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Response of *Solanum pseudocapsicum* to Watering Periods and Nitrogen Application

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Abstract: The response of *Solanum pseudocapsicum* to watering periods and nitrogen levels was investigated in a glasshouse experiment. The two factors studied significantly affected the vegetative growth and biomass production at $p \leq 0.05$. A significant interaction was also determined for 70% of the parameters studied. The application of 100 kg N ha^{-1} was found to be optimum for vegetative growth and biomass production no matter the watering period. Beyond this level, fertilizer application did not increase the magnitude of the growth parameters. The result of this study showed that this plant, although grows in the wild, is intolerant to drought condition and require small amount of fertilizer for its successful propagation. This might explain its adaptation to moist and shaded habitats and its survival ability as indoor ornamental plant.

Key words: *Solanum pseudocapsicum*, medicinal plant, biomass, growth, watering periods, nitrogen

INTRODUCTION

Solanum pseudocapsicum L. (Solanaceae), commonly known as winter cherry, is an erect and highly branched, non-spiny shrub that grows to a height of 0.6 to 1.2 m. It is a native of Africa but widely distributed in Argentina, Australia, Brazil, Hawaii and New Zealand (Holm *et al*., 1979). At maturity, its glabourous, red to yellow berries, are attractive and very poisonous. Although it is cultivated as an indoor ornamental plant due to its brightly coloured berries, its medicinal values have also been reported (Van Den Berghe *et al*., 1978; Shrishailappa *et al*., 2003). In homeopathy, it is used to treat acute abdominal pain (Boericke, 1927).

Phytochemical analysis of this plant has revealed the presence of solanocapsine, solanine and other alkaloids in the leaves and fruits (Hohne *et al*., 1970; Chakravarty *et al*., 1984). Both solanocapsine and solanine have been reported to be very poisonous (Larsen *et al*., 1975).

One of the unique features of this plant is its leafy and evergreen characteristics. In winter, the leaves remain green and very attractive among the usually dry vegetation. This luxuriant appearance posses great temptation to animals and man especially in times of food scarcity despite its poisonous nature. A number of fatalities have been reported following the consumption of *S. pseudocapsicum* (Parisi and Francia, 2000; Watson *et al*., 2004).

Despite the wide reports on the medicinal and ornamental potential of *S. pseudocapsicum*, little or no information is available in the literature on its water and nitrogen requirement. Yet, information on water and nitrogen requirement is vital for the successful propagation of a wild species.

Water and nutrients availability are important factors in plant physiological processes. Although the role of water regimes and fertilization has been studied extensively in a number of *Solanum* species (Torrecillas *et al*., 1995; Taub, 2002; Hebbar *et al*., 2004), no such information is available on *S. pseudocapsicum*. This study was carried out to evaluate the effects of watering periods and nitrogen levels on the growth of *S. pseudocapsicum*.

MATERIALS AND METHODS

Plant material: The berries of *Solanum pseudocapsicum* were collected from a natural population around Alice, South Africa. It was authenticated in the Department of Botany and a voucher specimen (Ali Med 01/05) was prepared and deposited in the Griffen Herbarium of the University of Fort Hare.

Potting medium and analysis: The soil used for the trial experiment was collected from University of Fort Hare garden at a depth of 0-15 cm. The soil sample was air-dried, grounded and sieved to pass through 2 mm mesh. Soil pH in water was determined using 2.5:1 procedure described in Okalebo *et al*. (2002). Electrical conductivity was measured from same sample used for pH using WTW conductivity meter 330i. Total N was determined using Truspec C/N determinator, Organic C was determined using the H_2SO_4 and potassium

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dichromate method described by Okalebo *et al*. (2002). Exchangeable cations K, Ca and Mg were determined in Ambic 1 extract. The soil was found to have the following chemical properties: 6.3 g kg^{-1} organic C; pH 6.4; 0.2 g kg^{-1} total N; 97.64 mg kg^{-1}-available P; 119.2, 90.6, 17.75 mg kg^{-1} exchangeable K, Ca and Mg respectively. The electrical conductivity of the soil was 0.1 mS cm^{-1}.

Experimental design and treatments: The trial was a 4×5 factorial experiment, laid out in split plot design with three replicate. The four factors tested include; watering regime at 4 levels (2, 4, 7 and 14 days interval) and fertilizer application at 5 levels (0, 100, 150, 200 and 300 kg N ha^{-1}). Nitrogen was applied using lime ammonium nitrate (LAN) prior to transplanting. The soil moisture content was determined at field capacity and moisture was applied at 80% and was allowed to equilibrate overnight. A 21 day-old seedling was transplanted into each pot and 150 mL water was uniformly applied. Watering was continued for 14 days to allow for seedlings establishment after which the watering period treatment was imposed at the intervals of 2, 4, 7 and 14 days at field capacity.

Parameter evaluated: Plant height and number of leaves of the seedlings were evaluated weekly for 14 weeks. At the end of the 16 week, plant height, number of branches and number of leaves were evaluated before harvesting. The plants were harvested by washing the bulk soil of the roots by water Jet. Each plant was separated into leaves, stems and roots, oven-dried at 65°C to a constant weight. The root: shoot ratio was also calculated (Zainudin *et al*., 2003).

Data analysis: The data were analysed using MSTAT-C statistical package. The treatment means that showed significant difference were compared using LSD at 5% probability.

RESULTS AND DISCUSSION

There were significant differences ($p \leq 0.05$) between the watering periods and nitrogen levels in 79% of the parameters evaluated. Watering periods had a significant effect on all the parameters except on the number of leaves and root: shoot ratio. Similarly, nitrogen levels had a significant effect on all the parameters with the exception of the root: shoot ratio. Significant interaction was observed in watering regimes and nitrogen levels in six out of seven parameters studied. The result of this analysis showed that the parameters evaluated were influenced markedly by varying the watering periods and the levels of nitrogen (Table 1).

The dynamics of plant height with varied watering period and fertilizer levels over the experimental period are presented in Fig. 1a-d. The plant was significantly tall in plants with 300 kg N ha^{-1} under 2 days watering period (Fig. 1a). Plants treated with 100 kg N ha^{-1} grew tallest in the 4, 7 and 14 days watering regimes (Fig.1b-d). At 16 weeks after planting, the analysis of variance showed that the plant height was significantly influenced by watering period and nitrogen application at $p \leq 0.05$ (Table 1). A careful observation of the results showed that plant height decreased at higher nitrogen levels and in the longest watering regime (Table 2). Shortage of soil-water was reported to reduce uptake of nutrients, as nutrients can only move to roots through water films within the soil (Shaxson and Barber, 2003). The N application did not follow any trend in relation to dose and vegetative growth. However, it was observed that vegetative growth was high with the addition of small amount of nitrogen as compared to the control.

The number of leaves increased with the application of 100 kg N ha^{-1} and decreased in 0 and 150 kg N ha^{-1} levels (Fig 2a-d), however, at harvest it was found to be insignificant ($p>0.05$) with the watering periods, and highly significant ($p<0.01$) with fertilizer application (Table 1). The plants watered every 2 days with 100 kg N ha^{-1} application had the highest number of leaves while those subjected to 14 days watering regime and higher levels produced the least number of leaves (Table 2). The insignificant difference observed in the number of leaves may be due to leaf falls. Yellowing and wilting of leaves were observed in most of the plants at a certain stage during the experimentation, which was attributed to soil water imbalance. According to Tyndall *et al*. (1986), low soil moisture could reduce nutrient uptake and affect overall plant growth. The water content of the soil is a turgor-dependent process which is believed to have a strong influence on plant growth (Kirnak *et al*., 2001).The number of branches differs significantly at $p \leq 0.05$ with watering periods and nitrogen

Table 1: ANOVAs for watering period, N level and interaction on parameters evaluated at harvest in *S. pseudocapsicum*

Plant parameters	Water (W) df	Water (W) F	N-level (F) df	N-level (F) F	W vs. F df	W vs. F F
Growth						
Plant height	3	8.91*	4	4.58**	12	4.74***
No. of leaves	3	3.44 (ns)	4	4.36**	12	3.14**
No. of branches	3	16.53**	4	10.08***	12	7.58**
Biomass						
Root biomass	3	5.48*	4	3.29*	12	3.66**
Shoot biomass	3	5.52*	4	9.46***	12	13.81***
Total biomass	3	270.76***	4	5.73**	12	1.46 (ns)
Root: shoot	3	1.30(ns)	4	0.34 (ns)	12	0.85 (ns)

ns: Not significant ($p>0.05$). * $p<0.05$ ** $p<0.01$ *** $p<0.001$

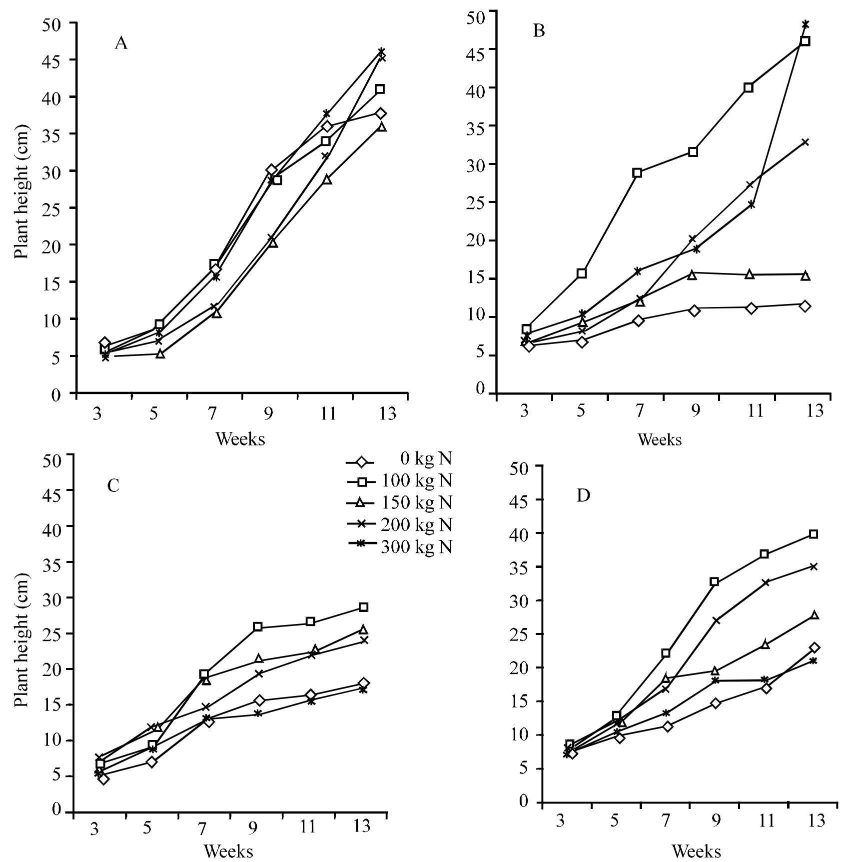

Fig. 1: Dynamics of plant height as affected by water regime and N-levels (kg ha^{-1}) in *S. pseudocapsicum*. (A) 2 days, (B) 4 days, (C) 7 days and (D) 14 days watering periods

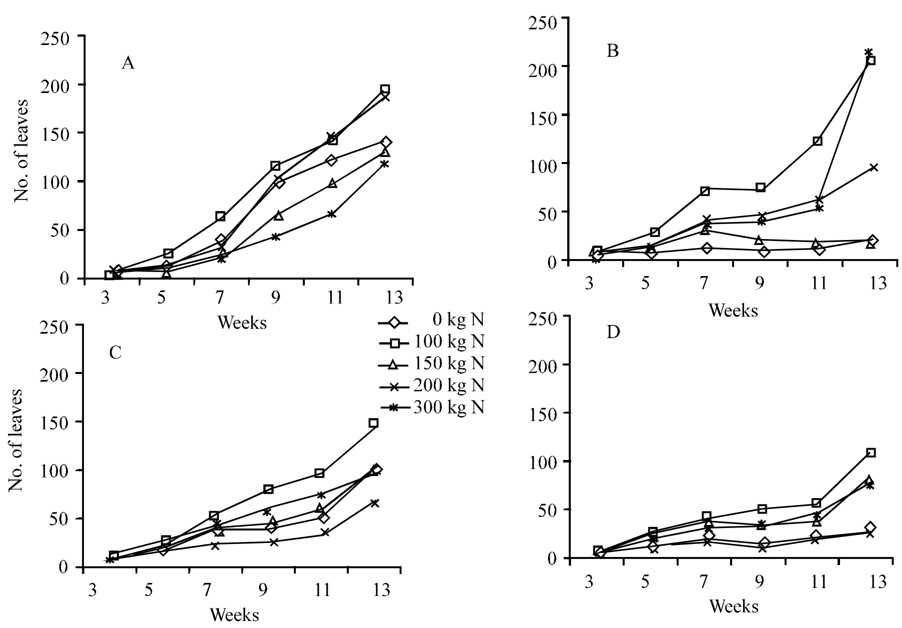

Fig. 2: The increase in the number of leaves as affected by watering regime and N-levels (kg ha^{-1}) in *S. pseudocapsicum*. (A) 2 days, (B) 4 days, (C) 7 days and (D) 14 days watering periods

Table 2: Effects of watering periods and N levels on vegetative growth and biomass accumulation in *S. pseudocapsicum* at harvest

				Biomass accumulation (g)			
Treatments	Plant height (cm)	No. of leaves plant	No. of branches/plant	Root: shoot	Total	Shoot	Root
Watering period (Days)							
2	36.21^{a}	129.80^{a}	12.13^{a}	0.37^{a}	11.91^{a}	8.71^{a}	3.21^{a}
4	28.14^{b}	95.47^{a}	7.93^{ab}	0.49^{a}	9.52^{ab}	6.37^{b}	3.15^{a}
7	28.89^{b}	109.07^{a}	6.40^{b}	0.39^{a}	8.45^{b}	6.17^{b}	2.38^{b}
14	25.52^{c}	72.53^{a}	6.73^{b}	0.37^{a}	6.40^{c}	4.67^{c}	1.73^{b}
N levels (kg N ha^{-1})							
0	22.92^{c}	71.58^{b}	5.25^{c}	0.60^{a}	5.30^{c}	3.31^{d}	1.99^{c}
100	38.84^{a}	157.25^{a}	12.25^{a}	0.41^{a}	13.72^{a}	9.68^{a}	4.04^{a}
150	27.25^{bc}	85.58^{b}	8.92^{b}	0.37^{a}	7.64^{b}	5.57^{c}	2.07^{b}
200	30.00^{b}	107.42^{ab}	8.33^{a}	0.41^{a}	10.37^{a}	7.32^{b}	3.05^{ab}
300	29.43^{b}	86.75^{b}	6.75^{c}	0.29^{a}	7.42^{bc}	6.48^{bc}	1.93^{c}

Means within each column of a treatment followed by the same superscript are not significantly different at $p<0.05$ as determined by LSD

application with significant interaction at $p<0.01$ (Table 1). However, it was observed that application of 100 kg N ha^{-1} and 2 days watering gave the highest number of branches. From the result of this investigation, increasing watering period and N levels affected the number of branches greatly (Table 2).

The total biomass was significantly affected by the watering periods ($p<0.001$) and fertilizer levels at $p<0.01$ (Table 1). A remarkable decrease in biomass accumulation was observed in treatments watered at 4, 7 and 14 days interval compared to those watered every 2 days (Table 2). The rate of accumulation of biomass in 100 kg N ha^{-1} was high in all the watering periods and decreased with increase in watering periods. A similar response on the effect of watering periods on dry matter accumulation was reported in eggplants (Kirnak *et al*., 2001). In this study, shoot growth appears to be less inhibited than the roots under watering regimes. However, root: shoot was not affected significantly by watering periods and nitrogen levels (Table 1).

In this study, the application of small amount of nitrogen enhanced plant productivity in terms of vegetative growth and biomass accumulation. This observation agreed with Shukla and Naik (1993) who reported that *Solanum* species have low nutrient requirements due to their ability to utilized nutrients readily available in the soil. According to Jackson and Bloom (1990), members of the genus *Solanum* can utilize a small amount of inorganic N available in large volume of soil explored by the roots and where N level is high, a very poor root development was observed. Although phosphorous is often described as the second limiting nutrient in crop after nitrogen (Thompson and Throch 1975), however, phosphorous was reported to be readily available to plants at pH ranges of 5.6-6.7 (Jan, 1973). The low performance of plant in the higher level of nitrogen could be attributed to the limiting effect of moisture. The effect of nitrogen was reported to increase with water supply and decreases when soil water content becomes excess (Nagy, 1996). Plants grown under high moisture and low nutrient supply were reported to perform better than those grown under low moisture and high nutrient (Zhang, 1996).

The results of this investigation showed that watering regimes and nitrogen level significantly influenced the growth performance of *S. pseudocapsicum*, 100 kg N ha^{-1} and 2 days watering period was found to be optimum for its vegetative growth and biomass production. Unlike other members of the genus, this species requires little amount of nitrogen. The application of higher level of nitrogen and prolong period of watering may be unbeneficial to the cultivation of the plant. The result of this study showed that this plant, although grows in the wild, it is intolerant to drought condition. This might explain its adaptation to moist and shaded habitats and its survival ability as indoor ornamental plant. The result of this finding could be beneficial in the propagation of this plant for its medicinal and toxicological exploitation.

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