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ROOT ZONE TEMPERATURE AFFECTS EMERGENCE AND GROWTH TRAITS OF SNAKE TOMATO (TRICHOSANTHES CUCUMERINA L.)

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ABSTRACT

Two Nigerian morphological variants of Trichosanthes cucumerina L., (Cucurbitaceae) an under-exploited tropical leaf and fruit vegetable were evaluated for response to root zone temperature (RZT) in a climate controlled growth chamber at 20, 25 and 30 °C. The Green variant [V_1] has long fruit with deep green background and white stripes at unripe stage while Light Green variant [V_2] has light green coloured long fruit when at unripe stage. Results showed that the first emergence for seeds at RZT of 30 °C occurred at 7 days after planting (DAP) for both variants while those planted at RZT of 20 °C and 25 °C showed first emergence at 10 and 14 DAP, respectively. At RZT of 20 °C, 25 °C and 30 °C, days to 50% emergence were 18, 12 and 8 DAP while last emergence was registered at 24, 15 and 10 DAP, respectively. This work showed that under controlled growth chamber conditions, days to first emergence was reduced by 5 days compared to the 12 DAP recorded under tropical field conditions. Root zone temperatures (T) produced statistically significant ($P \leq 0.05$) effects on the average number of tendrils, number of leaves, fresh leaf weight, stem length, fresh stem weight, root length, root weight and root volume while the main effect of T. cucumerina variants (V) and the interaction (V x T) produced no significant effects on all the parameters measured. The values recorded for each of the growth parameters were only numerically higher in the Green Variant (V_1) compared to Light Green Variant (V_2). The significantly highest value for each of the growth traits were recorded at 30 °C followed by 25 °C and 20 °C, in that order. Low root zone temperature of 20 °C produced adverse effects on both emergence and growth of T. cucumerina. This study established the need for providing soil warming facility for a successful cultivation of T. cucumerina in chilly (temperate) environment.

Key words: Trichosanthes cucumerina, root zone temperature, emergence, growth.

INTRODUCTION

Trichosanthes cucumerina L., also known as Snake Tomato, member of the family Cucurbitaceae, is an indigenous and under-exploited leaf and fruit vegetable in Southwest Nigeria (tropical Africa) that is now being studied in a temperate climate at the University of Bonn, Germany. It is just gaining prominence in Southwest Nigeria because the fruit pulp paste of T. cucumerina has been proven to be a suitable substitute/complement to the Solanaceous tomato (Lycopersicon esculentum (L.) Mill.), especially during the periods when the latter is scarce in Nigeria. The fruit pulp of T. cucumerina is sweet tasting, aromatic, deep red in colour and does not go sour as quickly as paste of L. esculentum [1, 2, 15]. Under the Southwestern Nigerian field conditions (temperature 24-26 ^{o}C, relative humidity 50-60% and rainfall 1100 mm as monitored by meteorological station), T. cucumerina seed germinates at 12 days after planting [15]. An optimum root temperature of 14-15 ^{o}C for optimum nutrient absorption and growth has been reported for cucumber (Cucumis sativus L.) [17]. It was also reported that fig-leaf gourd (Cucurbita ficifolia Bouche) maintained higher rate of water and nutrient absorption at low soil temperature [18]. In another study with cucumber, it was reported that a combination of 15 ^{o}C root temperature and 15 ^{o}C air temperature prohibited growth while 30 ^{o}C root temperature gave a slight increase in growth for cucumber plant maintained at 15 ^{o}C air temperature [12]. Maximum shoot growth was obtained at 30 ^{o}C air temperature and 25 ^{o}C root temperature. In the Netherlands, it was shown that earliness and total productivity of cucumbers were increased significantly by an increase in night temperature from 12 ^{o}C to 26 ^{o}C and in day temperature from 20 ^{o}C to 26 ^{o}C [8]. Grafted C. sativus was shown to grow faster with higher yields when grown at soil temperature ranging from 14 to 22 ^{o}C and 20 ^{o}C/12 ^{o}C day/night air temperature [9]. A study [19] on Lactuca sativa L. showed that root zone temperature of 20 ^{o}C is optimum for vigorous growth and highest leaf yield. In general root zone temperature has been shown to influence water and minerals uptake in plants [10, 11]. In fact, there are several reports on the effects of root zone temperature on different crops in the literature. The summary of the findings is that different crops require some location-specific favourable temperature for growth and ultimate survival.

Temperature is an important factor in controlling changes in development from germination and emergence through vegetative growth to floral initiation and reproductive growth [4]. For the introduction of crops from tropical to temperate climate and vice versa, temperature plays a critical role in production. Trichosanthes has not been given adequate research attention because its potential as a leaf and fruit vegetable has just been brought to the fore [1]. This study was necessitated by our observation that the seeds of the tropical T. cucumerina did not germinate at the ambient soil temperature in Bonn, Germany. The major task therefore is to artificially create an optimum soil temperature condition for the seeds to germinate. Based on the above mentioned observation and results of published works on tropical cucurbits the hypothesis has been made that emergence of T. cucumerina seeds and seedling growth will be optimum at day air temperature of 20 ± 1°C and night air temperature of 15 ± 1°C and at a medium root zone temperature of 25°C.

MATERIALS AND METHODS

The research was carried out at the Institute for Crop Science and Resource Conservation (Horticultural Science), University of Bonn, Germany. Stored seeds of two Nigerian morphological variants of T. cucumerina produced in October 2006 were used for the study. Green Variant [V1] has long fruit with deep green background and white stripes at unripe stage while the Light Green Variant [V2] has light green coloured long fruit when at unripe stage. The fruits of both variants turn red at ripening. The two variants have earlier been described [1]. The study was set up in a digitally controlled growth chamber (Model PVP, Phillips, Germany) maintained at 20 ± 1 ^{o}C air temperature during the day and at 15 ± 1 ^{o}C night air temperature. Relative humidity was 60 ± 5%. Chamber was supplied with sodium fluorescent lamps providing photosynthetic active radiation (PAR) of 160 µmol. s^{-1}. m^{-2} for a 14-hour-lightperiod daily throughout the duration of the experiment. The study was set up as a 2 x 3 factorial experiment with 3 replications. The factors were: two morphotypes of T. cucumerina and three root zone temperatures(RZT) (20, 25 and 30 ^{o}C). The temperature fluctuation was ± 1 ^{o}C for all the treatments. A 50 cm x 80 cm propagator (Model "Three-in-one-propagator", Jemp Engineering Ltd., UK) equipped with adjustable heating control elements was used for each temperature treatment. Supplemental temperature check was achieved by inserting mercury in-glass thermometers into the growth medium. The seeds were treated with Aatiram® fungicide (Stähler Agrochemie, Germany) at the rate of 0.5 g/100g seed before sowing. Seeds were sown in plastic cups (250 mL) filled with peat based compost which contained 4.0 mmol NO_3, 1.3 mmol P, 2.2 mmol K, 1.0 mmol Ca, 1.0 mmol Mg, 15.0 mmol Fe and 5.0 mmol Mn per liter. There were 45 cups per RZT treatment. Two seeds were sown per cup and later thinned to one seed after emergence. The propagator was stuffed with inert perlite to serve as insulator and conserve the heat so as to maintain the required temperature. The plastic cups were inserted into the insulated propagator. Moisture level in the cups was maintained by applying water of the same temperature as the soil substrate every other day. The seedlings were monitored from emergence until four weeks (28 days) after emergence when they were harvested for growth traits measurement.

Data were collected on number of days to first emergence, number of days to 50% emergence, days to last emergence and % total emergence for each treatment until 28 days after sowing. At four weeks (28days) after emergence, a sample of eight plants under each RZT treatment was carefully selected based on vigor uniformity and were uprooted and we ensured quantitative recovery of the roots from the soil by sieving the substrate to extract locked-up roots. The uprooted plants of each treatment were partitioned into leaves, stems, tendrils and roots. The fresh weights of leaves, stems and roots were measured by using digital balance. The stem and root lengths were measured using a measuring tape. The root volume was measured using the water displacement method.

All data collected were subjected to analyses of variance by using the SPSS package version 14.0. Means, where differences were significant, were separated using the least significant difference at 5% level of probability.

RESULTS AND DISCUSSION

The root zone temperatures significantly affected the emergence trend of the two variants of Trichosanthes cucumerina in a similar manner (Table 1). Results showed that the first emergence occurred for seeds sown at 30 ^{o}C at 7 days after planting (DAP) for both variants while those planted at 20 ^{o}C and 25 ^{o}C showed first emergence at 10 and 14 DAP, respectively. Seeds that were raised under normal greenhouse condition (data not reported) at 18 ^{o}C did not emerge within the period of 60 days when emergence count was terminated. At 20 ^{o}C, 25 ^{o}C and 30 ^{o}C, days to 50% emergence were 18, 12 and 8 DAP while days to last emergence were 24, 15 and 10 DAP, respectively. The total percentage emergence at 60 DAP when data collection was terminated showed that only 1/3 of the seeds planted at 20 ^{o}C emerged while seeds planted at 25 and 30 ^{o}C recorded ~100% emergence for both T. cucumerina variants. Earlier field studies in the southwestern tropical climate of Nigeria [15] showed that T. cucumerina seeds emerged at 12 DAP. Under the Southwestern Nigerian field condition according to meteorological station data, the air temperature is 25-28 ^{o}C, relative humidity is 50-60% and rainfall ~1100 mm [15]. The earlier emergence (7 DAP) recorded at 30 ^{o}C root zone temperature under controlled condition (20 ±1 C/15 ±1 C day/night air temperature) compared with the emergence (12 DAP) obtained under tropical field conditions may be related to the significant impact that a few degrees change in temperature could have on plant physiological processes e.g. biochemical, enzymatic and hormonal activities. Several earlier studies on some cultivated species have reported cardinal temperatures for the seed germination for many plant species [6,13]. Each species was shown to have a minimum and a maximum temperature at which no seeds will germinate and an optimum temperature at which germination will be the highest [4]. Also, studies with Arachis hypogaea L., showed that the rate of seedling emergence increased by about 1.4 calendar-days for every 1 °C rise in soil temperature [5]. When seeds were exposed to a mean soil temperature of 23.4 °C, an air thermal time (Q [a]) of 49 degree-days (°C d) was required for seedling emergence to start, and emergence was completed within 117 °C d. With a cooler soil (18.1 °C), seedling emergence began at 96 °C d and was completed by 237 °C d.

Root zone temperatures (T) had statistically significant ($P \leq 0.05$) effects on all the growth parameters measured while the T. cucumerina variants (V) and the interaction (V x T) showed no significant effects on all the growth parameters measured (Table 2). The values recorded for each of these parameters were only numerically higher

Table 1: Effect of root zone temperature and variant on seed emergence of *Trichosanthes cucumerina* L.

Variants	Root zone temperature (^{o}C)	Days to first emergence (DAP)	Days to 50% emergence (DAP)	Days to last emergence (DAP)^{x}	Emergence percentage (%)
V_1	20 ^{o}C	14 a	18a	24a	33.3b
(Green	25 ^{o}C	10b	12b	15b	99.5a
Variant)	30 ^{o}C	7c	8c	10c	100.0a
V_2	20 ^{o}C	14a	18a	26a	30.0b
(Light	25 ^{o}C	10b	12b	16b	100.0a
Green Variant)	30 ^{o}C	7c	8c	10c	99.5a

^{X} Emergence count was terminated at 60 days after planting.
Means in each column, under each variant, followed by different alphabets are significantly different at 5% level of probability.

Table 2: ANOVA showing the mean squares and statistical F values for the main effects and interaction of *T. cucumerina* variants and root zone temperature.

	df	No of tendrils/plant		No of leaves/plant		Fresh leaf wt/plant (g)		Stem length (cm/plant)		Fresh stem wt (g/plant)		Root length (cm/plant)		Root wt (g/plant)		Root volume (cm3/plant)	
		Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value
Rep	2	0.00083	0.81ns	0.0033	1.00ns	0.00008	0.026ns	1.021	10.563ns	0.0012	2.357ns	0.0075	0.593ns	0.001	0.774ns	0.000	0.000ns
Var (V)	1	0.005	0.489ns	0.00056	0.167ns	1.296	456.01ns	125.88	1299.1ns	0.176	345.76ns	0.269	21.25ns	0.0697	53.51ns	0.0193	20.324ns
Temp (T)	2	14.30	1398.4*	14.371	4311.2*	27.75	9777.8*	1391.2	14357.8*	15.105	29671.0*	86.004	6797.9*	7.462	5730.0*	7.774	8170.4*
V x T	2	0.0017	0.163ns	0.00389	1.17ns	0.0181	6.38ns	4.56	47.03ns	0.00891	17.49ns	0.294	23.23ns	0.0130	9.99ns	0.134	140.6ns
Error	11	0.0102		0.0033		0.0028		0.0969		0.00051		0.0127		0.0013		0.00095	

*: indicates that the effect is significant at 95% level of probability.
ns: indicates that the effect is not significant at 95% level of probability.

in the Green Variant (V_1) compared to Light Green Variant (V_2). Generally, the average number of tendrils, number of leaves, fresh leaf weight, stem length, fresh stem weight, root length, root weight and root volume for Green Variant (V_1) were 4.3/plant, 6.3/plant, 4.50 g/plant, 60.8 cm/plant, 2.42 g/plant, 11.9 cm/plant, 1.66 g/plant and 1.67 cm^3/plant, respectively while for the Light Green Variant (V_2) the values were 4.3/plant, 6.3/plant, 3.91 g/plant, 55.5 cm/plant, 2.22 g/plant, 10.5 cm/plant, 1.53 g/plant and 1.50 cm^3/plant, respectively. A major observation in this study is that V_1 that had higher root length, root weight and root volume also achieved higher leaf weight, stem length and stem weight compared to V_2. This can be explained by the stronger ability of V_1 (based on root properties) to explore the growth medium and extract the maximum from the mineral nutrients reservoir (the source). In addition to taking up water and nutrient, roots are also sources of vital growth hormones such as gibberellins, abscisic acid and cytokinins [4] and also send chemical signals that control whether or not leaves would grow.

The effects of root zone temperature on growth traits are presented in Figures 1 a-g. For both variants of T. cucumerina, significantly ($P \leq 0.05$) higher number of tendrils, number of leaves, fresh leaf weight, stem length, fresh stem weight, root length, root weight and root volume were recorded at 30 °C compared to 20 °C and 25 °C. Significantly higher values were recorded for these parameters also at 25 °C compared to 20 °C. Comparison showed that the number of tendrils, number of leaves, fresh leaf weight, stem length, fresh stem weight, root length, root weight and root volume were approximately 49.1, 35.8, 64.2, 38.8, 73.2, 45.6, 74.9 and 77.5 % higher at 30 °C compared to 20 °C for V_1. Also at 25 °C compared to 20 °C, the number of tendrils, number of leaves, fresh leaf weight, stem length, fresh stem weight, root length, root weight and root volume were higher by approximately 24.4, 14.8, 44.2, 28.6, 45.0, 25.8, 50.3 and 53.6 %, respectively for V_1. The corresponding differences for these parameters in V_2 follow closely similar trend as observed above for V_1. On the other members of Cucurbitaceae, especially cucumbers (Cucumis sativus L.), the influence of root zone temperature on growth had been evaluated. For example, an optimum root temperature of 14-15 °C has been reported for optimum nutrient absorption and growth of cucumber (Cucumis sativus L.) [17]. In another study with cucumber, [12] reported that a combination of 15 °C root temperature and 15 °C air temperature prohibited growth while 30 °C root temperature gave a slight increase in growth for cucumber plant maintained at 15 °C air temperature. The earliness and total productivity of cucumbers were increased

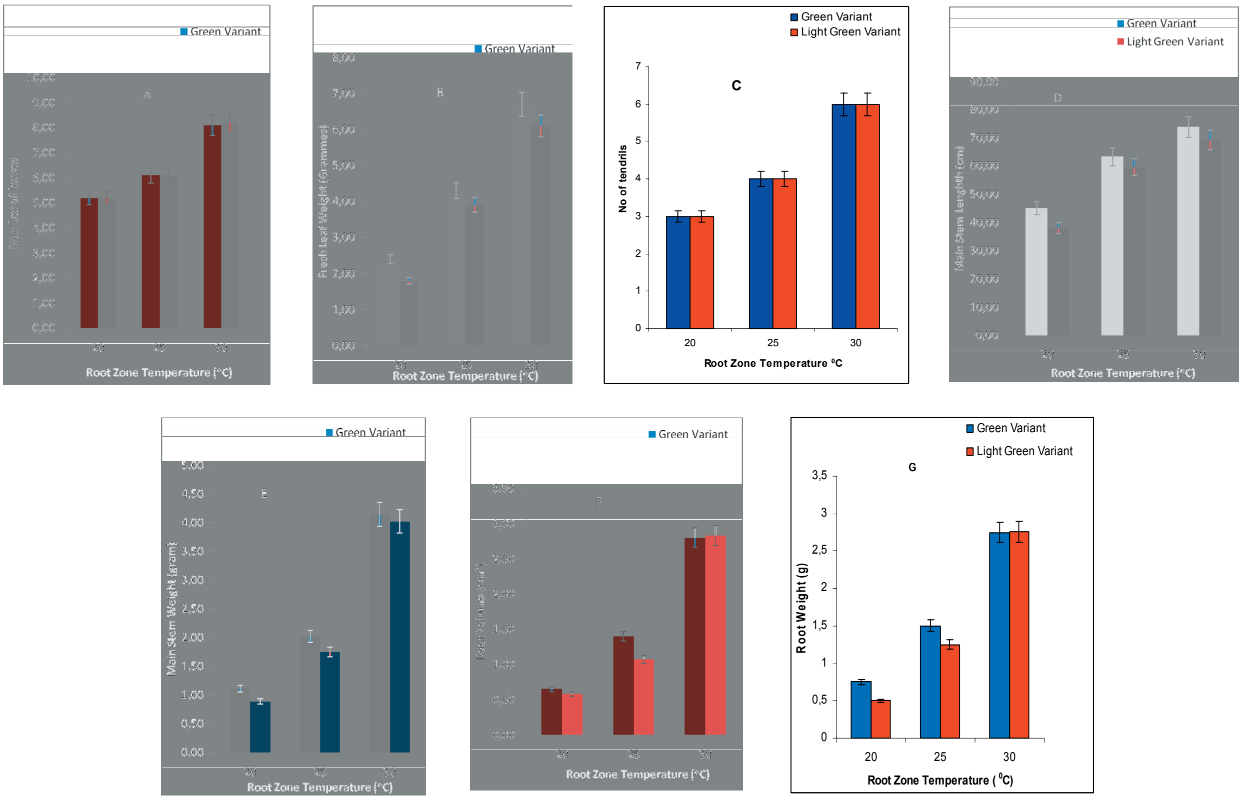

Figure 1: Effects of root zone temperature on growth traits (a) number of leaves, (b) fresh leaf weight, (c) number of tendrils, (d) main stem length, (e) main stem weight, (f) root volume, (g) root weight and (h) tap root length

significantly by an increase in night temperature from 12 °C to 26 °C and in day temperature from 20 °C to 26 °C [8]. Grafted C. sativus was shown to grow faster with high yields when grown at soil temperature ranging from 14 to 22 °C and 20 °C/12 °C day/night air temperature than [9]. Working also with cucumbers, [11] demonstrated that shoot growth significantly increased from 10-26 °C root zone temperatures while root growth did not and that root activity at 18 and 26 °C increased continuously from 2-6 weeks while the same decreased at 10 °C after 4 weeks. It was also reported that fig-leaf gourd (Cucurbita ficifolia Bouche) maintained higher rate of water and nutrient absorption at low soil temperature [17].

CONCLUSIONS

Two major observations in our study are: (1) Seeds sown at RZT of 30 °C emerged faster than at 20 °C and 25 °C and this is in contrast to our postulated hypothesis and also in contrast to findings of earlier authors on some other members of Cucurbitaceae [7,12,17]. It was surprising that we observed better growth and performance at 30 °C. The physiological basis for this observation is being investigated and may address differences in mineral uptake, antioxidant, chlorophyll contents and photosynthetic rates of the two variants of T. cucumerina. (2) The number of days to first emergence (7 DAP) under controlled condition was faster than the 12 DAP reported by [15] required for first emergence under tropical field condition. This is an indication that root zone temperature of 30 °C could speed up emergence by 5 days. We are into further investigation on the mechanism responsible for this observation.

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