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A Comparative Study on the Response of *Calotropis procera* (Ait.) Ait. (Sadom Apple) to a Combined Treatments of Drought and Salinity

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Abstract. For the well known importance of *Calotropis procera* (Ait.) Ait., the present work is therefore carried out to test the effect of drought and salinity on the germination, the vegetative growth of *Calotropis procera* as well as the concentrations of Ca, Mg, K, Na and Cl.

Different levels of soil moisture treatments were used (100, 75, 50, 25, 10 and 5%) in the presence or absence of salinity treatment (48 mmole).

The low soil moisture treatments affected leaf area and the root length especially in the presence of salinity, but the plant height and width were the least affected of all plant dimensions. The seedlings survived in a very low soil moisture contents (5% and 10%) in the presence and absence of salinity. The root weights and the plant water content had been affected by soil water deficit. Elements accumulation behavior by the root has been shown. The results suggested a drought tolerance in this plant.

Introduction

In Saudi Arabia, dry and saline habitats are extensive (Annon, 1985). These habitats are inhabited by different plant species including *Calotropis procera* (Ait.) Ait. (Mahmoud *et al.,* 1984) a plant species that has a reputation of wide amplitude in Saudi Arabia (Migahid, 1990). Some aspects of the biology of this plant in the region were investigated before. Mahmoud *et al.* (1983) investigated the germination responses of this plant to temperature; same authors (1984) reported on the germination responses of *Calotropis procera* to seawater treatments, whereas Hajar (1996) has reported on the photosynthetic pigments, growth, and elements content responses of this plant to seawater salinity. The latter author suggested that *Calotropis procera* has a good degree of salt tolerance.

On the other hand, as yet, there were no information available on the effect of drought on the growth and mineral content of this plant species. Thus, the present study was conducted to study the interactive effects of drought and salinity on the germination, the early vegetative growth of *Calotropis procera* along with the concentrations of some important minerals (Ca, Mg, K, Na and Cl).

Material and Methods

Seeds of *Calotropis procera* (Ait.) Ait. were collected from freshly gathered ripe fruits, obtained from various shrubs growing in Jeddah area (Lat. 40º, 21′ Longt. 9º, 39′). Five seeds were sown in each 10 cm diameter perforated plastic pot containing 206 g peat moss. Prior to seeds sowing the field capacity of this soil was determined to evaluate the available moisture range. Different levels of available moisture were then made (100%, 75%, 50%, 25%, 10% and 5%). Hajar (1997) modified this method from Abd-El-Rahaman and Monayeri (1968). Each treatment of soil moisture was a combined with 48 mmole of NaCl salinity or used without salinity.

The pots were arranged inside a greenhouse maintained at 25ºC ± 2º and 14 hr daylight in a completely randomized design. The seeds were started to germinate on the third day of sowing. Germinated seeds in all treatments recorded daily for a week. The germination test continued until no seedling emerged for another week. In the present work seeds were considered to be germinated by the seedlings emergence. The soil moisture in each treatment was regulated daily according to Premachandra *et al.* (1992). The seedlings were kept under the growing conditions stated above for two months. Then, various parameters were studied; these include plant height and width, the area of the largest leaf, root length, shoot and root fresh and dry weights, and the water content of the plants. Plants (5) from each treatment were collected, then dried in an aerated oven at 75ºC to constant weight, ground into a fine powder and assayed for minerals (Ca, Mg, K, Na and Cl). The flame photometer absorption method was used for the determination of Ca, Mg, K and Na (Humphries 1956). The Cl was determined according to Jackson and Thomas (1960). The data were tabulated in $\chi \pm$ S.E. Five replicates were used and the product-moment correlation coefficients (γ) were calculated.

Results and Discussion

It is clear from Table 1 that the plant dimensions of *C. procera* decreased with the decrease in the soil moisture, especially in the presence of salinity. The decrease was more pronounced in the leaf area and root length. The plant height and width were the least affected of the plant dimensions. Compared with the control (100% soil moisture), the decrease in both characters was less than 50% in the presence and absence of salinity. The individuals of this plant, however, managed to grow and persist in a very low soil moisture contents (*e.g.* 10% and 5%) in the presence and absence of salinity. This may suggest a degree of drought and salinity tolerance behavior in this plant, as reported by Hajar (1996) who found that the young plant of *C. procera* exhibited a salt tolerance.

The plant weights of *C. procera* were, in general, affected by the decrease in the soil moisture (Table 2). The root dry weights of plants grown under some of the water deficit treatments in the presence of salinity were, however, higher than those grown in the control treatment (*e.g.* the 10% and 25% treatments), and than those grown under drought treatments in the absence of salinity treatment (*e.g.* 5%, 10% and 25% treatments). The results of the shoots and roots water contents reflected a clear similarities between the water deficit treatments and the control treatment. This suggests that the water content of *C. procera* shoots and roots had not been affected by the drought treatments in both the presence and the absence of salinity, and may suggest a combined drought and salinity tolerance in this plant.

TABLE 1. Effect of soil moisture (0) and the combined effect of soil moisture and salinity (48) on the plant growth of *C. procera.*

Soil moisture %	Salinity level (mmole)	Plant height (cm)	Plant width (cm)	Leaf area (cm^2)	Root length (cm)
100	0	15 ± 0.3*	13 ± 0.2	13 ± 0.7	24 ± 0.3
	48	11 ± 0.3	11 ± 0.4	09 ± 0.6	11 ± 0.3
75	0	16 ± 0.9	12 ± 0.7	13 ± 0.3	22 ± 0.4
	48	11 ± 0.1	10 ± 0.4	08 ± 0.2	08 ± 0.2
50	0	14 ± 0.3	11 ± 0.8	09 ± 1.2	19 ± 1.3
	48	10 ± 0.3	10 ± 0.2	07 ± 0.9	06 ± 0.5
25	0	11 ± 0.3	10 ± 0.2	08 ± 1.2	18 ± 1.2
	48	09 ± 0.2	09 ± 00	05 ± 0.2	06 ± 0.5
10	0	10 ± 0.2	09 ± 0.3	07 ± 0.6	07 ± 1.3
	48	08 ± 0.2	07 ± 0.3	04 ± 0.1	06 ± 0.2
5	0	10 ± 0.5	08 ± 0.4	05 ± 0.5	06 ± 0.2
	48	07 ± 0.4	07 ± 0.5	03 ± 0.1	04 ± 0.3

*mean ± s.e.

TABLE 2. Effect of soil moisture (0) and the combined effect of soil moisture and salinity (48) on the plant weights and water content of *C. procera.*

Soil moisture %	Salinity level (mmole)	Shoot fresh weight (g)	Shoot dry weight (g)	Root fresh weight (g)	Root dry weight (g)	Shoot water content g.w / g.f.w.	Root water content g.w. / g.f.w.
100	0	1.3 ± 0.1	0.13 ± 0.024	0.15 ± 0.02	0.013 ± 0.002	0.90 ± 0.12	0.91 ± 0.2
	48	0.8 ± 0.14	0.06 ± 0.015	0.063 ± 0.0067	0.002 ± 0.0006	0.93 ± 0.15	0.97 ± 0.1
75	0	1.1 ± 0.14	0.073 ± 0.009	0.089 ± 0.007	0.01 ± 0.0003	0.93 ± 0.1	0.89 ± 0.15
	48	0.6 ± 0.06	0.057 ± 0.017	0.04 ± 0.006	0.0028 ± 0.001	0.91 ± 0.11	0.93 ± 0.16
50	0	1.03 ± 0.03	0.081 ± 0.005	0.087 ± 0.019	0.013 ± 0.0065	0.92 ± 0.12	0.85 ± 0.11
	48	0.73 ± 0.09	0.059 ± 0.009	0.047 ± 0.0033	0.0023 ± 0.0003	0.92 ± 0.10	0.95 ± 0.13
25	0	1.03 ± 0.03	0.074 ± 0.016	0.087 ± 0.002	0.01 ± 0.003	0.96 ± 0.2	0.89 ± 0.14
	48	0.73 ± 0.09	0.038 ± 0.0013	0.047 ± 0.0033	0.003 ± 0.0001	0.95 ± 0.3	0.94 ± 0.15
10	0	0.67 ± 0.05	0.074 ± 0.007	0.06 ± 0.01	0.0047 ± 0.0009	0.89 ± 0.1	0.92 ± 0.12
	48	0.4 ± 0.0	0.033 ± 0.0003	0.04 ± 0.002	0.0023 ± 0.0003	0.92 ± 0.2	0.92 ± 0.20
5	0	0.43 ± 0.009	0.033 ± 0.0013	0.053 ± 0.015	0.0037 ± 0.00009	0.92 ± 0.3	0.93 ± 0.30
	48	0.21 ± 0.005	0.017 ± 0.003	0.03 ± 0.0	0.0017 ± .00003	0.92 ± 0.1	0.94 ± 0.20

The influence of the drought treatments (in the presence and absence of salinity) on the shoot and root contents of Ca, Mg, K, Na and Cl are shown in Figures 1a, b; 2a, b; 3a, b; 4a, b and 5a, b respectively. Their linear regressions were fitted together with the product-moment correlation coefficient (γ) and their P-values. These figures showed different results, for the tested elements and both, shoot and root.

In the presence of salinity the shoot elements have shown a trend of increase with the decrease of soil moisture, but the increase was not significant except that of K which was significant at P = 0.1. In the absence of salinity, there was an increase in all elements with the decrease in the soil moisture except that of Ca which was significantly increased with the increase in the soil moisture (at p = 0.1). For the root, there was an increase in the Ca, Na and Cl contents, with that of the latter two elements being significant at p = 0.01 and at p = 0.05, respectively. A significant decrease (at p = 0.01 for both Mg and K) was noticed with the decrease in the soil moisture. In the absence of salinity there was an increase in all elements with the decrease in the soil moisture except for Ca, which had significantly decreased (at p = 0.1) with the decrease in the soil moisture. The increase was also significant for Mg (at p = 0.02) and for Cl (at p = 0.1), and not significant for K and Na.

The figures 1 to 5 showed that *C. procera* plants, in the presence or absence of salinity accumulated more elements in the roots than in the shoot, except Ca. Similar results were reported by Hajar (1996) for the same plant which was grown under salinity treatments. These results indicate that this plant may restrict the translocation of elements which have toxic effect (*e.g.* Na and Cl) from the root to the shoot, which reflected a tolerance behavior. The same author also reported an increase in the root content of elements which have antagonistic effects on the toxic elements, including Mg and K. This agrees with the results in the present work. Moreover, the accumulation of elements in the root by this plant in the presence of drought could be taken as a drought tolerant behavior. Such finding agrees with previous reports (*e.g.* Nezgovorova, 1957; Kramer, 1983 and Hajar, 1997).

In conclusion, the results of the present work strongly suggest that *C. procera* has a good degree of drought tolerance even in the presence of salinity. This should enhance more investigations on the ecology of this widely distributed plant species.

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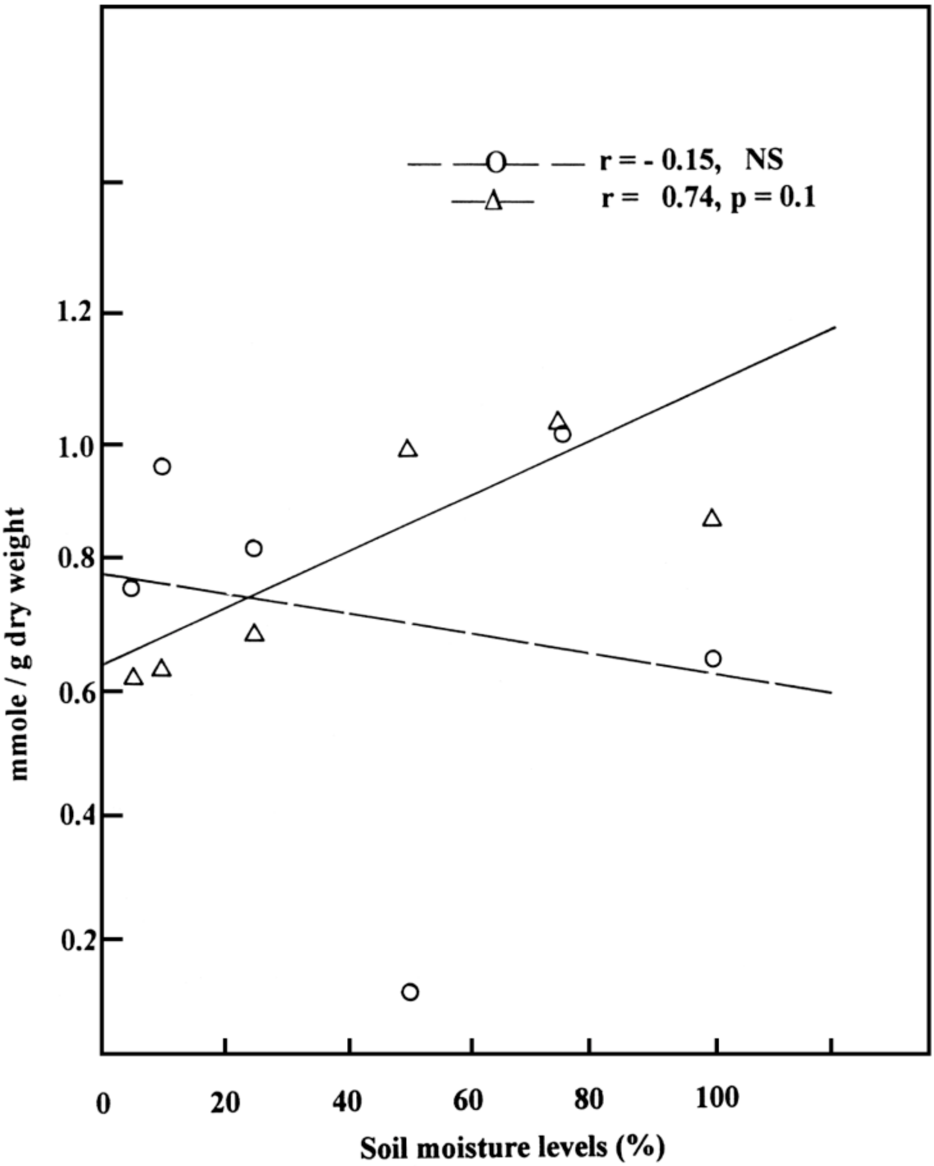

FIG. 1a. The relationships between Ca (mmol/g dry weight) in the shoot of *C. procera* and the soil different moisture levels, in the present (—— —— O —— ——) and absence (—— Δ ——) of salinity [Product moment correlation coefficients (γ) and their p-values].

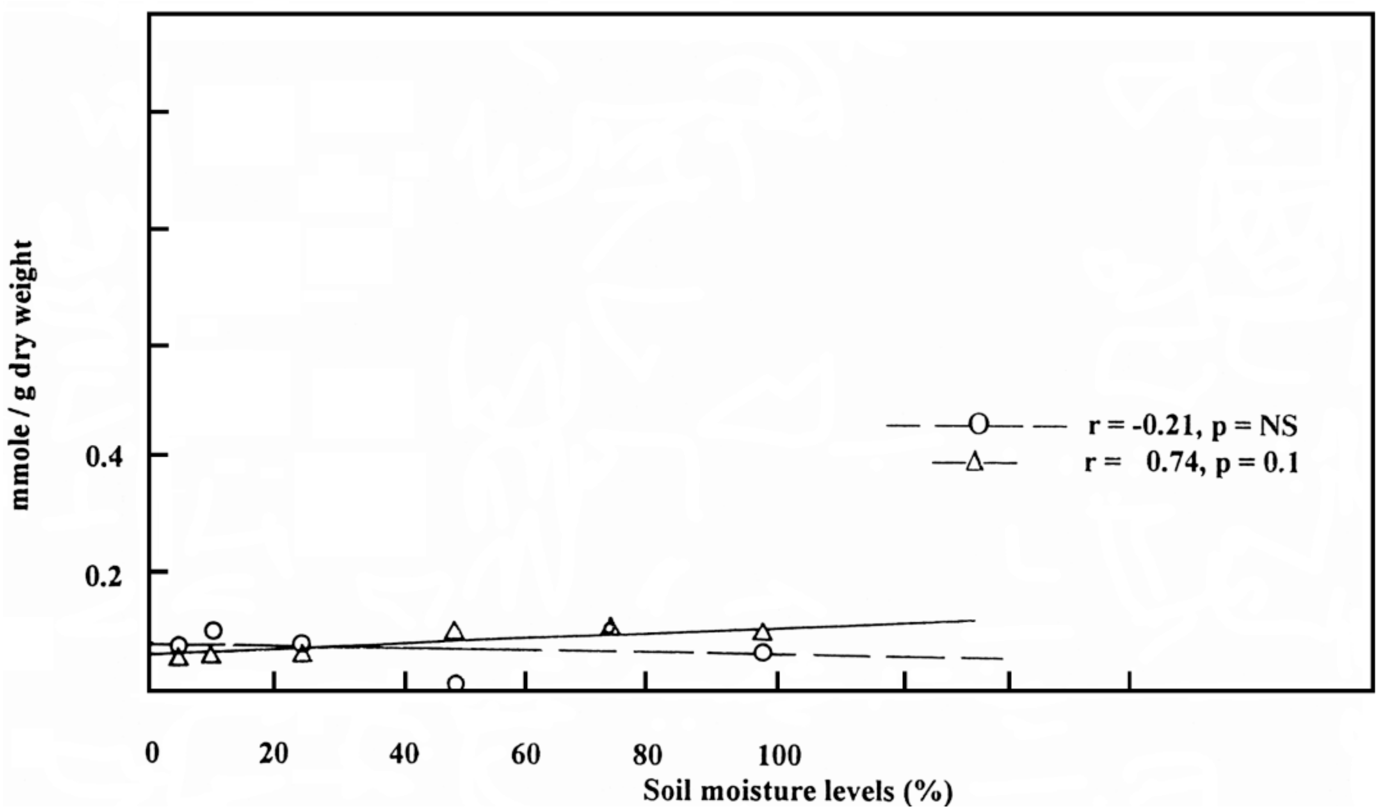

FIG. 1b. The relationships between Ca (mmol/g dry weight) in the root of *C. procera* and the soil different moisture levels, in the present (—— —— O —— ——) and absence (—— Δ ——) of salinity [Product moment correlation coefficients (γ) and their p-values].

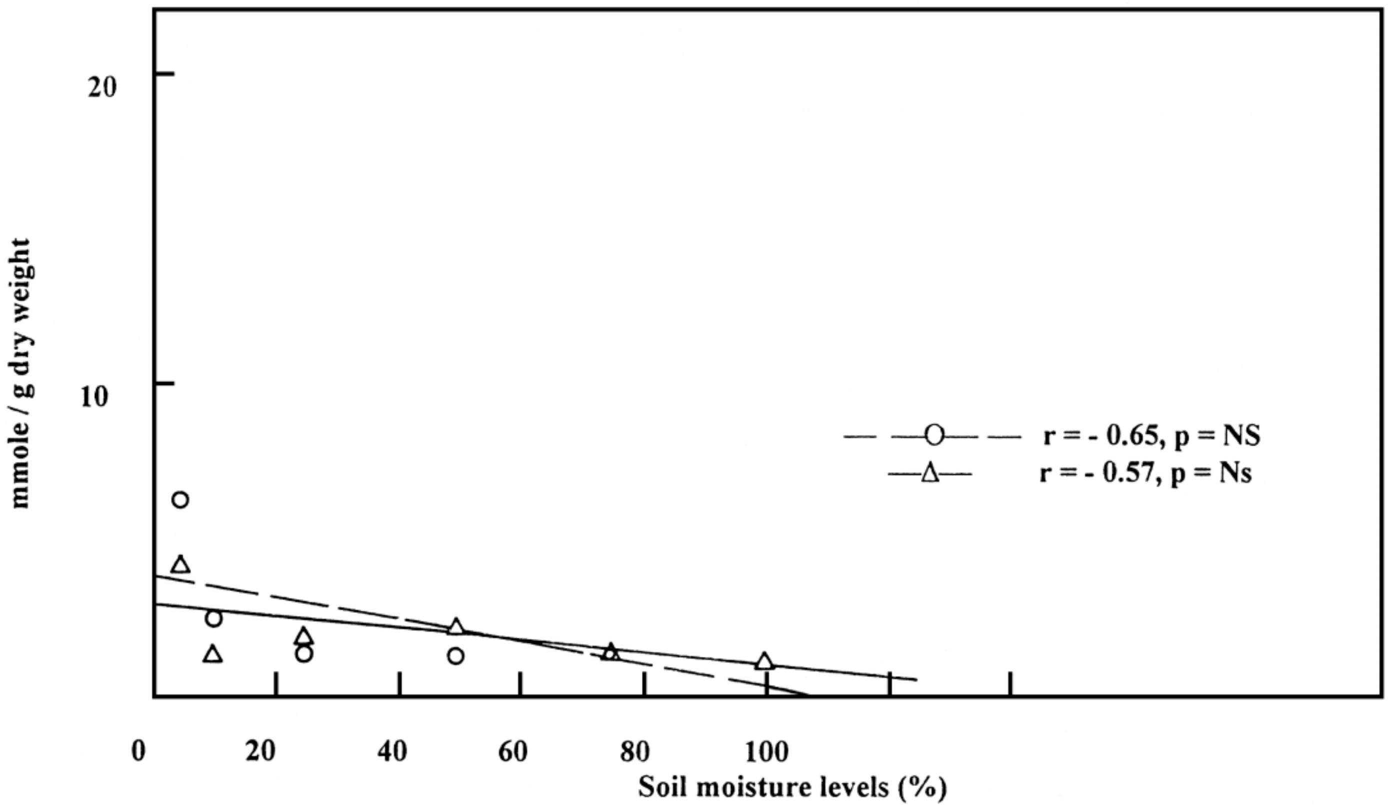

FIG. 2a. The relationships between Mg (mmol/g dry weight) in the shoot of *C. procera* and the soil different moisture levels, in the present (—— —— O —— ——) and absence (—— Δ ——) of salinity [Product moment correlation coefficients (γ) and their p-values].

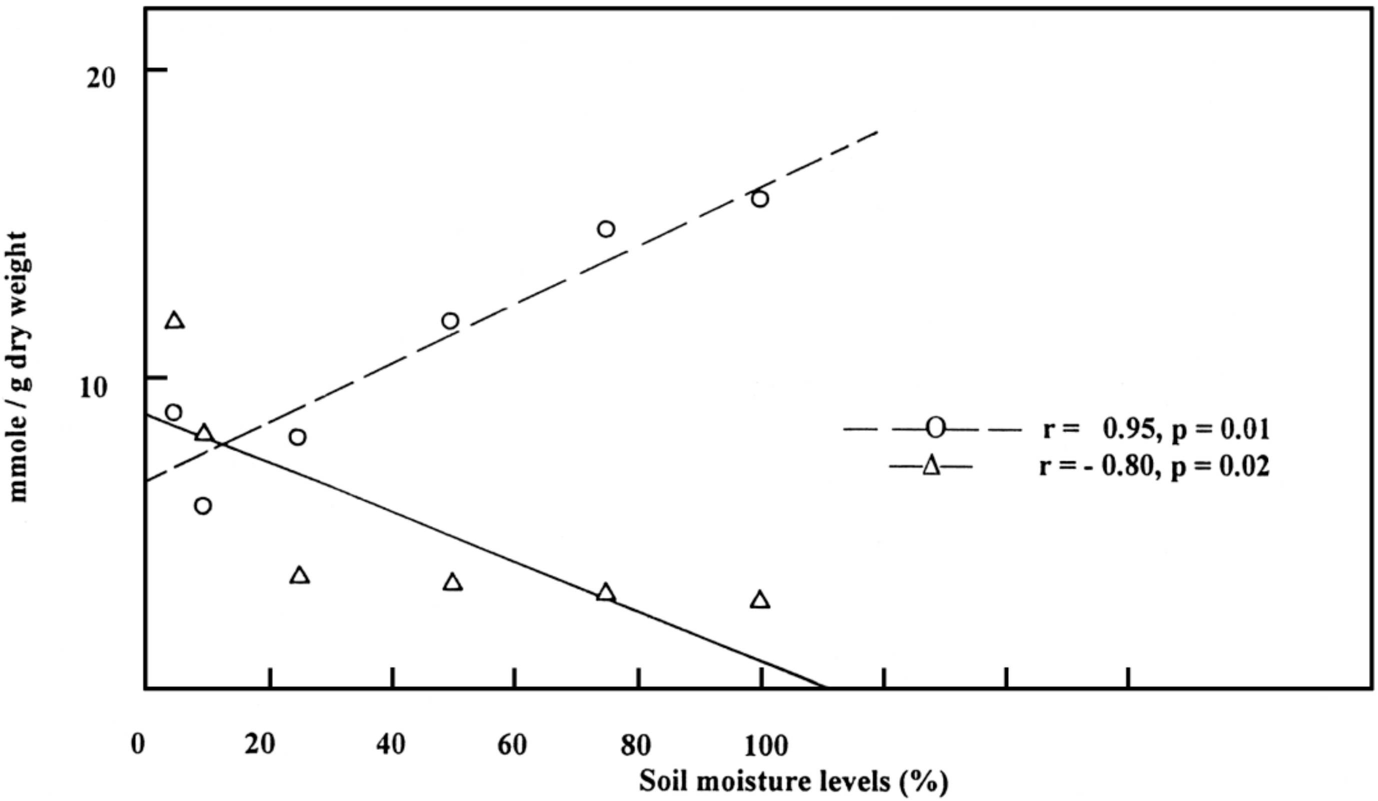

FIG. 2b. The relationships between Mg (mmol/g dry weight) in the root of *C. procera* and the soil different moisture levels, in the present (—— —— O —— ——) and absence (—— Δ ——) of salinity [Product moment correlation coefficients (γ) and their p-values].

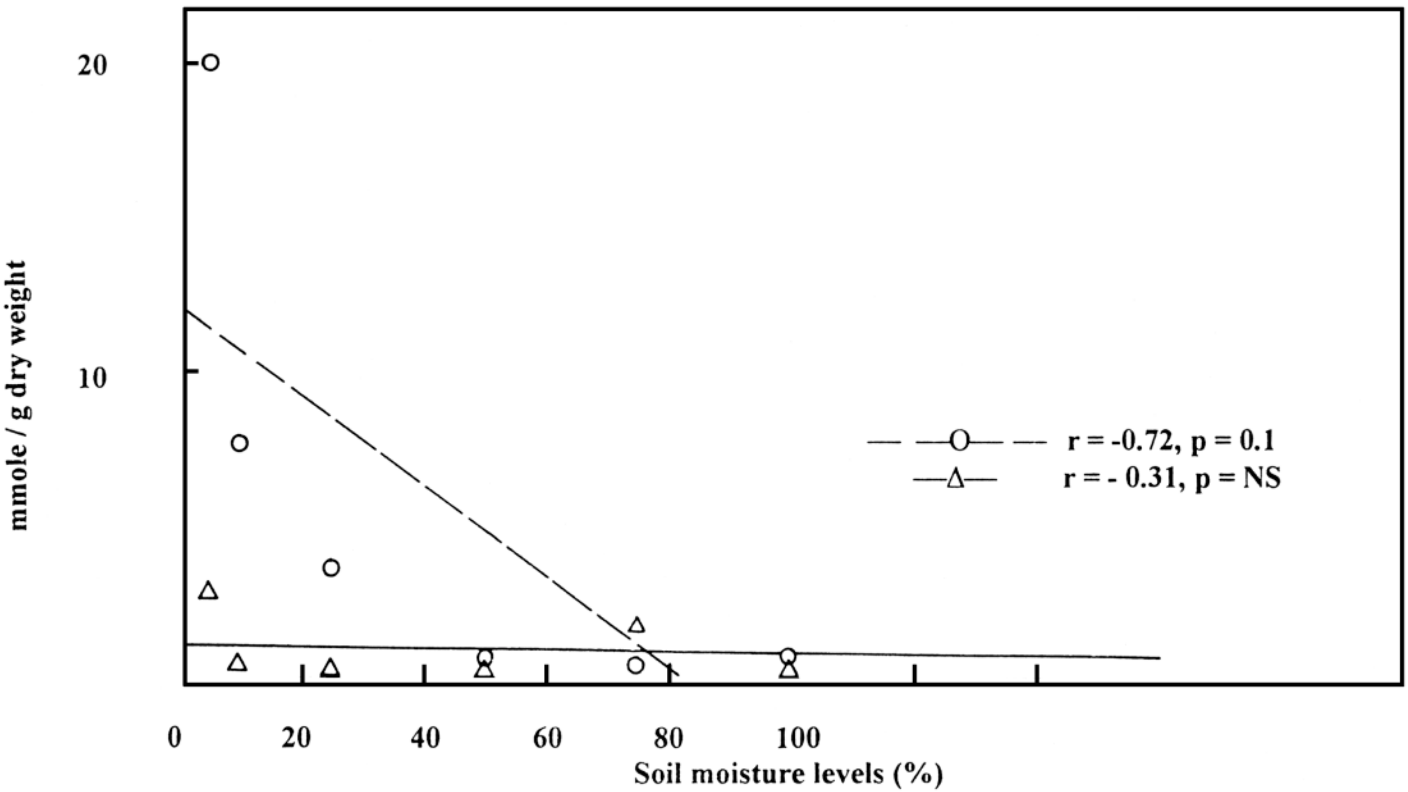

FIG. 3a. The relationships between K (mmol/g dry weight) in the shoot of *C. procera* and the soil different moisture levels, in the present (—— —— O —— ——) and absence (—— Δ ——) of salinity [Product moment correlation coefficients (γ) and their p-values].

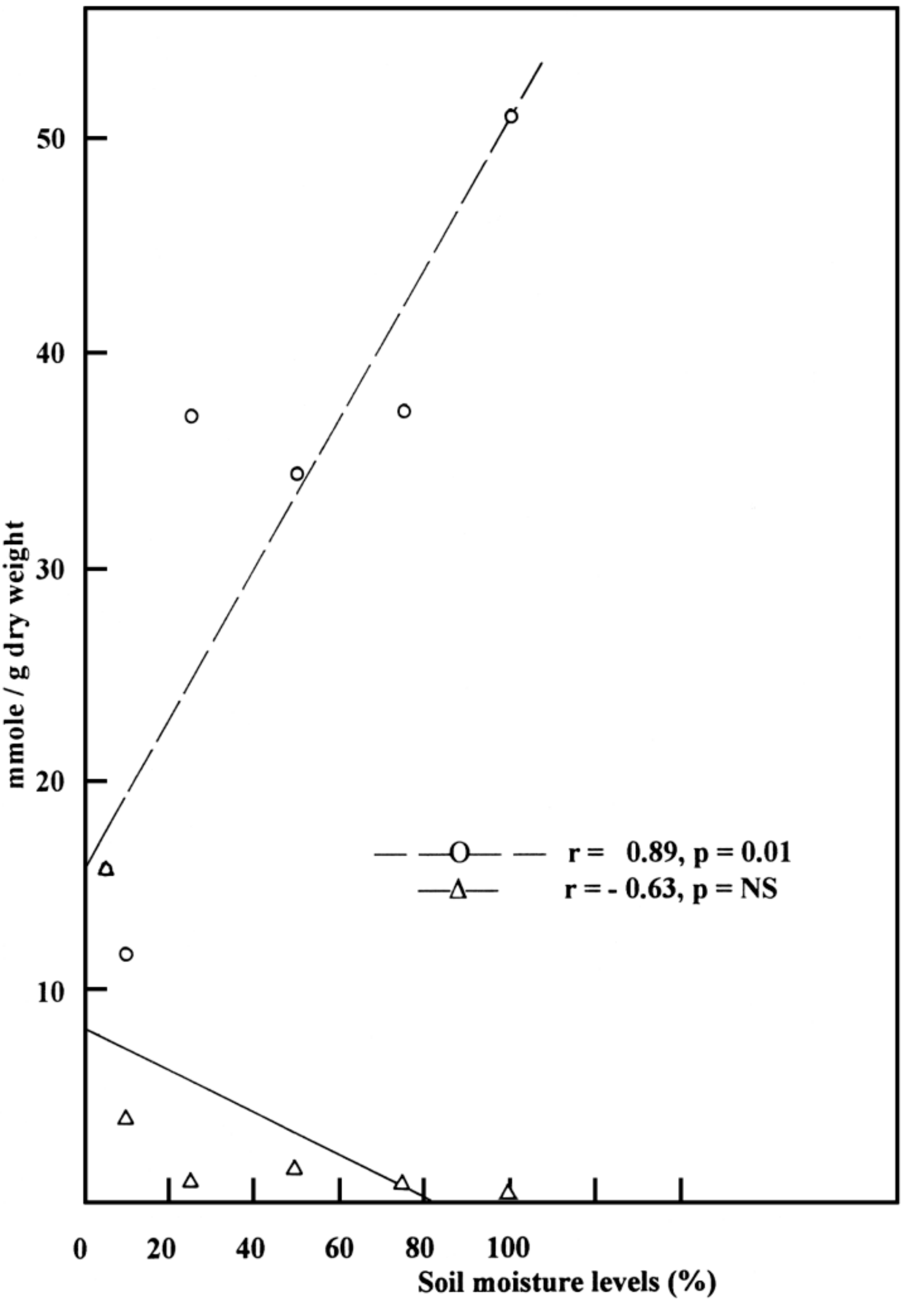

FIG. 3b. The relationships between K (mmol/g dry weight) in the root of *C. procera* and the soil different moisture levels, in the present (—— —— O —— ——) and absence (—— Δ ——) of salinity [Product moment correlation coefficients (γ) and their p-values].

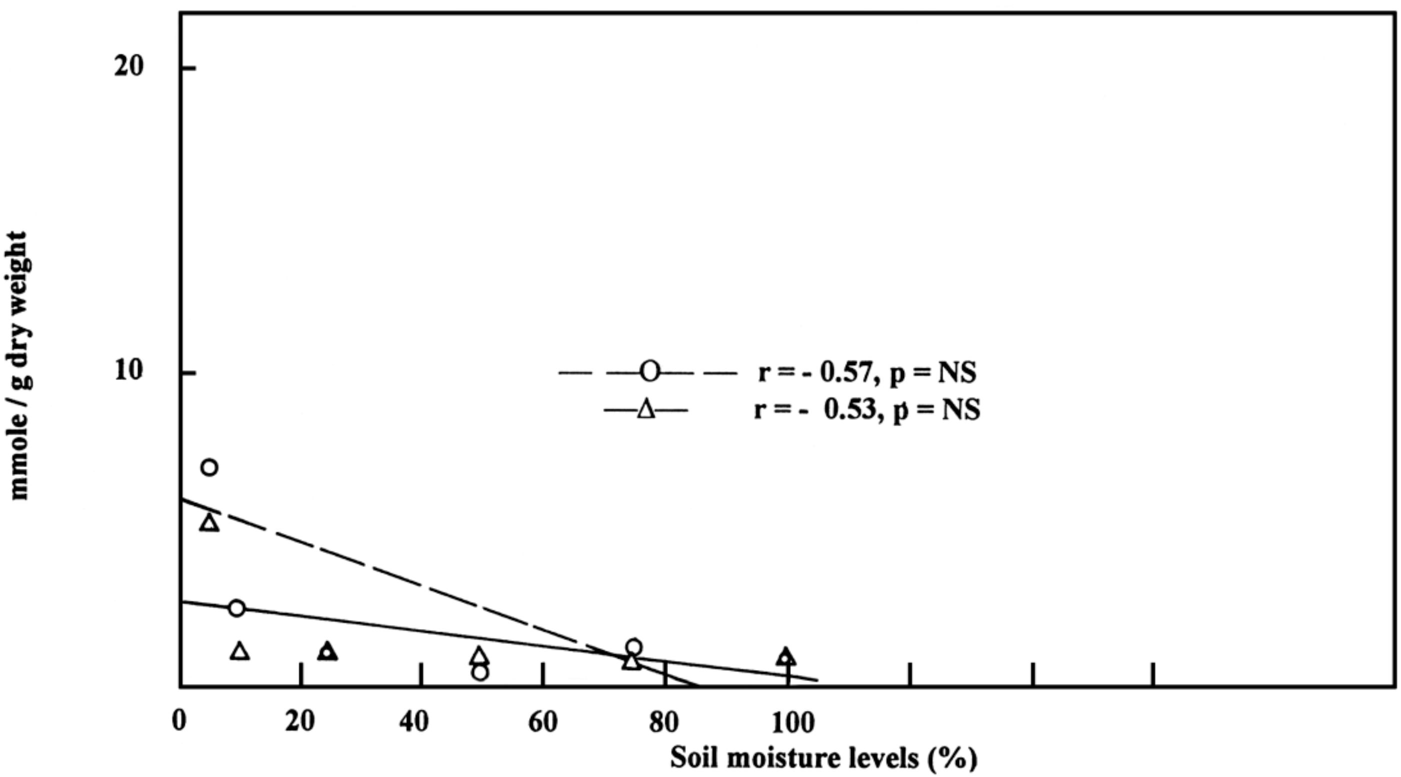

FIG. 4a. The relationships between Na (mmol/g dry weight) in the shoot of *C. procera* and the soil different moisture levels, in the present (—— —— O —— ——) and absence (—— Δ ——) of salinity [Product moment correlation coefficients (γ) and their p-values].

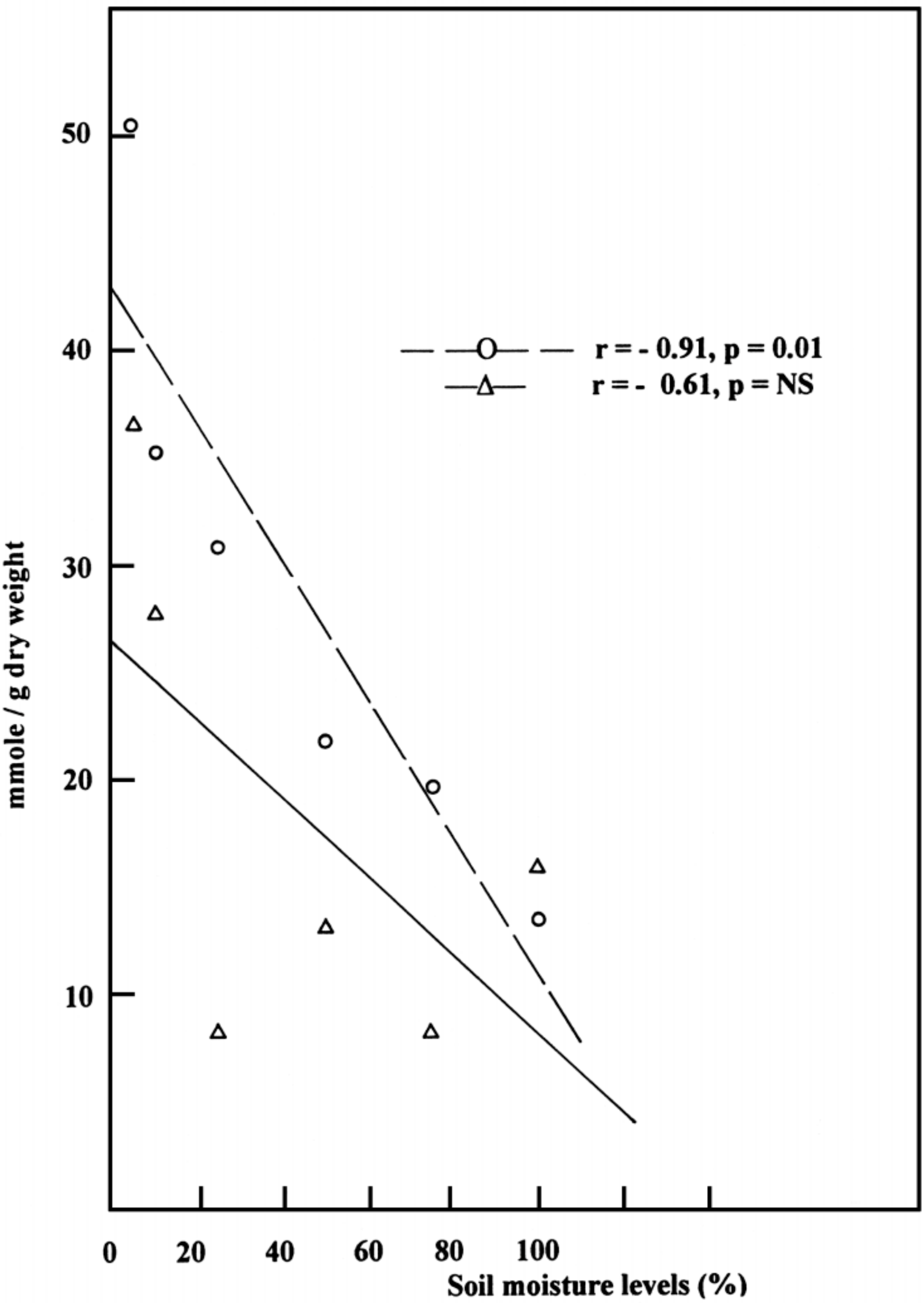

FIG. 4b. The relationships between Na (mmol/g dry weight) in the root of *C. procera* and the soil different moisture levels, in the present (—— —— O —— ——) and absence (—— Δ ——) of salinity [Product moment correlation coefficients (γ) and their p-values].

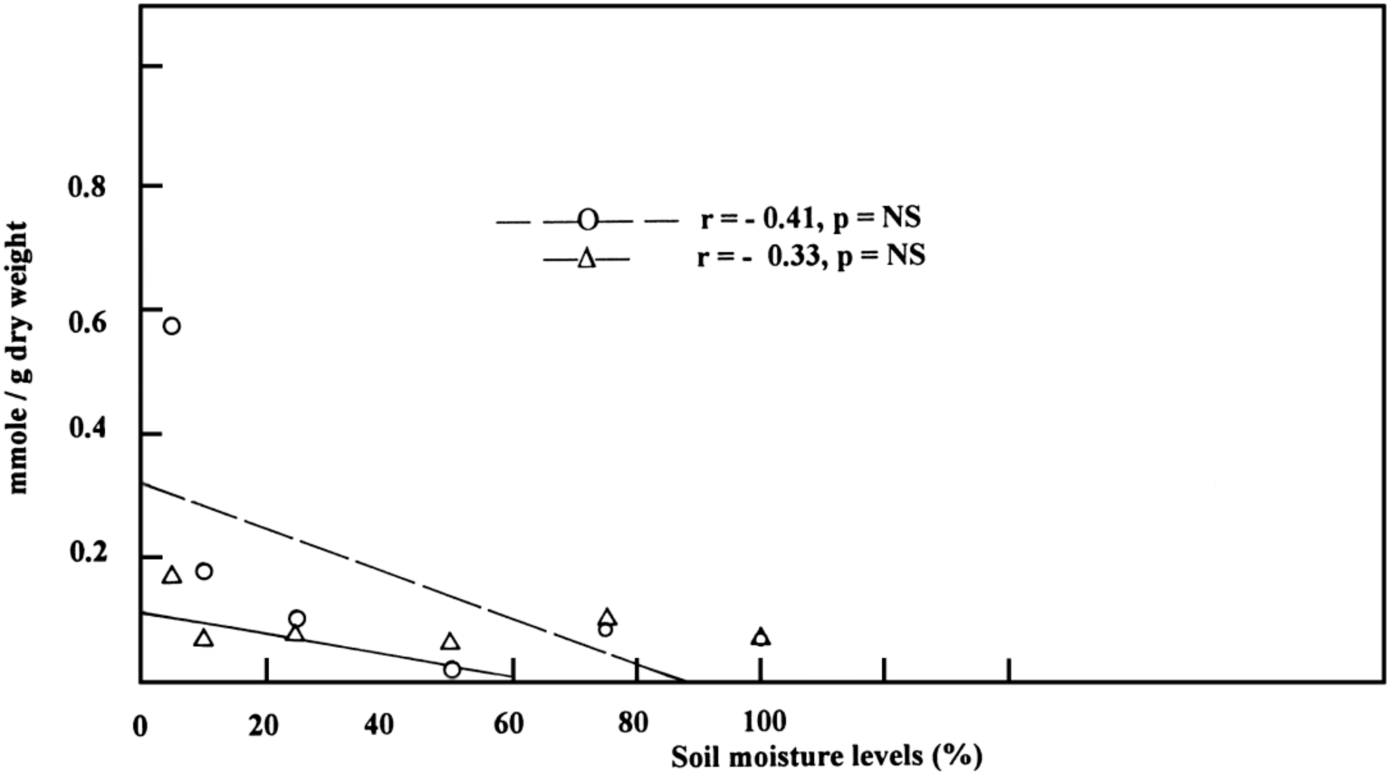

FIG. 5a. The relationships between Cl (mmol/g dry weight) in the shoot of *C. procera* and the soil different moisture levels, in the present (—— —— O —— ——) and absence (—— Δ ——) of salinity [Product moment correlation coefficients (γ) and their p-values].

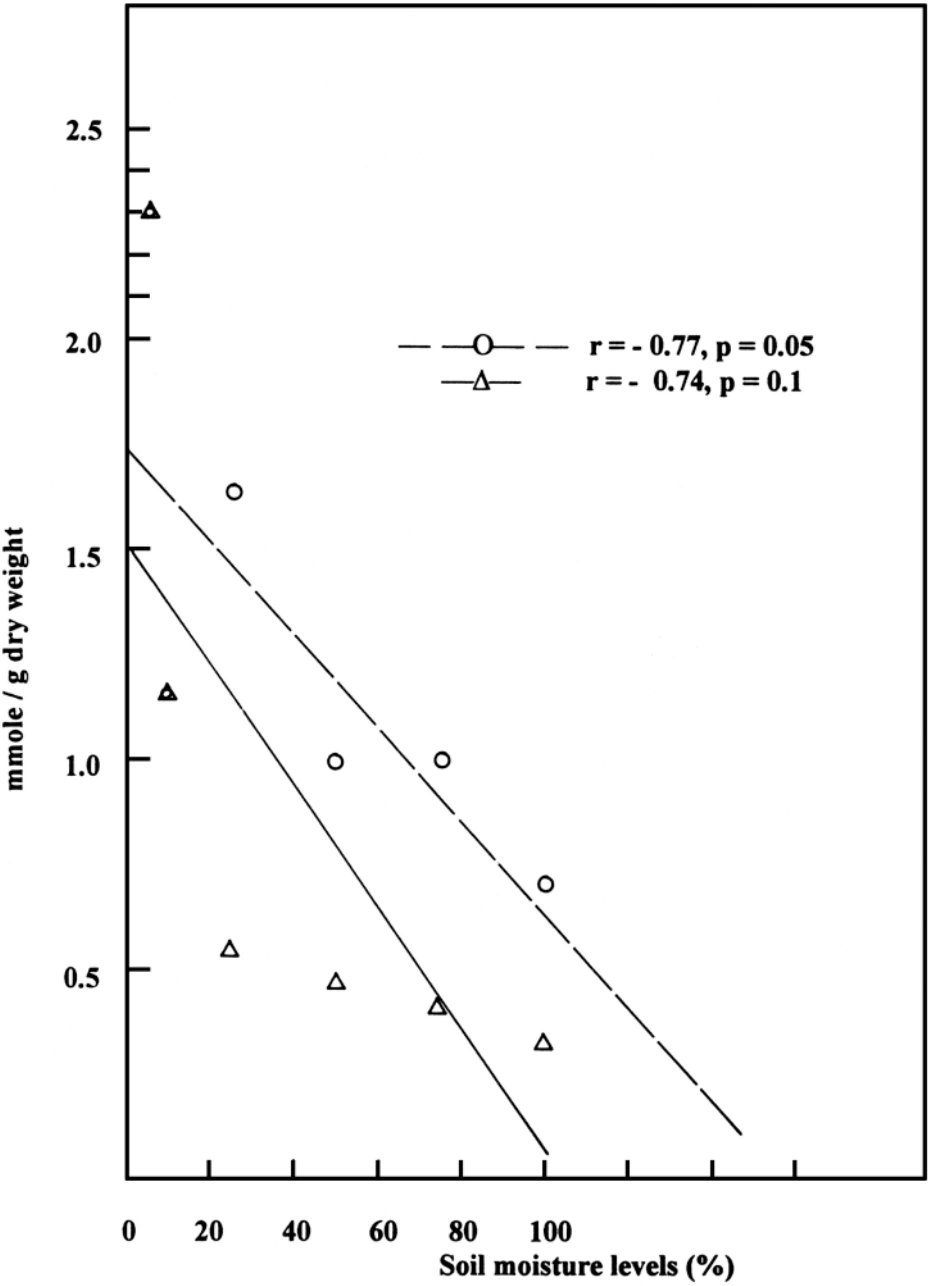

FIG. 5b. The relationships between Cl (mmol/g dry weight) in the root of *C. procera* and the soil different moisture levels, in the present (—— —— O —— ——) and absence (—— Δ ——) of salinity [Product moment correlation coefficients (γ) and their p-values].

دراسـة مقارنـة على استجابـة نبات العشر *Calotropis procera* (Ait.) Ait. (تفاحة سدوم) لمعامـلات مشتركة من الجفـاف والملوحـة

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المستخلص. لأهمية نبات العشر، أجري البحث الحالي لاختبار تأثير المعاملات الجفافية في وجود أوغياب الملوحة على إنبات ونمو بادرات هذا النبات ومحتواه من الكالسيوم، المغنسيوم، البوتاسيوم، الصوديوم والكلور. ولهذا الغرض استخدمت مستويات مختلفة من رطوبة التربة: ١٠٠٪، ٧٥٪، ٥٠٪، ١٠٪ و ٥٪ رطوبة تربة في وجود وغياب الملوحة.

هذا وقد أثرت المستويات المتدنية من رطوبة التربة على مساحة الأوراق وطول الجذور وخصوصًا في وجود الملوحة. إلا أن ارتفاع النبات وعرضه كانا الأقل تأثرًا من بين جميع أبعاد النبات. وقد استمرت بادرات هذا النبات في النمو حتى في المعاملات ذات العجز المائي العالي (١٠٪ و ٥٪) في وجود أوغياب الملوحة. كما أن وزن النبات ومحتواه المائي تأثرا بالكاد بهذا العجز. وأظهر البحث سلوكًا مميزًا لجذور هذا النبات في مراكمتها للعناصر. كما يقترح البحث الحالي وجود سلوك مقاومة للجفاف في هذا النبات.