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Optimization of elevated CO_2 levels and nutrient management for lowland rice ecosystem

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Abstract
Experiments were conducted to assess the optimum CO_2 levels and nutrient management strategy for enhancing the rice yield and soil fertility status with rice (var.CO. 50) as test crop in open top chambers (OTC). The treatments comprised of three levels of CO_2 enrichment viz., Atmospheric CO_2 (C_0): 370 ppm (Control); OTC I (C_1): 550 ppm and OTC II (C_2): 750 ppm. Both the OTC chambers were connected to a control monitoring system and the each chamber has a regulator to adjust CO_2 flow. Rice crop was fertilized with four varying nutrient management techniques viz., inorganic (150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1}), organic (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis), IPNS (Integrated Plant Nutrient System) (150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}) and untreated control. Maximum grain and straw yields were recorded due to the application of Integrated Plant Nutrient System (150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}) in the CO_2 concentration of 750 ppm. Highest acid phosphatase activity was registered at the CO_2 concentration of 750 ppm followed by 550 ppm and 370 ppm. Acid phosphatase activity was the highest due to the application of organics (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis) followed by the application of 150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}. With increase in CO_2 concentration an increase in CO_2 emission and microbial biomass were observed.

Keywords: Elevated CO_2 level, nutrient management, soil enzyme, microbial biomass, CO_2 emission

Introduction
Rice (*Oryza sativa* L.) is one of the most important crops in the world and the primary staple food in Asia. Cultivation practices such as crop rotations, soil tillage, fallow periods, and water management have been known to affect crop yields and soil carbon sequestration. Among the GHG s CO_2 is the main one, the effect of which should be related to the crop production. Carbon serves as the primary substrate for photosynthesis and is the one to contribute to the yield formation in plants. Rice responses to climate change vary with region and rice cultivars. There is a need for more experiments on various cultivars of rice under global warming situation in many areas. Hence this study was conducted with the objectives to determine the effect of elevated CO_2 levels on growth, yield and soil fertility status under lowland rice ecosystem. Depending on population growth and energy use scenarios, atmospheric CO_2 concentration is expected to rise from about 370 µ mol $^{-1}$ currently to about 485 to 1000 µ mol $^{-1}$ by 2100 (Prentice *et al*., 2001) [9]. Elevated CO2 typically increases plant photosynthesis and biomass production, whereas increasing temperatures might either decrease or increase photosynthesis and production (Baker *et al*., 1993) [2].

Materials and Methods
Pot experiments were conducted with rice (var.CO. 50) as test crop in open top chambers (OTC). The treatments comprised of three levels of CO_2 enrichment viz., Atmospheric CO_2 (C_0): 370 ppm (Control); OTC I (C_1): 550 ppm and OTC II (C_2): 750 ppm. Both the OTC chambers were connected to a control monitoring system and the each chamber has a regulator to adjust CO_2 flow. Rice crop was fertilized with four varying nutrient management techniques viz., inorganic (150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1}), organic (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis), IPNS (Integrated Plant Nutrient System) (150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @2 kg ha^{-1}) and untreated control.

Mean monthly climatic variables at different stages of crop growth viz., active tillering, panicle initiation, flowering and harvest stages were meseaured. Grain and straw yields were recorded. Field moist soil samples were analyzed for acid and alkaline phosphomonoesterase activity with a buffered disodium p-nitrophenyl phosphate tetrahydrate solution (Tabatabai, 1982) [12]. Soil dehydrogenase and urease activities were measured (Von Mersi and Schinner, 1991 [14]; Tabatabai and Bremner, 1972) [13]. Soil CO_2 emissions (Carter and Gregorich, 2008) [5] by alkali trap method, soil organic carbon (Walkely and Black, 1934) [15], microbial biomass C in soil by chloroform fumigation method (Beck *et al*. 1997) [3] and water soluble carbon were analysed.

Results and Discussion

The mean monthly climatic variables recorded at different stages of crop growth indicated that air temperature was the highest at harvest stage and humidity per cent was the highest at active tillering stage (Table 1).

Maximum grain and straw yields were recorded due to the application of Integrated Plant Nutrient System (150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}) in the CO_2 concentration of 750 ppm. Application of inorganics alone recorded higher yield than the application of organics (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis). The untreated control recorded the lowest yield of 33.6 g pot^{-1} (Table 2). Baker *et al*. (1992) [1] showed that shoot and root biomass increased under increasing CO_2 concentration. According to Yang *et al.* (2006) [16], the final total biomass of rice was increased by 16% under elevated CO_2.

Highest acid phosphatase activity was registered at the CO_2 concentration of 750 ppm followed by 550 ppm and 370 ppm. Acid phosphatase activity was the highest due to the application of organics (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis) followed by the application of 150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}. Application of inorganics alone recorded higher acid phosphatase activity than the untreated control. A similar pattern of results was obtained with alkaline phosphatase, dehydrogenase and urease activity also (Table 3). Larson *et al*. (2002) [7] and Lipson *et al*. (2005) [8] found a significant stimulation of soil extracellular enzyme activities under elevated CO_2.

With increase in CO_2 concentration an increase in CO_2 emission was observed. At flowering stage the emission was more followed by tillering and harvest stages. Application of organics (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis) recorded higher CO_2 emission followed by the application of 150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}. The application of organic substances or manure at high rates in the fields caused the deposition of soil and organic substances. The organic substances reacted with soil particles to form complex compounds that were hardly decomposed into carbon dioxide (Suwannarit, 2008) [11]. The optimum application rates of manure are between 3.13-6.25 t ha^{-1} because those application rates have the least effect on quantities of greenhouse gas emissions (Sampanpanish, 2012) [10]. Application of inorganics alone and untreated control recorded lowest CO_2 emission (Table 4).

With increase in CO_2 concentration, an increase in organic C content was observed. The labile soil C pools, namely microbial biomass C, readily mineralizable C, and potassium permanganate oxidizable C were increased by 27, 38 and 37% respectively under elevated CO_2 concentration of 550 µmol mol^{-1} than ambient CO_2, 394 µmol mol^{-1}. Application of organics (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis) recorded higher organic carbon content followed by the application of 150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}. Application of inorganics alone and untreated control recorded lowest organic carbon content. Water soluble carbon content was not remarkably changed due to the treat mental effects (Table 5).

With increase in CO_2 concentration, an increase in microbial biomass C was observed. Soil microbial biomass C under elevated CO_2 was significantly larger (by 18.9–25.2%) than that under ambient CO_2 (Inubushi *et al*. 2010) [6]. Application of organics (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis) recorded higher microbial biomass C content followed by the application of 150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}. Application of inorganics alone and untreated control recorded lowest microbial biomass C content (Table 5).

With CO_2 enrichment of 750 ppm and application of 150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1} enhanced the growth, yield and soil fertility status under lowland rice ecosystem.

Table 1: Mean monthly climatic variable during crop growing stages

Variables	Stage of the crop			
	Active tillering	Panicle Initiation	Flowering	Harvest
Air temperature ° C	35.1	33.0	35.5	40.2
Humidity %	49.9	48.6	35.3	34.2
Soil temperature ° C	36.8	33.8	28.8	35.7
Canopy temperature ° C	32.2	29.6	28.5	32.2

Table 2: Effect of elevated CO_2 and nutrient management on grain and straw yield of rice (g pot^{-1})

Treatments	Grain			Straw		
C_0: 370 ppm S_1	33.6			48.6		
S_2	54.3			68.6		
S_3	42.0			63.6		
S_4	81.0			98.6		
Mean	52.7			69.9		
C_1: 550 ppm S_1	46.6			65.3		
S_2	73.3			110.6		
S_3	67.0			71.6		
S_4	96.6			128.0		
Mean	70.9			93.9		
C_2: 750 ppm S_1	54.0			79.3		
S_2	98.3			144.3		
S_3	69.0			98.6		
S_4	142.6			167.6		
Mean	91.0			122.5		
CD(P:0.05)	C	N	CXN	C	N	CXN
	23.4**	27.0**	NS	17.5**	20.2**	NS

Table 3: Effect of elevated CO_2 and nutrient management on Soil enzyme activity: Acid and alkaline phosphatase activity (µg PNP g^{1}); dehydrogenase activity (DHA) (µg TPF g^{-1} day^{-1} and urease activity (µg NH_3 g^{-1}) (Harvest stage)

Treatments	Acid phosphatase			Alkaline phosphatase			DHA			Urease		
C_0: 370 ppm S_1	60.75			132.45			27.20			10.25		
S_2	60.66			142.13			30.75			12.12		
S_3	74.50			154.50			36.83			13.85		
S_4	63.17			162.29			37.51			14.03		
Mean	64.62			147.84			33.07			12.56		
C_1: 550 ppm S_1	67.16			151.27			25.09			11.57		
S_2	75.32			158.61			28.66			12.78		
S_3	86.62			161.29			28.81			17.03		
S_4	76.13			162.76			30.11			21.85		
Mean	76.31			158.48			28.00			15.81		
C_2: 750 ppm S_1	72.15			157.97			28.76			12.59		
S_2	77.80			162.10			35.53			14.29		
S_3	91.66			166.25			36.92			22.54		
S_4	80.20			175.00			39.13			27.10		
Mean	80.45			165.33			35.09			19.13		
CD(P:0.05)	C	N	CXN	C	N	CXN	C	N	CXN	C	N	CXN
	4.0	4.7	NS	8.1	9.3	NS	2.9	3.5	NS	3.0	3.5	6.0

Table 4: Effect of elevated CO_2 and nutrient management on CO_2 emission (mg CO_2 m^{-2} day^{-1})

Treatments	Tillering			Flowering			Harvest		
C_0: 370 ppm S_1	16.0			39.0			11.0		
S_2	14.8			33.2			8.7		
S_3	17.6			41.5			15.6		
S_4	14.8			35.0			10.2		
Mean	15.8			37.2			11.4		
C_1: 550 ppm S_1	31.2			55.4			26.5		
S_2	19.2			36.2			12.1		
S_3	53.2			76.1			44.3		
S_4	26.4			48.5			20.2		
Mean	32.5			54.0			25.8		
C_2: 750 ppm S_1	58.2			78.7			50.7		
S_2	29.2			49.2			23.2		
S_3	87.0			98.0			66.7		
S_4	36.8			53.4			27.6		
Mean	52.8			69.8			42.0		
CD(P:0.05)	C	N	CXN	C	N	CXN	C	N	CXN
	1.5**	1.7**	3.0	2.1**	2.4**	4.2	1.4**	1.7**	2.9

Table 5: Effect of elevated CO_2 and nutrient management on organic C, water soluble C (g kg^{-1}) and microbial biomass C (µg kg^{-1})

Treatments	Organic C			Microbial biomass C			Water soluble C		
C_0: 370 ppm S_1	5.1			275			12.3		
S_2	5.5			437			12.4		
S_3	6.5			520			12.6		
S_4	6.2			464			12.5		
Mean	5.8			424			12.4		
C_1: 550 ppm S_1	6.2			390			12.3		
S_2	6.6			545			12.4		
S_3	7.3			688			12.5		
S_4	6.8			626			12.5		
Mean	6.7			562			12.4		
C_2: 750 ppm S_1	6.6			437			12.3		
S_2	7.2			680			12.3		
S_3	7.5			931			12.5		
S_4	7.4			807			12.4		
Mean	7.2			714			12.4		
CD (P:0.05)	C	N	CXN	C	N	CXN	C	N	CXN
	0.16**	0.18**	0.31	11.61**	13.40**	23.22	NS	NS	NS

References

1. Baker JT, Allen LH Jr., Boote KJ, Jones P, Jones JW. Rice photosynthesis and evapotranspiration in subambient, ambient, and superambient carbon dioxide concentration. Agron. J. 1992; 82:834-840.
2. Baker JT, Allen LH, Boote KJ. Temperature effects on rice at elevated CO2 concentration. J. Exp. Bot. 1993; 43(**7**):959-964.
3. Beck T, Joergensen RG, Kandeler E, Makeschin F, Nuss E, Oberholzer HR, Scheu S. An inter-laboratory comparison of ten different ways of measuring soil

microbial biomass C. Soil Biol. Biochem. 1997; 29(7):1023-1032.
4. Bhattacharyya P, Roy KS, Neogi S, Dash PK, Nayak AK, Mohanty S, Baig MJ, Sarkar RK, Rao KS. Impact of elevated CO2 and temperature on soil C and N dynamics in relation to CH4 and N2O emissions from tropical flooded rice (*Oryza sativa* L.). Sci.total environ. 2013; (1):461-462, 601-611.
5. Carter MR, Gregorich EG. Soil Sampling and Methods of Analysis. 2nd Edition, Canadian Society of Soil Science, Taylor & Francis Group, LLC, Boca Raton, 2008.
6. Inubushi K, Cheng W, Mizuno T, Lou Y, Hasegawa T, Sakai H, *et al*. Microbial biomass carbon and methane oxidation influenced by rice cultivars and elevated CO_2 in a Japanese paddy soil. European Journal of Soil Science. 2010; 62(1):69-73.
7. Larson JL, Zak DR, Sinsabaughb RL. Extracellular enzyme activity beneath temperate trees growing under elevated carbon dioxide and ozone. Soil Sci Soc Am J. 2002; 66:1848-1856.
8. Lipson DA, Wilson RA, Oechel WC. Effects of elevated atmospheric CO2 on soil microbial biomass, activity and diversity in a chaparral ecosystem. Appl Environ Microbiol. 2005; 71:8573-8580.
9. Prentice IC, Farquhar GD, Fasham MJR, Goulden ML, Heimann M, Jaramillo VJ, *et al*. The carbon cycle and atmospheric carbon dioxide, 2001, pp. 183-237. In. Houghton JTY, Ding DJ, Griggs M, Noguer PJ. Van der Linden X, Dai Maskell K, Johnson CA (ed.) Climate Change: The scientific basis. Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge Univ. Press, Cambridge, 2001.
10. Sampanpanish P. Effect of organic fertilizer on CO_2, CH_4 and N_2O emissions in a paddy field. Modern Applied Science. 2012; 6(12):13-21.
11. Suwannarit A. Fertilizer for agriculture and the environment (2nd ed.). Kasetsart University, Bangkok, 2008.
12. Tabatabai MA. Soil enzymes. In*:* Page AL, Miller RH, Keeney DR. Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. American Society of Agronomy; Soil Science Society of America. Madison, WI, 1982.
13. Tabatabai MA, Bremner JM. Assay of Urease activity in soils. Soil Biol. Biochem. 1972; 4:479-487.
14. Von Mersi W, Schinner F. An improved and accurate method for determining the dehydrogenase activity of soils with iodonitrotetrazolium chloride. Biol. Fertil. Soils. 1991; 11:216-220.
15. Walkley A, Black IA. An Examination of Degtjareff Method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid Titration Method. Soil Sci. 1934; 37:29-37.
16. Yang L, Huang J, Yang H, Dong G, Liu G, Zhu J *et al*. Seasonal changes in the effects of free-air CO_2 enrichment (FACE) on dry matter production and distribution of rice. Field Crops Research. 2006; 98:12-19.