

## Canopy growth and tuber yield in Chinese potato (*Plectranthus rotundifolius*(Poir) Spreng.) under elevated CO<sub>2</sub> concentrations in the warm humid tropics of Kerala

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### ABSTRACT

Canopy growth and tuber yield of Chinese potato in response to CO<sub>2</sub> 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<sub>2</sub> in three replications during 2019-20. The treatments included, s<sub>0</sub>: no substrate, s<sub>1</sub>: cow dung, s<sub>2</sub>: coir pith, s<sub>3</sub>: cow dung + coir pith (2:1), s<sub>4</sub>: s<sub>2</sub> + Pleurotus 1g kg<sup>-1</sup> + N + P (2% w/w) and s<sub>5</sub>: s<sub>3</sub> + Pleurotus 1g kg<sup>-1</sup> + N + P (2% w/w). The CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> and temperature in the trenches at the expense of tuber formation.

**Keywords:** Chinese potato, elevated CO<sub>2</sub>, growth, organic substrates, temperature and tuber

Carbon dioxide (CO<sub>2</sub>) 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<sub>2</sub> 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<sub>2</sub> (eCO<sub>2</sub>) 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<sub>2</sub> (Kumari *et al.*, 2013). In Chinese yam (*Dioscorea opposita* Thunb.) vine length and leaf area under eCO<sub>2</sub> (ambient+200 ppm) were comparatively higher (Thinhet *et al.*, 2017) whereas Runion *et al.* (2018) reported increased fresh weight allocation to belowground plant organs in sweet potato under elevated CO<sub>2</sub>. Increased net photosynthetic rate and chlorophyll content under eCO<sub>2</sub> 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<sub>2</sub>. 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

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increase in CO<sub>2</sub> 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<sub>2</sub> 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<sub>0</sub>: no substrate, s<sub>1</sub>: cow dung, s<sub>2</sub>: coir pith, s<sub>3</sub>: cow dung + coir pith (2:1), s<sub>4</sub>: s<sub>2</sub> + *Pleurotus* 1g kg<sup>-1</sup> + N + P (2% w/w) and s<sub>5</sub>: s<sub>3</sub> + *Pleurotus* 1g kg<sup>-1</sup> + 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<sub>2</sub> 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<sup>-1</sup> and recommended (KAU, 2016) cultural operations adopted until harvest. The crop was planted on 7<sup>th</sup> November 2019 and harvesting was done on 3<sup>rd</sup> July 2020.

Microclimatic parameters (CO<sub>2</sub> 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<sub>2</sub>/Temperature monitor (GE sunsing, USA). Soil temperature (°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<sub>2</sub> evolution

A critical appraisal of the CO<sub>2</sub> 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<sub>2</sub> concentration (858 ppm) was observed in s<sub>5</sub> (cow dung + coir pith + *Pleurotus* + N + P), followed by s<sub>3</sub> [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<sub>2</sub> evolution remained concordant irrespective of the substrates added. Similar reports of high initial CO<sub>2</sub> release and slower evolution during the rest of incubation period have been documented (Abroet *al.*, 2011; Navale, 2014; Minu, 2015; Lahariaet *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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> (20.6:1) compared to the other substrates, and the lowest was in s<sub>1</sub>.

#### **Growth of Chinese potato**

The growth attributes in Chinese potato varied significantly with CO<sub>2</sub> 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<sup>2</sup>) and branches (13.2) were observed in the treatment in which cow dung + coir pith (2:1) was used as substrate (s<sub>3</sub>), but on par with coir pith + *Pleurotus* + N + P (s<sub>4</sub>) and cow dung + coir pith (2:1) + *Pleurotus* + N + P (s<sub>5</sub>). The superiority of substrate containing cow dung + coir pith (2:1) + *Pleurotus* + N + P (s<sub>5</sub>) on canopy attributes in the trench was evident at later stages. Canopy development was enhanced, plants were greener and grew luxuriantly in the CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> concentration. Elevated CO<sub>2</sub> 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<sub>2</sub> 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<sub>3</sub>) at 45 DAP and at 90 DAP, in s<sub>5</sub> (s<sub>3</sub> + *Pleurotus* 1g kg<sup>-1</sup> + N + P @ 2% w/w). The stages coincided with the period during which maximum CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> evolved, it was observed that it was delayed in the plants grown without CO<sub>2</sub> fertilization, no substrate (223 days). The greenness associated with eCO<sub>2</sub> did happen but duration of its impact was not for long. Accelerated senescence with eCO<sub>2</sub> 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<sub>2</sub> condition resulted in the accelerated senescence compared to non CO<sub>2</sub> 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<sub>3</sub>) + *Pleurotus* + N + P (s<sub>5</sub>) 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<sub>2</sub> fertilization (Plate 1). Excessive vegetative growth was elicited and despite the crop being retained for nearly 238 days, 98 to 118 days more than the normal duration. This was contradictory to the earlier reports on increased tuber yields in potato under eCO<sub>2</sub> (Schapendonk *et al.*, 2000). It was also surprising that tuberization was not recorded even in the treatment in which substrates for CO<sub>2</sub> 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<sub>2</sub> concentrations, were higher in the trenches especially during 8<sup>th</sup> to 12<sup>th</sup> 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<sub>2</sub>. 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> enrichment are also warranted.

**Table 1: Quantity of substrates used and changes in C: N ratio with CO<sub>2</sub> release**

Treatment	Quantity of substrate (kg)	<i>Pleurotus</i> (g)	N (Urea) (kg)	P (Rajphos) (kg)	C: N ratio	
					Before	After
<b>s<sub>0</sub>: No substrate</b>	0	0	0	0	-	-
<b>s<sub>1</sub>: Cow dung</b>	50	0	0	0	23.5	3.3
<b>s<sub>2</sub>: Coir pith</b>	30	0	0	0	70.1	20.6
<b>s<sub>3</sub>: Cow dung + Coir pith (2:1)</b>	40	0	0	0	46.8	4.1
<b>s<sub>4</sub>: s<sub>2</sub> + <i>Pleurotus</i> 1g kg<sup>-1</sup> + N + P (2% w/w)</b>	30	30	0.6 (1..30)	0.6 (3.00)	11.7	3.8
<b>s<sub>5</sub>: s<sub>3</sub> + <i>Pleurotus</i> 1g kg<sup>-1</sup> + N + P (2% w/w)</b>	40	40	0.8 (1.74)	0.8 (4.00)	10.3	3.5

Table 2: Effect of CO<sub>2</sub> fertilization on air and soil temperature (°C)

Date of observation	Air temperature							Soil temperature						
	S <sub>0</sub>	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	Ambient	S <sub>0</sub>	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	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<sub>2</sub> 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 <sup>2</sup> )			
	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 <sub>0</sub> : 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 <sub>1</sub> : 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 <sub>2</sub> : 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 <sub>3</sub> : 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 <sub>4</sub> : s <sub>2</sub> + <i>Pleurotus</i> + 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 <sub>5</sub> : s <sub>3</sub> + <i>Pleurotus</i> + 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<sub>2</sub> fertilization on chlorophyll content, days to senescence and nutrient uptake**

Treatments	Chlorophyll content (mg g <sup>-1</sup> )			Days to senescence	Nutrient uptake(g per plant)		
	45 DAP	90 DAP	135 DAP		N uptake	P uptake	K uptake
s <sub>0</sub> : No substrate	0.837	0.904	0.924	223.0	0.255	0.135	0.500
s <sub>1</sub> : Cow dung	0.944	0.956	0.970	218.3	0.280	0.128	0.517
s <sub>2</sub> : Coir pith	0.932	0.955	0.967	220.3	0.273	0.124	0.543
s <sub>3</sub> : Cow dung + Coir pith (2:1)	1.147	0.993	1.006	216.7	0.294	0.129	0.560
s <sub>4</sub> : s <sub>2</sub> + <i>Pleurotus</i> 1g kg <sup>-1</sup> + N + P (2% w/w)	0.897	0.969	1.002	217.0	0.298	0.132	0.576
s <sub>5</sub> : s <sub>3</sub> + <i>Pleurotus</i> 1g kg <sup>-1</sup> + 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

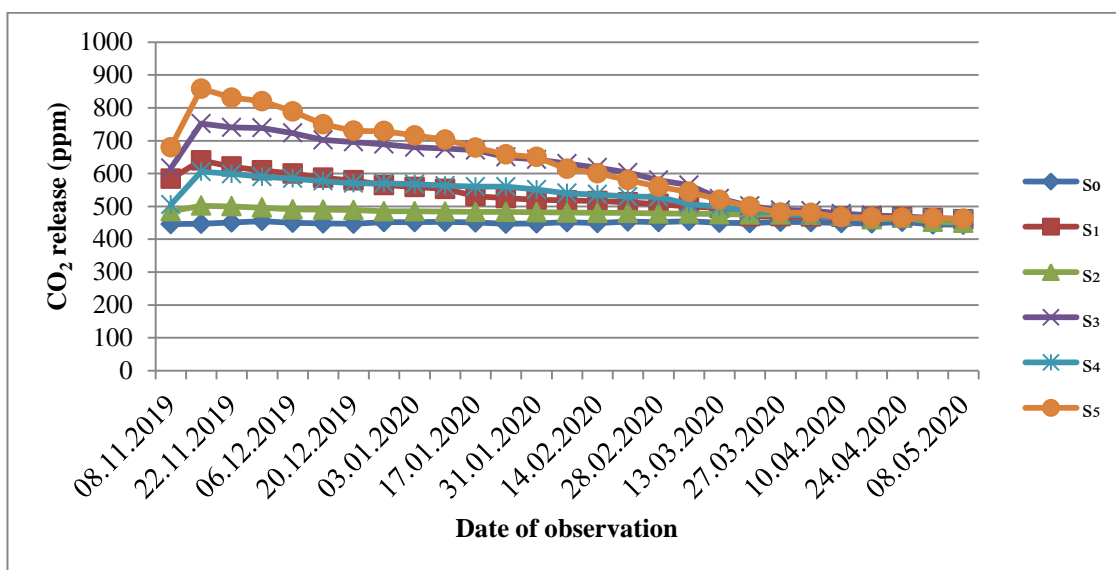


Fig. 1: CO<sub>2</sub> release in trenches from the different substrates at weekly intervals

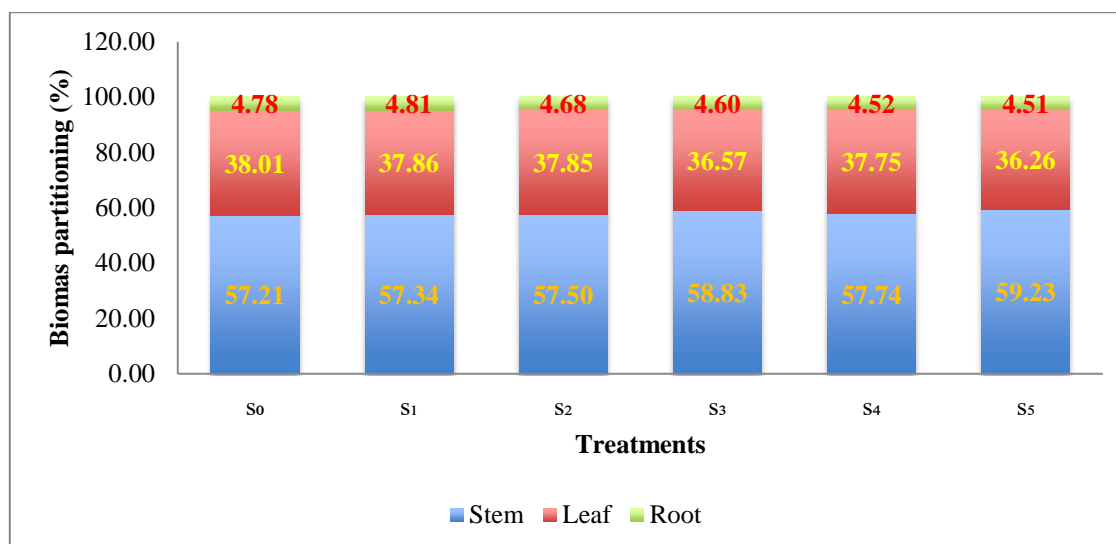


Fig. 2: Effect of CO<sub>2</sub> fertilization on plant biomass partitioning



Plate 1: Tuber development in CO<sub>2</sub> fertilization study



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