted from agricultural activities and 67% of which contributed by agricultural soil. A number of agricultural activities add nitrogen into soil and makes it available for microbes to carry out nitrification and de-nitrification to release nitrous oxide from soil. But temperature is also a major driving factor for nitrous oxide emission (Goodroad and Keeny, 1984; Zheng *et al.,* 1997). However the role of temperature under crop canopy in nitrous oxide emission is little be studied. Canopy temperature depends on crop water availability and the atmospheric condition. The sunshine hours regulate the atmospheric temperature which indirectly determines the canopy temperature. Due to differences in environmental parameters nitrous oxide fluxes from agricultural systems are highly variable in both time and space (Smith, 1990; Mcaggart *et al.,* 1994; Mosier and Kroeze, 1999). In Indo-Gangetic plains N_2O-N emission was 1.57 kg ha^{-1} (0.38% of applied N) from rice-wheat system where generally 240 kg N ha^{-1} yr^{-1} was applied through urea, (Pathak *et al*., 2002). Therefore in our research work we are trying to find out nitrous oxide flux from wheat grown under two nutritional practices and varied climatic conditions in a particular area of Gangetic plain of West Bengal. Hence, the present study aimed

i. To evaluate the influence of microclimate and ambient weather conditions on nitrous oxide emission from wheat crop and

ii. To identify some important indicators for sustaining productivity.

MATERIALS AND METHODS

Consecutive two years winter season (2012-2013 and 2013-2014) field experiment was performed at Kalyani 'C' Block Farm, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India at 22°572 N latitude, 88°202 E longitude and 7.8 meters above mean sea level.

Experiment was laid in randomized block design with three replicates. 15th and 30th November for sowing of two winter wheat cultivars (*Triticum aestivum* L. var. K0307 and KRL 288) under100% inorganic (recommended dose of N, P and K as 60:40:40) and 50% organic + 50% inorganic (where

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vermicompost was applied along with synthetic fertilisers) practices were considered in our plan of work. 60% of nitrogen and full dose of phosphorous and potassium was applied as basal application during land preparation and another 40% as top dressing (after 25 days of sowing).

Closed chamber was used for nitrous oxide measurement. The chamber is made of PVC (polyvinyl chloride) sheet covering 1.22 m^2 areas. Portable Nitrous oxide analyser (Technovation Series 2005, Serial No. 12045) was fitted with the chamber to measure the emission rate. A fan was fixed below the ceiling of the chamber for homogeneous mixing of air within the chamber. When measurements were done, the chamber was inserted 5 cm into the soil in each plot and fan was turned on. Nitrous oxide emission was continuously recorded at 0, 15 and 30 minutes i.e., at an interval of 15 minutes from all the plots during important phenophases of wheat crop. Simultaneously internal air temperature of the chamber had been recorded.

Nitrous oxide flux rate was calculated according to the following equation

$$F = \frac{PVMU}{ART} * dc / dt$$

Where, F is flux rate (gm m^{-2} day^{-1}), P is pressure of chamber, V is chamber volume (3.66m^3), M is molecular weight of nitrogen, U is unit converter factor (0.00144), A is the area covered by the chamber (1.22 m^2), R is gas constant (0.082), T is chamber temperature (Kelvin) and dc/dt is changes of concentration with changing time.

Canopy temperature was measured during important phenological phases by hand held infrared thermometer (Model: Metravi MT-2) at morning. Daily weather data were collected from University weather station where sunshine hours and rainfall were recorded using sunshine recorder and rain gauge respectively.

Yield was calculated during harvesting. Two years pooled data are subjected to analysis of variance (ANOVA) to find out the single and interaction impact of experimental factors on nitrous oxide emission and crop canopy temperature throughout the entire wheat growing period.

RESULTS AND DISCUSSION

Environmental conditions during experimentation

Distinct variation of sunshine hours and total rainfall was observed throughout the wheat growing seasons of 2012-2013 and 2013-2014. Two years average sunshine hours at 10 days intervals during crop growing season from 15th November to 30th March were graphically presented (Fig. 1).

In 2012-2013 sunshine hours were gradually decreased after 10 days of 1st sowing. But after 90 days of sowing it tends to increase and peak was 8.2 hours day^{-1}. From 110 day after sowing onwards sunshine hours were in decreasing trend. But during 2013-2014 there was no such ups and downs in sunshine hours. The range of sunshine hours was in between4.9 hours day^{-1} to 7.5 hours day^{-1} through out the wheat growing season.

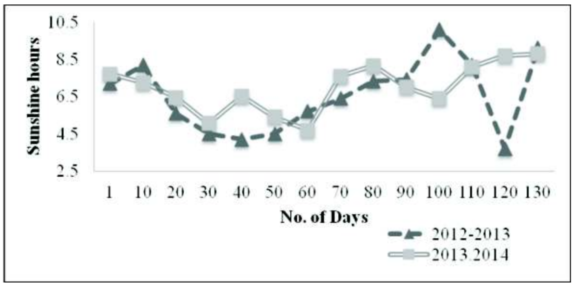

Fig. 1: Average (10 days) sunshine hours during wheat growing periods in consecutive two years

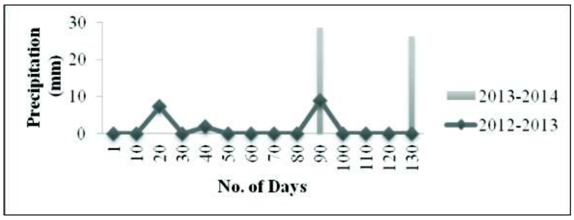

Fig. 2: Rainfall pattern during wheat growing seasons in consecutive two years

Figure- 2 depicts the rainfall pattern of consecutive two years during wheat growing season (mid November to end of March). It was noticed that crop grown in 2013-2014 experinced generally dry season upto flowering stage (90days after sowing) and then received relatively higher total rainfall (54.7mm) within two days during flowering stage. During 2012-2013 vegetative stage (10 to 50days) and milking stage received total rainfall (23.6mm) which was lower than 2nd year.

Emission of N_2O and microclimatic variation

From the table- 1 it is evident that year had greatest influence on N_2O emission during all the growth stages except flowering stage. N_2O emission was peak in the Y2 (2013-2014) during crown root initiation stage (0.268 g m^{-2} day^{-1}) and it was subsequently declined to the next phenophases. But in Y1 (2012-2013) nitrous oxide emission was lower in initial two phenophases and after that it increased gradually. Differences in N_2O emission rate between two years might be due to abrupt change in weather condition of target area (Fig. 1 and Fig. 2). The study of Bouwman *et al.,* 2002, Flynn *et al.,* 2005 reported a close association between inter-annual variation of N_2O emission and weather condition.

Table 1: Influence of sowing date, variety and nutritional approaches on nitrous oxide flux (g m^{-2} day^{-1}) and canopy temperature (°C) during important phenological phases of wheat

Factors	Phenological phase									
	CRI		Tillering		Jointing		Flowering		Milking	
	N_2O	CT	N_2O	CT	N_2O	CT	N_2O	CT	N_2O	CT
Y1 (2012-2013)	0.19	24.79	0.19	24.13	0.23	21.66	0.26	21.98	0.24	25.07
Y2 (2013-2014)	0.27	25.58	0.20	20.96	0.25	20.06	0.26	20.05	0.27	25.83
SEm(±)	**0.00**	**0.30**	**0.00**	**0.61**	**0.00**	**0.42**	**0.00**	**0.41**	**0.00**	**0.18**
LSD(0.05)	**0.01**	**NS**	**0.01**	**1.80**	**0.01**	**1.23**	**NS**	**1.22**	**0.01**	**0.53**
D1 (15th Nov)	0.21	24.89	0.20	23.86	0.25	19.75	0.28	19.70	0.25	23.74
D2 (30th Nov)	0.24	25.48	0.19	21.22	0.22	21.96	0.23	22.32	0.25	27.16
SEm(±)	**0.00**	**0.30**	**0.00**	**0.61**	**0.00**	**0.42**	**0.00**	**0.41**	**0.00**	**0.18**
LSD(0.05)	**0.01**	**NS**	**0.01**	**1.80**	**0.01**	**1.23**	**0.01**	**1.22**	**NS**	**0.53**
V1 (K0307)	0.23	25.53	0.19	22.44	0.24	20.90	0.27	20.82	0.25	25.44
V2 (KRL288)	0.23	24.84	0.20	22.64	0.23	20.82	0.24	21.21	0.26	25.46
SEm(±)	**0.00**	**0.30**	**0.00**	**0.61**	**0.00**	**0.42**	**0.00**	**0.41**	**0.00**	**0.18**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.01**	**NS**	**NS**	**NS**
N1 (100%inorganic)	0.22	24.92	0.19	22.13	0.23	20.88	0.25	21.12	0.25	25.27
N2 (50% inorg. + 50% org.)	0.24	25.45	0.20	22.95	0.24	20.84	0.26	20.90	0.26	25.63
SEm(±)	**0.00**	**0.30**	**0.00**	**0.61**	**0.00**	**0.42**	**0.00**	**0.41**	**0.00**	**0.18**
LSD(0.05)	**0.01**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.01**	**NS**	**NS**	**NS**

Canopy temperature (CT) showed variation during tillering to milking stage due to year where we have got different weather condition in respective years. Maximum canopy temperature was found during milking stage (25.83°C) followed by 25.58°C during CRI stage in 2nd year. In between these two stages canopy temperature was in decreasing trend. Same had been observed in case of 1st year.

Date of sowing had immense effect on N_2O emission as well as canopy temperature throughout the wheat growing period except CRI and milking stage. Largest N_2O flux was noticed during flowering stage (0.284 g m^{-2} day^{-1}) and milking stage (0.252 g m^{-2} day^{-1}) for D1 (15th November) and D2 (30th November) respectively. Consequently canopy temperature at these two growth phases was lowest for D1 (19.70 °C) and highest for D2 (27.16°C).

Maximum variation in N_2O flux and canopy temperature was measured during jointing stage for consecutive two years due to influence of year and date of sowing. The addition of nitrogen as topdressing just before jointing stage might stimulates the microbial activity resulting enhanced N_2O emission during jointing stage.

Significant increase in N_2O emission due to topdressing was reported by Steinbach and Alvarez, 2006.

Wheat crop grown under two dates of sowing were experienced with varied climatic conditions resulting variation in canopy architecture. Leaf orientation, Leaf angle, crop geometry is responsible for changing microclimatic environment leading to changes in canopy temperature. Such alteration in microclimatic condition can influence N_2O emission (Zhang *et al.,* 2014).

There was no distinct variation observed due to variety and nutrient for canopy temperature as well as N_2O emission during wheat growing season. But during CRI and flowering stage very less variation in N_2O emission had been found. Wheat crop was experienced with some water stress conditions during attaining CRI and flowering stage. This condition in turn may be resulted in less variation in nitrous oxide emission.

Previous studies of Liu *et al.* (2005) and Ding *et al.* (2007) reported the effect of fertiliser application rates on N_2O emission from agricultural fields. Nitrogen as mineral N and organic (from manure fertiliser) was applied in different doses to find out the N_2O emission rates in different studies (Davidson, 2009, Ginting *et al.,* 2003, Akiyama, 2000). But the role of organic manure applied together with mineral N fertilizers had been ignored often. Zhang *et al*. (2012) documented that coupling application of chicken manure and chemical fertilizer resulted in reduced N_2O-N loss from maize field of Hebei Province, China. But our experimental results showed that use of fertiliser N2 (50%synthetic+50%organic) resulted in higher N_2O emission than N1 (100% chemical). Research work of Bhatia *et al*., (2005) also supported our findings. From the analysis of variance table it was found that there were some associations in nitrous oxide emission due to each two factor interactions (Table 2). Year*Date of sowing had influence on nitrous oxide emission during tillering, jointing and flowering stage where maximum variation were found during jointing stage. For rest of the phenological phases there was no such variation. Peak emission (0.300g m^{-2} day^{-1}) occurred during flowering stage for D1 (15th November) * Y2 (2013-2014).

In case of Y * V differences in flux rate was observed during reproductive stage of wheat crop. Maximum (0.284 g m^{-2} day^{-1}) nitrous oxide emitted from Y1 (2012-2013) * V1(K0307) during flowering stage. The variation in N_2O emission due to varieties is primarily because of their differences in growth physiology.

The interactive factors Year * Nutrient and Date of sowing * Nutrient played most significant role in nitrous oxide emission throughout the wheat growing season except flowering stage and milking stage for Y * N and D * N respectively. But maximum nitrous oxide emission was recorded for D1 * N2 during flowering stage which was 0.298 g m^2 day^{-1}.

Variety and nutrient also had little variation on nitrous oxide emission during only CRI, tillering and flowering stage. There was no such variation for date of sowing * Variety during phenological phases. Also less variation was found at flowering stage.

Considering the effect of two factor interactions on canopy temperature we noticed significant variation during milking stage for all the factors. But during other phenophases variation was not significant. Wheat sown on two separate dates experienced various weather conditions. These weather variables also changed during crop growing periods but crop received sufficient amount of post monsoon rainfall during flowering to milking stage (Fig. 2) but we have got required sunshine hours during two important phenological stages like flowering and milking stage (Fig. 1). So there was an altering wetting and drying condition affecting the crop canopy temperature. This condition favours the nitrification and de-nitrification processes driven by soil microbes (Wang *et al.,* 2011) and enhance N_2O emission. Similar experiment by Zheng *et al.* (2000) documented that late wheat growing season of 1994-1995 receiving high rainfall resulted in higher N_2O emission.

Combined effect of all the factors revealed that nitrous oxide emission was influenced by all the factors in combinations during each phenological phase. Maximum variation in nitrous oxide emission observed during jointing and milking stages. But higher nitrous oxide (0.378 g m^{-2} day^{-1}) emitted from Y1 (2012-2013) * D1 (15th November) * V1 (K0307) * N2 (50%inorganic+5%organic) during flowering stage. Lowest nitrous oxide 0.149 g m^{-2} day^{-1} emitted from Y1 (2012-2013) * D1 (15th November) * V2 (KRL288) * N1 (100%inorganic) during tillering stage. Significant variation in canopy temperature was noticed during all the phenophases except tillering stage. In each and every year and treatment all factors could not be able to significantly influence the N_2O emission. Other studies also supported this (Wang *et al.,* 2005; Rowlings *et al.,* 2012).

Association between the N_2O flux efficiency and weather variables

The N_2O emission from variety K0307 (V1) during vegetative stage was significantly correlated with sunshine hours. Variety KRL288 had no such relation. Positive associations were noticed between sunshine hours and N_2O flux from both of nutritional approaches *i.e.* 100% chemical (N1) and 50% chemical + 50% organic (N2) especially during vegetative and milking stage.

Significant association between these two parameters also existed during flowering and milking stage for 1st (15th November) and 2nd (30th November) sowing date respectively. Same trend was observed for canopy temperature. Slight variation was present in case of D1. Canopy temperature directly correlated with N_2O emission during CRI and tillering stage for D1.

Table 2: Effect of two factor interaction on nitrous oxide flux (g m^{-2} day^{-1}) and canopy temperature (°C) during important phenophases of wheat under different years

Factor	CRI		Tillering		Jointing		Flowering		Milking	
	N_2O	CT	N_2O	CT	N_2O	CT	N_2O	CT	N_2O	CT
Y1*D1	0.18	24.79	0.18	23.91	0.23	21.21	0.27	21.38	0.24	24.79
Y1*D2	0.20	24.79	0.20	24.34	0.22	22.10	0.25	22.58	0.24	25.36
Y2*D1	0.25	26.27	0.22	20.97	0.27	20.58	0.30	20.26	0.27	26.09
Y2*D2	0.29	24.90	0.18	20.95	0.22	19.54	0.21	19.84	0.27	25.57
SEm(±)	**0.01**	**0.42**	**0.00**	**0.86**	**0.01**	**0.59**	**0.01**	**0.58**	**0.01**	**0.26**
LSD(0.05)	**NS**	**NS**	**0.01**	**NS**	**0.02**	**NS**	**0.02**	**NS**	**NS**	**0.75**
Y1*V1	0.19	24.21	0.19	23.39	0.24	21.48	0.28	21.93	0.24	24.41
Y1*V2	0.19	25.36	0.19	24.86	0.22	21.84	0.23	22.03	0.24	25.73
Y2*V1	0.26	25.63	0.20	20.88	0.24	20.28	0.25	20.32	0.25	26.13
Y2*V2	0.28	25.53	0.20	21.04	0.25	19.84	0.26	19.78	0.28	25.53
SEm(±)	**0.01**	**0.42**	**0.00**	**0.86**	**0.01**	**0.59**	**0.01**	**0.58**	**0.01**	**0.26**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**0.02**	**NS**	**0.02**	**NS**	**0.02**	**0.75**
Y1*N1	0.19	25.50	0.18	24.06	0.23	19.65	0.25	19.44	0.24	24.16
Y1*N2	0.19	24.28	0.20	23.67	0.22	19.85	0.26	19.97	0.23	23.31
Y2*N1	0.25	24.68	0.20	22.14	0.24	19.79	0.25	20.03	0.25	23.24
Y2*N2	0.29	25.40	0.20	21.62	0.25	21.79	0.26	22.45	0.28	27.62
SEm(±)	**0.01**	**0.42**	**0.00**	**0.86**	**0.01**	**0.59**	**0.01**	**0.58**	**0.01**	**0.26**
LSD(0.05)	**0.02**	**NS**	**0.01**	**NS**	**0.02**	**NS**	**NS**	**NS**	**0.02**	**0.75**
D1*V1	0.21	24.57	0.20	23.25	0.26	19.81	0.31	19.81	0.25	23.53
D1*V2	0.22	25.21	0.20	24.48	0.25	19.70	0.26	19.59	0.26	23.94
D2*V1	0.23	25.28	0.21	21.01	0.25	21.95	0.28	22.43	0.26	27.01
D2*V2	0.24	25.68	0.19	21.43	0.22	21.98	0.23	22.22	0.26	27.32
SEm(±)	**0.01**	**0.42**	**0.00**	**0.86**	**0.01**	**0.59**	**0.01**	**0.58**	**0.01**	**0.26**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.02**	**NS**	**NS**	**NS**
D1*N1	0.21	24.99	0.20	21.99	0.26	20.78	0.27	20.66	0.25	24.86
D1*N2	0.22	26.06	0.21	22.89	0.25	21.01	0.30	20.97	0.25	26.02
D2*N1	0.23	24.85	0.19	22.27	0.21	20.97	0.23	21.58	0.24	25.69
D2*N2	0.26	18.24	0.18	17.21	0.23	15.39	0.23	15.77	0.26	18.19
SEm(±)	**0.01**	**0.42**	**0.00**	**0.86**	**0.01**	**0.59**	**0.01**	**0.58**	**0.01**	**0.26**
LSD(0.05)	**0.02**	**NS**	**0.01**	**NS**	**0.02**	**NS**	**0.02**	**NS**	**NS**	**0.75**
V1*N1	0.20	24.79	0.20	23.91	0.24	21.21	0.25	21.38	0.24	24.79
V1*N2	0.26	24.79	0.19	24.34	0.24	22.10	0.28	22.58	0.25	25.36
V2*N1	0.24	26.27	0.19	20.97	0.23	20.58	0.24	20.26	0.26	26.09
V2*N1	0.15	224.90	0.15	20.95	0.17	19.54	0.20	19.84	0.19	25.57
SEm(±)	**0.01**	**0.42**	**0.00**	**0.86**	**0.01**	**0.59**	**0.01**	**0.58**	**0.01**	**0.26**
LSD(0.05)	**0.02**	**NS**	**0.01**	**NS**	**NS**	**NS**	**0.02**	**NS**	**NS**	**0.75**

Table 3: Effect of three factor interaction on nitrous oxide flux (g m^{-2} day^{-1}) and canopy temperature (°C) during important phenophases of wheat under different years

Factor	CRI		Tillering		Jointing		Flowering		Milking	
	N_2O	CT	N_2O	CT	N_2O	CT	N_2O	CT	N_2O	CT
Y1*D1*V1*N1	0.16	24.55	0.18	25.55	0.24	19.75	0.24	19.60	0.24	23.70
Y1*D1*V1*N2	0.18	25.00	0.19	26.10	0.24	21.10	0.38	20.70	0.23	25.78
Y1*D1*V2*N1	0.20	22.55	0.15	23.55	0.22	22.15	0.22	22.55	0.25	24.08
Y1*D1*V2*N2	0.18	25.45	0.21	26.55	0.23	22.10	0.23	22.40	0.24	25.88
Y1*D2*V1*N1	0.22	24.35	0.20	21.35	0.25	22.15	0.28	22.35	0.27	23.43
Y1*D2*V1*N2	0.22	25.25	0.18	22.65	0.22	21.85	0.24	22.85	0.23	26.25
Y1*D2*V2*N1	0.17	25.40	0.20	23.10	0.21	21.85	0.27	23.20	0.22	26.45
Y1*D2*V2*N2	0.20	25.75	0.20	24.15	0.20	22.30	0.20	22.15	0.23	25.03
Y2*D1*V1*N1	0.25	26.15	0.22	21.72	0.30	19.77	0.33	19.77	0.25	24.10
Y2*D1*V1*N2	0.25	26.30	0.22	22.88	0.26	17.98	0.28	17.68	0.27	23.08
Y2*D1*V2*N1	0.24	25.02	0.24	22.18	0.26	17.57	0.29	17.33	0.27	22.25
Y2*D1*V2*N2	0.26	24.10	0.23	22.38	0.27	17.60	0.31	17.58	0.28	21.03
Y2*D2*V1*N1	0.17	24.92	0.19	19.35	0.18	21.47	0.18	20.93	0.20	28.20
Y2*D2*V1*N2	0.38	27.70	0.17	19.93	0.24	23.10	0.23	22.65	0.29	28.97
Y2*D2*V2*N1	0.34	26.43	0.17	20.25	0.21	22.32	0.20	23.23	0.28	29.97
Y2*D2*V2*N2	0.26	24.03	0.18	18.97	0.26	20.68	0.24	21.22	0.29	29.03
SEm(±)	**0.01**	**0.84**	**0.01**	**1.72**	**0.01**	**1.18**	**0.01**	**1.16**	**0.01**	**0.51**
LSD(0.05)	**0.03**	**2.50**	**0.02**	**NS**	**0.04**	**3.49**	**0.03**	**3.44**	**0.04**	**1.51**

The result implies that during vegetative stage and in few cases during flowering and milking stages sunshine hours and canopy temperature significantly influence N_2O emission. Canopy temperature reflects the interactions among plant, soil and atmosphere. Sunshine hour an important atmospheric variable determine the ambient temperature and in turn regulates the canopy temperature. Temperature played key role in soil microbial activity to drive nitrification and de-nitrification processes. Wassman *et al.,* (1994), and Watanabe *et al.,* (2001) reported that emission rates became maximum during increased soil and air temperature and lowest during lower temperature.

Yield of wheat and its relationship with nitrous oxide emission

All individual factors have some influence on yield except nutrient. However there was no significant difference in yield between 100% inorganic and 50% inorganic + 50%organic fertilizer application. Because other factors such as favourable weather conditions, date of sowing and variety of wheat were more active than nutrient and significantly influence the yield. But when nutrient combined with variety (V * N) it had some influence on productivity. Y * D and Y * V also exerted some variation. Significant variation in yield of wheat had been observed due to influence of all the factors in combinations. Every factor had some individual and combined role on productivity of wheat. Maximum yield (505g m^{-2}) obtained from Y1 (2013-2014) * D1 (15th Nov) * V2 (KRL288) * N2 (50% inorganic + 50% organic). (Table 5) Devi *et al.* (2011) reported higher yield in wheat with the addition of vermicompost.

No significant relationship was observed between N_2O emission and yield of wheat. Thus we can suggest that wheat yield is not responsible for N_2O emission while using our treatment combinations. Huang *et al.,* 2002 also reported that there was no relation between above ground wheat biomass and N_2O emission.

Based on two years experiment we can recommend that the treatment combination D1 (15th November) V2 (KRL288) N1 (100%inorganic) may be adopted for sustaining wheat productivity with reducing nitrous oxide emission. However long-term field experiment in the same line is still required for better understanding.

Table 4: Relationships among the N_2O flux efficiency and weather variables

Treatments	Phenophases	Regression equation with coefficient of determination (R^2)			
		N_2O vs. Sunshine hours		N_2O vs. Canopy temperature	
		Linear equation	R^2 Value	Linear equation	R^2 Value
V1	CRI	-31.101x + 406.44	0.8079	-19.397x + 659.51	0.9878
	Tillering	-19.496x + 306.88	0.5868	-6.8799x + 371.19	0.4920
N1	CRI	-8.8582x + 250.63	0.1041	-14.751x + 537.34	0.8352
	Tillering	-37.934x + 376.96	0.787	-13.136x + 497.27	0.7632
	Milking	6.3186x + 214.81	0.8669	3.8281x + 169.92	0.9875
N2	CRI	-15.734x + 305.1	0.6154	-14.422x + 550.16	0.8426
	Tillering	-11.332x + 282.37	0.8903	-5.1041x + 349.29	0.9306
	Milking	8.547x + 169.03	0.8394	5.9598x + 80.705	0.6972
D1	CRI	———	———	-10.876x + 448.71	0.8162
	Tillering	———	———	25.654x - 477.85	0.7763
	Flowering	-125.01x + 1012.3	0.6084	——-	——-
D2	Tillering	1.4009x + 228.77	0.8633	0.3707x + 226.54	0.9224

Table 5: Effect of sowing date, variety and nutritional approaches on yield (g m^{-2}) of wheat under different years under different years

Individual factors		Two factor interactions				Combination of all factors	
Y1 (2012-2013)	406.9	Y1*D1	442.5	D1*V1	364.4	Y1*D1*V1*N1	450.0
Y2 (2013-2014)	326.6	Y1*D2	371.3	D1*V2	406.3	Y1*D1*V1*N2	345.0
SEm(±)	5.8	Y2*D1	328.1	D2*V1	340.0	Y1*D1*V2*N1	470.0
LSD(0.05)	17.1	Y2*D2	325.0	D2*V2	356.3	Y1*D1*V2*N2	505.0
D1 (15^{th} Nov)	385.3	**SEm(±)**	8.2	**SEm(±)**	8.2	Y1*D2*V1*N1	350.0
D2 (30^{th} Nov)	348.1	**LSD(0.05)**	24.1	**LSD(0.05)**	NS	Y1*D2*V1*N2	360.0
SEm(±)	5.8	Y1*V1	376.3	D1*N1	393.8	Y1*D2*V2*N1	380.0
LSD(0.05)	17.1	Y1*V2	437.5	D1*N2	376.9	Y1*D2*V2*N2	395.0
V1 (K0307)	352.2	Y2*V1	328.1	D2*N1	341.9	Y2*D1*V1*N1	342.5
V2 (KRL288)	381.3	Y2*V2	325.0	D2*N2	354.4	Y2*D1*V1*N2	320.0
SEm(±)	5.8		8.2		8.2	Y2*D1*V2*N1	312.5
LSD(0.05)	17.1		24.1		NS	Y2*D1*V2*N2	337.5
N1 (100%inorganic)	367.8	Y1*N1	412.5	V1*N1	370.0	Y2*D2*V1*N1	337.5
N2 (50% inorg+50%org)	365.6	Y1*N2	401.3	V1*N2	334.4	Y2*D2*V1*N2	312.5
SEm(±)	5.8	Y2*N1	323.1	V2*N1	365.6	Y2*D2*V2*N1	300.0
LSD(0.05)	NS	Y2*N2	330.0	V2*N1	290.6	Y2*D2*V2*N2	350.0
SEm(±)			8.2		8.2		16.3
LSD(0.05)			NS		24.1		48.2

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