Indian Journal of Weed Science (2022) **54**(3): 337–340
http://dx.doi.org/10.5958/0974-8164.2022.00063.6

RESEARCH NOTE

Effect of increased temperature and soil moisture levels on *Cyperus rotundus* L.

Ajit Kumar Mandal*[1], Ga. Dheebakaran[2], Mahamaya Banik[3] and C. Chinnusamy[4]

Received: 5 May 2022 | Revised: 16 August 2022 | Accepted: 18 August 2022

ABSTRACT

Indian agriculture would suffer from elevated temperature and drought during the second part of this century, due to climate change. Weeds respond quickly to stress and adapt to the environment faster than crops. In this context, an experiment was carried out in growth chamber during 2015-16 with an objective to evaluate the effect of increase in air temperature and variations in soil moisture on *Cyperus rotundus* L. (purple nutsedge). A complete randomized design with 10 treatments and three replications was used for this pot culture experiment. The *C. rotundus* plants were grown for three generations. The treatments comprised of three temperature levels, viz. daily ambient (control), ambient +2°C and ambient +4°C increase over the ambient and two soil moisture levels, *viz.* soil moisture provision at 100 per cent of evaporation (M_{100}) and 60 per cent of evaporation (M_{60}). The combination of treatment were imposed at all stages of growth. *C. rotundus* had high acclimatization capacity and better growth under elevated temperature up to +4°C and under sufficient moisture due to its C_4 pathway, which helped the weed to utilize the moisture and temperature more efficiently even during stress and record higher growth. It is concluded that, at projected future temperature (up to +4°C), *C. rotundus* may become more problematic, particularly during the rainy season.

Keywords*:* Climate change, *Cyperus rotundus L.*, Elevated temperature, Soil moisture, Purple nutsedge

Intergovernmental Panel on Climate Change (IPCC 2013) report indicated that, climate scenarios predict an increase of annual mean temperatures by 1.5 – 4°C by the end of 21th century. If these forecasts are realized, crops and cropping systems would likely experience significant changes, and it is so for the associated weeds. Because of climate change, plants may be subjected to high temperatures and low soil moisture during the growing season (Knapp *et al*. 2008). Recent studies had strongly suggested that geographic range transformations (spread and distribution) for agricultural weeds would be a highly probable outcome from global climate change (Fuhrer 2003, Naidu 2015). Globally, there is a growing list of recent changes in species distributions, abundances and life cycles that are likely to be due to climate change (Naidu *et al*. 2014). Climate change will impose several challenges for managing weeds.

Sedge weeds are distributed in all parts of the world, especially in damp, wet, dry, and marshy region of the tropical, temperate, and sub-tropical regions of the globe. *Cyperus rotundus* L. (purple nutsedge) is described as an aggressive competitor because of its fast growth, dense, rhizomatous habit, prolific reproduction, C_4 photosynthetic pathway and allelopathic properties. *C. rotundus* is the most problematic world's worst weed present in 92 countries in 52 crops (Holm *et al*. 1977). It is a perennial weed, mainly propagated by vegetative means and also by seeds.

Weeds have more adaptability to stress conditions than crops. Hence, it is important to understand the adoptability of weeds under future projected climate, particularly to elevated temperature and moisture stress. With this back ground, the present study was conducted to assess effect of increased temperature and soil moisture stress on *C. rotundus* during three generations.

A growth-chamber experiment was carried out at Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore, during

[1] Department of Agrometeorology, Dr. Kalam Agricultural College, Arrabari, Kishanganj-855107, (BAU-Sabour) Bihar, India

[2] Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore 641003, Tamil Nadu, India

[3] Department of Plant Breeding and Genetics, Dr. Rajendra Prasad Central Agricultural University, Pusa 848125, Bihar, India

[4] Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore 641003, Tamil Nadu, India

* Corresponding author email: ajitmeteorology@gmail.com

December 2015 – May 2016. Chamber 1 was setup to maintaining 4^0C higher than the ambient temperature (+4^oC) and the Chamber 2 was for 2^0C higher than the ambient temperature (+2^oC). A logger continuously recorded the weather at three minutes interval in both inside and outside of growth chamber.

The latitude, longitude and altitude of the experiment location are 11^0N, 77^0E and 426.7m above MSL, respectively and Coimbatore comes under the Western agro climate zone of Tamil Nadu**.** Coimbatore is climatically categorized as Semi-Arid Tropic (SAT) climate with an average annual rainfall of 696 mm distributed in 47 rainy days. The long period average annual mean maximum and minimum temperatures are 31.7 and 21.3^0C, respectively. The normal annual mean relative humidity is 85 and 49 per cent during morning and evening, respectively. The average mean bright sunshine is seven hour per day and solar radiation is 311 cal/cm^2/day

The study was conducted with 10 treatments and three replications in Completely Randomized Design (CRD). Each treatment was a combination of one temperature and one soil moisture level. The temperature levels were varied as ambient (control), ambient + two degree (+2^oC), ambient +four degree (+4^oC) increase over the ambient temperature. The soil moisture levels were, supply of soil moisture provision at 100 per cent (M_{100}) and 60 per cent of evaporation (M_{60}) occurred previous day. The treatment combinations were: ambient +2^0C + M_{100} (+2^oC + M_{100}) for all the three generation, +2^0C + M_{100} for 1st and 2nd generations, +4^0C + M_{100} for 3rd generation, +2^0C + M_{100} for 1st generation and +4^0C + M_{100} for 2nd and 3rd generation, ambient +4^0C + M_{100} for all the three generation (+4^oC + M_{100}), ambient + M_{100} (0^oC + M_{100}) for all the three generation, ambient +2^0C + M_{60} (+2^oC + M_{60}) for all the three generation, +2^0C + M_{60} for 1st and 2nd generations, +4^0C + M_{60} for 3rd generation, +2^0C + M_{60} for 1st generation and +4^0C + M_{60} for 2nd and 3rd generation, ambient +4^0C + M_{60} (+4^oC + M_{60})for all the three generation and ambient + M_{60} (0^oC + M_{60}) for all the three generation.

Trial was conducted for three generations of weed and the temperature and moisture levels were varied generation to generation, as per treatment. The tubers used in first trial was considered as first generation, further their progeny tubers used in the second trial were considered as second generation. Finally the harvested tubers from second generation were used for further experiment; which named as third generation. Each of the generation period was 45 Days.

Irrigation with good water was done to the pots based on pan evaporation reading as per the treatment schedule. The loss of water through evaporation was calculated every day and equal water was poured in the pots for 100 percent moisture level. In 60 percent moisture stress treatment, the quantity of water equal to 60 percent of open pan evaporation was poured. The water poured was calculated as detailed in **Table 1**.

Observations were recorded for plant height (cm), number of leaves (number/plant), leaf area (cm^2), number of flowers, number of tubers and total dry matter production (g) of *Cyperus rotundus* at 45 days after planting (DAP). The data was analyzed using AGRESS statistical software and F test was performed.

Effect on *C. rotundus* growth parameters

The plant height at 45 Day after planting (DAP) was ranged from 26.6 to 37.6, 17.4 to 31.6 and 12.2 to 30.3 cm during 1st, 2nd and 3rd generations, respectively (**Table 2**). In general, there was a decreasing trend in plant height from 1st generation to 3rd generation. The height of *C. rotundus* was significantly higher in T_4 (+4^0C with M_{100}) followed by T_9 (+4^0C with M_{60}) during all three generations as compared to all other treatments. The plant height was significantly lower in control (T_5, +0^0C with M_{100}), followed by T_{10} (+0^0C with M_{60}).

The average number of leaves per plant at 45 DAP were ranged from 10.1 to 13.8, 9.7 to 12 and 8.3 to 12.7 during 1st, 2nd and 3rd generations, respectively. It was observed that the number of leaves per plant was significantly higher in the treatment number T_4 (+4^0C with M_{100}) followed by T_9 (+4^0C with M_{60}), like that of plant height. Initially, there was significantly lower number of leaves per plant were observed in the treatment number T_6 and

Table 1. Water poured in the pots for irrigation requirement calculation

Diameter of pot	:	25cm	Radius of pot	:	12.5cm = 0.125m
Area of pot	:	22/7 x0.125 x 0.125 sq m = 0.049 sq m			
1mm of water in 1square meter =1 litre			1cubic meter = 1000 litre		
Hence, for 1mm in 0.049sq m = 49ml					
If pan evaporation reading is 5 then water required for 100 % level pots =5 x 49ml =245ml and for 60 % = 147 ml					

T_7 (+2^{0}C with M_{60}) during the 1st generation. During the 2nd and 3rd generations, lower number of leaves per plant were observed in T_5 which was on par with T_6, T_7 and T_{10}. In both the moisture level (M_{100} and M_{60}), the treatments that received elevated temperature of +4^{0}C produced a greater number of leaves per plant than +2^{0}C and ambient conditions.

The mean leaf area per plant at 45 Day after planting was ranged from 25.9 to 70.3 cm^2, 20.9 to 60.3 cm^2 and 10.9 to 58.3 cm^2 during 1st, 2nd and 3rd generations, respectively. As that of plant height, the leaf area was also shown decreasing trend from 1st generation to 3rd generation. It was observed that, the leaf area per plant was significantly higher in the treatment number T_4 (+4^{0}C with M_{100}) followed by T_9 (+4^{0}C with M_{160}). The leaf area per plant was significantly lower in control (T_5, +0^{0}C with M_{100}), followed by T_{10} (+0^{0}C with M_{60}) in all three generation.

The results of different treatments on growth parameters of *C. rotundus* were positively influenced by elevated temperature and negatively by soil moisture stress. The elevated temperature of +4^{0}C and 100 per cent moisture produced significantly more height, leaves and leaf area than all other treatments. Ghannoum *et al*. (2000) and Sage and Kubien (2003) reported that the C_4 species respond positively to elevated higher temperature. Thus, *C. rotundus* better performed better under elevated temperature with enough soil moisture. The physiological plasticity of weeds and their greater intraspecific genetic variation compared with most crops could provide weeds with a competitive advantage in a changing environment. Controlling weeds is likely to be more difficult and expensive under climate change (Naidu 2015). *C. rotundus* growth would be more during rainy season and severely restricted during summer due to soil moisture variation. Also, the availability of a resource changes within the environment, it is more likely that weeds will show a greater variations in growth and reproductive response (Trumble 2013). Hence, the *C. rotundus* grew better under elevated temperature (Mandal *et al*. 2017a and b).

The mean value of total dry matter produced per plant at 45 DAP were ranged from 0.456 to 1.104 g/plant, 0.368 to 0.908 g/plant and 0.212 to 0.937 g/plant during 1st, 2nd and 3rd generations, respectively (**Table 3**). In general, the total and partitioned dry matter production by the *C. rotundus* was significantly higher in T_4 (+4^{0}C with M_{100}) during all the generation. The dry matter production was recorded significantly lower in T_{10} (+0^{0}C with M_{60}) during 1st generation then 2nd generation onwards T_5 (+0^{0}C with M_{100}) recorded significantly lower dry matter production than all other treatments.

At 45 DAP, the mean value of *C. rotundus* tubers per plant were ranged from 3.7 to 5.5, 3.7 to 6.6 and 2.8 to 5.7 during 1st, 2nd and 3rd generations, respectively (**Table 3**). In general, there was lesser number of tuber production during 3rd generation. Among the temperature levels, +4^{0}C elevated temperature treatments produced significantly more number of tubers than ambient and +2^{0}C temperatures treatments. The elevated temperature of +4^{0}C and 100 per cent moisture (T_4) resulted in significantly higher tubers than all ambient and +2^{0}C treatments either with or without moisture stress.

In general, the moisture stressed treatments (T_6 to T_{10}) had produced more flower than the non-stressed plants (**Table 3**). Among the temperature treatments, the elevated temperature of +4^{o}C produced more flowers than the ambient and +2^{o}C treatments. The ambient temperature treatments produced very small number of flowers compared to

Table 2. Effect of elevated temperature and soil moisture levels on plant height, number of leaves and leaf area of *Cyperus rotundus* at 45 days after planting during three generations

Treatment				Plant height (cm)			No. of leaves			leaf area (cm^2)		
No.	I Gen	II Gen	III Gen	I Gen	II Gen	III Gen	I Gen	II Gen	III Gen	I Gen	II Gen	III Gen
T_1	+2^{o}C + M_{100}	+2^{o}C + M_{100}	+2^{o}C + M_{100}	33.7	27.1	20.6	10.8	12.0	10.3	52.7	41.3	36.4
T_2	+2^{o}C + M_{100}	+2^{o}C + M_{100}	+4^{o}C + M_{100}	33.0	26.1	23.9	11.0	11.5	11.3	51.7	41.5	43.3
T_3	+2^{o}C + M_{100}	+4^{o}C + M_{100}	+4^{o}C + M_{100}	32.5	27.2	26.9	11.4	11.6	11.7	53.6	47.4	55.1
T_4	+4^{o}C + M_{100}	+4^{o}C + M_{100}	+4^{o}C + M_{100}	37.6	31.6	30.3	13.8	11.9	12.7	70.3	60.3	58.3
T_5	0^{o}C + M_{100}	0^{o}C + M_{100}	0^{o}C + M_{100}	28.2	21.6	12.2	11.2	9.7	8.3	28.4	20.9	10.9
T_6	+2^{o}C + M_{60}	+2^{o}C + M_{60}	+2^{o}C + M_{60}	31.8	25.4	19.9	10.1	10.3	8.7	36.9	36.6	21.1
T_7	+2^{o}C + M_{60}	+2^{o}C + M_{60}	+4^{o}C + M_{60}	31.1	26.7	24.3	10.2	10.0	10.0	38.0	35.6	34.7
T_8	+2^{o}C + M_{60}	+4^{o}C + M_{60}	+4^{o}C + M_{60}	31.4	26.8	26.1	11.2	11.3	10.7	38.0	40.1	40.8
T_9	+4^{o}C + M_{60}	+4^{o}C + M_{60}	+4^{o}C + M_{60}	35.9	27.4	28.0	12.2	11.6	11.3	55.4	44.0	47.8
T_{10}	0^{o}C + M_{60}	0^{o}C + M_{60}	0^{o}C + M_{60}	26.6	17.4	15.3	10.9	10.6	9.7	25.9	24.1	18.2
	Mean			32.2	25.7	22.8	11.3	11.0	10.5	45.1	39.2	36.7
	LSD (p=0.05)			23.1	2.5	2.6	1.1	1.1	1.2	4.5	3.8	2.1

Table 3. Effect of elevated temperature and soil moisture levels on number of flowers, number of tubers and total dry matter production of *Cyperus rotundus* at 45 DAP during three generations

Treatment				No. of flowers			No. of tubers			Total Dry Matter production (g/plant)		
No.	I Gen	II Gen	III Gen	I Gen	II Gen	III Gen	I Gen	II Gen	III Gen	I Gen	II Gen	III Gen
T_1	+2°C + M_{100}	+2°C + M_{100}	+2°C + M_{100}	0.0	0.0	1.0	5.3	6.3	2.8	0.849	0.648	0.587
T_2	+2°C + M_{100}	+2°C + M_{100}	+4°C + M_{100}	0.0	0.0	1.0	5.3	6.2	3.8	0.840	0.650	0.700
T_3	+2°C + M_{100}	+4°C + M_{100}	+4°C + M_{100}	0.0	0.0	1.3	5.0	6.5	5.4	0.853	0.718	0.858
T_4	+4°C + M_{100}	+4°C + M_{100}	+4°C + M_{100}	0.0	0.0	1.7	5.5	6.6	5.7	1.104	0.908	0.937
T_5	0°C + M_{100}	0°C + M_{100}	0°C + M_{100}	0.7	0.7	0.3	3.7	3.7	2.9	0.503	0.368	0.212
T_6	+2°C + M_{60}	+2°C + M_{60}	+2°C + M_{60}	0.0	0.0	1.3	4.5	5.4	2.9	0.646	0.584	0.398
T_7	+2°C + M_{60}	+2°C + M_{60}	+4°C + M_{60}	0.0	0.0	1.3	4.7	4.9	4.4	0.644	0.571	0.583
T_8	+2°C + M_{60}	+4°C + M_{60}	+4°C + M_{60}	0.0	0.0	1.7	4.7	5.5	4.7	0.629	0.605	0.650
T_9	+4°C + M_{60}	+4°C + M_{60}	+4°C + M_{60}	0.0	0.0	2.3	5.3	6.3	5.4	0.865	0.657	0.751
T_{10}	0°C + M_{60}	0°C + M_{60}	0°C + M_{60}	0.0	0.7	0.7	3.8	4.2	3.9	0.456	0.369	0.313
	Mean			0.1	0.1	1.3	4.8	5.6	4.2	0.739	0.608	0.599
	LSD (p=0.05)						0.6	0.6	0.5	0.117	0.090	0.075

elevated temperature treatments. The *C. rotundus* had the advantage of being C_4 plant in tuber production under elevated temperature.

Conclusion

C. rotundus had high acclimatization capacity and produced more growth under elevated temperature up to +4°C, with sufficient moisture. It is concluded that in the future under elevated temperature accompanied by adequate rain/moisture, *C. rotundus* might become a greater problematic weed and necessary management techniques that are effective under changing climatic conditions need to be evolved and implemented.

REFERENCES

Fuhrer J. 2003. Agro-ecosystem responses to combinations of elevated CO_2, ozone, and global climate change. *Agriculture Ecology and Environment* **97**(13): 1–20.

Ghannoum OCS, Ziska LH and Conroy JP. 2000. The growth response of C_4 plants to rising atmospheric CO_2 partial pressure a reassessment. Plant, *Cell and Environment* **23**: 931–942.

Gunasekera TGLG and Fernando DNS. 1994. Agricultural importance, biology, control and utilization *Cyperus rotundus*. *The Planter* **70**: 537–544.

Heschel MS and Riginos C. 2005. Mechanisms of selection for drought stress tolerance an avoidance in *Impatiens capensis* (Balsaminaceae). *American Journal of Botany* **92**: 37–44.

Holm LG, Plucknett DL, Pancho JV and Herberger JP. 1977. The World's Worst Weeds. Distribution and Biology. Honolulu, Hawaii, USA University.

IPCC (Intergovernmental panel on climate change) 2013. Climate change 2013 the physical science basis. (<http://www.ipcc.ch/report/ar5/wg1/>, March 2014).

Knapp AK, Beier C, Briske DD, Slassen AT, Luo Y and Reichstein M. 2008. Consequences of more extreme precipitation regimes for terrestrial ecosystems. *Bioscience* **58** (9): 811–821.

Mandal AK, Dheebakaran G, Banik M, Kumar A and Kumar V. 2017b. Impact of climate change on adaptation capacity of Horse purslane (*Trianthema portulacastrum*). *The Pharma Innovation Journal* **6**(11): 414–418.

Mandal AK, Dheebakaran G, Banik M, Kumar A and Prasad AS. 2017a. Response of Bermuda grass (*Cynodon dactylon*) growth under elevated temperature and moisture stress. *The Pharma Innovation Journal* **6**(12): 83–87.

Naidu VSGR and Murthy TGK. 2014. Crop-weed interactions under climate change. *Indian Journal of Weed Science* **46**(1): 61–65.

Naidu VSGR. 2015. Climate change, crop-weed balance and the future of weed management. *Indian Journal of Weed Science* **47** (3): 288–295.

Parsons WT and Cuthbertson EG. 2001. Noxious weeds of Australia. Second Edition. CSIRO Publishing, Collingwood, Melbourne. pp. 60–62.

Sage RF and Kubien DS. 2003. An eco-physiological perspective on global change and the future of C_4 plants. *Photosynthesis Research* **77**: 209–225.

Trumble J. 2013. Climate change: predicting pest problems and planning for the future. Presented at the California department of food and agriculture climate change adaptation consortium, American Canyon, CA. pp.23–27.

Walck JL, Hidayati SN, Dixon KW, Thompson K and Poschlod P. 2011. Climate change and plant regeneration from seed. *Global Change Biology* **17**: 2145–2161.