

## Effects of Soil Moisture Stress on the Nitrate Reductase Activity of Selected Chilli (*Capsicum annuum* L.) Cultivars during the Flowering Stage and its Impact on Yield

S Mahendran and N Sujirtha\*

Department of Agricultural Biology, Faculty of Agriculture, Eastern University, Sri Lanka

### Abstract

Enzyme nitrate reductase (NR) plays a key role in the nitrogen metabolism in the plant kingdom. NR activity is sensitive to the changes in the water status of the plant and is inhibited when the water potential of the plants decreases. An experiment was conducted to determine the effects of soil moisture stress on the NR activity of three chilli cultivars viz. MI 2, KA 2 and "Arunalu". Moisture stress was imposed for a period of 15 days during the flowering stage. The plants, which served as the control, were watered to Field Capacity at 5 day intervals. Moisture stress significantly reduced the NR activity of all the chilli cultivars. The highest reduction was observed in the MI 2 followed by KA 2 and "Arunalu". Cultivar "Arunalu" showed the highest NR activity among the tested cultivars, despite the severe stress situation. A high NR activity would have contributed for stress tolerance in this cultivar. Moisture stress significantly reduced the yield of all the chilli cultivars. The highest reduction was found in the MI 2 followed by KA 2 and "Arunalu". No significant difference was observed in the yield of KA 2 and "Arunalu". These two cultivars were able to produce substantially high yields under water deficit situation. Increased NR activity of "Arunalu" under drought situation would have enhanced the growth and development, which would have resulted in a substantially high yield in this cultivar compared to the others.

**Keywords:** Nitrate reductase, Soil moisture stress, Stress tolerance, Yield

**\*Corresponding author:** sujee3@gmail.com

### Introduction

Agricultural production of crop plants has always been a risky business, which is strongly influenced by environmental stresses. Water deficit is often the major factor inhibiting crop yields in semi-arid and arid regions. Since multitude of factors potentially involved in drought resistance, it is unlikely that any single measurement can provide an all-encompassing test of drought resistance.

Chillies are the green or dried ripe fruits of pungent forms of *Capsicum annuum* L. The cultivars such as MI 1, MI 2, KA 2 and "Arunalu" are recommended for cultivation by the Department of Agriculture. Chili produce well under irrigation and under rain-fed cultivation, require 60–100 cm of rainfall. The moisture content of the soil has an important effect on the growth and yield of chillies (Senewiratne and Appadurai, 1996). Nitrate accumulation in plants happens due to several factors, among which drought is possibly the most important. Two enzymes, nitrate reductase and nitrite reductase catalyze reduction of nitrate to ammonia. Nitrate reductase is considered important in relation to nitrogen metabolism and plant growth. It is extremely sensitive to water stress and is inhibited rapidly under water stress (Sinha and Nicholas, 2000). It has been suggested that low water availability to plants may lead to changes in the enzyme activity due

to the change of the free energy of water within the cells.

The decrease in the NR activity may be an important mechanism for the control of plant metabolism under stress conditions. Since photosynthesis decreases under moisture stress conditions, energy requirements could be reduced by slowing the synthetic processes. These could be limited by the decrease of the rate of assimilation of nitrates, the principal source of nitrogen for most plants. Such a control would result from a substantial loss of NR activity in stress periods. Hence, the assessment of NR activity is used to screen crop plants for drought tolerant capacity.

The present study was conducted with the objectives of estimating the NR activity in selected chilli cultivars, which were subjected to moisture stress and to determine the extent of stress tolerance of these cultivars based on this enzyme activity.

### Materials and Methods

This experiment was conducted in the "Yala" 2015 on a farmer's field near the Eastern University of Sri Lanka, which is located at an elevation of 75 m above mean sea level. The soil of this area is sandy regosol. The mean annual rainfall ranges from 1200–1500 mm. The

maximum and minimum temperatures range from 33-36°C and 22 – 25°C, respectively.

#### Land preparation and Cultural practices

The land was cleared of stubbles and twenty-four plots (3m×2m) were constructed. Rain shelters were erected. Chilli (*Capsicum annuum* L.) seeds of cvs. MI 2, KA 2 and "Arunalu" were treated with captan (50% WP) solution (200 gl<sup>-1</sup> H<sub>2</sub>O) before sowing on the nursery beds. The seedlings were transplanted at a spacing of 60cm × 45cm. The fertilizer mixture was applied based on the recommendation of the Department of Agriculture and the experiment was managed in accordance with the recommended cultural practices.

The experiment was in 3×2 factor factorial arrangement and laid out in the Randomized Complete Block Design with four replicates.

Main treatment factors were three chilli cultivars (MI 2, KA 2 and *Arunalu*) and two water stress conditions (control; watering to field capacity every 5 days and water stress for 15 days during flowering period).

Therefore, the treatments were as follows:

- T<sub>1</sub> Moisture stress was imposed for the MI 2 chilli cultivar during the flowering stage for a period of 15 days
- T<sub>2</sub> Regular watering of MI 2 chilli cultivar to Field Capacity at 5 day intervals
- T<sub>3</sub> Moisture stress was given for the KA 2 chilli cultivar during the flowering stage for a period of 15 days
- T<sub>4</sub> Regular watering of KA 2 chilli cultivar to Field Capacity at 5 day intervals
- T<sub>5</sub> Moisture stress was exerted for the "Arunalu" cultivar of chilli during the flowering stage for a period of 15 days
- T<sub>6</sub> Regular watering of "Arunalu" cultivar of chilli to Field Capacity at 5 day intervals

#### Estimation of Nitrate Reductase Activity

Nitrate reductase activity was determined by applying the *in vivo* nitrate reductase assay by described by Kapoor and Li (2002). Samples of fully expanded leaves (third and fourth leaves from the apex) were combined (four replicates) and the analysis was performed.

#### Fruit Yield

Ripened fruits were harvested in six pickings at two week intervals from the tested plants. The fruits were oven dried at 105°C for 48 hours and their dry weights were recorded. The data were statistically analyzed and the difference between means was compared using DMRT.

#### Results and Discussion

In all the treatments where moisture stress was imposed for the selected chilli cultivars during the flowering stage, NR activity on the 15<sup>th</sup> day from the commencement of the stress was significantly lower than the control values (Table 1).

**Table 1:** The effect of soil moisture stress on the nitrate reductase activity of selected chilli cultivars during the flowering stage

Cultivars	Nitrate Reductase Activity µg NO <sub>2</sub> g <sup>-1</sup> h <sup>-1</sup>	
	Stressed	Control
MI 2	529 <sup>d</sup>	1897 <sup>a</sup>
KA 2	810 <sup>c</sup>	1935 <sup>a</sup>
"Arunalu"	1203 <sup>b</sup>	2112 <sup>a</sup>

Values in the same column followed by the same letter do not differ significantly (p < 0.05).

\*Values are the means of 40 plants in 4 replications.

It was also observed that there were significant differences between treatments in the NR activity of chilli on the 15<sup>th</sup> day from the commencement of the stress. "Arunalu" cultivar of chilli showed the highest NR activity followed by KA 2 and MI 2 chilli cultivars under moisture stress condition.

Based on this observation it is suggested that moisture stress reduced the NR activity of all the chilli cultivars. The highest reduction was observed in the MI 2 followed by KA 2 and "Arunalu". As pointed out by Pandey and Agarwal (2006), NR activity showed a decline under stress conditions. In various crop species, NR activity was often shown to decline due to water stress. In field – grown wheat plants, water stress caused a gradual decline in NR activity in leaves. Chen and Sung (2007) stated that the NR in the leaves of higher plants is very sensitive to changes in water status of the plant. They also indicated that the inhibitory effect of water stress on NR has been attributed to the reduced enzyme synthesis or enzyme induction.

NR activity is considered to be a limiting factor for higher plant protein production, development and growth. It is generally accepted that drought stress has a negative effect on plant photosynthetic activity, N concentration, free aminoacids or soluble protein contents accompanied by a decline in NR activity. As energy and C skeletons required for N assimilation are provided by photosynthesis, a high rate of CO<sub>2</sub> assimilation favours a high rate of N assimilation and vice versa. The NR activity decline during water stress is mainly attributed to low NO<sub>3</sub><sup>-</sup> absorption and availability resulting from water uptake deprivation.

The chilli cultivar "*Arunalu*" exhibited the highest NR activity among the tested cultivars despite a severe stress situation. A high NR activity would have contributed for stress tolerance in this cultivar. Maranville and Sullivan (2005) have established distinct classes of drought tolerance in sorghum, ranging from tolerant to susceptible types. When they tested the effect of drought on a range of these genotypes, they observed that the most tolerant types showed highest NR activity. The rate of disappearance of enzyme activity and leaf water status are indications of drought tolerance/susceptibility. However, according to Sinha and Nicholas (2000), it is difficult to establish a cause and effect relationship between growth and NR activity, although it is generally true that plants showing high growth rates also actively assimilate inorganic nitrogen compounds and often have high NR activity.

#### **Yield**

It was found that there were significant differences between treatments in the yield of chilli. The yield of regularly watered MI 2, KA 2 and "*Arunalu*" chilli cultivars were 3413 kg ha<sup>-1</sup>, 2417 kg ha<sup>-1</sup> and 2183 kg ha<sup>-1</sup>, respectively. Moisture stress significantly reduced the yield of all the chilli cultivars. 772 kg ha<sup>-1</sup> of yield was observed in MI 2, 982 kg ha<sup>-1</sup> in KA 2 and 1099 kg ha<sup>-1</sup> in "*Arunalu*". There was no significant difference in the yield of KA 2 and "*Arunalu*". These two cultivars were able to produce substantially high yield under water deficit situation. Increased NR activity of "*Arunalu*" under drought condition would have contributed for the growth and development and as a result "*Arunalu*" was able to produce a substantially high yield compared to the others.

#### **Conclusions**

Moisture stress reduced the NR activity of all the tested chilli cultivars. Chilli cultivar "*Arunalu*" showed the highest NR activity followed by "KA 2" and "MI 2" under moisture stress condition. Moisture stress also reduced the yield of all the chilli cultivars. "*Arunalu*" showed the highest yield and while MI 2 recorded the lowest yield, under water deficit conditions. Increased NR activity of "*Arunalu*" compared to the other chilli cultivars under drought condition would have contributed for the increased yield obtained in this cultivar.

#### **References**

- Chen CL and Sung JM 2007. Effect of Water Stress on the Reduction of Nitrate and Nitrite by Soybean Nodules. *Plant Physiol.* 97:1065-1066.
- Kapoor AC and Li PH 2002. Effects of age and variety on nitrate reductase and nitrogen fractions in potato plants. *J. Sci. Food Agric.* 53:401-406.
- Maranville JW and Sullivan CY 2005. In "The Physiology of yield and management of sorghum in relation to genetic improvement". University of Nebraska Press, Lincoln, Nebraska.
- Pandey R and Agarwal RM 2006. Water stress-induced changes in proline contents and Nitrate Reductase Activity in rice under light and dark conditions. *Physiol. Mol. Biol. of Plants* 12:53-57.
- Senewiratne ST and Appadurai RR 1996. Field crops of Ceylon. Lake House Investments Ltd, Lake House, Colombo, Sri Lanka.
- Sinha SK and Nicholas DJD 2000. Nitrate Reductase In: The Physiology and Biochemistry of Drought Resistance in Plants. (LG Paleg and D Aspinall) Eds. Academic Press, London, UK. Pp.145-169.