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## ASSESSING THE COMPETING ABILITY OF WEEDY RICE (*Oryza sativa f. spontanea*) WITH CULTIVATED RICE UNDER ELEVATED CO<sub>2</sub> CONDITIONS

K. Anjali<sup>1</sup>, M. Ameena<sup>1\*</sup>, Nimmy Jose<sup>2</sup>, A. P.Pooja<sup>1</sup>, Fathima Umkhulzum<sup>1</sup>, S. Anjana<sup>1</sup>

<sup>1</sup>Department of Agronomy, College of Agriculture, Vellayani, Kerala (India)-695522

<sup>2</sup>Rice Research Station, Moncompu, Aleppey, Kerala 688 503

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### KEYWORDS

Climate change

Crop-weed competition

Elevated carbon dioxide

Rice

Weedy rice

### ABSTRACT

Climate change can adversely affect rice production, especially for weed management in the context of emergence and proliferation of newer weed species like weedy rice (*Oryza sativa f. spontanea*) in the rice growing tracts of Kerala. In the past decade, atmospheric carbon dioxide (CO<sub>2</sub>) has risen from 371.82 to 407.05 ppm from 2000 to 2018 which might have an impact on the competitive ability of a C<sub>3</sub> plant like weedy rice. The competitiveness of weedy rice was studied in an open top chamber (OTC) under a CO<sub>2</sub> concentration of 500 ppm (Chamber A), OTC without external CO<sub>2</sub> supply (Chamber B), and open condition along with two popular cultivated rice varieties *Uma* and *Jyothi* with both air and soil temperature inside the chamber to the tune of 40-43<sup>o</sup>C and 35-40<sup>o</sup>C respectively. The study revealed a higher competitive potential of weedy rice in terms of tillering ability under elevated carbon dioxide as it responded well compared to cultivated rice varieties. There was a differential response of rice varieties to elevated CO<sub>2</sub> conditions with medium duration variety responding well compared to short duration one. Compared to ambient conditions (chamber B and open condition), higher tillering was observed under elevated CO<sub>2</sub> (chamber A) in which weedy rice tillered profusely (17.33) than cultivated rice species (9 and 11.33). There was a linear increase in plant height of weedy rice in chamber A (108.97 cm) during the initial stages and in chamber B (112.77 cm) during reproductive stages. The study evidenced that in the coming future, higher CO<sub>2</sub> levels can stimulate biomass production of C<sub>3</sub> weed like weedy rice with a greater increase in tillering which could be an important trait affecting inter specific competition.

\* Corresponding author

E-mail: [drameenaubaid@gmail.com](mailto:drameenaubaid@gmail.com) (M. Ameena)

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## 1 Introduction

Studies on the effects of climate change on rice production forecast negative effects. This necessitates a reformulation of crop management practices especially weed management because of the emergence and proliferation of newer weed species in rice. As environmental conditions have a huge impact on the effectiveness of weed management, newly emerged weed species like weedy rice (*Oryza sativa* f. *spontanea*) demands newer options in rice. Weedy rice has progressed primarily by natural hybridization between wild and cultivated rice and affects rice production, harvest quality, and income. With newer biotypes, weedy rice has infested the majority of rice growing areas in Asia and the main rice tracts of Kerala. This new weed has now invaded India with an infestation of 5 to 60% across different states. In Kerala, heavy infestation in recent years has caused a reduction in the yield by 30 to 60% (Seneweera et al., 1994; Abraham et al., 2012) depending on the severity of infestation (3 to 10 mature plants of weedy rice per square meter). Early flowering was observed in weedy rice compared to cultivated rice and it resulted in early grain maturing and seed shattering thus enhancing the weed seed bank (Anjali et al., 2018).

Atmospheric carbon dioxide (CO<sub>2</sub>) has risen from 371.82 to 407.05 ppm from 2000 to 2018 as a result of continuous anthropogenic activities and it is expected to reach 600 ppm around 2050. As per the projections of the Intergovernmental Panel on Climate Change (IPCC), the atmospheric carbon dioxide concentration is expected to reach 730 to 1020 ppm by 2100 (Meehl et al., 2007). Studying crop weed response in elevated CO<sub>2</sub> conditions will help to assess the nature of weediness in rice production systems in the era of climate change. In this background, the present study was undertaken to assess the impact of climate change, particularly elevated CO<sub>2</sub> and higher temperature on the growth and competitiveness of weedy rice in the rice production system.

## 2 Materials and Methods

The experiment on the competitiveness of weedy rice was conducted in open top chambers (OTC) maintained under a carbon dioxide concentration of 500 ppm called chamber A and another without carbon dioxide called chamber B. Both air and soil temperatures inside the chamber were to the tune of 40-43<sup>o</sup>C and 35- 40<sup>o</sup>C, respectively. Pre-germinated seeds of Jyothi, Uma, and weedy rice were sown in plastic pots filled with clayey soil collected from rice fields and transferred to OTC at 10 DAS. A flooded situation was maintained throughout the crop growth period. The experimental design used was a completely randomized design with nine treatments replicated thrice inside OTC. The treatments were *Jyothi* in Chamber A (T<sub>1</sub>), weedy rice in Chamber A (T<sub>2</sub>), *Uma* in Chamber A (T<sub>3</sub>), *Jyothi* in Chamber B

(T<sub>4</sub>), weedy rice in Chamber B (T<sub>5</sub>), *Uma* in Chamber B (T<sub>6</sub>), *Jyothi* under open condition (T<sub>7</sub>), weedy rice under open condition (T<sub>8</sub>) and *Uma* under open condition (T<sub>9</sub>). After panicle emergence weedy rice panicles were separately bagged to prevent the shattering of grains. Panicles from weedy rice, *Jyothi*, and *Uma* were harvested separately, grains removed and yield was recorded. All the yield attributing characters were observed separately for *Uma*, *Jyothi*, and weedy rice at 30 DAS and 50% flowering. The data recorded were subjected to statistical analysis.

## 3 Results and discussion

### 3.1 Effect of elevated CO<sub>2</sub> conditions on rice and weedy rice growth attributes

The study revealed significant variations in vegetative attributes of rice and weedy rice under elevated CO<sub>2</sub> levels (Table 1). However, the extent of response varied among the cultivars under varying atmospheric situations. Of the various growth and yield attributes analyzed, weedy rice responded well to elevated carbon dioxide compared to cultivated rice showing its higher competitive potential. Ziska et al. (2010) reported that weedy rice responds more strongly to rising carbon dioxide levels than cultivated rice with its greater competing ability suggesting the magnitude of weedy rice as a problem weed in the future rice production system. There was a differential response between rice varieties to elevated CO<sub>2</sub> conditions with *Uma* responding well compared to *Jyothi*.

Elevated CO<sub>2</sub> had a significant influence on plant height in both rice and weedy rice in all three situations. There was a linear increase in plant height of weedy rice in chamber A during the initial stages and in chamber B during reproductive stages. This indicated that weedy rice responded well to elevated CO<sub>2</sub> condition during the initial stages and at the reproductive stage, the response was more to the ambient conditions of chamber B. Singh & Jasrai (2011) reported that effects of elevated CO<sub>2</sub> to plant growth was more pronounced during early growth stages and reduced greatly at later stages. On analyzing the plant height, the response between cultivated rice and weedy rice it was observed that *Jyothi* responded well under elevated CO<sub>2</sub> conditions as compared to the *Uma*.

Tillering ability of both weedy rice and cultivated rice was significantly affected by various growing situations. Compared to ambient conditions (chamber B and open condition), higher tillering was observed under elevated CO<sub>2</sub> (chamber A) in which weedy rice tillered profusely (17.33) than cultivated rice species (9 and 11.33 for *Jyothi* and *Uma* respectively). The results of the present study are in confirmation with the findings of Ziska et al. (2010), who reported that weedy rice responded more strongly to rising CO<sub>2</sub> levels than cultivated rice with greater competing ability. In Kerala, 60 percent of kharif crop is raised under direct

Table 1 Performance of rice varieties and weedy rice under elevated CO<sub>2</sub> in ambient and open conditions

Chambers	Treatments	Plant height (cm)	No of tillers at 30 DAS	No of tillers at 50% flowering	Days to 50% flowering (Days)	Number of grains per panicle	Grain yield per plant (g)
Chamber A	Jyothi (T <sub>1</sub> )	96.17	3.00	9.00	61.78	100.00	7.22
	Weedy rice (T <sub>2</sub> )	108.97	3.67	17.33	45.97	63.67	9.88
	Uma (T <sub>3</sub> )	90.72	3.33	11.33	77.57	114.00	17.75
Chamber B	Jyothi (T <sub>4</sub> )	98.16	3.33	9.33	62.28	95.67	6.80
	Weedy rice (T <sub>5</sub> )	112.77	3.33	13.33	48.27	60.08	6.79
	Uma (T <sub>6</sub> )	91.06	3.33	8.67	79.69	105.00	14.36
Open condition	Jyothi (T <sub>7</sub> )	92.43	2.00	4.33	67.78	98.33	9.28
	Weedy rice (T <sub>8</sub> )	105.07	2.33	6.00	51.57	48.33	5.70
	Uma (T <sub>9</sub> )	88.37	1.00	3.33	81.88	90.67	8.62
	SE (±)	1.43	0.27	1.09	0.34	3.93	1.06
	LSD (0.05)	4.26	0.81	3.26	1.02	11.67	3.15

seeding in the rainfed situation. Weedy rice being a serious problem in direct seeded rice system, the production system turns more vulnerable to direct effects of climate change in terms of increased competition from weedy rice. Though for a C<sub>3</sub> crop like rice, elevated CO<sub>2</sub> levels may favour crop competitiveness, the dynamics take a reverse turn with weedy rice. Amongst the cultivars, Uma showed better response to elevated CO<sub>2</sub> producing tillers thrice than in open conditions. However, Jyothi was found less responsive to elevated CO<sub>2</sub> levels in terms of tiller production indicating variation in varietal response to carbon dioxide levels.

### 3.2 Yield attributes of rice and weedy rice influenced by elevated CO<sub>2</sub> conditions

Earliness in flowering was observed under elevated CO<sub>2</sub> conditions for both weedy rice (45.97 days) and cultivated rice compared to open condition (51.57 days) (Table 1). Compared to the open condition, weedy rice recorded an earliness of 15 and 7 days in Chamber A and B respectively, indicating the favourable effect of elevated CO<sub>2</sub> on flowering. Chauhan et al. (2014), observed that climate change not only affects the crop-weed competition but also triggers early flowering and weed seed germination in several flushes causing serious weed management issues. This earliness in the flowering of weedy rice might help to complete its life cycle faster and initiation of more life cycles even within a single crop period. Jyothi and Uma also recorded an earliness of 17 and 8 days in Chamber A and B respectively. Hence, it could be

concluded that early flowering induced from elevated carbon dioxide levels would contribute to more weed seed banks and might pose serious threats to rice cultivation in the future.

The number of grains per panicle was found to increase with the increase in CO<sub>2</sub> levels. Weedy rice recorded a greater response to the number of grains per panicle in chamber A with a percentage increase of 20.69 to 24.09. Kim et al. (2003) reported a linear relationship between elevated CO<sub>2</sub> and spikelet number. Varietal variations were observed with Jyothi recording a poor response and Uma exhibiting a greater response to elevated CO<sub>2</sub> concentration. But this conflicted with the findings of Sherchand & Sharma (2004), who reported that elevated CO<sub>2</sub> had little effect on the number of grains per panicle. Though Uma recorded the highest number of grains per panicle (114) compared to weedy rice (64) and Jyothi (100), the percentage increase in the number of grains per panicle was greatest for weedy rice under elevated CO<sub>2</sub> conditions.

Grain yields varied under various CO<sub>2</sub> concentrations, for weedy rice with a higher grain yield per plant in Chamber A followed by Chamber B which were 1.73 and 1.19 times respectively than open condition. Uma showed a greater percentage increase in grain yield (51.4% in chamber A and 40% in chamber B) followed by weedy rice (42.3% in chamber A and 16% in chamber B). The higher grain yield of Uma was a result of the greater number of grains per panicle, lower sterility percentage, and higher thousand grain

weight. Similar results were also reported by Upreti et al. (2003) and Sherchand & Sharma (2004). Jyothi recorded a negative response to elevated CO<sub>2</sub> levels. A significant variation was observed between chambers, indicating the effect of elevated CO<sub>2</sub> on grain yield. This increase in grain yield might be due to an increase in the number of grains per panicle under elevated levels of CO<sub>2</sub>.

### Conclusion

From the results of the study, it could be concluded that weedy rice responded more strongly to rising CO<sub>2</sub> conditions than cultivated rice during the initial stages as evidenced by the higher plant height and profuse tillering. It is apparent that in the future, the higher concentration of CO<sub>2</sub> in the atmosphere might enhance the competitive ability of weedy rice plants with deleterious effects on rice production.

### Conflict of interest

The authors declare no conflict of interest.

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