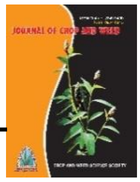
ISSN-O : 2349 9400; P : 0974 6315
Journal of Crop and Weed, 20(1):75-84 (2024)



https://www.cwss.in
www.cropandweed.com

Canopy growth and tuber yield in Chinese potato (*Plectranthus rotundifolius*(Poir) Spreng.) under elevated CO_2 concentrations in the warm humid tropics of Kerala

[*1]P.ARUNJITH, [1]S. R. ISAAC, [2]R.V.MANJU AND [1]A. P.POOJA

[1]Department of Agronomy, [2]Department of Plant Physiology,
College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India

Received: 05.09.2023, Revised: 27.03.2024; Accepted: 05.04.2024

DOI: https://doi.org/10.22271/09746315.2024.v20.i1.1762

ABSTRACT

Canopy growth and tuber yield of Chinese potato in response to CO_2 fertilization were evaluated in a closed trench system at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala in completely randomized design with six substrates as sources of CO_2 in three replications during 2019-20. The treatments included, s_0: no substrate, s_1: cow dung, s_2: coir pith, s_3: cow dung + coir pith (2:1), s_4: s_2 + Pleurotus 1g kg^{-1} + N + P (2% w/w) and s_5: s_3 + Pleurotus 1g kg^{-1} + N + P (2% w/w). The CO_2 evolved, air and soil temperature were monitored regularly during the cropping season and the growth and physiological attributes in Chinese potato were recorded. Data collected showed that in all the substrate applied treatments, maximum release of CO_2 occurred during the first two weeks of application and thereafter declined. The highest release was observed in combination of cow dung and coir pith with Pleurotus, N and P. The C: N ratio of the substrates in the trench after the experiment was narrower. Growth attributes and chlorophyll content were significantly higher in these treatments. Biomass partitioning followed the order, stem > leaf > roots irrespective of the treatments included. Tuber formation was meagre implying that shoot growth was favoured by the elevated CO_2 and temperature in the trenches at the expense of tuber formation.

***Keywords*:**Chinese potato, elevated co_2, growth, organic substrates, temperature and tuber

Carbon dioxide (CO_2) is an essential environmental resource required as raw material for the orderly development of all green plants. But, plant responses to increased concentrations of CO_2 in the atmosphere vary. In view of the ongoing changes in climate and emerging food crisis, the innate advantages and climate resilience of tropical tuber crops to these extreme and unpredictable variations need to be assessed (Nayar, 2014). Tubers and root crops are the second-most important group of cultivated crops after cereals in tropical countries (Bhardwaj *et al*., 2023). Chinese potato [*Plectranthus rotundifolius*(Poir.) Spreng.] is relished for the carbohydrate and mineral rich tubers that have an aromatic flavour.

Elevated CO_2 (eCO_2) are reported to positively influence plant growth. Significantly higher shoot length, number of leaves and leaf area were reported in *Beta vulgaris* grown under elevated CO_2 (Kumari *et al*., 2013). In Chinese yam (*Dioscorea opposite* Thunb.) vine length and leaf area under eCO_2 (ambient+200 ppm) were comparatively higher (Thinh*et al*., 2017) whereas Runion *et al*. (2018) reported increased fresh weight allocation to belowground plant organs in sweet potato under elevated CO_2. Increased net photosynthetic rate and chlorophyll content under eCO_2 in eddo were reported by Zaher *et al*. (2021).Photosynthetic regulation partly depends on the balance between the substrate for photosynthesis and sink capacity. Tuber crops have high sink capacities and are prophesied to respond positively to eCO_2. Lee *et al*. (2020) documented that although elevated temperature can negatively influence the growth and yield of potato, especially towards the late-growth phase, a concurrent and appropriate

**Email:arunjithp0077@gmail.com*

How to cite: Arunjith, P., Isaac, S.R., Manju, R.V. and Pooja, A.P.2024. Canopy growth and tuber yield in Chinese potato (*Plectranthu srotundifolius*(Poir) Spreng.) under elevated CO_2 concentrations in the warm humid tropics of Kerala. *J. Crop and Weed*, 20(1): 75-84.

increase in CO_2 and temperature can favour balanced development of source and sink organs which will positively impact potato productivity and quality. However, documented literature is not plenty, and almost nil in Chinese potato. In this backdrop, a study was envisaged with the objective to assess the canopy growth and tuber yield responses of the Chinese potato to increased CO_2 fertilization.

MATERIALS AND METHODS

The experiment was laid out in the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India (8°25'43"N latitude, 76°59'98"E longitude and 29 m above mean sea level) during the period November 2019 to July 2020. 'Suphala' variety (120-140 days duration) released by Kerala Agricultural University was planted in the experimental plots laid out in completely randomised design with six treatments replicated thrice. Different organic substrates constituted the treatments of the experiment [s_0: no substrate, s_1: cow dung, s_2: coir pith, s_3: cow dung + coir pith (2:1), s_4: s_2 + *Pleurotus* 1g kg^{-1} + N + P (2% w/w) and s_5: s_3 + *Pleurotus* 1g kg^{-1} + N + P (2% w/w)]. Six trenches of size 2 m x 1 m x 1m, lined with bricks covered with a dome shaped frame fitted with 200 µ uv stabilised polyethylene sheet formed the CO_2 enriched field for Chinese potato. The trenches were kept covered from 4.00 pm to 10.30 am daily and left open during the rest of the day during the entire crop growth period.

An area of 2 m × 30 cm was demarcated in the middle of each trench with polyvinyl chloride (PVC) sheets fixed to a depth of 30 cm in soil. Top soil from the adjacent open area was added and weighed quantities of prepared organic substrates (Table 1) spread to a uniform thickness of 5 cm. Terminal cuttings each of 15 cm length were planted in the middle of marked area in a single row at spacing of 15 cm. A total of 12 plants were maintained in each trench (4 plants per replication). The crop was fertilized at an NPK dose of 60:60:120 kg ha^{-1} and recommended (KAU, 2016) cultural operations adopted until harvest. The crop was planted on 7th November 2019 and harvesting was done on 3rd July 2020.

Microclimatic parameters (CO_2 release, air and soil temperature) within the trenches and in the open were recorded at weekly intervals (7.30 am). Carbon dioxide release from the organic substrates and air temperature (°C) inside the trench were recorded using GE Telaire® 7001 CO_2/Temperature monitor (GE sunsing, USA). Soil temperature (^{o}C) at 5 cm depth was measured using Probe type digital thermometer (Divinest TP 101, India).

The observations on growth attributes (plant height, number of branches, number of leaves and leaf area per plant) at 30 days interval and chlorophyll content at 45 days interval were recorded. The number of days to senescence and biomass partitioning at the start of senescence were noted. Carbon and N contents of the substrates were analysed before and after the experiment as per standard procedures to assess the C:N ratio. Plant uptake (NPK) was estimated by multiplying the dry matter recorded at the start of senescence with respective nutrient contents.

The data were analysed statistically by analysis of variance for completely randomized design (Cochran and Cox, 1965), and the significance was tested by F test. For statistical analysis, OP stat software was used and the graphs were prepared in Microsoft excel using the data.

RESULTS AND DISCUSSION

CO_2 evolution

A critical appraisal of the CO_2 evolved from the different substrates used revealed a comparatively higher evolution immediately after application up to two weeks (Fig. 1), indicating the rapid decay in the initial days. The highest peak of CO_2 concentration (858 ppm) was observed in s_5 (cow dung + coir pith + *Pleurotus* + N + P), followed by s_3 [cow dung + coir pith (2:1)]. The percentage increases recorded within a week were 26.2 and 22.7 per cent respectively. Towards the later stages of the crop, CO_2 evolution remained concordant irrespective of the substrates added. Similar reports of high initial CO_2 release and slower evolution during the rest of incubation period have been documented (Abro*et al*., 2011; Navale, 2014; Minu, 2015; Lahariа*et al*., 2020).

Green plants, and photo- and chemoautotrophic microbes transfer carbon from the atmosphere to soil *via* 'carbon-fixing' process of photosynthesis converting them into organic compounds (Liang and Basler, 2011), while the reverse route of decomposition of organic material by 'organic carbon-consuming' heterotrophic microorganisms as CO_2 back to the atmosphere is also functional. In the present study, the substrates used were coir pith, cow dung solely and amended with the fungal decomposer *Pleurotus* and nutrients N and P. The results on the higher amount of release from coir pith amended substrate may be attributed to the accelerated degradation of coir pith with the addition of cow dung compared to coir pith alone, but maximum CO_2 evolution was recorded with the addition of *Pleurotus* and a source of N and P along with cow dung. The nutrient addition would also have favoured the activity of microorganisms and hence the CO_2 release. It was also inferred that the extra carbon made available with the addition of cow dung might have resulted in more carbon in the decaying system (Amlan and Devi, 2001).

While monitoring the air and soil temperature, it was observed that the temperatures within the trenches were 3 to 5.2°C higher than in the open/ ambient condition (Table 2). The trenches were kept closed for 18 ½ h daily, as a result of which the CO_2 released was trapped within and caused its built-up in the crop microclimate temperature.

C: N ratio of substrates

Carbon and N content of organic materials influence microbial decomposition (Rahman, 2013). Release of CO_2 depends on C: N ratios of organic materials applied to the soil. Analysis of the C: N ratio of the substrates revealed wider C: N ratio (70.1: 1) in coir pith used (Table 1) endorsing the lowered quantum of CO_2 release. Literature cited revealed nearly 37 per cent lignin in coir pith (Thomas *et al*., 2013), another factor slowing down the decomposition. Nevertheless, mixing coir pith with cow dung in 2:1 lowered the ratio to 46.8: 1, on account of the augmented N content which would have facilitated the decomposition process. The C: N ratio was the lowest (10.3:1) in the substrate containing cow dung and coir pith with *Pleurotus,* N and P additions. The C: N ratio of the decomposed substrate on the soil surface in the trench after the experiment was narrower than the initial values, but the ratio was maximum in s_2 (20.6:1) compared to the other substrates, and the lowest was in s_1.

Growth of Chinese potato

The growth attributes in Chinese potato varied significantly with CO_2 fertilization. At 30 days after planting (DAP), significantly taller plants (19.98 cm) with more number of leaves (72.7), leaf area (1051.38 cm^2) and branches (13.2) were observed in the treatment in which cow dung + coir pith (2:1) was used as substrate (s_3), but on par with coir pith + *Pleurotus* + N + P (s_4) and cow dung + coir pith (2:1) + *Pleurotus* + N + P (s_5). The superiority of substrate containing cow dung + coir pith (2:1) + *Pleurotus* + N + P (s_5) on canopy attributes in the trench was evident at later stages. Canopy development was enhanced, plants were greener and grew luxuriantly in the CO_2 fertilized treatments and the growth attributes were the lowest in the treatment of no substrate addition (Table 3).

The positive effect perceived on canopy development is the manifestation of increased rates of photosynthesis under increased CO_2 conditions. This accords to the reports of Yubi *et al*. (2021) in potato and Ruiz-Vera *et al*. (2021) in cassava. Hence, it is surmised that the increased growth was due to the additional photosynthates made available at the higher CO_2 concentration. Elevated CO_2 can accelerate photosynthesis as the carboxylation rate of RuBisCo is increased and the oxygenation of ribulose-1, 5- bisphosphate is competitively inhibited (Drake *et al*., 1997). Previous studies also assigned the stimulation in growth attributes to a higher photosynthetic rate (Ainsworth and Long, 2005) and lower photorespiration (Booker *et al*., 2007). The influence of CO_2 on leaf development evident in the study is supported by the works of Kumari *et al*. (2013) and Zaher *et al*. (2021).

Physiological attributes

Chlorophyll content in the leaves was significantly higher in cow dung + coir pith (2:1) substrate (s_3) at 45 DAP and at 90 DAP, in s_5 (s_3 + *Pleurotus* 1g kg^{-1} + N + P @ 2% w/w). The stages coincided with the period during which maximum CO_2 was released and the effects were evinced in the plants (Table 4). Higher chlorophyll content could be related to the RuBisCo production (Wilkins *et al*., 1993) and is suggested to be an adaptation of the plants under eCO_2 to increase the photosynthetic activity (Bhatt *et al*., 2010).

Comparing the days taken by the plants to reach the senescence stage in response to the substrates and CO_2 evolved, it was observed that it was delayed in the plants grown without CO_2 fertilization, no substrate (223 days). The greenness associated with eCO_2 did happen but duration of its impact was not for long. Accelerated senescence with eCO_2 was documented in sweet potato (Bhattacharya *et al*., 1985) and potato (Kimbal *et al*., 2002). Ludewig and Sonnewald (2000) have reasoned that the production of more ethylene under elevated CO_2 condition resulted in the accelerated senescence compared to non CO_2 fertilized plants.

Biomass partitioning, indicate the allocation of photosynthates in plants and it followed the order, stem > leaf > roots/tubers irrespective of the treatments (Fig. 2). The treatment cow dung + coir pith (2:1) and (s_3) + *Pleurotus* + N + P (s_5) recorded the significantly highest biomass (stem, leaf and root) accumulation per plant and it remained the lowest when grown without substrate application. This is consequent to the increased number of branches, leaves, and leaf area noted in substrate applied treatments compared to that with no substrate application. Dutt *et al*. (2017) documented higher diversion to shoots rather than tubers at higher temperatures. Elevated day and night (29°/27°C) temperatures impaired photosynthesis and assimilate production in potato (Hastilestari *et al*., 2018) and the ensuing biomass allocation shifted away from tubers towards leaves indicating reduced sink strength of developing tubers.

Yield attributes and yield

Tuber formation was not observed in Chinese potato in the trench system of CO_2 fertilization (Plate 1). Excessive vegetative growth was elicited and despite the crop being retained for nearly 238 days, 98 to118 days more than the normal duration. This was contradictory to the earlier reports on increased tuber yields in potato under eCO_2 (Schapendonk *et al*., 2000). It was also surprising that tuberization was not recorded even in the treatment in which substrates for CO_2 evolution were not included.

An insight to the physiology of tuberization brought to focus the significant role of environmental factors that govern tuber induction and development in root crops apart from the genetic control. The key factors that influence tuberization are recorded to include photoperiod, temperature, light (intensity and quality), mineral nutrition, water availability and incidence of viruses. High temperatures inhibit or delay tuberization in tuber crops(Melis and van Staden, 1984). There are reports of non-expression of transported tuberization stimulus in potato at warm temperatures (Reynolds and Ewing, 1989). Under unfavourable conditions of high temperature and low light intensity, large amounts of assimilates were used for shoot growth with poor tuber production. A shift in assimilate allocation under high temperature conditions favouring the shoots is also documented in sweet potato by Gajanayake *et al*. (2015) that led to decreased tuber growth.

Ravi *et al*. (2009) stated that both air and soil temperature regulates the competition between shoot and storage root growth in sweet potato. In the present study, the air temperature and soil temperature, irrespective of the CO_2 concentrations, were higher in the trenches especially during 8^{th} to 12^{th} week of planting during which tuber initiation should have occurred in consonance with the open field crop.

Further, the process of tuberization and assimilate partitioning are inseparable and controlled by endogenous hormones. Changes in environmental conditions such as temperature, photoperiod and light intensity can influence the levels of the endogenous plant growth hormones (Jackson, 1999). Gibberellins inhibit and abscisic acid promotes tuber induction. Similar reports of the inhibitory role of GA in tuber induction were documented earlier (Menzel, 1980; Ewing, 1987; Corsini *et al*., 1989; Xu *et al*., 1998). High temperature increases the gibberellin levels (Railton and Wareing, 1973; Menzel, 1980) and the poor tuberization in the present experiment can as well be ascribed to the above mentioned influence of GA.

Opaleye *et al*. (2018) opined that there exists a lack of balance between the source potential and sink capacity in Chinese potato and this became more pronounced with the enrichment of CO_2. The increased vegetative growth stipulated high photosynthate production but the phloem source to sink (tuber) transport seemed inhibited. Thus, it is concluded that the eCO_2 coupled with the modified microclimate within the trench influenced the crop phenology and would have caused non tuberization in Chinese potato.

The study revealed the potential of the substrates, cow dung + coir pith (2:1) + *Pleurotus* + N + P and cow dung + coir pith (2:1) as sources for CO_2 evolution. Increased photosynthesis manifested as the increased canopy growth was evident. However, the negative impact on tuberization contrary to the assumption of increased productivity in tuber crops with CO_2 enrichment has been evinced. It is assumed that the soil and air temperature along with the other microclimatic parameters decided the phenological development and assimilate partitioning that influenced tuber development. Hence, further investigations on the controls of tuber induction and development under eCO_2 conditions and the physiological effects on phloem loading and photosynthate translocation are to be carried out. Manipulation of the modified microclimate to alter the negative effects and formulation of ameliorative measures to beneficially utilize the increased photosynthesis realized with CO_2 enrichment are also warranted.

Table 1: Quantity of substrates used and changes in C: N ratio with CO_2 release

Treatment	Quantity of substrate (kg)	*Pleurotus* (g)	N (Urea) (kg)	P (Rajphos) (kg)	C: N ratio	
					Before	After
s_0: No substrate	0	0	0	0	-	-
s_1: Cow dung	50	0	0	0	23.5	3.3
s_2: Coir pith	30	0	0	0	70.1	20.6
s_3: Cow dung + Coir pith (2:1)	40	0	0	0	46.8	4.1
s_4: s_2 + *Pleurotus* 1g kg^{-1} + N + P (2% w/w)	30	30	0.6 (1..30)	0.6 (3.00)	11.7	3.8
s_5: s_3 + *Pleurotus* 1g kg^{-1} + N + P (2% w/w)	40	40	0.8 (1.74)	0.8 (4.00)	10.3	3.5

Table 2: Effect of CO_2 fertilization on air and soil temperature (^0C)

Date of observation	Air temperature							Soil temperature						
	s_0	s_1	s_2	s_3	s_4	s_5	Ambient	s_0	s_1	s_2	s_3	s_4	s_5	Open
08.11.2019	26.5	26.8	26.7	26.9	26.9	27.1	26.8	27.4	27.6	27.5	27.8	27.6	27.9	25.4
15.11.2019	26.5	27.2	27.1	27.3	27.4	27.4	26.6	27.5	27.7	27.5	27.5	27.9	28.0	24.5
22.11.2019	26.6	27.0	27.0	27.1	27.1	27.2	25.2	27.5	27.6	27.4	27.5	27.7	27.8	25.4
29.11.2019	26.5	27.1	27.0	27.2	27.2	27.3	26.6	27.6	27.7	27.6	27.9	28.0	28.2	25.0
06.12.2019	26.5	26.9	26.8	27.0	26.9	27.1	25.8	27.5	27.7	27.6	27.8	27.9	28.1	25.2
13.12.2019	26.3	26.7	26.7	26.9	26.9	27.1	25.6	27.4	27.8	27.6	27.9	27.7	27.9	25.3
20.12.2019	26.4	26.6	26.6	26.9	27.0	27.0	25.2	27.5	27.7	27.7	28.1	28.0	28.1	25.3
27.12.2019	26.5	26.8	26.7	27.0	27.0	27.1	25.8	27.6	27.8	27.7	27.8	27.8	27.9	25.7
03.01.2020	26.7	26.9	26.8	27.1	26.9	27.2	25.4	27.7	27.9	27.8	27.9	27.9	27.9	25.5
10.01.2020	26.6	26.8	26.7	27.0	26.9	27.1	23.8	27.4	27.9	27.8	27.8	27.9	28.0	25.0
17.01.2020	26.8	27.1	27.0	27.2	27.1	27.3	22.8	27.6	28	27.8	27.9	28.0	28.1	25.2
24.01.2020	26.7	27.2	27.3	27.7	27.6	27.9	25.8	27.3	27.8	27.7	27.8	27.8	27.9	25.6
31.01.2020	27.0	27.8	27.5	27.8	27.8	27.9	23.8	27.9	27.9	27.8	28.1	28.2	28.3	25.6
07.02.2020	27.1	27.2	27.3	27.5	27.8	27.9	24.6	27.8	27.9	27.9	28.1	28.3	28.4	25.8
14.02.2020	27.9	28.0	27.9	28.1	28.0	28.3	27.2	28.0	28.1	28.0	28.4	28.3	28.5	30.3
21.02.2020	27.4	27.6	27.5	27.6	27.5	27.6	25.4	27.9	28.2	28.1	28.5	28.4	28.6	25.8
28.02.2020	27.5	27.6	27.7	27.8	27.7	27.9	25.4	28.6	28.5	28.5	28.7	28.7	28.8	31.0
06.03.2020	28.6	28.5	28.3	28.4	28.3	28.4	25.4	28.6	28.9	28.5	28.6	28.6	28.6	25.3
13.03.2020	28.5	28.4	28.4	28.6	28.6	28.7	26.8	28.7	28.9	28.4	28.6	28.6	28.6	30.8
20.03.2020	28.4	28.5	28.5	28.6	28.7	28.8	26.6	28.9	28.7	28.9	28.8	28.9	28.9	32.0
27.03.2020	28.6	28.7	28.7	28.9	28.8	29.0	27.4	28.5	28.6	28.5	28.6	28.6	28.7	30.7
03.04.2020	29.1	29.3	29.3	30.3	30.2	30.4	27.8	29.2	29.3	29.3	29.4	29.2	29.6	30.4
10.04.2020	28.8	29.0	29.1	29.1	29.0	29.1	27.2	28.7	28.8	28.7	28.9	28.8	29.0	30.2
17.04.2020	30.2	30.4	30.3	30.5	30.4	30.6	28.2	29.8	29.9	29.8	30.0	29.9	30.2	30.6
24.04.2020	29.7	30.3	30.2	30.1	30.2	29.8	27.4	29.5	29.7	29.7	29.8	29.7	29.9	30.2
01.05.2020	29.6	29.9	29.8	30.1	30.0	30.2	28.4	29.6	29.6	29.6	29.7	29.6	29.7	30.2
08.05.2020	29.8	30.0	29.8	29.9	29.8	30.1	26.8	29.5	29.6	29.7	29.8	29.8	29.9	28.2

Table3: Effect of CO_2 fertilization on plant height, number of branches, number of leaves and leaf area per plant

Treatments	Plant height (cm)				Number of branches per plant				Number of leaves per plant				Leaf area per plant (cm^2)			
	30 DAP	60 DAP	90 DAP	120 DAP	30 DAP	60 DAP	90 DAP	120 DAP	30 DAP	60 DAP	90 DAP	120 DAP	30 DAP	60 DAP	90 DAP	120 DAP
s_0: No substrate	15.40	19.54	21.92	23.70	9.2	15.2	19.2	19.8	58.0	79.3	83.5	86.7	749.44	1019.48	1049.95	1104.95
s_1: Cow dung	18.01	21.72	22.83	24.90	11.5	16.0	29.5	29.8	67.5	98.2	108.8	116.2	843.28	1243.20	1321.48	1346.48
s_2: Coir pith	17.47	21.98	22.65	24.56	11.3	15.5	27.8	28.8	64.7	86.7	107.2	113.5	932.91	1169.73	1318.95	1334.02
s_3: Cow dung + Coir pith (2:1)	19.98	22.29	24.31	25.51	13.2	16.8	32.8	33.2	72.7	108.3	121.3	127.5	1051.38	1389.84	1467.60	1475.94
s_4: s_2 + *Pleurotus* + N + P (2% w/w)	18.58	22.63	25.29	25.79	11.2	17.0	29.8	30.5	68.5	100.3	120.5	126.5	792.03	1213.03	1340.39	1362.05
s_5: s_3 + *Pleurotus* + N + P(2% w/w)	18.83	23.65	26.98	27.96	12.0	18.0	36.7	37.0	69.8	115.7	126.7	132.8	960.84	1446.84	1499.06	1514.06
SEm ±	0.50	0.37	0.59	0.71	0.4	0.2	0.7	0.8	1.5	2.7	2.7	2.8	33.77	34.74	43.21	40.52
CD (0.05)	1.530	1.125	1.821	NS	1.38	0.68	2.05	2.42	4.49	8.21	8.37	8.53	104.055	107.051	133.133	124.868

DAP, Days after planting; NS, Non-significant

Table 4: Effect of CO_2 fertilization on chlorophyll content, days to senescence and nutrient uptake

Treatments	Chlorophyll content (mg g^{-1})			Days to senescence	Nutrient uptake(g per plant)		
	45 DAP	90 DAP	135 DAP		N uptake	P uptake	K uptake
s_0: No substrate	0.837	0.904	0.924	223.0	0.255	0.135	0.500
s_1: Cow dung	0.944	0.956	0.970	218.3	0.280	0.128	0.517
s_2: Coir pith	0.932	0.955	0.967	220.3	0.273	0.124	0.543
s_3: Cow dung + Coir pith (2:1)	1.147	0.993	1.006	216.7	0.294	0.129	0.560
s_4: s_2 + *Pleurotus* 1g kg^{-1} + N + P (2% w/w)	0.897	0.969	1.002	217.0	0.298	0.132	0.576
s_5: s_3 + *Pleurotus* 1g kg^{-1} + N + P (2% w/w)	0.948	1.153	1.138	215.7	0.322	0.151	0.629
SEm ±	0.020	0.015	0.039	0.9	0.012	0.005	0.022
CD (0.05)	0.0620	0.0459	NS	2.87	NS	NS	NS

DAP, Days after planting; NS, Non-significant

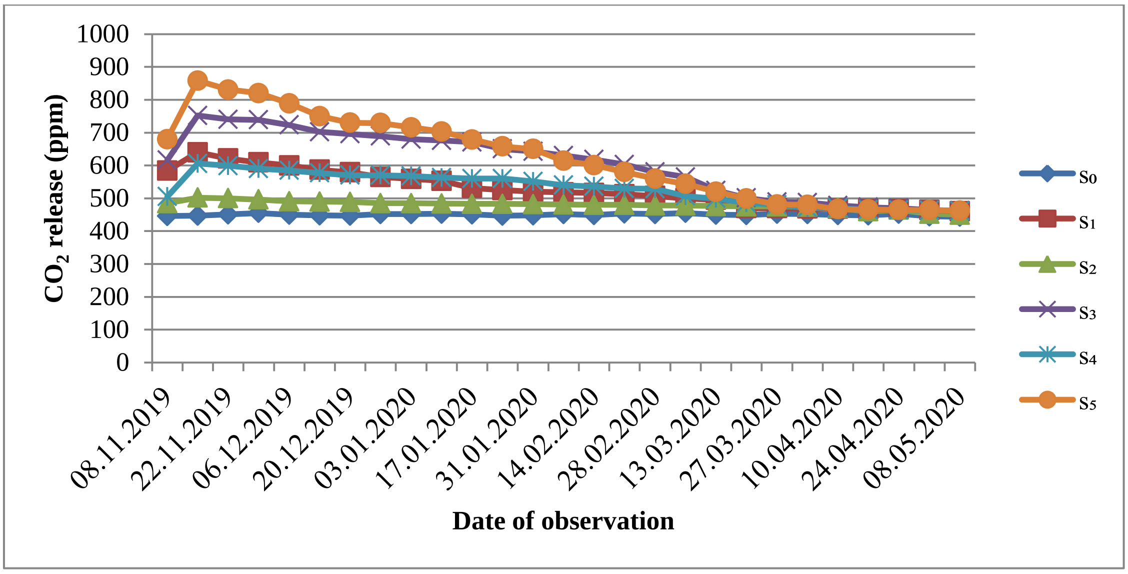


Fig. 1: CO_2 release in trenches from the different substrates at weekly intervals

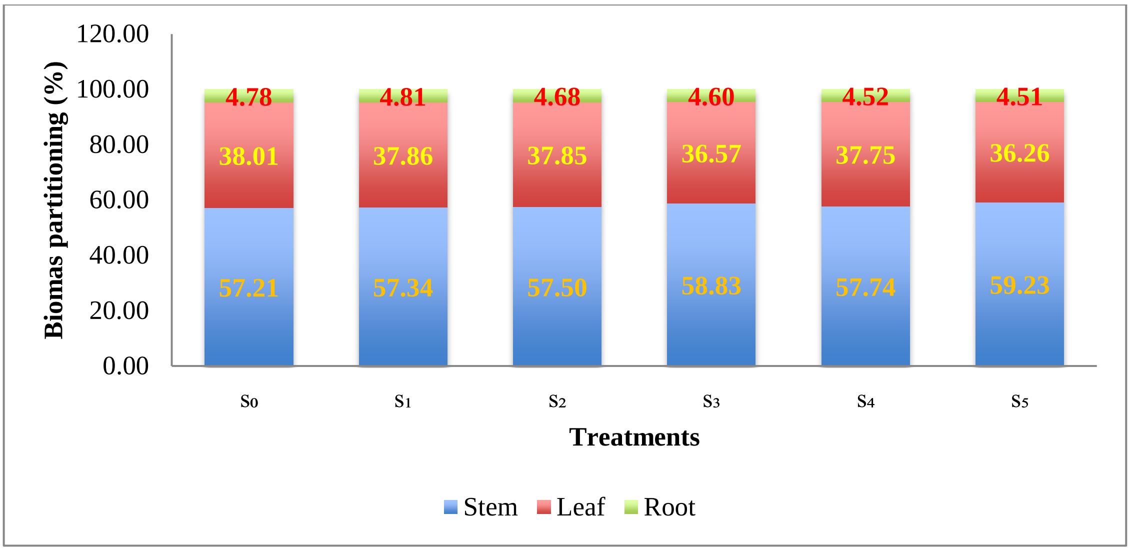


Fig. 2: Effect of CO_2 fertilization on plant biomass partitioning

Plate 1: Tuber development in CO_2 fertilization study

ACKNOWLEDGEMENT

The paper forms a part of Ph.D. thesis submitted by the first author for the award of his Doctoral degree. The authors gratefully acknowledge the physical and financial support provided by Kerala Agricultural University, Thrissur for the successful completion of the research work.

REFERENCES

Abro, S.A., Tian, X., Wang, X., Wu, F. and Kuyide, J.E. 2011. Decomposition characteristics of maize (*Zea mays* L.) straw with different carbon to nitrogen (C/N) ratios under various moisture regimes. *African J. Biotechnol.*, **10**(50): 10149-56.

Ainsworth, E.A. and Long, S.P. 2005. What have we learned from 15 years of free-air CO_2 enrichment (FACE)? A meta-analytic review of the responses of photosynthesis, canopy properties and plant production to rising CO_2. *New Phytol.*,**165**: 351-72.

Amlan, D. and Devi, S.L. 2001. Effect of organic and inorganic amendments on CO_2 evolution and rate of decomposition of coir dust. *J. Trop. Agric*., **39**:184-85.

Bhardwaj, A., Purohit, S. and Sharma, V. 2023. Asian fermented root and tuber-based products. *In. Indigenous Fermented Foods for the Tropics* (Eds. Adebo, O. A., Obadina, A. O., Panda, S. K., Chinma, C. E., Soares, A. G. andGanR. U.), Academic Press, pp. 285-96.

Bhatt, R.K., Baig, M.J. and Tiwari, H.S. 2010. Elevated CO_2 influences photosynthetic characteristics of *Avenasativa* L. cultivars. *J. Environ. Biol.*,**31**:813-18.

Bhattacharya, N.C., Biswas, P.K., Bhattacharya, S., Sionit, N. and Strain, B.R. 1985. Growth and yield response of sweet potato to atmospheric CO_2 enrichment. *Crop Sci*.,**25**(6): 975-81.

Booker, F.L., Burkey, K.O., Pursley, W.A. and Heagle, A.S. 2007. Elevated carbon dioxide and ozone effects on peanut: I. Gas exchange, biomass, and leaf chemistry. *Crop Sci*.,**47**: 1475-87.

Cochran, W.G. and Cox, G.M. 1965. *Experimental Designs*. Asia Publishing House, Bombay, 611p.

Corsini, D.L., Thompson, C. and Pavek, J.J. 1989.The effect of plant growth regulators on *Verticillium* wilt of potato. *Am. Potato J*.,**66**: 125-36.

Drake, B.G., Gonzalez-Meler, M.A. and Long, S.P. 1997. More efficient plants: A consequence of rising atmospheric CO_2? *Annu. Rev. Plant Biol.*,**48**(1): 609-39.

Dutt, S., Manjul, A. S., Raigond, P., Singh, B., Siddappa, S., Bhardwaj, V., Karwar P.G., Patil, V.U. and Kardile, H.B. 2017. Key players associated with tuberization in potato: potential candidates for genetic engineering. *Crit. Rev. Biotechnol*.,**37**(7): 942-57.

Ewing, E.E. 1987. The role of hormones in potato (*Solanum tuberosum* L.) tuberization. *In.Plant Hormones and Their Role in Plant Growth and Development*(Ed. Davies, P. J.), MartinusNijhoff Publishers, Boston, pp. 515-38.

Gajanayake, B., Reddy, K.R. and Shankle, M. W. 2015. quantifying growth and developmental responses of sweetpotato to mid-season temperature. *Agron. J.*, **107**(5): 1854-62.

Hastilestari, B.R., Lorenz, J., Reid, S., Hofmann, J., Pscheidt, D., Sonnewald, U. and Sonnewald, S. 2018. Deciphering source and sink responses of potato plants (*Solanum tuberosum* L.) to elevated temperatures. *Plant Cell Environ.*, **41**(11): 2600-16.

Jackson, S.D. 1999. Multiple signalling pathways control tuber induction in potato. *Plant Physiol.*, **119**(1): 1-8.

KAU [Kerala Agricultural University]. 2016. *Package of Practices Recommendations: Crops* (15^{th} Ed.). Kerala Agricultural University, Thrissur, 393p.

Kimball, B.A., Kobayashi, K. and Bindi, M. 2002. Responses of agricultural crops to free-air CO_2 enrichment. *Adv. Agron.*,**77**: 293-68.

Kumari, S., Agrawal, M. and Tiwari, S. 2013. Impact of elevated CO_2 and elevated O_3 on *Betavulgaris* L.: Pigments, metabolites, antioxidants, growth and yield. *Environ.Pollut.*,**17**: 279-88.

Laharia, G. S., Navale, V. D., Jadhao, S. D., Rathod, P. H. and Aage, A. B. 2020. Changes in biological properties during decomposition of various crop residues.*J. PharmacognosyPhytochem*.,**9**(1): 571-73.

Lee, Y.H., Sang, W.G., Baek J.K., Kim, J.H., Shin, P., Seo, M.C. and Cho, J.2020. The effect of concurrent elevation in CO_2 and temperature on the growth, photosynthesis, and yield of potato crops. *PLoS ONE***15(10)**: e0241081. https://doi.org/ 10.1371/journal.pone.0241081.

Liang, C. and Balser, T.C. 2011. Microbial production of recalcitrant organic matter in global soils: implications for productivity and climate policy. *Nat. Rev. Microbiol.*, **9**: 75-75.

Ludewig, F. and Sonnewald, U. 2000. High CO_2-mediated down-regulation of photosynthetic gene transcripts is caused by accelerated leaf senescence rather than sugar accumulation. *FEBS letters*, **479**(1-2): 19-24.

Melis, R. J. M. and van Staden, J. 1984. Tuberization and hormones. Zeitschrift Für Pflanzenphysiologie, 113(3): 271-283.

Menzel, C.M. 1980. Tuberization in potato at high temperatures: responses to gibberellin and growth inhibitors.*Ann. Bot.*,**46**: 259-65.

Minu, M. 2015. Physiological and molecular analyses of growth responses in black pepper (*Piper nigrum*L.) under elevated carbon dioxide environments. M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 119p.

Navale, V.D. 2014. Biochemical and biological changes during decomposition of crop residues. Ph. D thesis, Dr.PanjabraoDeshmukhKrishiVidyapeeth, Akola, 83p.

Nayar, N. M. (2014). The contribution of tropical tuber crops towards food security. *J. Root Crops*,**40(1)**: 3-14.

Opaleye, S.A., Namo, O.A.T., and Akinbola, O.J. 2018. Studies on dry matter distribution, harvest index and proximate composition in different accessions of hausa potato (*Solenostemonrotundifolius*(Poir) J. K. Morton) in Jos-plateau, Nigeria.*Hortic. Int J.*,**2**(3):129-34.

Rahman, M.M. 2013. Nutrient-use and carbon accumulation efficiencies in soils from different organic wastes in rice and tomato cultivation. *Commun. Soil Sci. Plant Anal.*,**44**(9):1457-71.

Railton, I.D. and Wareing, P.F. 1973. Effects of daylength on endogenous gibberellins in leaves of *Solanumandigena*. I. Changes in levels of free acidic gibberellin-like substances. *Physiol. Plant.*,**28**: 88-94.

Ravi, V., Naskar, S.K., Makeshkumar, T., Babu, B. and Krishnan, B.S.P. 2009. Molecular physiology of storage root formation and development in sweet potato [*Ipomoea batatas*(L.) Lam.]. *J. Root Crops*,**35**:1-27.

Reynolds, M.P. and Ewing, E.E. 1989. Effects of high air and soil temperature stress on growth and tuberization in *Solanum tuberosum*. *Ann. Bot.*, **64**(3): 241-47.

Ruiz-Vera, U.M., De Souza, A.P., Ament, M.R., Gleadow, R.M. and Ort, D.R. 2021. High sink strength prevents photosynthetic down-regulation in cassava grown at elevated CO_2 concentration. *J. Exp. Bot.*, **72**(2): 542-60.

Runion, G.B., Prior, S.A., Monday, T.A.and Ryan-Bohac, J. 2018. Effects of elevated CO_2 on growth of the industrial sweet potato cultivar CX-1. *Environt Control Biol.*,**56**(2): 89-92.

Schapendonk, A.H.C. M., Oijen, M.V., Dijkstra, P., Pot, C.S., Jordi, W.J.R.M. and Stoopen, G.M. 2000. Effects of elevated CO_2 concentration on photosynthetic acclimation and productivity of two potato cultivars grown in open-top chambers. *Funct. Plant Biol.*,**27**(2): 1119-30.

Thinh, N.C., Shimono, H., Kumagai, E. and Kawasaki, M. 2017. Effects of elevated CO_2 concentration on growth and photosynthesis of Chinese yam under different temperature regimes, *Plant Prod. Sci.*,**20**(2): 227-36.

Thomas, G.V., Palaniswami, C.S., Prabhu, R., Gopal, M. and Gupta, A. 2013. Co-composting of coconut coir pith with solid poultry manure. *Curr. Sci.*,**104**(2): 245-50.

Wilkins, D., Van, O.J.J. and Besford, R.T. 1993. Effect of elevated CO_2 on growth and chloroplast proteins in *Prunusavium*. *Tree Physiol.*,**15**: 769-79.

Xu, X., van Lammeren, A.A., Vermeer, E. and Vreugdenhil, D. 1998. The role of gibberellin, abscisic acid and sucrose in the regulation of potato tuber formation in vitro.*PlantPhysiol*.,**117**: 575-84.

Yubi, Y., Jun, L., Haiyang, N. and Xiuyun, Z. 2021. Combined impact of elevated CO_2 concentration and climatic warming on potato yield and quality in semi-arid regions. *Potato Res.*, **64**(1): 97-113.

Zaher, M.A.B., Kumagai, E., Yabiku, T., Nakajima, M., Matsunami, T., Matsuyama, N., Thinh, N.C., Hasegawa T.and Kawasaki, M. 2021. Effects of elevated atmospheric CO_2 concentration on growth and photosynthesis in eddo at two different air temperatures. *Plant Prod. Sci.*, **24**(3): 363-73.